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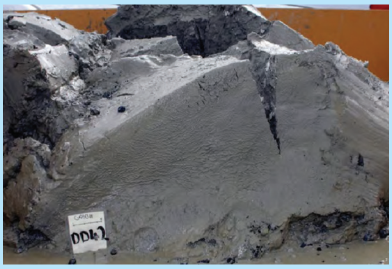
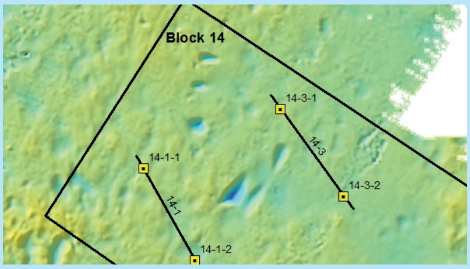
Chatham Rock Phosphate Limited
Proposed Mining Operation, Chatham Rise

Marine Consent Application and Environmental Impact Assessment



Prepared and compiled by Golder Associates (NZ) Limited

Chatham Rock Phosphate Ltd

SUMMARY

Introduction

Chatham Rock Phosphate Limited (CRP) proposes to mine phosphorite from the crest of the Chatham Rise. Phosphorite contains phosphorus one of the main components of commercial fertiliser, whose use has contributed to the growth in agricultural productivity in New Zealand and around the world.

The well-being of New Zealanders and the New Zealand economy depend on agriculture and fertiliser is an important requirement for our agriculture. Every year approximately one million tons of rock phosphate is imported into New Zealand for processing into fertiliser. Security of supply and price instability are risks to New Zealand's agricultural sector and thus its economy.

On the seabed east of Banks Peninsula, about half way to the Chatham Islands, there is a deposit of rock phosphate sufficient to supply New Zealand's present needs for at least 25 years. This phosphate has very low cadmium content and can be applied directly to the land as a slow-release fertiliser, thereby reducing the runoff issues associated with processed fertilisers.

Economic gains from the mining activity will result in New Zealand's GDP being boosted by NZ$280 million per year. Domestic consumption will increase with a predicted welfare gain of NZ$130 million per year of mining, and implementing the project over a 15 year period will be equivalent to New Zealand becoming NZ$900 million richer today. There are also environmental gains which include lower cadmium input to soils, reduced emissions during shipping and reduced phosphate runoff.

CRP has a mining permit for an 820 km^2 area covering the known richest area of the phosphate deposit. CRP also holds a prospecting licence surrounding the mining permit and has applied for prospecting permits for adjacent areas, to the west and east of the prospecting licence, where phosphate has been previously discovered.

In addition to its mining permit, CRP requires a marine consent under the Exclusive Economic Zone and Continental Shelf Act (Environmental Effects) Act 2012 (EEZ Act) before mining can commence. CRP is now seeking that consent. This application document and environmental impact assessment (EIA) describes the potential environmental, economic and social impacts of the project and how adverse impacts will be avoided, reduced or mitigated.

The application covers the full 10,192 km^2 of the permits and licences CRP holds, or has applied for, because this provides improved options for balancing mining operations and protection of ecological values.

The Chatham Rise extends east for more than 1,000 km from Banks Peninsula to beyond the Chatham Islands. It lies entirely within New Zealand's Exclusive Economic Zone (EEZ) and has significant seabed deposits of phosphorite and other potentially valuable minerals (Figure 1). The phosphorite deposits, discovered in 1952, formed about 5 million years ago.

Commercial mining of the resource was investigated in the 1980s, but it was not considered viable as there were cheaper sources of phosphorite available and there were limitations in the mining technology. However, recent increases in the market value of phosphorite, driven largely by population increases, growing affluence and demand for protein-rich foods in developing countries, and advances in offshore mining methods mean that it is now economically feasible to mine the Chatham Rise's phosphorite resource.

Mining Approach

The world's largest dredging company, Royal Boskalis Westminster (Boskalis), has designed a mining system for the project that is based on conventional dredging technology. The specifications for the vessel and the operations plant evolved from CRP's and Bosklalis' evaluation of available mining methods, the nature of the resource, the weather and wave conditions on the Chatham Rise, and the phosphate market. Managing the impact on the environment was also a key aspect of the design process, of equal importance as technological feasibility, reliability and economic viability.

Mining will be carried out from a specially built or modified vessel. The conceptual layout of the mining vessel and its key mining components are illustrated in Figure 13.

Mining will involve sucking the sediment from the seabed with a trailing suction drag-head (Figure 21). The phosphorite-bearing material will be retrieved from the seabed and mechanically processed on the vessel to separate the coarse phosphatic material from the finer non-phosphatic sediments. No chemicals will be used in the separation process. The non-phosphatic material will be returned to the seabed through another flexible hose. The phosphorite nodules will be retained and when the holds are full, after four to five days of mining, the phosphorite will be transported to a New Zealand port. Annually, there will be about 30 cycles of mining with each cycle separated by a period when the mining vessel transits to and from port. This means that mining operations on the Rise will only occur for the equivalent of about four months a year.

CRP proposes to mine about 30 km^2 of seabed per annum throughout the life of mining operations on the Rise, mined as three 2 km wide by 5 km long blocks, to meet its minimum annual production target of 1.5 million tonnes of phosphorite. During the initial 15 years of mining, about 450 km^2 of seabed would be mined. In the marine aggregates industry, restricting disturbance to relatively small blocks is common practice as it facilitates the recolonisation and recovery of the seabed in areas where dredging has ceased.

The mining plan also includes provision for mining exclusion areas. These exclusion areas protect areas of particular scientific or conservation sensitivity and values identified through a marine spatial planning exercise which covered a large portion of the crest of the Chatham Rise. They also provide sources of recolonising species for areas that have been mined.

Licences, Permits and Consents

CRP currently holds and has applied for prospecting licences and permits and a mining permit that cover an area of 10,192 km^2 (Figure 4). These areas have the most potential to become an economically viable mining operation, based on exploration surveys and resource analysis undertaken between 1952 and the early 1980s and six surveys carried out by CRP.

CRP's minerals prospecting licence (MPL 50270) covers around 4,726 km^2 of the Chatham Rise, but CRP has offered to relinquish 1,019 km^2 of MPL 50270. The mining permit, which was granted in December 2013 by New Zealand Petroleum and Minerals (NZPaM) pursuant to the Crown Minerals Act 1991, covers an area of approximately 820 km^2 in the western half MPL 50270 (Figure 5).

In November 2013 CRP lodged applications with NZPaM for two additional prospecting permit areas located to the west and east of MPL 50270 (Figure 4). The western permit area covers an area of 1,501 km^2 and the eastern 4,985 km^2.

CRP is now seeking a marine consent pursuant to the EEZ Act covering the areas associated with CRP's mining permit and prospecting licences and permits (a total area of 10,192 km^2). A marine consent is required to authorise the environmental aspects of CRP's proposed mining operations, initially within the mining permit area. If further economic resources are discovered, then mining may proceed to the prospecting areas provided monitoring results and environmental investigations described in marine consent conditions are met and a mining permit is granted. A 35 year term is being sought for the marine consent.

The 10,192 km^2 marine consent area provides CRP with an opportunity to identify proposed mining exclusion areas over a broader area beyond the mining permit area. These areas were determined as part of a marine spatial planning exercise which identified areas of particular ecological sensitivity or value. The proposed mining exclusion areas, which will not be disturbed during mining, are within the marine consent area and therefore not outside of CRP's control.

Consultation and the EIA Process

Since it was granted MPL 50270, CRP has consulted with existing interests (as required by the EEZ Act), Iwi and Imi, the Chatham Islands community and other interested parties. Existing interests consist of the commercial fishing industry, including the Iwi fishing industry, and other vessels traversing the mining area. The nature of consultation and the issues raised are outlined in the EIA.

The issues raised during consultation generally reflect the potential impacts identified by the CRP project team in the early stages of project development. These issues have all been considered by CRP, assessed as part of the impact assessment process and, where possible, mitigation measures to address them have been incorporated into the project's design.

As part of the preparation of this EIA, expert technical assessments have been commissioned by CRP to more fully understand the nature of the Chatham Rise environment and the potential impacts associated with CRP's proposed mining operations. These assessments are appended to the EIA and, along with the outcomes of consultation, have been used to inform and guide avoidance, remediation and mitigation measures which have also been incorporated into proposed marine consent conditions.

The Chatham Rise Environment

The crest of the Chatham Rise is characterised by low sedimentation rates, a consequence of the distance from land and currents at the seabed, and high productivity in the shallow part of the water column resulting from the uplift of nutrient-rich water along the flanks of the Rise. This high productivity supports some of New Zealand's most important commercial fisheries. The distribution of communities of organisms found on the seabed varies along and across the Rise, and is a function of the nature and shape of the seabed and of oceanographic conditions.

Most of the surface sediments in the marine consent area on the crest of the Chatham Rise are at least five million years old. They are predominantly an unconsolidated mixture of greenish-grey sands and muds containing spatially-varying amounts of phosphorite grains and nodules. The phosphorite formed about five million years ago, and the surrounding sediment is the eroded remains of limestones and chalks that are 10 to 20 million years old. These sediments overlie chalk that is about 25 million years old. The nodules occur as irregularly shaped grains and nodules, 0.5 to 350 mm in size, on and within the seabed's uppermost sedimentary layer at water depths of 350 to 450 m (Figure 2 and Figure 3).

Small outcrops of hard igneous or metamorphic basement rock also occur on the Rise. Other geomorphological features on the Rise include seamounts and elevated banks, furrows created by icebergs, and pockmarks associated with the release of methane from the sediments.

The Chatham Rise lies at the boundary between warm, saline subtropical water to the north and cooler, less saline sub-Antarctic water to the south. The boundary is known as the Subtropical Convergence or Subtropical Front. Although the surface sea conditions can be harsh, these do not influence water movement at the seabed in the proposed marine consent area.

The water chemistry of the Chatham Rise is significantly influenced by the interaction of the water masses on either side of the Rise. The sub-Antarctic waters are enriched in nutrients and this drives the high productivity of the phytoplankton in the surface waters along the crest of the Rise. This high productivity supports commercially important populations of demersal and deep water fish, and is the primary driver of marine food webs on the Rise.

A model of food chain (trophic model) on the Chatham Rise has been developed and is represented by 36 key groups. The five most important groups on are (in order): phytoplankton, small demersal fish, mesozooplankton, hoki and flagellates (a group of protozoans).

There are typically no micro-nutrient limitations in the Chatham Rise's surface waters and trace element concentrations are low as the waters are remote from terrestrial and atmospheric sources of contaminants.

The physical features of the seabed habitat and the related fauna vary significantly along and across the Rise. Surveys of the seabed show that the seabed communities are usually characterised by a wide range of invertebrate species. Most of these species live within the sediments (infauna) although some live on the seabed (epifauna). Corals and some other seabed organisms need to be attached to solid materials such as phosphorite nodules or rock outcrops. Suitable habitats for these organisms are predicted to be widespread along the crest of the Rise.

The main commercial fisheries of the Chatham Rise are hoki, hake, ling, silver warehou, scampi, orange roughy and oreos. Except for ling, commercial fishing is generally focussed on the flanks of the Chatham Rise. Juvenile fish of a number of these species are reported from the crest of the central part of the Chatham Rise, although many are found more commonly on the flanks and on the crest west of CRP's marine consent area. Immature and mature scampi are reported along the entire length of the Rise crest, with highest densities in areas west of the marine consent area.

Significant populations of marine mammals and seabirds are supported along the Chatham Rise by the high primary productivity of its ecosystem. Sperm and pilot whales are the whale species most commonly sighted on the Chatham Rise, and habitat modelling indicates the southern flank of the Chatham Rise is probably an important foraging habitat for southern right whales during summer.

Among the wide range of seabirds seen on the Chatham Rise, the magenta petrel (the Chatham Islands taiko), the Chatham petrel and the Chatham albatross are endemic to the Chatham Islands and are likely to use the Rise for foraging or related activities.

Assessment of Potential Environmental Impacts

The potential impacts on the marine environment of CRP's mining proposal, as assessed within the EIA, are:

- The immediate impacts of seabed disturbance from drag-head operations.
- Physical impacts of returning the non-phosphatic material to the seabed.
- The impacts on ecological and conservation values.
- The impacts of sediment disposal on water and sediment quality.
- Impacts associated with vessel and mining related noise, including on marine mammals.
- Vessel lighting impacts on seabirds.
- Vessel waste discharges, biosecurity issues and project operational management and risks.
- Cumulative impacts - mining impacts in addition to similar impacts already occurring on the Chatham Rise, namely the impacts associated with bottom trawling for fish.

Immediate impacts of seabed disturbance from drag-head operations

The immediate impact of mining is removal of the seabed, including benthic fauna in and on the seabed (discussed below). CRP has proposed an environmental compensation package given that this impact cannot be avoided, remedied or mitigated.

This mining operations are likely to result in a small near-bed plume of sediment associated with drag-head operations. However, the plume will be small compared with that generated by return of non-phosphate sediments to the seabed following separation on-board the dredging vessel.

Physical impacts of returning the non-phosphatic material to the seabed

The return of sediments to the seabed will form a near-seabed plume of suspended sediment with subsequent transport of suspended sediment away from where it was discharged. As the sediment is transported away some of the sediment settles, with the greatest amount settling close to where it was discharged. The transport of suspended particles and sedimentation have been modelled with techniques used worldwide for similar projects.

The proposed mining system minimises the possibility that the suspended sediment will affect the biologically productive surface waters. This is achieved by returning the material, via a pipe, that discharges approximately 10 m above the seabed and within the area that is being mined. This ensures that there is no impact within the euphotic zone and that adverse impacts on the organisms that live in this zone, including a number of the key fisheries resources, are effectively avoided.

The most significant impacts of the suspended sediment plume are predicted to be in the bottom 10 m of the water column and within less than a kilometre of the mining blocks. The suspended solids concentration in the plume is predicted to be near background levels within about 15 km of the mining blocks. The plume is predicted to rapidly dissipate and the levels of suspended sediment are predicted to return to ambient levels within about two days of mining operations stopping. The majority of sediment is predicted to be deposited within about 500 m of the mining blocks, with some minor impacts extending to a distance of about 7 km.

Physical impacts and impacts on ecological and conservation values

Given the proposed implementation of avoidance, remediation and mitigation measures, potential impacts on other conservation values, including marine mammals and seabirds, will be minor.

The removal of the seabed and the return of the non-phosphatic sediment to the seabed results in impacts on benthic fauna (loss of fauna and habitat within the mining area and potential sedimentation impacts adjacent to), and potential impacts on other Chatham Rise ecological values, including values of conservation significance.

The benthic habitats, and thus fauna, most significantly affected by mining operations, are the areas of phosphorite nodule exposed at the seabed. This loss cannot be avoided.

The ability of marine communities to recover over time is of key importance in the environmental management strategy for this project. Organisms that live in soft sediments are generally resistant to intermittent increases in suspended sediment concentrations and deposition, whereas animals that attach to hard surfaces are often less tolerant of these changes. The communities immediately adjacent to the mining blocks will be impacted by sedimentation, but the impacts are predicted to decline rapidly away from the mining blocks as the plume disperses and sedimentation decreases. Restricting mining operations during the first five years such that sedimentation impacts from mining blocks do not overlap on an annual basis, and the establishment of the mining exclusion areas, will encourage recovery of communities by lateral movement of mobile adults and recolonisation by larvae. Recolonisation of the mined areas, and areas covered by sediment will commence within a relatively short period and recovery to a diverse soft-sediment benthic community is likely within several years.

Recolonisation and recovery of animals that depend on hard outcrops will be much slower, and will not occur if all the hard material, for example the phosphorite, is removed. These animals include cold water coral species. Efforts to protect these species include the identification of mining exclusion areas to protect their habitat, design of the mining system to minimise the area affected by significant sedimentation, and experiments to test the feasibility of replacing hard substrate at the seabed, and thus create habitat.

Scientific study of the food web on the Chatham Rise indicates that it is unlikely that the loss of benthic fauna in the mining blocks will have a significant impact on the Chatham Rise ecosystem. This ecosystem is largely driven by phytoplankton growth and although the benthic ecosystem does play an important role for some components of the system, the mining block loss is considered to be minor in the context of the marine consent area and the Chatham Rise environment as a whole.

In addition, although the marine consent area overlaps with a fishing benthic protection area, CRP has undertaken a marine spatial planning exercise that it considers better recognises the values associated with the central crest of the Chatham Rise. If the areas (including the area beyond the marine consent area) identified from this exercise (or any other similar exercise) are protected from seabed disturbance through an appropriate legal mechanism, as proposed by CRP through a condition of its marine consent, then more environmental suitable areas will be protected in the future. Irrespective of broader national issues associated with the establishment of marine protection areas, CRP has set aside mining exclusion areas which were identified through a process designed to balance environmental and economic values.

Impacts of sediment disposal on water and sediment quality

The risk of adverse impacts on water and sediment quality from the returns has been assessed as very low.

In common with many other mineral sands, the phosphorite and associated sediment has a natural geochemistry that results in the release of some constituents into seawater when the sediment is mixed during the mining and separation process. In addition, biota will also become entrained with the returns. There is no indication that the addition of small amounts of either inorganic or organic material from the phosphorite, sediments or entrained organisms will result in a significant degradation of water or sediment quality

Impacts associated with vessel and mining related noise

Studies have shown that the zone within which some response might occur, however small, to noise from the mining operations is restricted to less than 2 km from the vessel in the case of several whale species, and to the immediate vicinity of the vessel in the case of other marine mammals.

The best information on behavioural responses to sound is available for marine mammals, particularly whales and dolphins. The sound levels generated by an operating dredger similar to the equipment that will be used on the mining vessel are comparable to those of a similar-sized ship in transit across the Chatham Rise area and well below those known to cause injury to marine mammals. They are much less than the potentially damaging sound levels of activities such as pile-driving during engineering works or seismic surveys with large energy sources.

To avoid impacts on marine mammals, visual search will be made for marine mammals near the vessel before the start of mining operations, and mining will not start until all marine mammals are clear of the area.

Vessel lighting impacts on seabirds

Lighting on vessels at sea can cause disturbance to seabirds at night. CRP has identified lighting policies and procedures for the vessel that will minimise these impacts, in line with international best practice.

Vessel waste discharges, biosecurity issues and project operational management and risks.

All commercial vessels at sea are required to comply with regulations governing control of waste discharges, including discharge of ballast water and related biosecurity issues. CRP has developed policies and procedures for its vessel operations that will ensure compliance with regulations relating to the operational safety of the vessel and with protection of the environment.

Cumulative impacts

Currently, the only human use of resources on the Chatham Rise is commercial fishing, including long-lining and trawling. Bottom trawling by fishing vessels has a significant impact on the Chatham Rise environment. Studies have shown that bottom trawling affects organisms living on the seabed, generates a plume of suspended sediment, and that repeated trawling can change the characteristics of the sediments at the seabed. During the 1989/90 to 2010/11 fishing years, the area of the Chatham Rise seabed above the 1,000 m contour, swept by trawling is estimated to be 92,346 km^2.

Research shows that the seabed environments and communities on the Rise flanks are generally different from those on the crest, and the impacts of fishing and mining are unlikely to have significant cumulative impacts on these environments and communities. Mining will result in cumulative impacts on seabed resources on the crest of the Chatham Rise but this loss is proportionally very small when compared with the area on the flanks that has been and continues to be affected by commercial fishing.

Summary - Potential impacts and assessment of environmental risk

An environmental risk matrix approach was used to assist in assessing the significance of these impacts and environmental risks. The level of environmental risk is usually determined after the application of avoidance, remediation and mitigation measures. Mitigation is proposed for potential impacts with high or serious environmental risk, and in instances where it reflects responsible corporate environmental behaviour and industry best practice.

CRP's mining operations will be carried out in accordance with environmental management and operational procedures, including environmental monitoring, in accordance with the Environmental Management and Monitoring Plan (EMMP). The EMMP and its supporting management plans will form CRP's environmental management system for its mining operations.

If mining is conducted according to the environmental management system and industry best practice then the physical impacts from drag-head operations, impacts on water and sediment quality, impacts on commercial fisheries (including on the Chatham Rise and at the Chatham Islands), impacts on conservation values, noise impacts, vessel waste discharges, biosecurity issues and project operations risks outside the mining area are minor, and they are low to medium environmental risks.

Potential impacts on seabirds from vessel lighting prior to the application of mitigation approaches were assessed as a medium to high environment risk, but following the application of proposed avoidance, remediation and mitigation measures the potential environmental risk reduced to medium or low.

The potential impacts from the loss of seabed habitat and fauna within the mining blocks and sedimentation impacts on seabed habitat adjacent to the mining blocks remain a high or serious environmental risk even after the adoption of proposed mitigation measures. For this reason, a programme to monitor the impacts, including the nature and timing of recolonisation of mined areas, is proposed prior to and during the initial stages of mining.

Social, Cultural and Economic Assessments

The potential social and economic impacts are considered to be positive. Mining phosphorite on the Chatham Rise will improve New Zealand's security of supply for phosphate fertilizer. The project is predicted to reduce phosphate imports by NZ$85 million per year, boost GDP by NZ$280 million per year and implementing the project over 15 years, if it occurred now, would mean that New Zealand would be NZ$900 million richer.

Chatham Islanders have a direct connection to the Chatham Rise and the activities that occur there. For this reason, CRP has consulted with the Chatham Islanders to understand the issues and benefits that they consider may be associated with the project. Beneficial social impacts that CRP has either committed to or are considering as part of its environmental compensation for the project, following consultation with the Chatham Islanders, include employment opportunities, subsidised fertiliser for Chatham Island farmers, educational scholarships, and support of Chatham Island-based ecological improvement projects. Other potential social impacts identified during consultation include impacts on the Chatham Islands' fishing industry, including the rock lobster and paua fisheries. These potential impacts have been assessed as a very low environmental risk.

Potential impacts on cultural values have been outlined by Ngati Mutunga o Whakekauri (Ngati Mutunga) in their draft Cultural Impact Assessment and Hokotehi Moriori Trust (Moriori) in a letter to CRP. Both Ngati Mutunga and Moriori, who claim the Chatham Islands in their rohe, outline a range of issues that they associate with the proposal. The issues largely revolve around the mining technique, potential impacts on the marine environment including fisheries, rangatiratanga and economic development opportunities. These are similar to the issues raised by other Iwi, particularly impacts on the marine environment and impacts on the broader fishery resource, although Te Runanga o Ngai Tahu have also identified impacts on marine mammals, a taonga species, as being of cultural significance. Ngati Mutunga and Moriori also advise that they wish to receive more technical information in relation to these potential impacts and they wish to continue to develop a relationship with CRP. CRP has committed to do so.

Existing interests, given the EEZ Act's definition, include the fishing industry and other vessels traversing the area. Potential impacts on existing interests are directly connected to potential impacts to the fisheries, which are considered to be of low environmental risk. Provided international and national navigational safety laws are complied with by all vessels in the area, conflict between CRP's mining vessel and other vessels will not occur.

Other positive impacts associated with CRP's proposed mining operations include reduced nutrient run-off if Chatham Rise phosphorite is applied directly to land (rock phosphate is not as water soluble as superphosphate), reduced cadmium build up in soils (Chatham Rise phosphorite has low cadmium levels), a reduced carbon footprint from shorter transport distances compared to current transport distances for sources of rock phosphate imported into New Zealand, an improved knowledge and understanding of New Zealand's marine environment, and increased employment opportunities.

Mitigation Measures

As outlined above, the measures to avoid, remedy or mitigate the potential impacts associated with CRP's proposed mining operations include:

- A mining system designed to avoid and minimise potential impacts.
- Mining exclusion areas, defined through a broad marine spatial planning exercise, have been incorporated into the proposal to avoid impacts on areas of particular sensitivity or value.
- Ensuring the mining blocks in any year, during the first five years of mining, are sufficiently separated to avoid sedimentation impacts on other blocks. Monitoring will assess the actual impacts of sedimentation.

- Evaluation of the feasibility and viability of creating hard substrate habitat to enhance recolonisation, and, if viable, creating of such habitat.
- Prior to each deployment of the mining system, a 200 m radius from the mining vessel will be checked for marine mammals. If they are observed within this zone then mining will not commence until the area has been clear for at least 30 minutes.
- Adoption of vessel lighting mitigation strategies to minimise impacts on seabirds.

Environmental compensation

Assessment of the potential impacts of the CRP's mining project has shown that the benthic communities in the mining blocks will be removed by the drag-head, and the communities adjacent to the mining blocks will also be adversely affected as a result of sediment deposition. Recolonisation of soft-sediment communities is expected to occur within several years.

As these impacts cannot be avoided, remedied or mitigated, CRP proposes to implement an environmental compensation package that will include establishing a trust that will receive $200,000 per annum from CRP while mining operations are occurring. The trust's objectives will focus on ecological sustainability and enhancement, preferably in relation to the marine environment of the Chatham Rise or the Chatham Islands. The trust will also provide financial support for targeted research connected to the impacts of CRP's mining operations.

Consent conditions

The conditions proposed by CRP include the application of adaptive management practices to guide the mining operations. Adaptive management provides for monitoring of the activities and impacts of the mining operation, and uses the results to guide operational practices and policies to minimise impacts on environmental resources.

Adaptive management decisions will be guided by the results of monitoring of the environmental effects of the project. Monitoring will test whether the actual impacts are similar to the predicted impacts. Monitoring will include collecting baseline oceanographic information, measuring water turbidity, and observing changes in the seabed ecology.

One component of the adaptive management regime is that mining will be restricted to the area associated with the existing mining permit area for at least the first five years of mining operations. Mining will only be undertaken outside of that area and within the prospecting permit / licence areas, if an economic resource is identified, monitoring that has been carried out shows that the impacts of mining are as predicted, investigations of the new area as specified in the consent conditions have been completed and CRP has obtained a new mining permit covering the additional area to be mined. There will be no significant changes to the mining plan or operations, other than those that may arise from the adaptive management conditions and that result in reduced environmental impacts or increased mining efficiency.

CRP has proposed other consent conditions that stipulate reporting requirements and establish an Environmental Reference Group to ensure that stakeholders are fully informed about the project and the results of mitigation and monitoring activities. CRP has also committed to use its best endeavours, in conjunction with interested parties, to identify legal mechanisms to protect areas identified through the marine spatial planning exercise, both inside and outside the marine consent area, from seabed disturbances.

CRP's proposed environmental management approach is consistent with the International Marine Minerals Society's Code for Environmental Management of Marine Mining. These management processes allow for review and refinement of mitigation measures throughout the life of the project

Conclusion

CRP has developed a plan to mine phosphate from the Chatham Rise. It is technologically robust, environmentally sound, economically attractive and socially responsible. The mining plan is based on scientific research and consultation with stakeholders. The mining system will be operated according to industry best practice. Mining operations will be governed by policies and procedures, including an environmental management system, that are designed to minimise, avoid, remedy or mitigate environmental impacts. The environmental management system is based on the principles of adaptive management, and includes mitigation strategies, a comprehensive monitoring programme, and an environmental compensation package.

Any adverse impacts beyond the mining area will be avoided, remedied or mitigated and the life-supporting capacity of the wider Chatham Rise environment will be safeguarded (irrespective of the loss of benthic habitat within the mining blocks). Within the mining blocks, the benthic environment will be adversely affected. As a consequence, avoidance, remediation and mitigation measures include the provision for mining exclusion areas to avoid impacts on areas of particular sensitivity or value, and assessment of the feasibility of restoring hard substrate removed by mining. These measures will not fully offset the loss of habitat within the mining areas, and a package of environmental compensation is also proposed.

CRP's proposed mining operations will achieve the sustainable management purpose of the EEZ Act (section 10). Development of the phosphorite resource will contribute significantly to New Zealand's economy, and use of the product in New Zealand will have environmental benefits from reduced levels of cadmium in the soil and reduced runoff of phosphorus to waterways. Other than the phosphate resource that is mined, the natural resources of the Chatham Rise will be sustained for future generations.

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TABLES

FIGURES

Abbreviations and Glossary of Terms

ACE	Annual catch entitlements
ADCP	Acoustic Doppler Current Profiler
AUV	Autonomous underwater vehicle
BD Convention	Convention of Biological Diversity 1992
Boskalis	Royal Boskalis Westminster
BOMEC	Benthic Optimised Marine Environment Classification
Bonn Convention	Convention on the Conservation of Migratory Species
BPA	Benthic Protection Area
BPA Regulations	Fisheries (Benthic Protection Areas) Regulations 2007
BRT	Boosted regression trees
Business NZ	Business New Zealand
CCFZ	Clarion Clipperton Fracture Zone
CEDA	Central Dredging Association
CIA	Cultural Impact Assessment
CIET	Chatham Islands Enterprise Trust
CPT	cone penetrometer testing
cm	centimetre
CM Act	Crown Minerals Act 1991
CRP	Chatham Rock Phosphate Limited
CS Act	Continental Shelf Act 1964
CTD	conductivity, temperature and depth
dB	decibels
DISCOL	German DISturbance and reCOLonization experiment
DO	dissolved oxygen
DOC	Department of Conservation
DOM	dissolved organic matter
DP	dynamic positioning system
DRSi	dissolved reactive silicate
DSIR	Department of Scientific and Industrial Research
DT	dynamic tracking system
DTIS	NIWA's deep towed imaging system

ECMWF	European Centre for Medium Range Weather Forecast
EDS	Environmental Defence Society
EEZ	New Zealand's Exclusive Economic Zone
EEZ Act	Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012
EEZ Amendment Act	Exclusive Economic Zone and Continental Shelf (Environmental Effects) Amendment Act 2013
EIA	Environmental (and Social) Impact Assessment
EMMP	Draft Environmental Management and Monitoring Plan
EMS	Environmental management system
ENSO	El Nino-Southern Oscillation cycle
EPA	Environmental Protection Authority
Federated Farmers	Federated Farmers of New Zealand
Fonterra	Fonterra Co-operative Group Limited
Forest & Bird	Royal Forest and Bird Protection Society
FTU	Formazin turbidity unit
GDP	Gross domestic product
Global Marine	Global Marine Incorporated
Golder	Golder Associates (NZ) Limited
Greenpeace	Greenpeace New Zealand
HSE Act	Health and Safety in Employment Act 1992
Hz	hertz
ICMM	International Council on Mining and Metals
IMMS	International Marine Minerals Society
IMO	International Maritime Organisation
INDEX	INdian Deep see Environment eXperiment
IOMBIE	Inter Ocean Metal Benthic Impact Experience
IOPPC	International Oil Pollution Prevention Certificate
ISA	International Seabed Authority
IUCN	International Union for Conservation of Nature
JET	Japan's Deep-sea Impact Experiment
JBL	JBL Exploration NZ Limited
KASM	Kiwis Against Seabed Mining
Kenex	Kenex Limited

kHz	kilohertz
km	kilometres
LMP	Draft Vessel Lighting Management Plan
LOM	labile organic matter
London Convention	Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972, and its 1996 Protocol
m	metre
Ma	Mega-annum, or million years
Marine Mining Code	Code for Environmental Management of Marine Mining
Maritime NZ	Maritime New Zealand
MARPOL	International Convention for the Prevention of Pollution from Ships 1973, as modified by the Protocol of 1978. MARPOL is derived from 'marine pollution'.
MEC	Marine Environment Classification
mesopelagic	middle trophic-level organisms living in the water column
MfE	Ministry for the Environment
mm	millimetres
MMP Act	Marine Mammals Protection Act 1978
MMP Regulations	Marine Mammals Protection Regulations 1992
MP 55549	Mining permit 55549 held by CRP and covering an area of 820 km^2.
MPA	Marine Protected Areas
MPI	Ministry for Primary Industries
MPL 50270	Minerals prospecting licence 50270. MPL 50270 covers an area of about 4,726 km^2, although CRP applied to relinquish 1,019 km^2 leaving an area of 2,886 km^2, or 3,706 m^2 if the mining permit area is included. These numbers are rounded.
Mt	million tonnes
MT Act	Maritime Transport Act 1994
MW	megawatt
NABIS	National Aquatic Biodiversity Information System
NCODA	Navy Coupled Ocean Data Assimilation
NIOZ	Netherlands Institute for Sea Research
NIWA	National Institute of Water and Atmospheric Research
NOAA	National Oceanographic Atmospheric Administration
NPP	net primary production

NTCS Act	Ngai Tahu Claims Settlement Act 1998
NTU	nephelometric turbidity unit
NZAX	New Zealand's alternative sharemarket
NZBS	New Zealand Biodiversity Strategy 2010
NZIER	New Zealand Institute of Economic Research (Inc.)
NZOI	New Zealand Oceanographic Institute
NZPaM	New Zealand Petroleum & Minerals, a division of the Ministry of Business, Innovation and Employment
NZTCS	New Zealand Threat Classification System
OS20/20	New Zealand's Ocean Surveys 20/20
OSI	organism-sediment index
PauaMac	Paua Industry Council Limited
PCA	Principal Component Analysis
POP	persistent organic compounds
PP 55967	Proposed prospecting permit 55967. Located to the east of MPL 50270 and covering an area of 4,985 km^2.
PP 55971	Proposed prospecting permit 55971. Located to the west of MPL 50270 and covering an area of 1,501 km^2.
ppt	parts per thousand
QMA	Quota Management Areas
QMS	Quota Management System
RL	received level (as it relates to underwater noise)
RMA	Resource Management Act 1991
ROV	remotely operated vehicle
Sanford	Sanford Limited
SAW	Sub-Antarctic water
Seafood NZ	Seafood NZ
SEL	sound exposure level
Seismic Code	2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations
SOP	Standard Operating Procedure in the EMMP
SOPEP	Shipboard Oil Pollution Emergency Plan
SPL	sound pressure level
SST	sea surface temperature
STF	Subtropical Front (also known as the Subtropical Convergence)

STW	saline subtropical waters
TACC	Total allowable commercial catch
Talleys	Talley's Group Limited
TI	Trophic Importance
TL	transmission loss (as it relates to underwater noise)
TOM	total organic matter
TSS	Total suspended solids
Tuia	Tuia Group
UNCLOS	United Nations Convention on the Law of the Sea 1982
WMP	Draft Vessel Solid Waste Management Plan
WODA	World Organisation for Dredging Association

Sections 20 to 20J of the EEZ Act – Marine Consent Triggers

The table below identifies the provisions of the EEZ Act that trigger the need to seek a marine consent for CRP's mining proposal.

Section 20 to 20J[1] of EEZ Act	EEZ Act provision	Activity that requires consent[2]
20(2)(a)	the construction, placement, alternation, extension, removal, or demolition of a structure on or under the seabed	Monitoring equipment consisting of no more than four mooring landers, will be placed, relocated on the seabed and eventually removed.
20(2)(b)	the construction, placement, alteration, extension, removal or demolition of a submarine pipeline on or under the seabed	Not applicable. CRP's proposal does not involve the placement of any pipelines on or under the seabed.
20(2)(c)	the placement, alteration, extension, or removal of a submarine cable on or from the seabed	Not applicable. CRP's proposal does not involve the placement of any submarine cables on or from the seabed.
20(2)(d)	the removal of non-living natural material from the seabed or subsoil	Phosphorite nodules, a non-living material, will be removed from the seabed and subsoil. In addition, as part of the environmental monitoring programme, seabed samples, including non-living material, will be collected and removed from the seabed and subsoil.
20(2)(e)	the disturbance of the seabed or subsoil in a manner that is likely to have an adverse effect on the seabed or subsoil	Mining will disturb the seabed and subsoil. The nature of the seabed where mining has occurred will be modified as described and assessed in Section 8 of the EIA. In addition, the collection of seabed samples will also disturb the seabed and subsoil, although the impacts of this activity are minor (Section 4.4.7 of the EIA).
20(2)(f)	the deposit of any thing or organism in, on, or under the seabed	Non-phosphatic material, following processing on the mining vessel, will be returned / deposited on the seabed. Note: This material is also defined as a harmful substance, being a mining discharge from a ship. In addition, hard substrate is to be placed on the seabed initially as part of the proposed recolonisation trials, and if successful then possibly as part of subsequent habitat creation.
20(2)(g)	the destruction, damage, or disturbance of the seabed or subsoil in a manner that is likely to have an adverse effect	The seabed and subsoil, and associated marine species and habitats, will be disturbed, if not damaged, as a result of the mining proposal. The impacts on the seabed, marine species and habitats are assessed in

Section 20 to 20J[1] of EEZ Act	EEZ Act provision	Activity that requires consent[2]
	on marine species or their habitat	Section 8 of this EIA. In addition, the collection of seabed samples will also disturb the seabed and subsoil and associated marine species and habitats, although the impacts of this activity are minor (Section 4.4.7 of the EIA).
20(3) and (4)	Specified activities in the waters of the EEZ, including activities related to structures, causing of vibrations and causing of explosions	Section 20(4)(b) is potentially applicable in relation to noise. CRP's mining proposal is unlikely to cause vibrations that adversely affect marine life, noise has been assessed in Section 8.7 of the EIA.
20B	Discharges of harmful substances from structures, including mining structures, and submarine pipelines	Not applicable. CRP's mining proposal does not involve discharges from any structures or submarine pipelines. CRP's mining operations take place from the mining vessel and the only proposed structures are monitoring equipment.
20C	Discharges of a harmful substance, which includes any mining discharge from a ship	Under the 2013 amendments to the EEZ Act, the return of the non-phosphatic material to the seabed is defined as a discharge of a harmful substance from a mining vessel. Therefore, these provisions are likely to apply to CRP's proposal, when they come into force.
20D to 20H	Prohibitions and restrictions on various dumping activities	Not applicable. The return of the non-phosphatic material to the seabed is a discharge (as discussed above), not a dumping activity.
20J	Burial at sea	Not applicable.

Note: (1) Sections 20A to 20J are not in force at the time that this application was lodged. Irrespective of this, the considerations and assessments required by these sections have been addressed within this EIA.

(2) Although the monitoring equipment mooring landers, seabed samples and hard substrate recolonisation trials are permitted activities under the Regulations to the EEZ Act. However, CRP has included these monitoring and exploration activities in the marine consent being sought as they are inherently linked to its mining operations.

Sections 39(1), 59 and 60 of the EEZ Act – Impact Assessment and Decision Making Considerations

The table below identifies the impact assessment requirements and the relevant decision making considerations under the EEZ Act, and where these are addressed in this marine consent application and EIA.

Section of EEZ Act	EEZ Act provision	Sections of the EIA
Section 39(1) – Impact assessment requirements		
(1)(a)	describe the activity for which consent is sought	The nature of the proposed mining operations is described in Section 4.
(1)(b)	describe the current state of the area where it is proposed that the activity will be undertaken and the environment surrounding the area	Sections 5 and 6 describe the physical and biological environment associated with the Chatham Rise. Section 9 describes the social, cultural and economic environment of relevance to the mining proposal.
(1)(c)	identify the effects of the activity on the environment and existing interests (including cumulative effects) and effects that may occur in New Zealand or in the sea above or beyond the continental shelf beyond the outer limits of the exclusive economic zone	The potential impacts associated with the mining proposal are assessed in Sections 8 and 9.
(1)(d)	identify persons whose existing interests are likely to be adversely affected by the activity	Section 9.2.2 identifies the persons / organisations who are considered to be existing interests in relation to this mining proposal. Existing interests are considered to be the commercial fishing industry, including Iwi fishing industry, and other vessels traversing the area. Appendix 34 contains a list of fishery quota and annual catch entitlement holders.
(1)(e)	describe any consultation undertaken with persons described in paragraph (d) and specify those who have given written approval to the activity	The nature of consultation with all interested parties, which includes existing interests (but not solely existing interests), is outlined in Section 7. CRP has not sought any written approvals for this project.
(1)(f)	include copies of any written approvals to the activity	Not applicable. CRP has not sought any written approvals.
(1)(g)	specify any possible locations for, or methods for undertaking, the activity that may avoid, remedy or mitigate any adverse effects	An assessment of the alternative options in terms of location, mining method and the return (or discharge) of the non-phosphatic material to the seabed, is provided in Section 12.
(1)(h)	specify the measures that the	The proposed avoidance, remediation and mitigation

Section of EEZ Act	EEZ Act provision	Sections of the EIA
	applicant intends to take to avoid, remedy, or mitigate the adverse effects identified.	measures, and other environmental management approaches, are described in Sections 10 and 11.
Section 59 – EPA's consideration of application		
(2)(a)	any effects on the environment or existing interests of allowing the activity, including- (i) cumulative effects; and (ii) effects than may occur in New Zealand or in the water above and beyond the continental shelf beyond the outer limits of the exclusive economic zone	The effects on the environment, and existing interests (i.e., the commercial fishery), are predominantly assessed in Section 8. Social (including existing interests), cultural and economic impacts are assessed in Section 9. CRP considers that the existing interests are commercial fishers, including Iwi fishing companies, and other vessels traversing the area.
(2)(b)	the effects on the environment or existing interests of other activities undertaken in the area covered by the application or in its vicinity, including- (i) the effects of activities that are not regulated under this Act; and (ii) effects than may occur in New Zealand or in the water above and beyond the continental shelf beyond the outer limits of the exclusive economic zone	Other activities taking place in the area or the broader vicinity are commercial fishing operations. The effects on commercial fisheries, and thus the related operations (i.e., the existing interests), are assessed in Sections 8.6 and 9.2.2 respectively. The only other activity which is not regulated by the EEZ Act is the movement of vessels in and around the area. This matter is assessed in Section 8.11. As outlined in Sections 8 and 9, it is considered that there are no impacts associated with the proposed mining operations that will occur in New Zealand or the water beyond the area of jurisdiction of the EEZ Act.
(2)(c)	the effects on human health that may arise from effects on the environment	It is considered that there are no potential adverse human health effects associated with CRP's proposed mining operations, including the return, or discharge, of non-phosphatic material to the seabed (as required by section 87D of the EEZ Act). Section 8.4 and 8.5 describe the potential impacts associated with the return of the material to the seabed. Section 8.9 describes the controls on vessel discharges and the potential impacts of discharges, while Section 8.11 assesses project operational management and risks.
(2)(d)	the importance of protecting the biological diversity and integrity of marine species, ecosystems, and processes	Section 6, and related appendices, describes the biological environment of the Chatham Rise. Appendix 32 and Section 8.6.6.4 describe a marine spatial planning exercise commissioned by CRP, and the

Section of EEZ Act	EEZ Act provision	Sections of the EIA
		proposed mechanisms to be used to protect areas of particular sensitivity or value. In relation to this marine consent application, protection relates the identification of mining exclusion areas. CRP has also committed to use its best endeavours (as reflected in a proposed marine consent condition) to try and establish permanent protection from seabed disturbance activities over the areas identified in the broader marine spatial planning exercise.
(2)(e)	the importance of protecting rare and vulnerable ecosystems and the habitats of threatened species	Section 6, and related appendices, identifies such ecosystems, habitats and threatened species. Potential impacts on these values are assessed in Section 8.6 to 8.8. Also, refer to comment above in relation to section (2)(d) of the EEZ Act.
(2)(f)	the economic benefit to New Zealand of allowing the application	The Economic Assessment (Appendix 6) assesses economic benefit. Section 9.4 provides an overview.
(2)(g)	the efficient use and development of natural resources	The potential impacts of the mining operations on natural resources are assessed in Section 8. The mining proposal itself is considered to reflect an efficient use and development of an available mineral resource (refer to Sections 4 and 9.4 and Appendix 6).
(2)(h)	the nature and effect of other marine management regimes	Appendix 1 and Section 2 identify the marine management regimes established by legislation and regulation that are applicable to the proposal, including the Benthic Protection Area established under the Fisheries Act 1996. Section 8.6.6.4 also comments on the benthic protection area. Section 11.4 outlines CRP's commitment to try to establish permanent protection from all seabed disturbance activities (not just trawling, or mining) for areas identified through a marine spatial planning exercise.
(2)(i)	best practice in relation to an industry or activity	Appendix 1 and Section 2 describe the industry best practice documents. Where relevant, the provisions of these documents have been considered as part of the preparation of the EIA.
(2)(j)	the extent to which imposing conditions under section 63 might avoid, remedy or mitigate the adverse effects of the activity	Avoidance, remediation and mitigation (and environmental management) approaches are identified within Sections 8 and 9. These are overviewed in Sections 10 and 11, with proposed consent conditions reflecting these approaches outlined in Section 11.4.
(2)(k)	relevant regulations	Appendix 1 and Section 2 discusses the legislative and regulatory framework of relevance to this proposal. Sections 4 and 8.9 to 8.11 also identify other regulations
(2)(l)	any other applicable law	

Section of EEZ Act	EEZ Act provision	Sections of the EIA
		and laws that CRP will comply with, while proposed marine consent conditions (Section 11.4) reiterate the requirement to comply with relevant provisions. Section 8.6.6.4 also comments on the benthic protection area. Also, refer to comment above in relation to section (2)(e) of the EEZ Act.
(2)(m)	any other matter the EPA considers relevant and reasonably necessary to determine the application	CRP considers that this application document and associated EIA addresses other matters of relevance to EPA's consideration of this application.
Section 60 – Matters to be considered in deciding extent of adverse effects on existing interests		
(a)	the area that the activity would have in common with the existing interest	These matters are considered in Section 9.2.2. As an overview, long-line and potentially mid-trawl commercial fishing are the only existing interests that will potentially take place within the marine consent area. Exclusive occupation of the area is not required by CRP or these fishers. Both fishing operations can and do take place outside of the marine consent area but CRP cannot mine outside of this area. Irrespective, in terms of occupation, no permanent structures (with the exception of the proposed monitoring landers which will be clearly identified) are associated with either operation. Therefore, given that such vessels will be operating in accordance with international law and the Maritime Transport Act 1994, CRP anticipate that no conflicts will occur. The potential impacts of CRP's mining operations on the commercial fishery itself are assessed in Section 8.6.

1. Introduction

1.1 The Chatham Rise and Phosphorites

The Chatham Rise is an area of relatively shallow ocean floor that stretches for approximately 800 km from the east coast of the South Island to the Chatham Islands and more than 1,000 km to its eastern limit. The Chatham Rise lies within New Zealand's Exclusive Economic Zone (EEZ) (Figure 1).

The area has significant seabed deposits of phosphorite which were formed about 5 million years ago, and were first discovered on the Chatham Rise in 1952. They occur as irregularly shaped nodules, ranging in size from around 0.5 to 350 mm, lying on and within the seabed at relatively shallow water depths of between 350 to 450 m (Figure 2 and Figure 3). The nodules occur at the seabed surface and within the upper sediment, generally extending to a depth of about 0.5 m. The Chatham Rise deposit is the most significant known phosphorite deposit within the New Zealand EEZ.

Phosphorite, often known as rock phosphate, is a key raw material for manufactured fertilisers. It is currently imported to New Zealand, primarily from Morocco. Exploration and field trials in the 1970s and 1980s suggested that the phosphorite resource on the Chatham Rise could meet New Zealand's needs for at least 25 years.

Studies by the Ministry of Agriculture and Fisheries in the 1980s showed that when directly applied to pasture Chatham Rise phosphorite fertiliser can be more effective than superphosphate for pasture growth, with less environmental impact from nutrient run-off into adjacent waterways. In addition, the Chatham Rise phosphorite contains significantly lower concentrations of cadmium than the phosphate rock imported from Morocco, reducing the potential for soil contamination by cadmium, an issue which has recently arisen in some intensively-farmed areas of New Zealand. Therefore, the Chatham Rise phosphorite deposits can provide a major source of phosphate fertiliser for New Zealand as an alternative to importation from overseas countries, many of which are not politically stable, while also having significant environmental benefits over imported phosphate rock.

At the time of the major exploration of Chatham Rise phosphorite in the 1970s and 1980s, commercial extraction was not considered viable because there were cheaper sources of phosphate fertiliser available for import, and there were limitations in relation to the available mining technology.

It is now considered feasible to mine this local resource. Depletion of nearby phosphorite resources in Nauru and Christmas Island resulted in New Zealand having to seek its rock phosphate from further afield. Recent increases in the market value of phosphorite have been driven largely by population increases, growing affluence and demand for protein rich foods in emergent developing countries. It is anticipated that this demand will continue in the near future. Finally, there have been significant off-shore engineering advances, largely based on the modification of existing technology developed by the dredging and oil industries, that make it technologically feasible and economically viable to mine the Chatham Rise phosphorite resource.

1.2 Project Overview

Chatham Rock Phosphate Limited (CRP) (previously Widespread Energy) was established in 2010/11 as a single project company to explore and mine the Chatham Rise phosphorite deposit. It intends to supply phosphate to the New Zealand and international market for both direct application and incorporation into other phosphatic fertilisers.

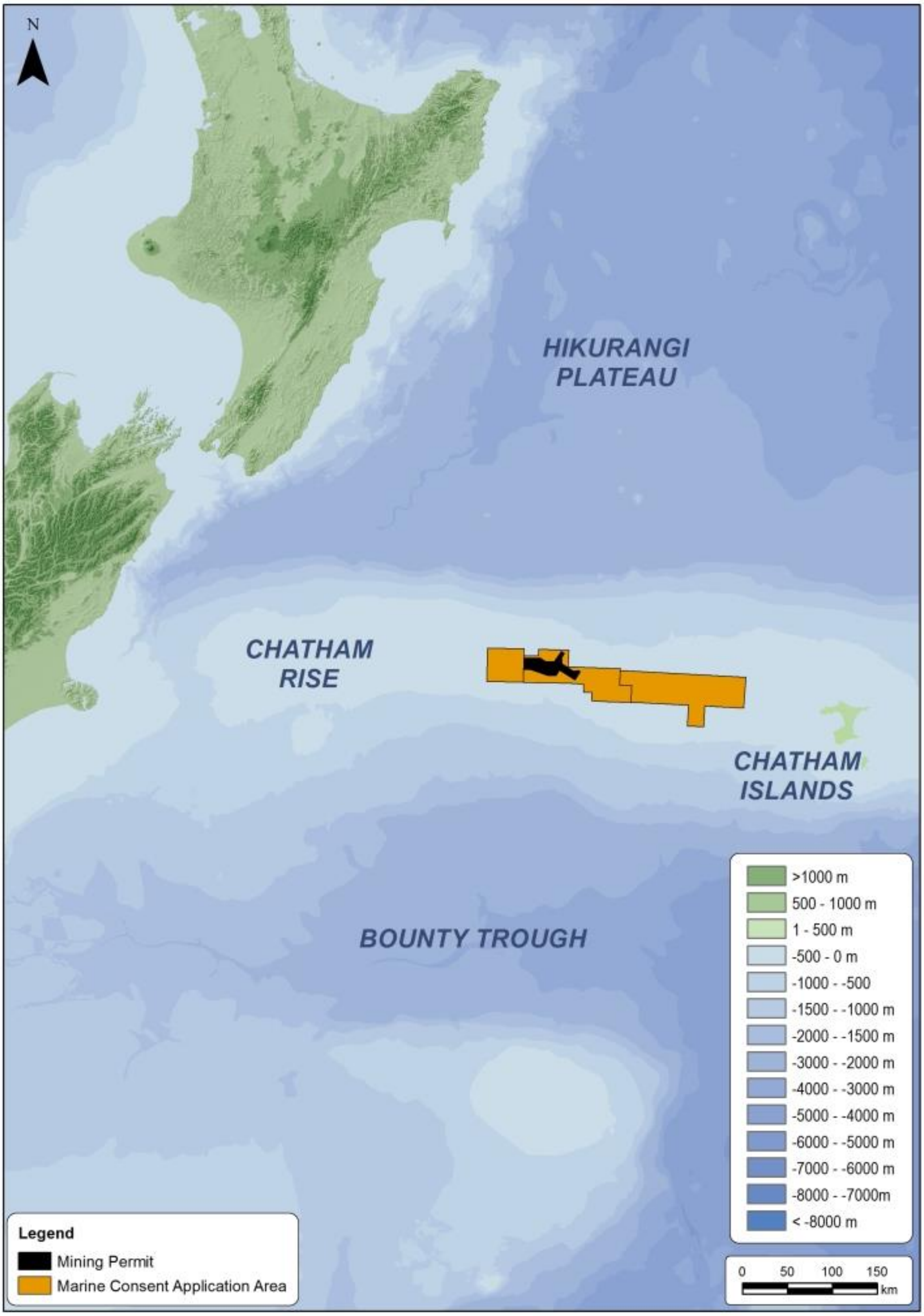

Figure 1: The Chatham Rise and CRP's marine consent application area, including the mining permit area (MP 55549, in black). The total marine consent area is 10,192 km^2.

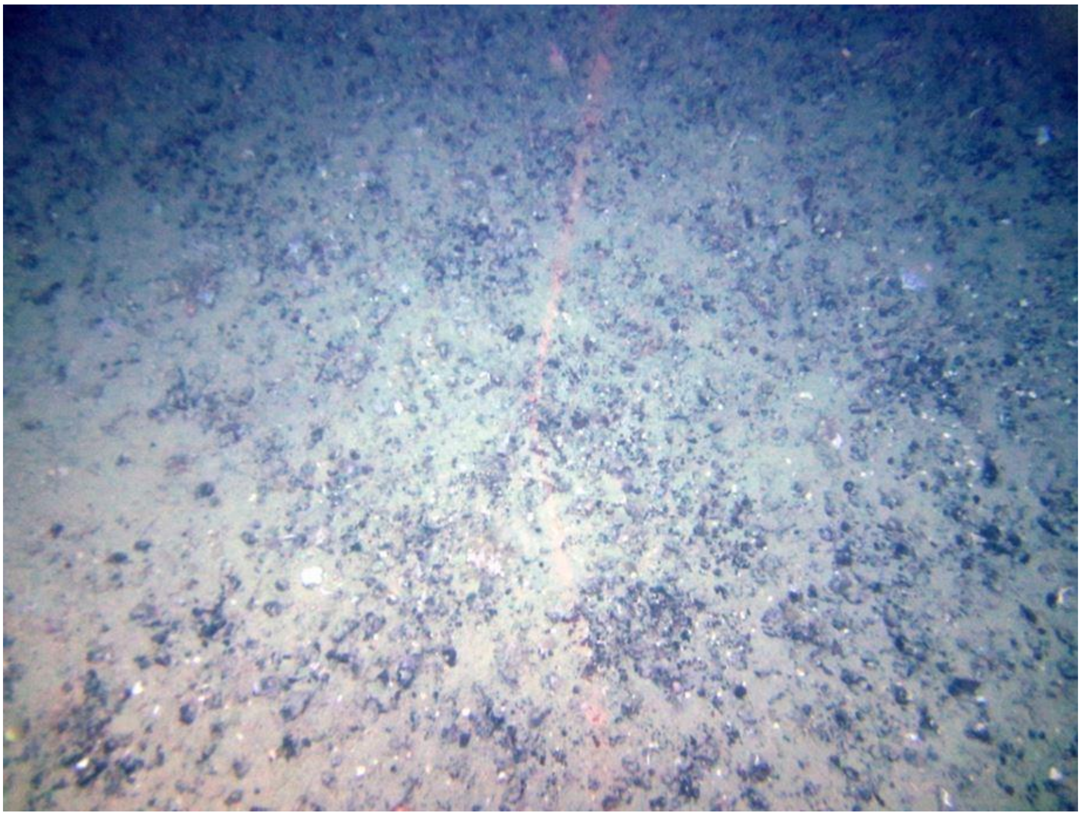

Figure 2: Dense concentrations of medium sized phosphorite nodules on the seabed on the crest of the Chatham Rise. The seabed in this photograph is approximately 4 m wide.

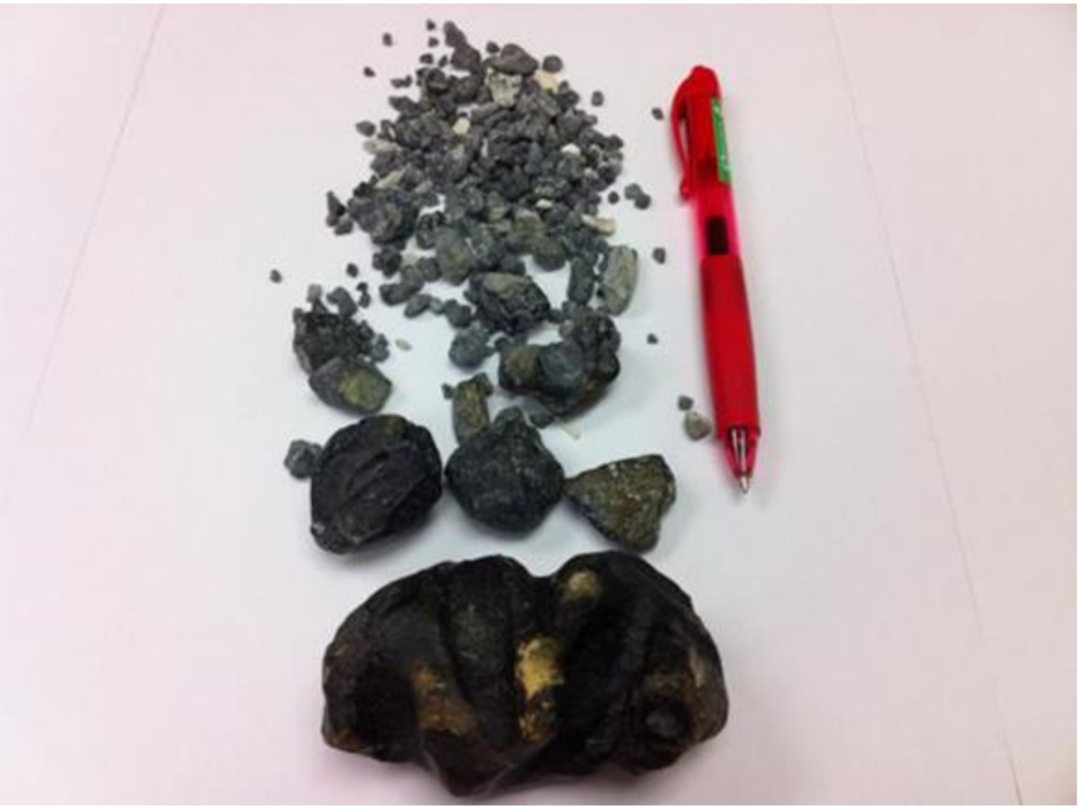

Figure 3: Phosphorite gravel and nodules from the Chatham Rise.

CRP's current and proposed prospecting licence and permits cover an area of 10,192 km^2 on the crest of the Chatham Rise, approximately 450 km east of Christchurch (Figure 1). Initially, CRP proposes to mine within its mining permit area (820 km^2).

CRP's proposed mining operations are fully described and illustrated in Section 4. As an initial overview, mining will be carried out from a specially modified vessel based on the concept of a conventional trailing suction hopper dredger. The trailing suction drag-head will use pumps to suck the nodule-bearing sediment from the seabed and lift the material to the vessel. The phosphorite nodules will be separated from other finer material, using mechanical separation processes, and stored on the vessel for transportation to a port. The non-phosphatic material will be returned to the seabed close to its original location.

CRP expects to mine an area of approximately 30 km^2 annually, recovering at least 1.5 million tonnes (Mt) of phosphorite from the seabed. Mining will be carried out in stages, and for the first three years about three 10 km^2 (2 by 5 km) mining blocks per year will be mined to meet the annual minimum production targets. Depending on the level of phosphorite recovery, the area mined annually may vary and may exceed 30 km^2. Throughout the duration of mining activities, even if mining extends to other areas in the marine consent area, the production target will be about 1.5 Mt and the amount of seabed affected by mining will remain about 30 km^2. There is no intention to significantly increase production or area affected by changes to the mining operations such as the use of a second vessel or radically changing the mining technology.

CRP anticipates commencing mining operations in 2017. An initial mine life of 15 years is proposed, but CRP anticipate that investigations during this initial mining phase may identify additional areas for mining within the mining permit area and the current and proposed prospecting areas. This timeframe is accommodated within CRP's existing mining permit (MP 55549) which expires in December 2033.

CRP has established an environmental philosophy which underpins all decisions made in relation to its exploration and proposed mining operations:

> *"CRP wishes to be known and respected as an environmentally responsible seabed resource extraction company. We are acutely aware of our duty to protect the environment as much as possible, while developing New Zealand's natural resources.*
>
> *CRP has always supported the need for defined and comprehensive safeguards for environmental management; it is part of our ethos as a responsible corporate citizen. We aim to achieve sustainable development, while continuing to safeguard the environment.*
>
> *Our policy is that we will remove phosphate nodules from only that area of seabed required, in a manner cognisant of the potential environmental issues surrounding the proposed activity, and able to rapidly adapt to any monitoring results and information that might demonstrate that things are "not going to plan."*[1]*.*

In relation to potential effects on the marine environment, CRP has previously stated on its website that:

> *"CRP is acutely aware of its responsibilities to minimise impact on the environment. As a matter of good business and a desire to succeed in our project objectives, integration of environmental considerations in all stages of project planning is a standard process. The project will adopt the environmental guidelines in the International Marine Minerals Society Code for Environmental Management of Marine Mining."*

[1] www.rockphosphate.co.nz/consultation (February 2014).

This and other public statements from CRP in relation to environmental performance illustrate CRP's commitment to responsible corporate environmental practices. It is the clear intention that sound environmental practices will be employed by CRP for the proposed mining of phosphorite nodules.

1.3 Project History

In 2010 CRP was granted a minerals prospecting licence (MPL 50270), pursuant to the Continental Shelf Act 1964 (CS Act), covering about 4,726 km^2 of the Chatham Rise. This area is estimated to contain at least 25 million tonnes of rock phosphate.

Since MPL 50270 was granted, CRP has carried out background work as part of the prospecting licence requirements to further characterise the phosphorite resource at the Chatham Rise, and assess the potential impacts of a possible mining operation on the marine environment. Initially this work involved desktop studies to review existing information and data, followed by six survey voyages between May 2011 and April 2012 to collect environmental, geotechnical, geophysical and oceanographic data, and seafloor samples. This work confirmed the earlier estimates of the amount and location of phosphorite in the area and its mine-ability, and provided information to support an application document for the required environmental approvals.

During this initial phase of the project, CRP also commenced consulting with a range of potentially interested parties to identify and try to resolve any issues related to the mining proposal.

In September 2012, CRP applied for a mining licence (now a mining permit under the Crown Minerals Act 1991). The application was lodged with New Zealand Petroleum and Minerals (NZPaM) and the mining permit was granted in December 2013 (MP 55549). CRP's mining permit covers 820 km^2 on the Chatham Rise and is located within the area covered by MPL 50270 (at the western end of this area). Mining will initially occur within the mining permit area. During the first 15 years of mining it is anticipated that approximately 450 km^2 of seabed will be mined, and if mining was to occur for an additional 20 years then an additional area of approximately 600 km^2 of seabed will be mined.

In November 2013, CRP lodged applications with NZPaM for two additional prospecting permit areas west and east of MPL 50270. CRP has also offered to relinquish 1,019 km^2 of MPL 50270 as part of its application to renew this prospecting licence leaving 2,886 km^2, excluding the mining permit area. The total area covered by these prospecting licences and permits is 10,192 km^2 (Figure 4).

CRP is now seeking a marine consent pursuant to the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (EEZ Act) to authorise its proposed mining of phosphorite within the proposed marine consent area identified in Figure 4, the area covered by the existing mining permit, the prospecting licence area and the proposed prospecting permit areas. Although the total marine consent area[2] is 10,192 km^2, mining will only occur within the mining permit area (820 km^2) (Figure 5) unless other economic concentrations of phosphorite are found within the prospecting areas and associated mining permits granted.

[2] Using UTM60S WGS84, the boundary of the marine consent area can be plotted, starting in the northwestern most corner with the following coordinates 621600E, 5201076N; traversing through the following coordinates creates the northern boundary: 662135E, 5200226N; 661957E, 5192822N; 678153E, 5192414N; 678349E, 5199816N; 712128E, 5198840N; 711547E, 5180332N; 729064E, 5179758N; 769489E, 5178259N; 769415E, 5176408N; 909527E, 5169323N. The eastern boundary is formed by traversing south to the following coordinate: 907373E, 5134147N; the southern boundary can be plotted by traversing through the following coordinates: 863148E, 5136715N; 862032E, 5116350N; 844664E, 5117280N; 845726E, 5137645N; 781401E, 5140682N; 737241E, 5142403N; 737545E, 5151681N; 728133E, 5151992N; 728432E, 5161247N; 714995E, 5161693N; 701557E, 5162111N; 688120E, 5162503N; 674682E, 5162868N; 620479E, 5164150N. The western boundary is formed by traversing back to the first coordinate 621600E, 5201076N.

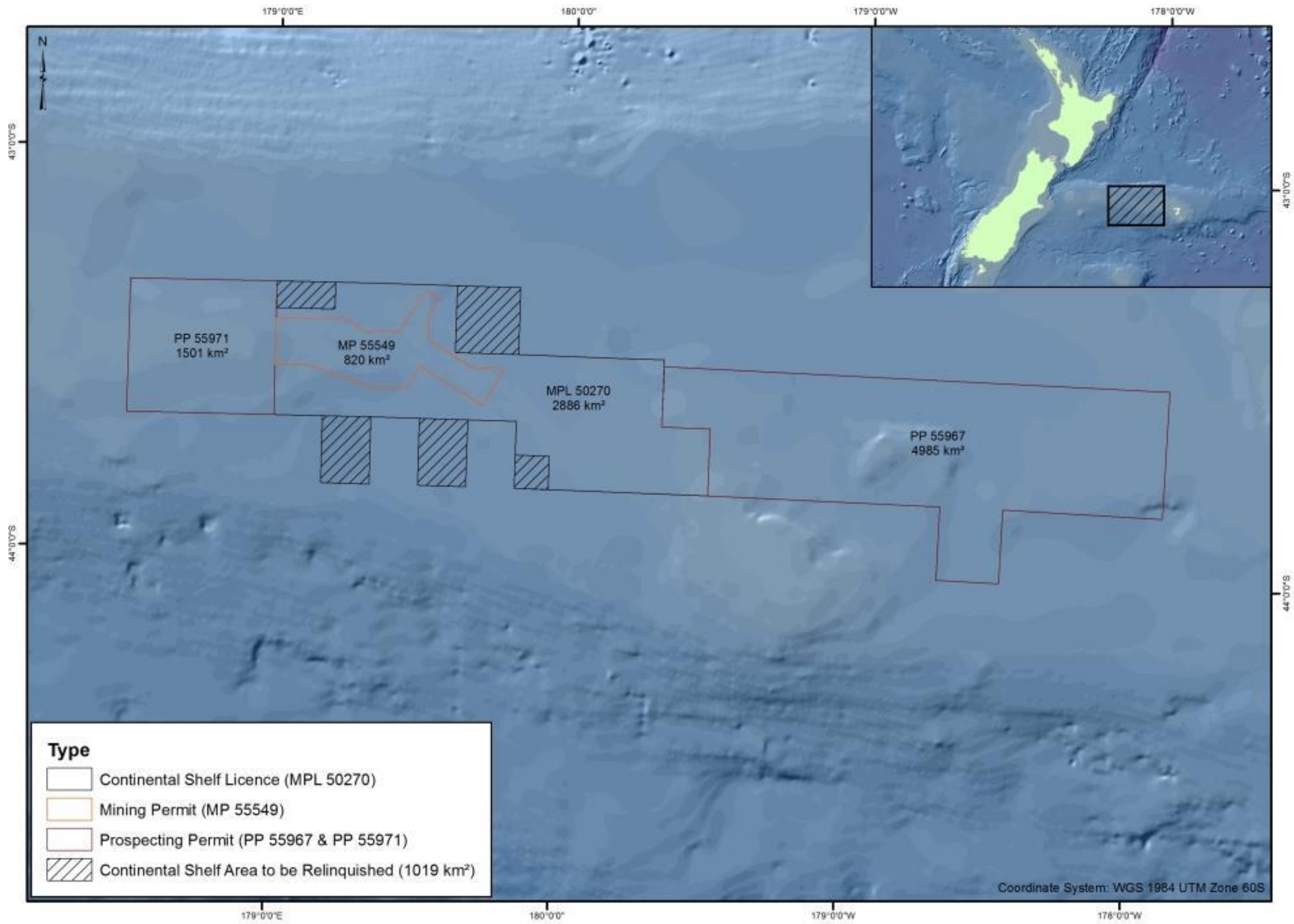

Figure 4: CRP's proposed marine consent area which includes the two new prospecting permit area (PP 55971 and PP 55967), the revised area associated with MPL 50270 and the mining permit area (MP 55549). The total marine consent area is 10,192 km^2.

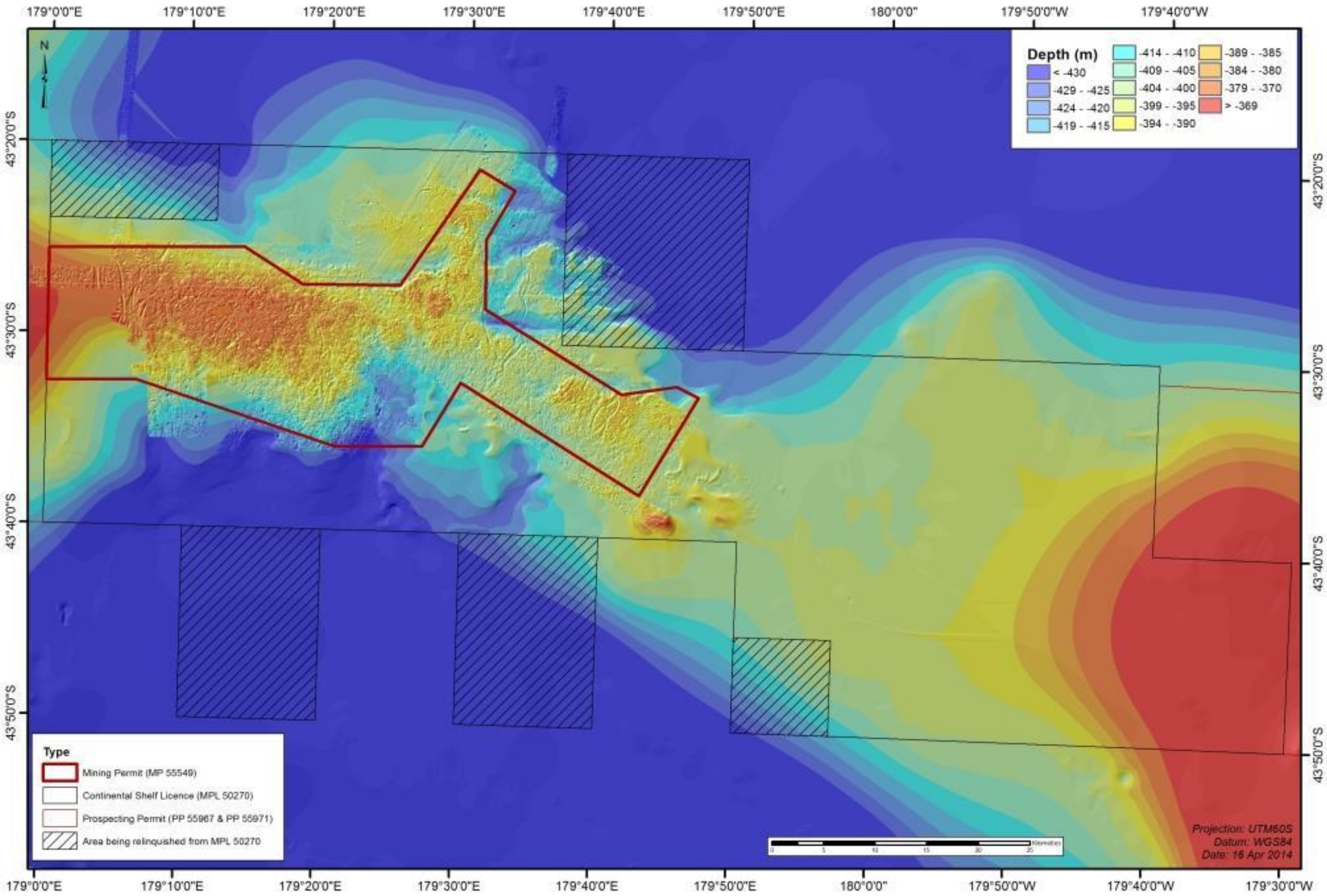

Figure 5: CRP's mining permit area (MP 55549), highlighted by the heavy red line, is in the western part of CRP's minerals prospecting licence (MPL 50270, shown by thin black line). The bathymetry of the area is shown, red areas are shallower than the blue areas.

The marine consent area provides CRP with an opportunity to identify proposed mining exclusion areas over a broader area beyond the mining permit area, based on a marine spatial planning exercise which identified areas of particular ecological sensitivity or value, and to ensure that these areas are not disturbed during mining. CRP (and the EPA) can undertake this exercise because the area would be within CRP's control through its proposed marine consent and mining and prospecting permits / licence. CRP also intends to seek all encompassing legal protection for the areas identified for protection through the broader marine spatial planning exercise (refer to Sections 8.6.6.4 and 11.4).

This document is therefore a marine consent application and Environmental Impact Assessment (hereafter referred to as the 'EIA') to mine phosphorite within the proposed marine consent area on the crest of the Chatham Rise. This EIA will be lodged with the Environmental Projection Authority (EPA) for processing in accordance with the requirements of the EEZ Act (which includes public notification and a subsequent decision-making process).

1.4 Environmental Impact Assessment

1.4.1 Purpose of the EIA

This document is an EIA in support of the application by CRP for a marine consent.

The purpose of this EIA is to assess the potential effects of CRP's proposed mining operations on the Chatham Rise environment, including impacts on existing interests in the area. This EIA has been prepared in accordance with the requirements of section 39 of the EEZ Act (refer to Section 2.3 and Appendix 1) and New Zealand and overseas best practice. The EIA contains sufficient detail to enable the EPA and any potentially affected persons to understand the nature of the activity and its effects, and the information provided corresponds to the scale and significance of the potential impacts of the activity placed within the context of potential environmental risk.

In addition, the matters that the EPA must consider when making a decision (sections 59 and 60 of the EEZ Act) have also been taken into account when preparing this EIA (as outlined in the table provided at the beginning of this application document and EIA).

As the key consideration for decision makers, the manner in which CRP's mining proposal meets the purpose of the EEZ Act (section 10) is also assessed in the conclusion to the EIA. Section 10 of the EEZ Act provides for the use, development and protection of natural resources such that people can provide for their economic well-being while sustaining the resources for future generations, safeguarding the life-supporting capacity of the environment and avoiding, remedying or mitigating the adverse effects of any activities.

1.4.2 Structure of this EIA

This EIA consists of two volumes. Volume One contains the EIA and Volume Two contains appendices that support the information provided in the EIA.

Volume One contains:

- **Section 1** introduces the proposal and this EIA and provides an overview of the proposed mining project, history of the project and brief details about CRP.
- **Section 2** contains a summary of the regulatory and legislative framework of relevance to CRP's mining proposal. This includes the legislation that is directly applicable to this marine consent application, as well as other relevant legislation and international conventions and guidance principles.

- **Section 3** provides an overview of CRP's proposed mining project. It summarises the discovery and research into the phosphorite resource and Chatham Rise environment and provides an overview of CRP and its project as a whole.
- **Section 4** provides a full description of the proposed mining operation.
- **Section 5** describes the Chatham Rise's physical environment and establishes the existing physical environment baseline for the impact assessment.
- **Section 6** describes the biological characteristics of the Chatham Rise in and around the proposed marine consent area to establish the existing biological baseline for the impact assessment.
- **Section 7** provides an overview of the consultation carried out by CRP since the beginning of this project.
- **Section 8** assesses the potential impacts on the marine environment utilising an environmental risk assessment approach which is described at the beginning of this section of the EIA.
- **Section 9** assesses the potential impacts, also utilising the environmental risk assessment approach, on social (including existing interests), cultural and economic matters. Positive impacts are also assessed.
- **Section 10** outlines the project's proposed avoidance, remediation and mitigation measures that evolved from consultation and the impact assessments.
- **Section 11** describes the environmental management and monitoring processes that are part of CRP's proposed mining project. Proposed marine consent conditions are also identified.
- **Section 12** contains an assessment of the alternative locations and mining methods that have been considered as part of the project's development.
- **Section 13** contains a conclusion for this EIA which includes an assessment, of CRP's proposed mining operations against the purpose of the EEZ Act. The benefits associated with the proposal are also assessed.

Volume Two contains appendices with detailed information relevant to the EIA:

- **Appendix 1** contains an assessment of the regulatory and legislative framework, as existed in July 2013, relevant to CRP's proposed mining operations on the Chatham Rise.
- **Appendices 2 to 5** contain literature reviews and reports that summarise how the phosphorite nodules were formed, discovered and analysed prior to the grant of MPL 50270.
- **Appendix 6** contains the economic assessment of the potential economic impacts of the proposal.
- **Appendix 7** contains an overview of other research voyages to the Chatham Rise.
- **Appendices 8 to 12** and **23 to 26** contain reports that describe the physical environment of Chatham Rise, and some of these reports also contain assessments of potential impacts on these values from CRP's proposed mining operations.
- **Appendices 13 to 24** and **27 to 32** contain reports describing the characteristics of the Chatham Rise's biological environment. As with the physical environment reports, some of the biological reports also assess potential impacts of CRP's proposed mining operations.

- **Appendix 33** contains a draft Cultural Impact Assessment (CIA) from Ngati Mutunga o Wharekauri and initial comments from Hokotehi Moriori Trust in relation to CRP's proposal, while **Appendix 34** contains a list of fishing quota and annual catch entitlement holders.
- **Appendix 35** contains draft management plans developed as a means of avoiding, remedying or mitigation potential impacts associated with the proposed mining operations.

For information purposes only, it is noted that**:**

(1) Previous versions of some of the above appendices are in the public domain as part of the consultation process undertaken by CRP. The appendices forming part of this application document (as noted by the dated cover pages) are the only ones that should be referred to. However, it is acknowledged that some appendices are unchanged from those contained in the July 2013 version of the application which has been made available to interested parties. The unchanged appendices are Appendices 1 to 4, 8 to 9, 12 to 14, 20 to 24 (Appendices 15 to 19 in the July 2013 application), Appendix 30 (Appendix 27 in the July 2013 application) and Appendix 33 (Appendix 28 in the July 2013 application).

(2) In some of these unchanged appendices, MPL 50270 has been used to define the extent of CRP's proposed mining operations rather than the marine consent area now proposed. As the relevant reports assess the environment in and around MPL 50270, the information required for this EIA has still been provided. Where considered necessary, additional comment has been provided within the relevant sections of this EIA.

2. Regulatory and Legislative Framework

KEY ELEMENTS

- This section of the EIA discusses relevant regulatory and legislative requirements are how CRP's operations will comply with them.
- The legislation relevant to CRP's proposal includes: Continental Shelf Act 1964, Crown Minerals Act 1991, The Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012, Biosecurity Act 1993, Fisheries Act 1996, Marine Mammals Protection Act 1978, Maritime Transport Act 1994, Resource Management Act 1991, Wildlife Act 1953 and the Health and Safety in Employment Act 1992.
- CRP's mining operations require a mining permit under the CM Act and a marine consent under the EEZ Act before CRP can commence mining operations at the Chatham Rise.
- International environmental conventions and guidance principles are also relevant to the proposed mining operations. Any requirements arising from these conventions and principles, even when accommodated within the New Zealand legislation, are reflected in the EIA.
- CRP has committed to undertake its operations in accordance with The International Marine Minerals Society's Code for Environmental Management of Marine Mining (Marine Mining Code) if it sets a higher standard than required by a marine consent granted under the EEZ Act.

2.1 Introduction

An assessment of the regulatory and legislative framework relevant to CRP's proposed mining activity on the Chatham Rise, as applicable in July 2013, is attached as Appendix 1 to this EIA. A summary of the key matters arising from the assessment, along with any changes that have come into force since July 2013, is provided below.

Given that CRP is proposing to undertake mining on the Chatham Rise outside of New Zealand's Territorial Sea[3] but within New Zealand's EEZ[4], both 'resource' and 'environmental' approvals are required before mining operations can commence. Until May 2013, the CS Act governed access to the resource to be mined as well as environmental considerations, but the legislative amendments that came into force at that time transferred resource allocation (but not environmental) considerations from the CS Act to the Crown Minerals Act 1991 (CM Act). The EEZ Act establishes the management framework for the likely environmental impacts associated with the utilisation of the EEZ's resources, including CRP's proposed mining activity. CRP was granted a mining permit (the 'resource allocation' approval) in December 2013 for the initial area to be mined and now seeks a marine consent pursuant to the EEZ Act (the 'environmental' approval). A summary of the relevant provisions of these pieces of legislation is provided in Sections 2.2 and 2.3 below.

[3] The outer limit of New Zealand's territorial sea is generally a distance of 12 nautical miles from New Zealand's shoreline. The territorial sea is fully defined in section 3 of the Territorial Sea, Contiguous Zone and Exclusive Economic Zone Act 1977.

[4] New Zealand's exclusive economic zone is the area of the sea, seabed, and subsoil which generally extends from 12 to 200 nautical miles off New Zealand's shoreline. 12 nautical miles off shore is the outer boundary of New Zealand's territorial sea. The EEZ is fully defined in section 9 of the Territorial Sea, Contiguous Zone and Exclusive Economic Zone Act 1977.

The Regulatory and Legislative Framework Assessment (Appendix 1) also describes the implications for CRP's project arising from other legislation including the Biosecurity Act 1993, Conservation Act 1987, Fisheries Act 1996, Marine Mammals Protection Act 1978 (MMP Act), Maritime Transport Act 1994 (MT Act), Resource Management Act 1991 (RMA) and the Wildlife Act 1953. An overview of the implications of relevant legislation is provided in Section 2.4 below. The Conservation Act is not directly relevant to CRP's proposal and it has not been discussed within this section of the EIA. Given the requirements of section 39(4) of the EEZ Act, the implications of the Health and Safety in Employment Act 1992 (HSE Act) is also provided in Section 2.4.

In addition, the Regulatory and Legislative Framework Assessment (Appendix 1) also describes the applicability of international conventions, guidance principals and related strategies, and marine mining codes of practice. Summaries of key relevant documents are assessed in Appendix 1 are also provided Section 2.5 below.

2.2 Continental Shelf Act 1964 and Crown Minerals Act 1991

The CS Act, until its 2013 amendment, governed the exploration and exploitation of the New Zealand's EEZ and Continental Shelf and its natural resources, including minerals. Under the CS Act, a licence was required before any 'person' could prospect, mine, or carry out any operations associated with the recovery of minerals from the *"seabed or subsoil of the continental shelf"* (section 5(1) of the CS Act).

As outlined in Section 1, CRP holds a minerals prospecting licence (MPL 50270) granted by the Minister of Energy under the CS Act. As the EEZ Act was not yet in place when MPL 50270 was granted, a number of the conditions attached to this licence address environmental matters.

The passing of the Crown Minerals Amendment Act 2013 and the Continental Shelf Amendment Act 2013 in May 2013 resulted in the transfer of minerals resource allocation considerations to the CM Act. This means that prospecting, exploration and mining activities within the EEZ and Continental Shelf now fall under the same legislative framework as mining activities on land and within New Zealand's Territorial Sea.

In September 2012 CRP lodged an application with NZPaM under the CS Act for a mining licence for 820 km^2 of the western part of MPL 50270. This application was considered as a mining permit application under the CM Act requirements. The mining permit, which was granted in December 2013, does not consider environmental matters as because these matters would be addressed within the marine consent application.

2.3 The Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012

The EEZ Act fills the legislative gaps that previously existed in terms of the lack of a management framework for many activities taking place outside of the territorial sea but within New Zealand's EEZ and Continental Shelf. The EEZ Act came into force on 28 June 2013 with Regulations which provided for specific permitted activities and fees and charges coming into force at the same time. In February 2014, Regulations which provide for non-notified activities also came into force.

The majority of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Amendment Act 2013 (EEZ Amendment Act) took effect from February 2014 (at the time of writing some provisions of the Act are yet to commence). This amendment transfers the regulation of specific discharge and dumping activities from the MT Act and Maritime NZ to the EEZ Act and EPA.

The management approach in the EEZ Act is similar to that of the RMA. The purpose of the EEZ Act (section 10 of the Act) is the sustainable management of the natural resources of the EEZ and the Continental Shelf and also, as a result of the EEZ Amendment Act, to protect the associated environment from pollution by regulating the discharge and dumping of specific wastes. Sustainable management, as provided for by section 10(1)(a) is to be achieved by providing for the use, development and protection of the area's natural resources such that people can provide for their economic well-being[5] while sustaining the resources for future generations, safeguarding the life-supporting capacity of the environment and avoiding, remedying or mitigating the adverse effects from activities (sections 10(2)).

Sections 20, 20B and 20C of the EEZ Act identify a range of activities that are restricted from occurring within the EEZ and Continental Shelf[6], unless:

- The activity is classified as a permitted activity under the EEZ Act's Regulations.
- A marine consent authorises the activity.
- The activity is authorised by sections 21 to 23 of the EEZ Act.

Sections 20D to 20J outlines the regulatory environment, including restrictions and prohibitions for specific dumping activities. These provisions do not apply to CRP's proposed mining operations.

CRP's mining plan involves activities specifically identified in sections 20, 20A and 20C of the EEZ Act, including:

- The placement of monitoring equipment, consisting of up to four mooring landers, including their relocation and eventual removal, on the seabed as part of CRP's proposed monitoring programme (section 20(2)(a)).
- The removal of non-living material (phosphorite nodules as part of the mining operations, and seabed samples as part of the environmental monitoring programme) from the seabed and subsoil (section 20(2)(d)).
- The disturbance (if not damage) of the seabed and subsoil as part of CRP's mining operations and the collection of seabed samples as part of the environmental monitoring programme, such that there is the potential for adverse effects on the seabed and marine species and habitats (sections 20(2)(e) and (g)).
- The deposition, or discharge (a mining discharge from a ship), of material back onto the seabed through the return of the non-phosphatic material following processing of the mined material on the vessel (sections 20(2)(f), 20A(2) and 20C).
- The deposition of hard substrate onto the seabed as part of the proposed monitoring programme's recolonisation trials, and any subsequent habitat creation activities that may follow these trials (section 20(2)(f)).
- The generation of noise, and possibly vibrations, may be associated with the operation of the mining equipment in the water column and on the seabed, namely the drag-head and return and associated equipment (section 20(4)(b)).

[5] The RMA differs that in addition to providing for people's economic well-being, the purpose of the RMA also refers to communities and social and cultural well-being as well as health and safety.

[6] The Fisheries Act provides the legislative framework for all fishing activities are covered by the Fisheries Act and therefore fishing is specifically excluded from the EEZ Act (section 20(5)(a)).

The Regulations that came into force in 2013 provide for a range of permitted activities, subject to meeting certain conditions. The permitted activities include marine scientific research, prospecting and exploration, some marine structures, seismic surveys and submarine cables. The placement of monitoring equipment, the collection of seabed samples and the deposition of hard substrate as part of possible recolonisation trials are classified as marine scientific research and prospecting and exploration and are therefore permitted under the Regulations. However, they are included in this marine consent because seabed mining is a discretionary activity, not a permitted activity, and these components of the monitoring and exploration programmes are inherently linked to CRP's mining operations. CRP is seeking the maximum 35 year term of consent provided for under the EEZ Act (section 73(1)(a) and 87H). This term correlates to the initial period of mining associated with the mining permit that CRP has been granted (i.e., an initial term of 20 years), while also enabling CRP, subject to meeting adaptive management approaches in accordance with section 64 (i.e., undertaking resource and environmental investigations and complying with water quality turbidity requirements) and gaining additional mining permits, to mine areas associated with its current and proposed prospecting licences and permits. The proposed adaptive management approach is outlined in proposed conditions contained in Section 11.4.

As required by the EEZ Act, this application documentation fully describes the proposal and includes an impact assessment in accordance with section 39 of the EEZ Act. It provides details in a manner that reflects the scale and significance of effects on the environment as well as 'existing interests'[7] (section 39(2)(a)). This EIA provides the information requirements of section 39 of the EEZ Act as follows:

- Section 3 (CRP's Mining Project) and Section 4 (Proposed Mining Operation) describe the proposed mining activity on the Chatham Rise (section 39(1)(a)).
- Section 5 (The Chatham Rise – Physical Environment) and Section 6 (The Chatham Rise – Biological Environment) describes the nature of the environment where the proposed mining activity will be undertaken and the surrounding environment (section 39(1)(b)).
- Section 8 (Environmental Impact Assessment) and Section 9 (Social, Cultural and Economic Impact Assessment) identify and assess the impacts that the proposed mining activity may have on the environment and existing interests (section 39(1)(c)).
- Section 7 (Consultation) describes the consultation that has been undertaken, including that with existing interests, and its outcomes (section 39(1)(d) to (f)).
- Section 12 (Alternatives Assessment) assesses alternative locations and methods that have been considered, particularly as a means of avoiding, remedying or mitigating adverse impacts (section 39(1)(g) and 87D).
- Section 10 (Environmental Mitigation) and Section 11 (Environmental Management, Monitoring and Proposed Marine Consent Conditions) describe the measures that are proposed to avoid, remedy or mitigate potential adverse impacts associated with the proposed mining activity (section 39(1)(h)). These measures are also reflected in the proposed conditions attached to the marine consent, as outlined in Section 11, in accordance with section 63 of the EEZ Act.

[7] The EEZ Act defines existing interests as a person with a lawfully established activity including rights of access, navigation and fishing, holders of marine consents or resource consent, historic or current claims under the Treaty of Waitangi Act or Treaty of Waitangi (Fisheries Claims) Settlement Act 1992 and holders of a protected customary right or customary marine title recognised under the Marine and Coastal Area (Takutai Moana) Act 2011.

Appendices attached to this EIA contain information that addresses the requirements of section 39 of the EEZ Act.

In addition to the EIA requirements outlined in section 39 of the EEZ Act, sections 59, 60 and 87D identify matters that must be considered when making a decision on an application for a marine consent. These matters, where relevant to the proposal, have also been addressed within this EIA and the appendices as identified in the table provided at the beginning of the EIA.

The EIA concludes (Section 13 of the EIA) that the proposed mining activity is aligned with the purpose of the EEZ Act (section 10) and therefore there are no barriers to granting the marine consent being sought.

2.4 Other Relevant Legislation

2.4.1 Introduction

This section of the EIA identifies the implications or obligations that arise from the Biosecurity Act, Fisheries Act, MMP Act, MT Act, RMA and Wildlife Act in relation to CRP's proposed mining operations on the Chatham Rise. The implications of the HSE Act, as required by the EEZ Act, are also assessed.

2.4.2 Biosecurity Act 1993

The Biosecurity Act, administered by the Ministry for Primary Industries (MPI), establishes the management framework for biosecurity related issues in New Zealand. This includes the management of craft (vessels) that arrive in New Zealand's Territorial Sea and EEZ.

CRP is proposing to utilise a vessel that will be imported into New Zealand waters for its mining operations at the Chatham Rise, and will therefore need to comply with the appropriate provisions of the Biosecurity Act. For CRP's project, the potential biosecurity risks are associated with ballast water and hull biofouling.

Under the Biosecurity Act, these potential risks are managed through the setting of craft related requirements specified within the 'import health standards' (Part 3 of the Act). However, as a result of amendments to the Act in September 2012, these risks will be managed through requiring compliance with 'craft risk management standards' (sections 24E to 24K of the Act). Craft risk management standards specifically provide for the effective management of biosecurity risks associated with the entry of craft into New Zealand waters, and once they have been developed they will replace the craft related requirements currently specified in the import health standards.

At present, the import health standards require that for vessels that have ballasted in foreign waters, particularly in identified risk areas, ballast water is either treated to a stipulated standard or exchanged en-route to New Zealand in mid-ocean areas (preferably 200 nautical miles or more from land in water depths greater than 200 m) or in fresh water.

In relation to hull biofouling, the import health standards effectively require that *"the hull of any vessel arriving into New Zealand[8] is clean".* The vessel owner/operator is also required to maintain all areas of the hull such that they are clean of any visible biofouling apart from a slime layer. The Biosecurity Act also outlines the process for clearing craft to come into New Zealand (refer to Sections 4.7.5 and 8.10).

[8] In this instance, *"arriving into New Zealand"* means New Zealand's Territorial Sea (12 nautical miles from New Zealand's shoreline).

2.4.3 Fisheries Act 1996

The Fisheries Act contains the management framework for commercial fishing activities in New Zealand waters. As CRP is mining (not fishing), the Fisheries Act is not of direct relevance. However, CRP's prospecting operations have occurred, and mining operations are proposed to occur, within a benthic protection area (BPA) established via the Fisheries (Benthic Protection Areas) Regulations 2007 (BPA Regulations), an area known as the Mid-Chatham Rise BPA. Figure 6 shows the location of this BPA in relation to CRP's licence and permit areas[9].

The BPAs were established by Government in conjunction with the fishing industry to protect marine biodiversity within un-fished areas of the EEZ from bottom trawling and dredging. Regulation 7 of the BPA Regulations effectively prohibits the fishing industry from bottom trawling in all BPAs. In addition, Regulations 8 and 9 place restrictions on the use of trawl nets within the lower and upper buffer zones, generally between 50 to 100 m above the seabed, above any BPA.

Although the BPA is recognised by CRP, these fishing related restrictions and prohibitions do not mean that mining cannot occur within the BPA.

As described in Section 8.6.6.4, CRP has commissioned a robust marine spatial planning exercise to examine Chatham Rise seabed values and to identify area of particular sensitivity or value (including biodiversity and resource value). The output from this exercise has then been used to identify proposed mining exclusion area (i.e., areas CRP will not mine). As outlined in Section 11.4, CRP has also committed, through a proposed consent condition, to use its best endeavours to try and ensure that the areas identified as potential reserves through this exercise are legally protected from all seabed disturbance activities.

2.4.4 Marine Mammals Protection Act 1978

The MMP Act, administered by the Department of Conservation (DOC), aims to ensure that all marine mammals (which includes all species of seal, whale, dolphin, porpoise and dugong/manatee (section (2)(1)) are fully protected such that it is an offence to harass, disturb or take any marine mammals.

Under the MMP Act and the Marine Mammals Protection Regulations 1992 (MMP Regulations), obligations in relation to behaviour around marine mammals are placed on all parties that operate vessels and machinery at sea. The MMP Regulations include requirements for minimising disruption to the normal movement and behaviour of marine mammals, contact, waste disposal, manoeuvring of vessels including speed and safe distances, distance of aircraft from marine mammals, and disturbance and harassment of marine mammals. The Act requires the reporting of accidental death or injury to a marine mammal to DOC (giving details on the event and location).

CRP's mining vessel/s (and thus personnel on the vessel) will be required to operate in accordance with an Environmental Management and Monitoring Plan (EMMP) that includes procedures that minimise disruption of marine mammals (refer to Section 11 and Appendix 35(i)).

[9] Approximately 51 % of the proposed marine consent area and 96 % of the mining permit area lies within the BPA. Approximately 59 % of the total area of the BPA is 'occupied' by CRP's proposed marine consent area and 8 % by the proposed mining permit area.

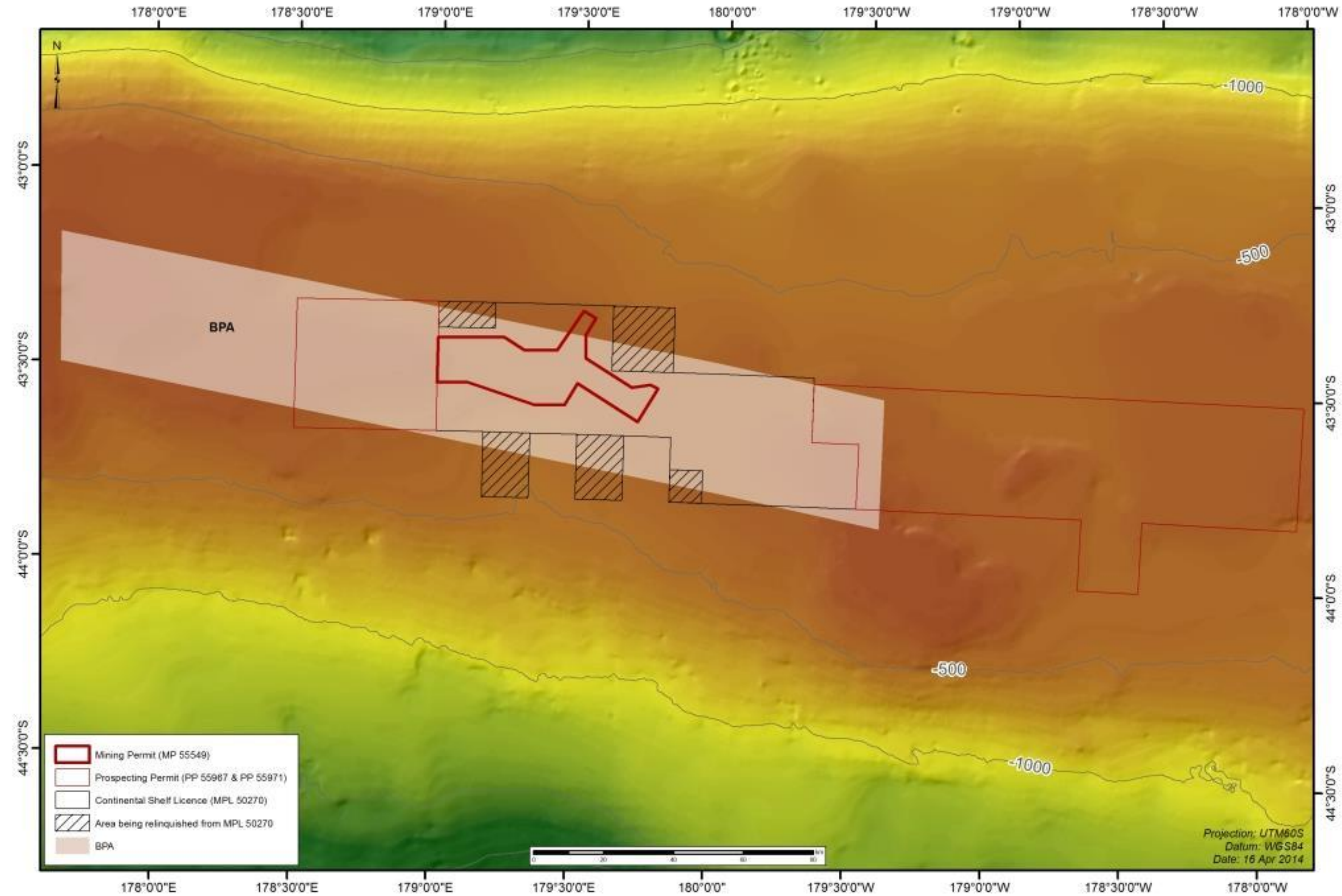

Figure 6: Mid Chatham Rise benthic protection area (BPA) (shaded) and CRP's current prospecting licence, proposed prospecting permit sand mining permit areas (outlined). The area of the BPA is 8,732 km^2.

2.4.5 Maritime Transport Act 1994

Maritime New Zealand (Maritime NZ) has a range of responsibilities under the MT Act including, but not limited to: maritime transport safety obligations, the protection of the marine environment, and ability to respond to marine oil pollution spills (section 5A).

CRP will ensure that personnel on its vessel comply at all times with all of the relevant requirements of the MT Act and associated Rules and Regulations.

The Maritime Transport Amendment Act 2013, previously referred to as part of the Marine Legislation Bill, which passed into law in October 2013 transferred responsibility for regulation of specific discharges and the dumping of waste under the MT Act from Maritime NZ to EPA and the EEZ Act. This change enabled such activities to be assessed as part of the consent application and also to be assessed as part of one consenting regime.

2.4.6 Resource Management Act 1991

The RMA, along with associated statutory planning documents, identify the circumstances when ‘permissions’ are required for activities utilising New Zealand’s resources.

The RMA management framework covers all resource utilisation activities within New Zealand’s land mass and coastal marine area (i.e., out to the outer limits of the Territorial Sea). The RMA does not apply to CRP’s mining operations on the Chatham Rise as those activities are beyond the coastal marine area (i.e., outside the Territorial Sea) and within the EEZ.

The provisions of the RMA will apply to land-based activities and activities within the coastal marine area associated with the proposed mining operations. Such activities may include CRP’s port related activities (unloading, storage and dispatch of the mined material). However, CRP is not seeking any resource consents for this aspect of its operations because the project is expected to utilise a port that already has the necessary ‘permissions’ under the RMA in place.

2.4.7 Wildlife Act 1953

The Wildlife Act establishes a legislative framework for the protection and control of wild animals and birds, as well as the management of game, whereby most species of wildlife are protected such that no-one may kill or have in their possession the wildlife unless a permit has been issued under the Wildlife Act. The Act (sections 3 to 8 and associated Schedules 1 to 8) identifies the protective status of wildlife species.

Schedule 7A lists marine species that have absolute protection under the Wildlife Act, including black corals, gorgonian corals, stony corals, hydrocorals, five shark species (oceanic whitetip, basking, deep water nurse, white pointer and whale), two ray species (manta and spinetail), giant groper and spotted black grouper. Schedule 2 lists partially protected wildlife which includes the brown skua that is protected on the Chatham Islands only. This bird is naturally uncommon and at risk in New Zealand, and small numbers could be encountered throughout the Chatham Rise area (Thompson 2013 - Appendix 21).

In relation to CRP’s proposed mining operations, the mobile species listed in Schedules 2 and 7A are not expected to be directly affected as assessed in Section 8. However, sessile species (i.e., the cold water corals) are present within the mining area and will be removed by the mining operations (refer to Section 8 and related appended technical assessments). Given the presence of cold water corals, mitigation and management measures (Sections 10 and 11) are proposed which include identifying mining exclusion areas (refer to Section 4.4.1) identified through a marine spatial planning exercise (Appendix 32) as well as areas of geologic interest (significant iceberg furrows). These areas include habitat for cold water corals.

However, as noted above, corals located outside of the proposed mining exclusion areas but within the mining blocks will be taken as a result of mining operations. Although it was initially considered that a Wildlife Act permit may not be required for this activity because the taking of corals would be incidental to the mining operations (akin to corals taken by bottom trawling), DOC have advised that they now consider that a permit is required under the Wildlife Act. Accordingly, CRP is currently in the process of seeking such a permit.

2.4.8 Health and Safety in Employment Act 1992

The HSE Act relates to the safety of persons within a workplace. It concerns human safety, rather than environmental effects or impacts. Section 39(4) of the EEZ Act contemplates situations where measures taken under the HSE Act may directly or indirectly avoid, remedy or mitigate an activity's adverse impacts on the environment or existing interests. Section 39(4) states:

> *"The measures that must be specified under subsection (1)(h) include any measures required by another marine management regime and any measures required by or under the Health and Safety in Employment Act 1992 that* ***may have the effect of avoiding, remedying, or mitigating the adverse effects of the activity on the environment or existing interests****."*

For ease of reference, section 39(1)(h) of the EEZ Act states that an impact assessment must:

> *"(h) specify the measures that the applicant intends to take to avoid, remedy, or mitigate the adverse effects identified."*

Therefore, the effect of section 39(4) is that the EIA must specify any measures that CRP will undertake through its obligations under the HSE Act that may avoid, remedy, or mitigate the adverse impacts of its proposal on the environment or existing interests. Section 39(4) does not require a marine consent applicant to set out how it will comply with the HSE Act generally, because those matters are governed by the HSE Act itself and are beyond the scope of the EEZ Act. Compliance with the HSE Act is now administered by Worksafe New Zealand after the Worksafe New Zealand Act 2013 came into force in December 2013.

CRP is committed to the welfare and health and safety of its workers, and will fully comply with the HSE Act and other statutory obligations related to the well-being and safety of its workers. However, for its project, measures undertaken in compliance with the HSE Act will not of themselves avoid, remedy or mitigate the adverse impacts of its activity on the environment or existing interests.

For completeness, CRP's compliance with its health and safety obligations is relevant to vessel lighting and potential impacts associated with bird strike. CRP is committed to minimising bird strike and has proposed a LMP (refer to Section 8.8.3 and Appendix 35(ii)). However, as noted in the LMP, CRP will also ensure that its workers have sufficient light to perform their tasks safely and this may restrict some of the light and bird strike mitigation strategies.

2.5 Other Relevant Guidance Documents

2.5.1 Introduction

New Zealand is a signatory to international conventions that may have implications for CRP's proposed mining operations. These conventions include: International Convention for the Prevention of Pollution from Ships 73/79 (MARPOL), the United Nations Convention on the Law of the Sea (UNCLOS), Convention on the Conservation of Migratory Species (Bonn Convention) and the Convention of Biological Diversity Rio de Janeiro 1992 (BD Convention). They are briefly summarised below. In addition, the 'New Zealand Biodiversity Strategy' (NZBS), developed as part of New Zealand's obligations under the BD Convention, is also briefly summarised (Section 2.5.3).

The International Marine Minerals Society's (IMMS) Code for Environmental Management of Marine Mining (Marine Mining Code), as well as the International Council on Mining and Metal's (ICMM) sustainable development principles, are also relevant to CRP's proposed operations on the Chatham Rise. These codes are also summarised in Section 2.5.4[10].

The full assessment (Appendix 1) discusses the London Convention and the Equator Principles, but as they are not directly relevant to CRP's proposed mining operations they are not discussed in this section.

2.5.2 International Conventions

MARPOL's stated objective is to preserve the environment through the complete elimination of pollution by oil and other harmful substances and the minimisation of accidental discharge of such substances. To achieve this, the Annexures to MARPOL specify pollution prevention standards for the disposal of sewage (i.e., sewage must be treated prior to discharge), garbage, oil discharges, noxious liquid substances and atmospheric emissions from vessels with which CRP's mining vessel will comply (specifically Annexures I, IV and VI).

UNCLOS defines the rights and responsibilities of nations in their use of the world's oceans. Part V of UNCLOS identifies that within the EEZ coastal states have the right to explore, exploit, conserve and manage all living and non-living resources of the area. Part XII of UNCLOS expands on the conservation and management of resources considerations of UNCLOS by establishing a framework for the protection of the marine environment (including rare and fragile ecosystems and the habitats of depleted, threatened or endangered species) and the prevention and management of pollution. An effects assessment process, monitoring and reporting is also required. New Zealand has ensured that its obligations under UNCLOS are reflected in appropriate legalisation, particularly now the CM Act and EEZ Act. CRP is seeking a marine consent under the EEZ Act and therefore the relevant environmental requirements of UNCLOS will have been appropriately considered and complied with should the marine consent be granted.

The Bonn Convention aims to conserve terrestrial, marine and avian migratory species throughout their range. The Fundamental Principles of the Bonn Convention, as outlined in Article II, are to provide for the protection and conservation of migratory species and their habitats, and to avoid such species becoming endangered. New Zealand's commitments under the Bonn Convention are given effect through the New Zealand Biodiversity Strategy (NZBS) discussed in Section 2.5.3 below. In relation to CRP's proposed mining activities, the EIA identifies whether migratory species (marine and seabird) may be present within the marine consent area, and, if these species are likely to be present, the potential impacts and mitigation measures that may be required to avoid adverse impacts on them (refer to Section 8).

The BD Convention is relevant in so far as the mining activity may impact on the biological diversity of the Chatham Rise. The aim of the BD Convention is the promotion of the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of benefits arising from the utilisation of genetic resources. New Zealand has implemented its obligations under the BD Convention through the NZBS (Section 2.5.3 below) and the EEZ Act (as well as the Wildlife Act, even though it was enacted in 1953) in relation to effects on biodiversity in the EEZ. In relation to CRP's proposed mining operations, the requirements outlined in Article 7 (Identification and Monitoring), Article 8 (In-situ Conservation) and Article 14 (Impact Assessment and Minimising Adverse Impacts) of the BD Convention have been specifically addressed within this EIA. This EIA is consistent with the impact assessment requirements of the EEZ Act which in turn address the requirements of Article 14. Sections 8, 10 and 11 (and related appendices) identify whether known threatened or endangered species are located in and around the proposed marine consent area and the nature of monitoring that will be undertaken to ascertain the effects on

[10] The International Seabed Authority (ISA) has also produced mining codes for marine mining activities. However, these codes are specific to other resources, not phosphorite, and are therefore not relevant to CRP's proposed mining operations.

biological diversity associated with the proposed mining activity (Article 7). Also, as outlined in the EIA (refer to Sections 8, 10 and 11), a number of avoidance, remediation and mitigation measures, including mining exclusions areas, have been identified to avoid potential impacts on the diversity of marine species.

2.5.3 New Zealand Biodiversity Strategy

The NZBS has been prepared in response to the decline of New Zealand's indigenous biodiversity and to help stem the loss of biodiversity worldwide. The NZBS establishes a strategic framework for action in relation to the conservation, sustainable use and management of New Zealand's biodiversity.

Theme 3 of the NZBS contains the 'action plan' for coastal and marine biodiversity as well as desired outcomes to be achieved by 2020. Those relevant to CRP's proposed mining operations include: ensuring marine habitats and ecosystems are maintained in a healthy state, enabling degraded habitats to recover, ensuring that protection mechanisms cover a full and representative range of habitats and ecosystems, that human activities do not result in the extinction of marine species, and that rare or threatened marine species are protected so that they can recover.

It is noted that the NZBS pays particular attention to the management needs of seamounts, including those present on the Chatham Rise, as they are home to diverse assemblages of marine organisms. CRP's proposed mining area does not contain any seamounts and those in the broader area are located principally on the northern slopes of Chatham Rise (over 50 km away from CRP's proposed marine consent area) in water depths of about 1,000 m or more (refer Section 6).

The technical studies and investigations undertaken for CRP's proposed mining EIA have presented an opportunity to better understand the Chatham Rise's biodiversity and enabled the likely impacts (and where appropriate, mitigation, management and monitoring approaches) of the proposed mining activity to be identified. Biodiversity related matters, along with potential mitigation measures in relation to the loss of benthic biodiversity within the marine consent area, are discussed in Sections 8, 10 and 11 and associated appendices.

2.5.4 Marine Mining Codes

As well as following the requirements of the EEZ Act, CRP has also followed the Marine Mining Code for all phases of the project. Compliance with the Marine Mining Code is a condition of MPL 50270. Initiated by the IMMS following a request by the marine mining industry, the Marine Mining Code anticipates and integrates environmental considerations for responsible marine mining.

Since the granting of MPL 50270, the EEZ Act has been passed and it will provide the principal guidance for CRP's proposed mining activity. If the Marine Mining Code sets higher standards than those of the EEZ Act, then it encourages parties to apply those standards and strive to improve upon the legally binding requirements accordingly. For this reason, the guidance and requirements of the Code have been referred to during preparation of this EIA to ensure that the proposed mining approach (including environmental mitigation, management and monitoring as well as the adaptive management approach) is consistent with the Marine Mining Code.

The Marine Mining Code establishes six overarching environmental principles for marine mining. These principles cover the need to observe the requirements of relevant laws and policies, apply best practical and fit-for-purpose approaches to provide for environmental and resource protection, consider the environmental implications of all project phases while also observing the precautionary approach, consult with relevant parties throughout the project life, maintain and deliver on an environmental quality review programme, and to publicly report on environmental performance and implementation.

These six environmental principles are expanded into 11 operating guidelines to be utilised as appropriate for specific mining operations. The operating guidelines are designed to serve industry, regulatory agencies, scientists and other stakeholders as benchmarks for development, implementation and assessment of environmental management plans, and provide advice on best fit-for-purpose practices at sites targeted for marine minerals research, exploration and extraction.

Finally, the ICMM's Sustainable Development Framework has also been embraced by CRP in the development of this EIA. The 'Sustainable Development Framework' revolves around 10 sustainable development principles[11] that were benchmarked against leading international standards. These principles reflect many of the issues and approaches already discussed in this section of the EIA.

2.6 Summary

CRP is committed to undertaking its project in an environmentally responsible manner and will ensure that all relevant legislative requirements are complied with as part of its operations.

This EIA, and related appendices, provide the relevant information required by the EEZ Act, addresses relevant aspects of the Biosecurity Act, MMP Act, MT Act and the Wildlife Act, and considers international environmental and mining conventions and guidance principles.

A mining permit and a marine consent are required before CRP's proposed mining operations on the Chatham Rise can commence.

In September 2012 CRP applied for, in accordance with the requirements of the CS Act, a mining licence to develop the phosphate resource. A mining permit (MP 55549) was granted in December 2013 in accordance with the CM Act.

CRP has also prepared this EIA in support of an application for a marine consent pursuant to the EEZ Act regime and framework. The relevant requirements of the EEZ Act, particularly the purpose of the EEZ Act and the decision-making considerations, have been considered within the EIA. From the assessment undertaken within this EIA, it is considered that the proposed mining activity is aligned with the purpose of the EEZ Act (section 10) and therefore there are no barriers to granting the marine consent.

[11] The 10 sustainable development principles are: 1. Implement and maintain ethical business practices and sound systems of corporate governance; 2. Integrate sustainable development considerations within the corporate decision-making process; 3. Uphold fundamental human rights and respect cultures, customs and values in dealings with employees and others who are affected by our activities; 4. Implement risk management strategies based on valid data and sound science; 5. Seek continual improvement of our health and safety performance; 6. Seek continual improvement of our environmental performance; 7. Contribute to conservation of biodiversity and integrated approaches to land use planning; 8. Facilitate and encourage responsible product design, use, re-use, recycling and disposal of our products; 9. Contribute to the social, economic and institutional development of the communities in which we operate; and, 10. Implement effective and transparent engagement, communication and independently verified reporting arrangements with our stakeholders.

3. CRP's Mining Project

KEY ELEMENTS

- The phosphorite lies on the crest of the Chatham Rise within the upper seabed sediments and at water depths of between 350 to 450 m.
- Targeted research voyages and data analysis between 1952 and the 1980s identified the quality, distribution and volume of the phosphorite resource. The resource was considered significant, but it was not economically or technically feasible to mine at that time.
- CRP has completed six research voyages to improve its understanding of the resource, the physical properties of the seabed, and the marine environment in the proposed marine consent area.
- CRP and its engineering partners, Royal Westminster Boskalis, consider mining phosphorite on the Chatham Rise is now economically feasible.
- CRP proposes to initially mine 1.5 Mt of phosphorite from about 30 km^2 of the seabed each year.

3.1 Introduction

In the early stages of this project, CRP was able to rely on a significant body of previous research related to both the resource and marine environment that had been gathered following the discovery of the phosphorite resource in 1952. This background material is summarised in Section 3.2 and 3.6.

Since the granting of MPL 50270 in 2010, CRP has compiled and consolidated the existing information and data relating to the phosphorite resource on the Chatham Rise. In addition, CRP commissioned specific research projects looking at the resource, the marine environment and the engineering feasibility of the proposal. These included six research voyages on the Chatham Rise described in Section 3.6. All of this information has been utilised throughout this EIA and associated appendices.

CRP's decision to proceed to a mining operation is based on:

- The historical information.
- The investigations undertaken by CRP, particularly Royal Boskalis Westminster's (Boskalis), engineering assessments, which concluded that mining of the phosphorite nodules is feasible.
- The demand both nationally and internationally for phosphate rock (refer to Section 3.5).

As a result of CRP's decision to commit to mining, CRP has sought and been granted a mining permit (MP 55549) and is now seeking a marine consent.

Preliminary design of the mining system has been completed and detailed design of the equipment to be used in the mining operation commenced in January 2013.

An overview of the mining concept (which forms the basis of the impact assessment) is provided in Section 3.3 and a full description of the proposed mining operation is provided in Section 4. An overview of the nature of the phosphorite deposit is provided in Section 3.4.

3.2 Discovery and Assessment of the Chatham Rise Phosphorite Resource

The phosphorite deposits were discovered in 1952 when scientists from the New Zealand Geological Survey, on board the R.R.S. Discovery II, found marine phosphorites in the mineralised material retrieved from the seabed of the Chatham Rise. Subsequent Government and commercial exploration of the phosphorite deposits took place in 1966, 1971, 1975 to 1978 and 1981 (refer Appendix 2 - Kenex 2010). At the time these exploration activities were taking place engineering solutions were not available to make mining at these water depths viable.

The first company to hold a mineral prospecting licence, granted in 1966 under the CS Act, was Global Marine Incorporated (Global Marine). Global Marine's licence covered an area on the Chatham Rise in excess of 100,000 km^2. As part of its exploration activities, Global Marine collected samples from within an area of approximately 18,500 km^2. As a result of its investigations, it identified four areas within its licence area that were considered to have mineable concentrations of phosphorite nodules.

In 1971, JBL Exploration NZ Ltd (JBL) was granted a prospecting licence that covered a portion of the area previously held under licence by Global Marine. JBL did not undertake any fieldwork within the licence area although it did undertake a range of desktop studies on resource estimates, economic potential and mining feasibility.

Between 1975 and 1978, the New Zealand Oceanographic Institute (NZOI) initiated a detailed investigation of the phosphorite resource resulting in joint exploration campaign with the German Geological Survey under the auspices of scientific cooperation between the New Zealand and the West German Governments. Following the promising results of this exploration, Fletcher Challenge Limited and West German company Preussag also became interested in exploring the deposit. As a result of this increased interest, the New Zealand Department of Scientific and Industrial Research (DSIR) collaborated with German institutions in four major research voyages between 1978 and 1981. In 1981, Fletcher Challenge Limited also became involved in this research (the 1981 Sonne cruise) and subsequently gained a prospecting licence under which it carried out feasibility studies and resource estimates. However, it undertook no further fieldwork prior to the lapse of the permit in 1984.

A brief overview of these voyages is provided in Section 3.6 and Appendix 2. It is estimated that approximately NZ$70 million in current dollar terms was spent on this research. Although it was determined at the time that it was not economically feasible to mine the phosphorite on the Chatham Rise, the deposit was well defined by these exploration activities. CRP has relied heavily on this information during the development of its proposed mining project.

3.3 CRP and Mining Project Concept

3.3.1 Introduction

CRP has considered the commercial, technical and environmental aspects of developing the resource, and has decided, in association with its mining partner Boskalis, to proceed to a mining operation. Relatively high and stable fertiliser prices indicate an attractive market for the product and there are environmental and economic benefits to New Zealand accruing from the utilisation of the Chatham Rise resource (refer to Section 9).

New data supports the resource analysis based on the existing exploration data, and engineering studies have shown it is now feasible, as a result of substantial improvements in offshore mining technology, to cost effectively mine the phosphorite resource on the Chatham Rise (i.e., it is now highly competitive in comparison to the cost of importing phosphate).

This section provides an overview of the company, the mining approach and the land-based activities that may be associated with the proposed mining operations.

3.3.2 Chatham Rock Phosphate Limited[12]

CRP was incorporated in April 2004 as WPL (Newco) Limited, a wholly-owned subsidiary of Widespread Portfolios. In May 2006 it changed its name to Widespread Energy Limited and in April 2011 to Chatham Rock Phosphate Limited. This latter company entity reflected a company restructuring in March 2011 whereby the focus of the company solely related to prospecting and mining activities on the Chatham Rise.

CRP is listed on the alternative sharemarket (NZAX) operated by NZX Limited. CRP currently (as at March 2014) has a market capitalisation value of approximately NZ$41.8 million. CRP's assets are approximately NZ$22.4 million.

CRP's shareholders holding more than 5 % of shares are listed in Table 1. CRP has approximately 665 shareholders in total.

Table 1: CRP's shareholders holding more than 5 % of shares (as at March 2014).

Shareholder	Percentage of shareholding
Subsea Investments II, LLC (Private equity fund based in Florida, USA)	25.4 %
Boskalis	17.6 %
Aorere Resources	10.4 %
Odyssey Marine Exploration	6.5 %

In addition to being a CRP shareholder (through Boskalis Offshore B.V.), Boskalis is also in a contractual arrangement with CRP. Boskalis is the world's largest integrated dredging and marine servicing company. Through a series of contracts, Boskalis has been responsible for undertaking the design engineering, logistics studies and preliminary design work, including consideration of methods to minimise potential environmental impacts for the proposed mining project. Boskalis has finished preliminary designs for all of the mining system components, and the two companies will enter negotiations relating to the detailed design and construction or modification of the mining vessel when the marine consent is granted. Once mining commences, Boskalis will manage the mining vessel and related mining operations.

3.3.3 Mining approach

This section summarises the proposed mining operations contained in Section 4 (including figures that illustrate the nature of the mining equipment and operations).

CRP proposes to initially mine within its mining permit area (MP 55549), a 820 km^2 area (refer to Figure 5) in the western half of MPL 50270.

[12] Further information about CRP is available in CRP's prospectus (http://rockphosphate.co.nz/share-offer/)

Using a mining vessel built or modified to meet the specific requirements of the project, phosphorite nodules and surrounding seabed material will be retrieved from the seabed using the principles of a conventional trailing suction hopper dredger or drag-head (refer to Figure 21 in Section 4). This material will be processed on-board the mining vessel, the phosphorite nodules being retained and stored on the vessel and the non-phosphatic material returned to the seabed (generally within a previously mined area). When the vessel's holds are full the mining vessel will stop mining and proceed to a port where the phosphorite will be unloaded, stored and distributed to the market.

CRP plans to mine 1.5 Mt or more of nodules per annum by mining about three mining blocks each year. Each mining block covers 10 km^2 (5 km long by 2 km wide), so annually it is anticipated that about 30 km^2 of seabed will be mined. For at least the first 5 years of operation mining will only occur within the mining permit area. .

In the future, if prospecting identifies that economic deposits are present within the prospecting licence and permit areas, and mining permits are granted, then mining may extend into these areas. If mining extends to new areas in the marine consent area then there will be no significant changes to the mining operations – the production target will remain the same, the area of seabed affected will remain the same, and the fundamentals of the mining system and operations will remain the same

Over the initial 15 year period it is anticipated that an area of 450 km^2 will be mined, approximately half of the mining permit area. All factors being equal, the mining blocks will initially target areas of high resource value.

3.3.4 Other activities

The other components of CRP's proposed mining project include:

- Operations at a port facility, namely the unloading, storage and dispatch of the mined material. CRP is currently negotiating with several ports that will be able to meet its needs.
- Mining support activities including:
    - Environmental monitoring (Sections 4.4.7 and 11.3). It is possible that vessels based on the Chatham Islands could be used to undertake some of these activities.
    - Medi-vac support facilities, potentially based on the Chatham Islands.
- On-going research and investigations (refer to Sections 4.4.7 and 11.3), for both prospecting and mining components of the project, to:
    - Assess resource distribution and benthic habitats for the purposes of future mine planning.
    - Survey work to identify optimal mining locations and review the areas that have been mined.
    - Environmental research and monitoring.
- On-going consultation with interested parties to keep them informed about CRP's operations and as part of CRP's commitment to continue to listen to and resolve issues or ideas raised by these parties.

3.4 The Phosphorite Deposit

The nature of the phosphorite deposits on the Chatham Rise has been described in Section 1.1. Phosphorite occurs as irregularly shaped nodules, ranging in size from around 0.5 to 350 mm, lying on and within the seabed generally at water depths of between 350 to 450 m (Figure 2 and Figure 3). The nodules occur at the seabed and within the upper sediment, generally extending to a depth of about 0.5 m.

Figure 7 provides an indication of the distribution of phosphorite on the Chatham Rise from the surveys undertaken over the last 60 years.

Although the phosphorite is widely distributed, its concentration is not uniform. Most of the exploration effort has focused on the area identified by early surveys as having the highest amount of phosphorite. This area is included in the mining permit (MP 55549). Section 3.6 discusses the research surveys.

There are a limited number of samples in the prospecting licence and permit areas with high concentrations of phosphorite, but the quality of these samples in terms of navigational accuracy, completeness and reliability is low. Considerable work will have to be done to determine whether economically attractive concentrations of phosphorite lie within the broader marine consent area but outside the mining permit.

Estimates of the abundance and volume of the phosphorite deposit on the Chatham Rise have been derived from the data collected during the targeted research cruises that have taken place since the discovery of the resource in 1952. Initial resource estimates were based on analysis of grab samples obtained from the 1978 RV Valdivia cruise (Kudrass & Cullen 1982) and from the 1981 RV Sonne cruise (Kudrass 1984).

The 1978 RV Valdivia survey obtained 689 samples that provide information about the distribution and concentration of the phosphorite resource. An analysis of the samples using a simple calculation based on the abundance of nodules at each sample site, the thickness of nodule-bearing sand at each site, and an average area of influence for each sample gave an estimate of 14 Mt of phosphorite in an area of 227 km^2, with an average abundance of 61 kg/m^2 (Figure 8 – refer to Va-E and Va-W).

A geostatistical analysis of these data using variographic analysis and two-dimensional kriging of nodule abundance and distribution gave an estimate of 18 Mt at a lower cut-off of 15,000 m^3/km^2.

Analyses of phosphate content from 63 bulk samples of nodules from the 1978 RV Valdivia survey gave P_2O_5 grades ranging from 20.1 % to 23.7 %, with most in the range of 21.0 % to 22.5 %.

Data from the 1981 RV Sonne cruise was analysed by two-dimensional kriging and by estimation of mean abundance from cumulative frequency curves. Kriging gave an estimate of 9.5 Mt with an average abundance of 57 kg/m^2 in an area of 167 km^2 (Figure 8). The cumulative frequency approach gave an estimate of 7.5 Mt with an average abundance of 54 kg/m^2 in an area of 140 km^2.

Analysis of the overlap of the 1978 RV Valdivia data with the 1981 RV Sonne data (Figure 8) led to a combined estimate of 25 Mt of nodules in 378 km^2, averaging 22 % P_2O_5 (diphosphorus pentoxide), with an overall abundance of 66 kg/km^2 (Kudrass 1984). Appendices 3 and 4 (Boskalis 2013a, b) provide further information on the resource assessment from the Valdivia and Sonne cruises.

Sterk (2014) (Appendix 5) derived an assessment of the phosphorite resource including CRP's data. Following a thorough review of the quality of all the input data, he used ordinary kriging in domains based on the seismic facies in Falconer et al. (1984) to estimate an inferred resource of 23.4 Mt of phosphorite with a cut-off of 100 kg/m^3. This resource is predicted to cover about 397 km^2 of the mining permit area. Additionally, Sterk (2014) estimated that there may be 8 to 12 Mt of phosphorite in the rest of the mining permit area.

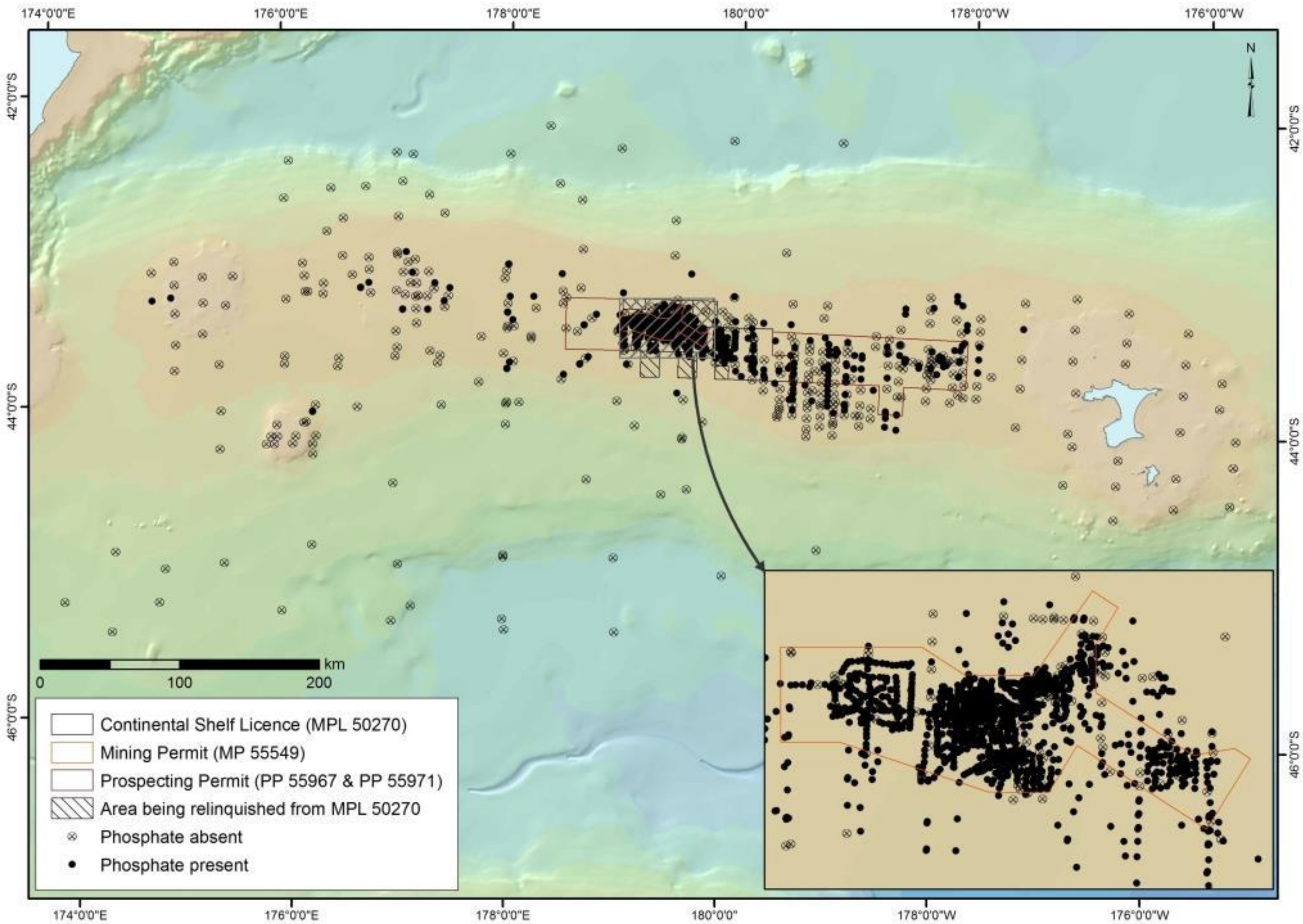

Figure 7: Presence and absence information for phosphorite on the Chatham Rise (Note: 'Absence' locations do not necessarily mean there is not phosphorite at that location. The sample method could have failed and resulted in an 'absence' result.

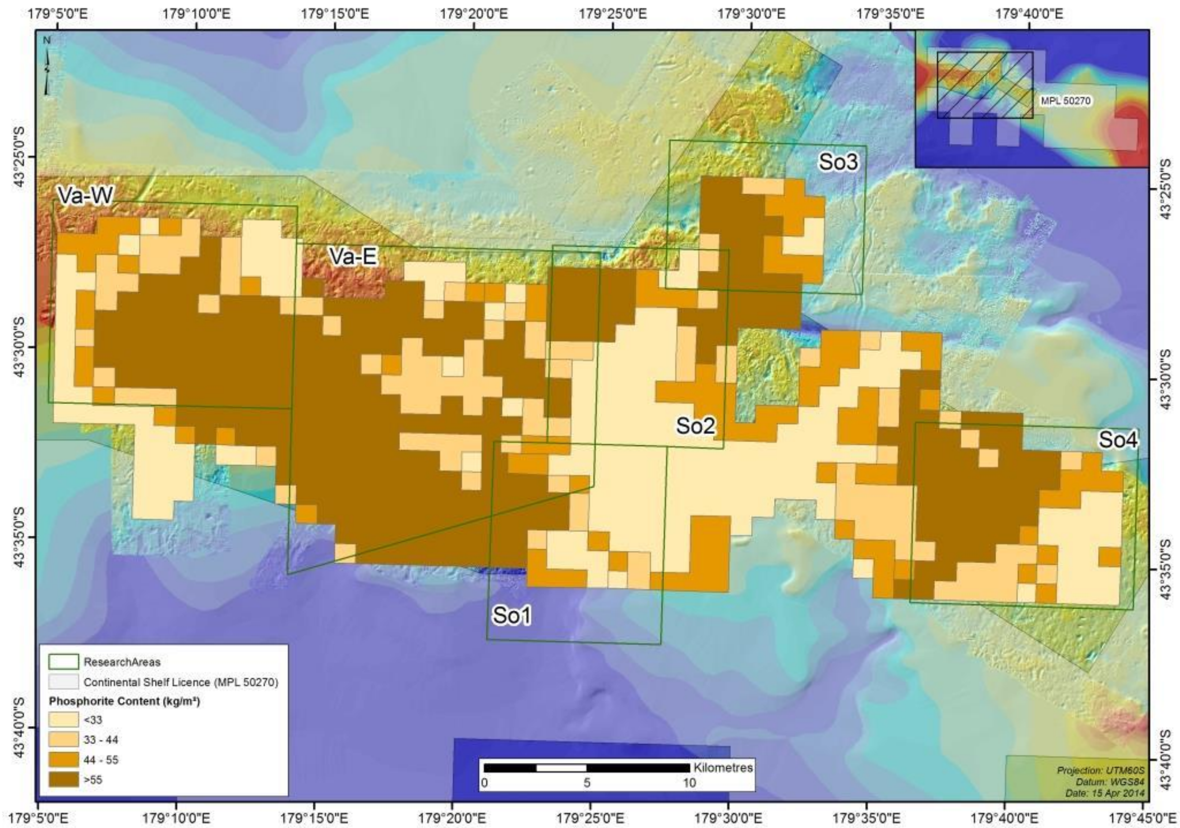

Figure 8: Resource estimate blocks for Valdivia and Sonne data (adapted by Kenex from Kudrass 1984). Areas of high concentration are dark colours. This estimate indicates spatial variability on the scale of 1 to 5 km.

A prospectivity model derived by Kenex, based on a 'mineral system concept' indicates that the morphological and geological features that appear to be correlated with concentrations of phosphorite extend along the crest of the Chatham Rise. This indicates that the overall mineral endowment has good probability of extending into the prospecting licence and permit areas included in the marine consent area.

Surveys undertaken by CRP in 2011 and 2012 (refer to Section 3.6.2) confirmed the variability in the distribution of the phosphorite resource as noted by Kudrass (1984). The data collected by these surveys show that the deposit has been extensively modified by iceberg scours or furrows, as first suggested by Kudrass & von Rad (1984a). This modification makes it very difficult to predict the distribution of phosphorite at scales of tens or hundreds of metres but is unlikely to affect the larger scale estimates described above.

3.5 Market Demand

The Economic Assessment prepared by NZIER (Appendix 6) contains an analysis of market demand in New Zealand and worldwide for phosphate and related products. A brief overview is provided here.

In New Zealand agriculture relies heavily on fertiliser. Fertiliser products currently make up around 15 % of dairy farming's inputs and 8 % of those for horticulture and sheep and beef farming. Phosphatic fertiliser (superphosphate and other phosphate fertilisers) accounts for over 40 % of the fertiliser used as part of New Zealand's agricultural activities.

Globally the use of rock phosphate, whether in its raw form or as a manufactured product, has increased significantly since World War II. In 2009, rock phosphate production was about 160 Mt and by 2012 this had risen to 191 Mt. Over recent years, increased consumption has been largely driven by the rapidly expanding economies in East Asia, as well as increased foodstuff and biofuel production in North America. It is anticipated that increases in demand for phosphate will continue into the future, driven by population increases, growing affluence and demand for protein rich foods in emergent developing countries.

As New Zealand has no significant land-based phosphate resource, imported rock phosphate is the core ingredient of the phosphatic fertilisers used in New Zealand. Approximately NZ$185 million per annum is spent on importing rock phosphate into New Zealand, although this amount varies as a result of the variation in the price for phosphate (i.e., in February 2008 the price was about US$45/tonne but rose to a peak of US$430/tonne later that year) and the actual amount of rock phosphate imported. Since the 2008 price spike, prices have generally fluctuated between US$100 to US$200/tonne, depending on the grade of the product.

Statistics New Zealand reports that New Zealand rock phosphate imports are variable. For example, in 2009 320,000 tonnes was imported (which is low compared to other years) and in 2010 this figure was 890,000 tonnes. For the purposes of NZIER's Economic Assessment (Appendix 6), an average of 2010 and 2011 phosphate imports has been used as it closer to predominant range of recent years (i.e., 770,000 tonnes of rock phosphate per annum). CRP estimates that, from discussions with industry sources, import volumes may be closer to 1 million tonnes per annum.

CRP's mining project is expected to produce at least 1.5 Mt of rock phosphate per year for both the domestic and international markets.

3.6 Overview of Voyages and Work Undertaken

3.6.1 Historic Phosphorite-related voyages

Appendix 2 (Kenex 2010) and Table 2 summarise the voyages that investigated the phosphorite deposits between 1952 and 1981.

3.6.2 CRP's research voyages

Since the granting of MPL 50270, CRP has undertaken six research voyages costing approximately NZ$8 million. These voyages deployed moorings to monitor oceanographic conditions, collected multi-beam swath bathymetry data and seabed samples, measured the physical properties of the seabed with CPT tests, and collected magnetic and seismic reflection data (Table 3 and Figure 9). The data collected and analysed from these voyages have been used in the design of the mining system, to confirm the resource estimate, to establish an environmental baseline and to assess the potential impacts of the proposed mining project as outlined within this EIA. These data, where relevant, have also been used by NIWA, in conjunction with data and information that NIWA holds from its research on the Chatham Rise, in the preparation of its technical reports appended to this EIA. CRP also contributed financially to NIWA's 2013 Ocean Survey 20/20 voyage (OS20/20) (refer below).

As outlined in Section 8.2.1, the initial environmental research plan was determined following a scoping exercise. The scoping exercise was carried out by members of CRP's project team in conjunction with NIWA and Deltares (through Boskalis) personnel with the skills and knowledge to identify the potential environmental issues associated with the proposal. This broader team identified the additional research that needed to be undertaken and the additional technical assessments utilised within this EIA.

A summary of CRP's voyages is provided in Table 3. Surveys 1 and 2 were carried out by IXSURVEY Australia Pty Limited and Surveys 3 to 6 were undertaken by Odyssey Marine Exploration Incorporated with the vessel Dorado Discovery.

Table 2: Phosphorite related voyages between 1952 and 1981.

Date	Vessel	Organisation	Purpose
1952	R.S.S Discovery II	New Zealand Geological Survey	• Voyage discovered the phosphorite resource on the Chatham Rise
1967	-	Global Marine	• Reconnaissance voyage • Drag bucket samples collected over much of the Chatham Rise
1968	-	Global Marine	• Detailed survey between 178°48’ E and 177°50’ W • 331 samples collected • Phosphorite nodules recovered in 125 samples (covering an area of 18,500 km^2)
1975 to 1978	R.V. Tangaroa (4 voyages)	NZOI	• Detailed investigations of the phosphorite resource on the Chatham Rise.
1978	R.V. Valdivia	NZOI and Bundesanstalt fuer Geowissenschaften und Rohstoffe	• Cruise objective to determine regional distribution, quantitative assessment of reserve, investigate near-surface seabed and nature of phosphorite nodules and associated sediments • 689 samples collected over 227 km^2 of seabed • Estimated reserve of 14 to 20 Mt over the area sampled
1981	R.V. Sonne	DSIR and Bundesanstalt fuer Geowissenschaften und Rohstoffe Fletcher Challenge Limited, Preussag	• Cruise objectives similar to those of the R.V. Valdivia • Regional survey covering 11,400 km consisting of 40 km^2 wide strips along the 270 km long crest of the Rise • Four detailed surveys, within the survey area, were carried out including: seismic profiles (2,700 km), sidescan sonar (176 km), collection of 532 large grab samples (1.3 t per sample) and 18 smaller samples, 24.5 km of underwater photos and video, near surface and bottom current measurements and continuous weather observations • Estimated reserve of 7.5 Mt over 140 km^2

Table 3: CRP's research voyages.

Date	Survey	Purpose
May 2011	Survey 1	• Deployment of two current meters • Collection of bottom samples
July 2011	Survey 2	• Deployment of two turbidity meters • Collection of bottom samples. Surveys 1 and 2 collected 45 samples
December 2011	Survey 3	• 12 day voyage for the collection of bathymetry, geomorphological and subsurface data • Retrieved the two current and turbidity moorings deployed during Surveys 1 and 2 • Data collected included: mapping of the seabed using multi-beam swath bathymetry data (715 km^2) and sidescan sonar data (199 km^2) and seismic reflection data (199 km^2)
February 2012	Survey 4	• 9 day voyage to collect geotechnical data for mining design, to test grab sampling equipment and ground truth historic information • Data collection included: further multi-beam swath bathymetry data, 50 grab samples (total of 32 t), 43 30 cm push cores from suitable grab samples, 172 subsamples from the grab samples
March 2012	Survey 5	• 18 day voyage to collect benthic ecology data • Data collected from 13 survey areas included: ROV[1] video transects (77 km, 150 hours and 62,000 observations), 130 box core samples from 38 sites, 17,000 still photos along video transects, high-resolution bathymetry data (3 km^2), regional bathymetry data (500 km^2), and 12 benthic biological samples and associated close-up photos (within ROV transects)
April 2012	Survey 6	• 13 day voyage for the collection of phosphorite and sediment data • Data collected from 5 survey areas included: 14 vibrocores from 13 locations, 2 box cores, 134 cone penetration tests, 3 ROV jet tests, more regional bathymetry data (400 km^2), 4 additional ROV transects (including 600 environmental observations)

Note: (1) Remote operated vehicle.

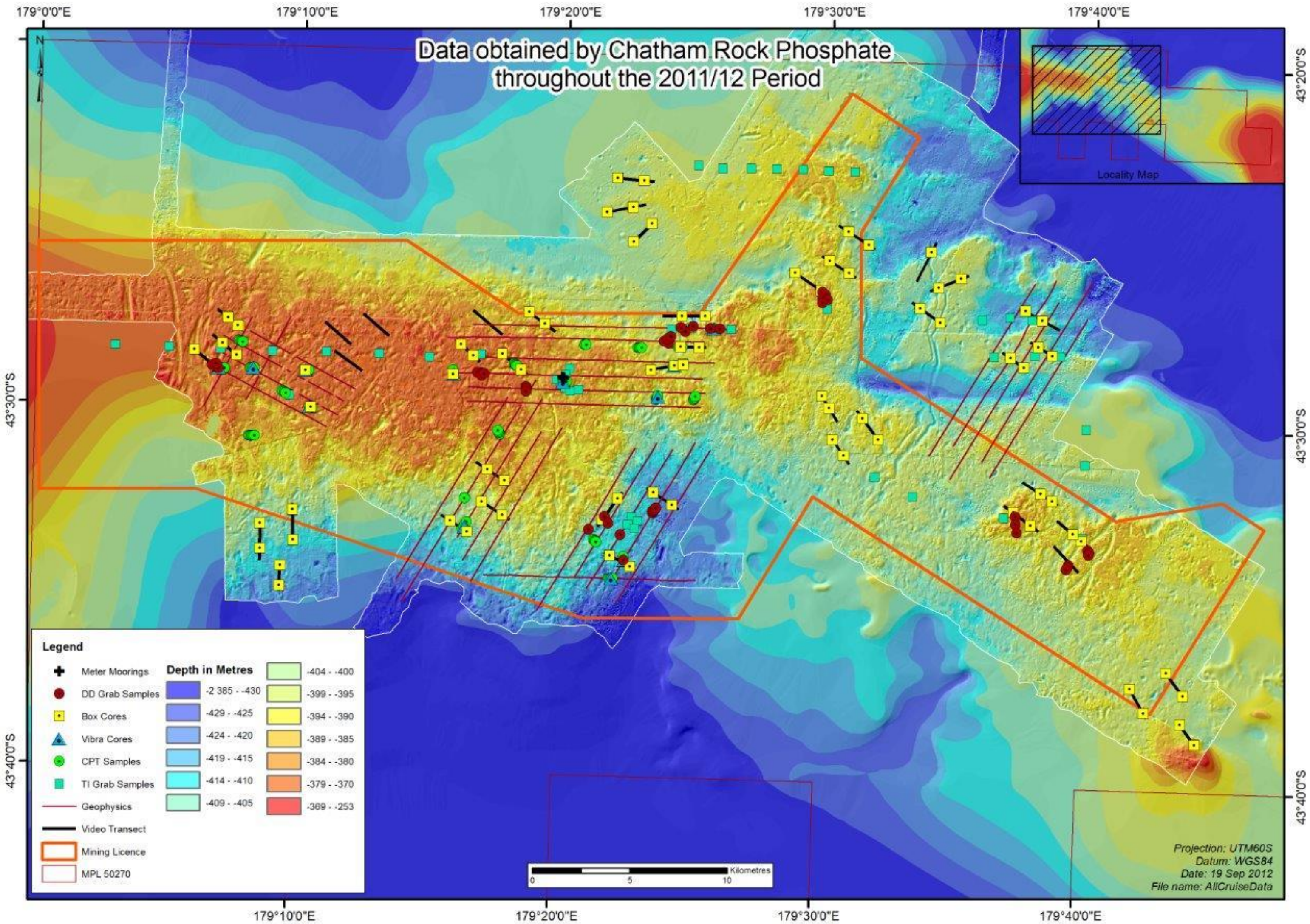

Figure 9: Data obtained during CRP's six research voyages during 2011/12. The surveys collected bottom samples, multi-beam swath bathymetry data, video and still images, geophysical data and cone penetrometer data. Two moorings were deployed to gather oceanographic data.

3.6.3 Other research voyages

The Chatham Rise is one of the most extensively studied areas of New Zealand's EEZ. An overview of other research voyages undertaken on the Chatham Rise, in the vicinity of CRP's marine consent area, is in Appendix 7. This shows that a considerable amount of research effort, for a variety of purposes, has been undertaken within and around CRP's proposed mining area.

Analysis of the benthic environment and communities on the crest of the Chatham Rise has greatly benefitted from the integration of data collected by CRP on its 2011 and 2012 voyages, and data collected for New Zealand's OS20/20 voyages to the Chatham Rise in 2007 and 2013 (TAN0705 and TAN1306) (refer to Appendix 7). An overview of these research voyages is provided below.

In June 2013, MPI, in consultation with NIWA, collected data from previously unsampled areas on the Chatham Rise. The purpose of this data collection was to improve the understanding of biodiversity distributions, and to support the refinement of existing marine environment classifications and environmental management decisions. This survey complemented similar data collected on an OS20/20 voyage in 2007 to the Chatham Rise and Challenger Plateau. The data, where relevant, from the 2007 OS20/20 was utilised by NIWA in its technical reports prepared for this project.

The purpose of the 2013 OS20/20 voyage was to provide additional exploration and mapping of the distribution of seabed habitats and fauna on the Chatham Rise. The voyage collected multi-beam swath bathymetry data, seabed photographs, and samples of the seabed sediment and organisms. The 2013 OS20/20 voyage surveyed eight areas on the crest of the Chatham Rise (Figure 10), located between the transects collected by the 2007 OS20/20 voyage, inside the BPA and in the region of CRP's detailed benthic study areas. The survey design was comparable to that used in CRP's benthic survey (as discussed more fully in Section 6). In each survey area, a box of approximately 10 by 10 km was mapped with a multi-beam echo sounder and bathymetric and backscatter data were collected. Within the mapped area, three towed camera transects directed to the seabed were completed (approximately 1.6 km) and box-core samples were taken from transects in the boxes closest to MPL 50270. The significant portion data collected from this voyage has been utilised in the preparation of the technical report contained in Appendix 16 (Rowden et al. 2014a).

3.7 Summary

The marine consent area covers the known distribution of phosphorite on the crest of the Chatham Rise. The mining permit area, based on current knowledge, contains the highest concentrations and thus a known economic deposit. The resource, in the mining permit area, is estimated to contain between 23.4 to 25 Mt of phosphorite in an area of 378 to 397 km^2, averaging 22% P_2O_5 (diphosphorus pentoxide). An additional 8 to 12 Mt of phosphorite may be present in the rest of the mining permit area.

In 2008, CRP was granted a prospecting licence under the CS Act (MPL 50270). This enabled CRP to undertake further resource and environmental research while reassessing the engineering feasibility of a mining project. In 2013, CRP was granted a mining permit (MP 55549) in accordance with the CM Act.

Total investment in exploring the resource includes surveys and analysis up to the 1980s, estimated to have cost NZ$70 million in current dollar terms, and six voyages by CRP that cost about NZ$8 million.

The mining concept developed by Boskalis uses a specially designed mining vessel that will use a trailing suction head dredger and drag-head. The drag-head will retrieve the seabed material and this material will be processed on-board the vessel. The phosphorite will be retained and stored for later transport to a port and the non-phosphatic material will be returned to the seabed.

CRP proposes to mine at least 1.5 Mt of phosphorite annually, sold to local and international markets. Annual production will from mining about 30 km^2 of the seabed.

In addition to the mining activities, CRP's mining project will also entail port based loading and unloading operations (at a port yet to be determined), mining support activities, on-going research and investigations and on-going consultation with interested parties.

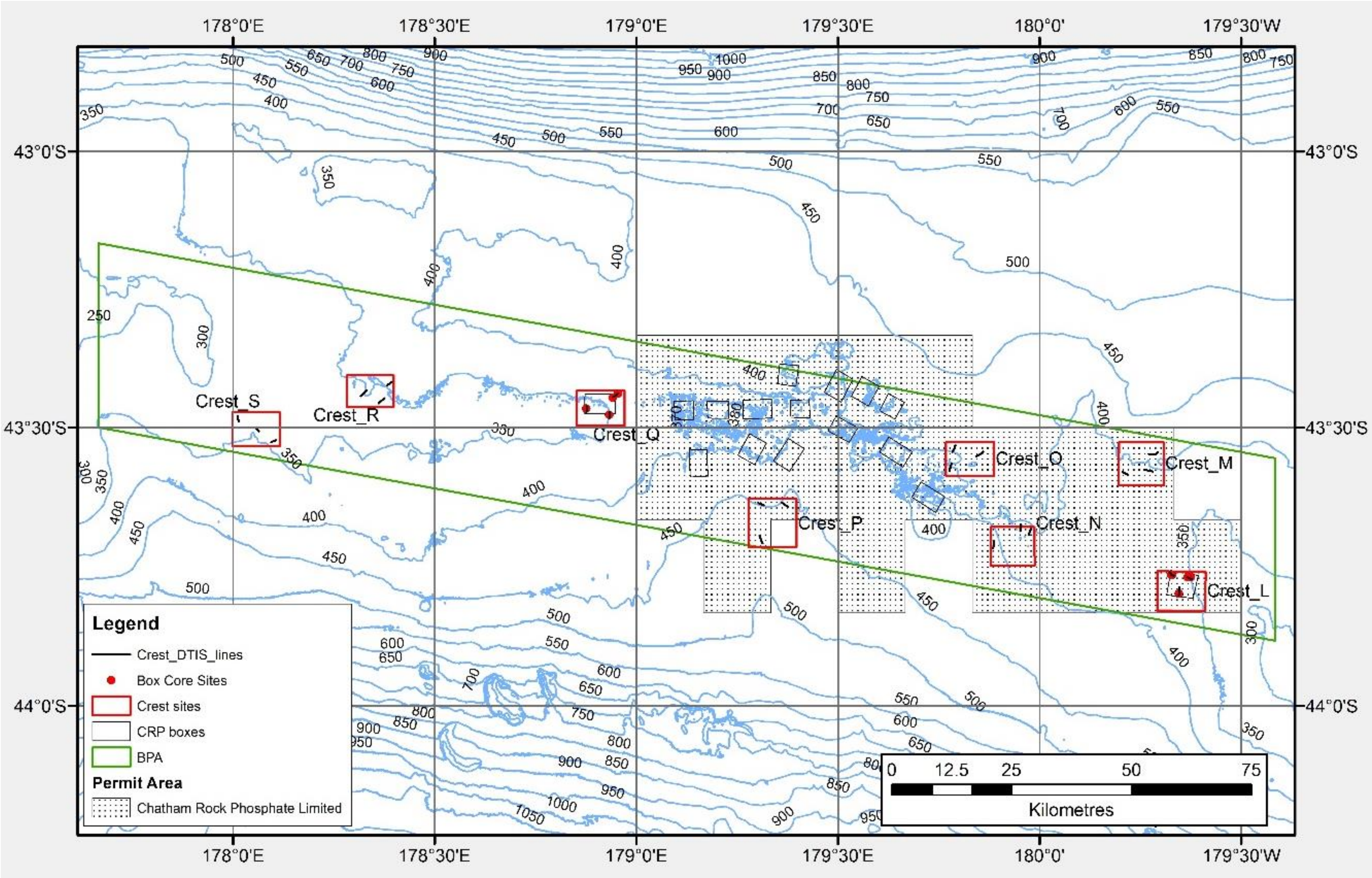

Figure 10: Chatham Rise 2013 OS20/20 survey: overview map showing the seabed areas surveyed on the crest of the rise (red outline), towed camera transects (black lines), and box core stations (red dots). These areas contributed data to the environmental analyses and modelling in the region of the CRP proposed marine consent area. (Green box is BPA, shaded area corresponds to MPL 50270 including areas which CRP has applied to relinquish).

4. Proposed Mining Operation

KEY ELEMENTS

- A mining vessel will be specifically built or modified to meet the requirements of the project.
- The mining vessel will have a trailing suction drag-head that will move along the seabed. The top 30 to 50 cm of seabed sediments will be loosened by water jets (possibly assisted by cutting teeth incorporated into the drag-head) and then pumped through a flexible riser hose to the mining vessel for on-board mechanical separation. The separated phosphorite nodules will be stored on the vessel and the non-phosphatic material (sand size and smaller) will be returned to the seabed through a flexible sinker hose and diffuser.
- The vessel and mining system concept design are based on the need to ensure safe operations in the prevailing sea conditions, the physical properties of the seabed sediments, the need to minimise potential environmental impacts, and the production target of 1.5 Mt per annum. Vessel and mining operations will also meet New Zealand and international requirements.
- Each mining cycle is likely to be about 10 days. This will depend on the capabilities of the vessel, the on-board processing plant and the choice of port.
- The concept mining plan is based on a grid of 10 km^2 (5 by 2 km) mining blocks oriented northeast-southwest to align with the predominant swell. Mining is expected to spiral out from the centre of each mining block. Mining of about three blocks per year will be required to meet the initial production target.
- The mining plan includes provision for mining exclusion areas. These unmined areas will protect areas of particularly sensitivity or values that have been identified through a marine spatial planning exercise commissioned by CRP.

4.1 Introduction

Mining on the Chatham Rise will be carried out using a mining vessel specifically built or modified to meet the requirements of the project. The vessel will be similar in size and concept to the trailing suction hopper dredger "Queen of the Netherlands" (33,423 gross tonnes, approximately 230 m long and 32 m wide) (Figure 11). Another vessel, the heavy lift vessel "Black Marlin" (57,021 gross tonnes, approximately 217.5 m long and 42 m wide) (Figure 12) is also being considered for modification. For the purposes of clarity, throughout the life of mining operations, CRP only intend to have one mining vessel operating on the Chatham Rise.

The vessel will dredge and process phosphorite-bearing sediments from the seabed, store phosphorite nodules on board, return the finer non-phosphoritic material and some unwanted coarse material back to the seabed (generally within previously mined areas), and when fully laden proceed to a port to off-load the nodules and re-provision. The vessel will be equipped with a drag-head, dredge-pump unit and riser to bring material to the surface, and a sinker and diffuser to return material onto or near the seabed.

Figure 11: "Queen of the Netherlands", example of a Boskalis vessel that could be significantly modified for mining.

Figure 12: "Black Marlin", another example of a Boskalis vessel that could be significantly modified for mining.

This section provides information on:

- The conceptual mining approach.
- The metocean conditions on the Chatham Rise that affect the type of vessel to be used.
- Describes, in more detail, how mining will be carried out, including the on-board processing and the return of the non-phosphatic material to the seabed.
- The mining plan and cycle.
- Vessel operations.

4.2 Mining Concept

The mining concept is based on modern conventional trailing suction hopper dredge operations. A key feature of the mining vessel is a detached, suspended drag-arm and drag-head, capable of dredging in the water depths associated with the mining area and under harsh metocean conditions. The mined material will then be transported up to the vessel for on-board separation of the phosphorite nodules from the finer sediments, and returned to the seabed through a sinker (similar to the riser) and a diffuser. In lay terms, the vessel will 'suck' up the seabed under the drag-head and return the unwanted material to the seabed.

Figure 13 illustrates the proposed configuration of the vessel, drag-head, riser, sinker and diffuser.

The core elements of the proposed seabed mining activity include:

- Mining to generally occur in 350 to 450 m of water on the Chatham Rise.
- Mining an area of approximately 30 km^2 each year, consisting of three 2 km wide by 5 km long mining blocks.
- The trailing drag-arm carrying the suction head is suspended from the vessel by wires (dependent on the mining vessel used, this could either be off one side of the vessel or from the centre of the stern.)
- The trailing suction drag-head will excavate up to 0.5 m and, on average, the top 0.35 m of seabed.
- Pumping of mined sediment (all material < 150 mm[13]) through a riser to the surface vessel
- On-board processing (physical processes only) of the recovered material to separate and retain phosphorite nodules larger than 2 mm in the vessel's hold/s.
- No overflow of mined sediment before, during or after processing, at the sea surface or from the mining vessel.
- Controlled disposal of the unwanted sediment (the non-phosphatic material) onto the seabed and within previously mined areas, through a sinker deployed from the opposite side of the vessel from the drag-arm.

[13] A screen on the drag-head means that only seabed material < 150 mm will be taken by the drag-head and thus pumped to the mining vessel.

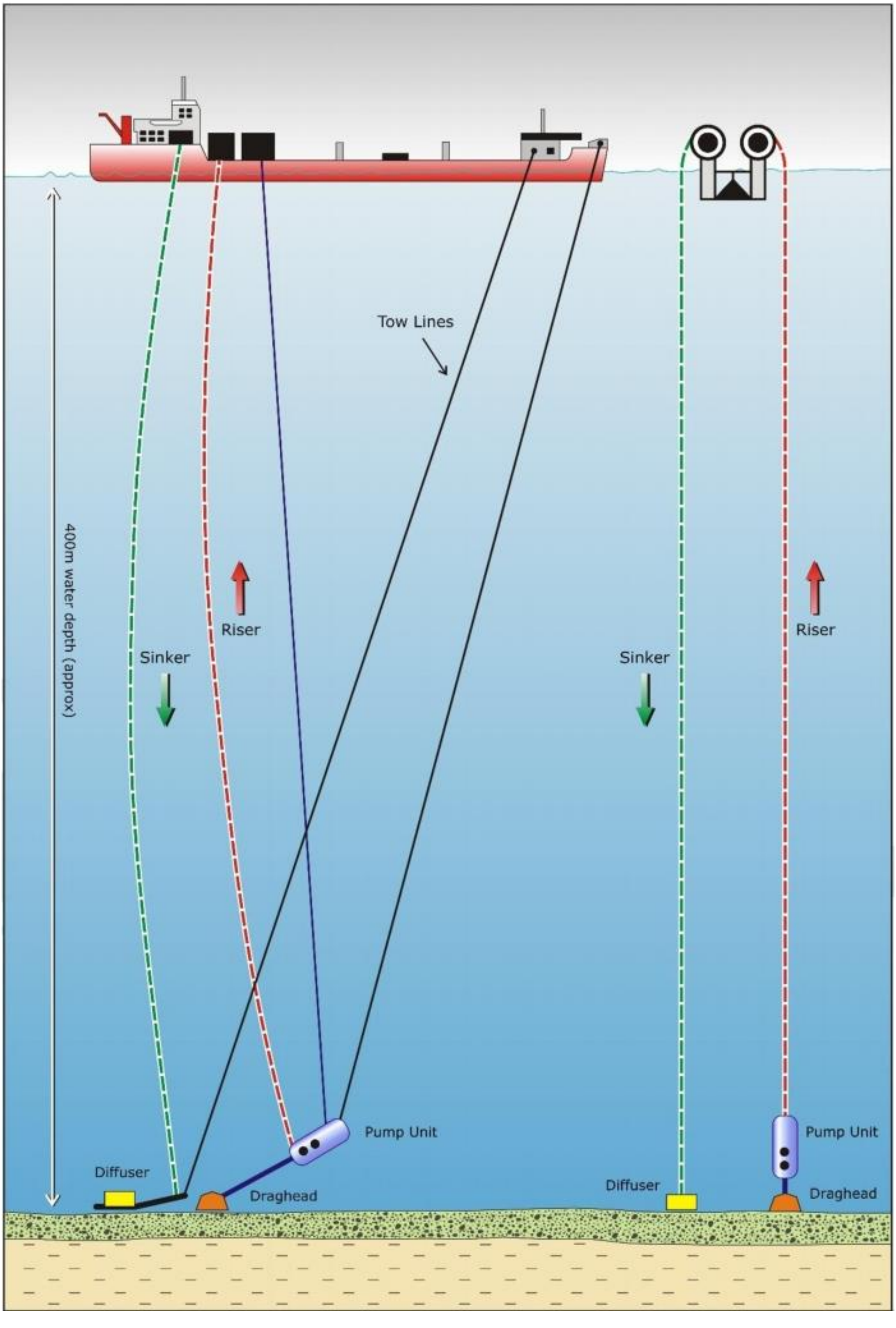

Figure 13: Mining system concept. The seabed sediment goes up through the drag-head and riser, is processed on the mining vessel, and the non-phosphorite sediments are returned to the seabed through the sinker and diffuser.

4.3 Metocean Conditions Influencing Mining Method

Metocean conditions have a strong influence on the proposed mining operations. Metocean conditions were analysed by Boskalis to assess vessel and equipment operability. Oceanographic conditions on the Chatham Rise have been described by Chiswell (2013) (Appendix 8). National Oceanographic Atmospheric Administration (NOAA) data have also been used to determine workability for the mining vessel while operating on site.

As shown in Figure 14 below, waves generally come from a narrow sector, around 210 degrees (approximately southwest). The vessel is most stable heading into or with the wind so the preferred mining directions are 30 and 210 degrees, northeast and southwest. This has a direct bearing on the mining strategy.

The wave climate on the Chatham Rise is considered to be harsh (Figure 15 and Figure 16). A mining system capable of working in sea states up to a significant wave height (Hs) of 4 m, with a fairly wide wave period[14] range (Tz, the zero upcross period in seconds) of between 5 to 11 seconds, is considered as a minimum workability limit for efficient and effective mining operations. It is estimated that if the vessel design utilises these limits, this may result in weather downtime for the vessel of about 15 % (averaged over a year) for the time that the mining vessel is operating in the mining area. Final weather limits for mining safety will be estimated following completion of vessel modification design.

The mining system will be designed to meet these operating limits, taking into account wave induced motion, motion induced dynamic forces, and requisite motion compensation.

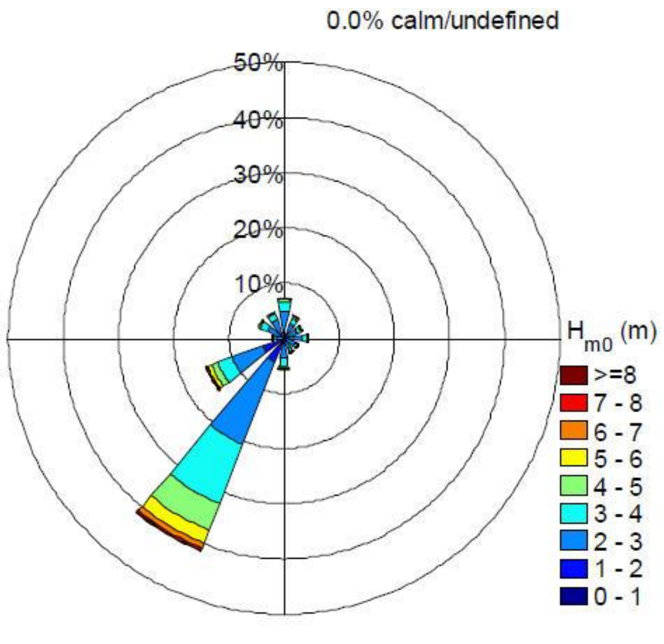

Figure 14: Wave rose showing year-averaged wave height and direction (source: NOAA NWW3 model data 43.0°S 180°E, 1997-2010). The dominant wave direction is from the southwest.

[14] A "wave period' is time interval between the arrival of consecutive crests at a stationary point.

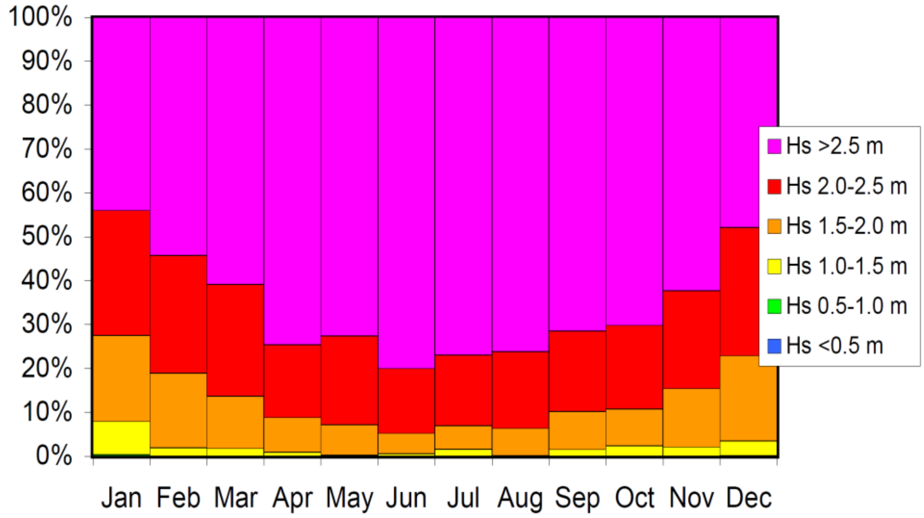

Figure 15: Metocean wave conditions – wave height frequency.

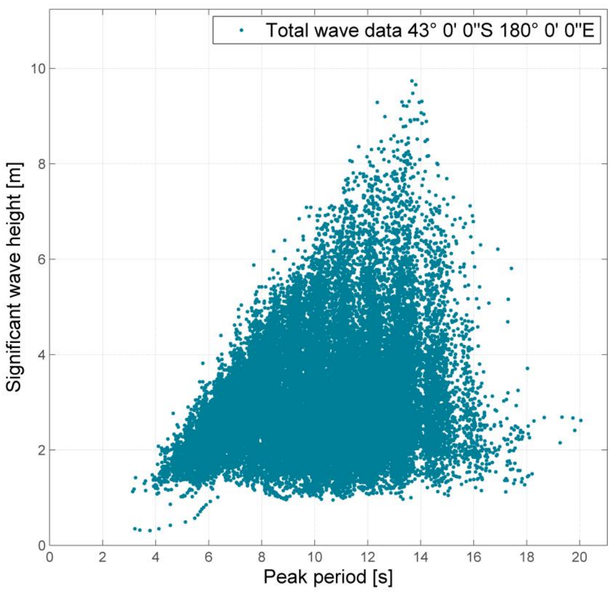

Figure 16: Metocean wave conditions – wave height versus period.

The metocean conditions present engineering challenges for Boskalis, although there are no critical issues that are expected to prohibit the development of a reliable and safe mining operation. For example, the main system component deployed under water (dredging pump unit) will be at least 10 m above the seabed, and therefore there is no risk that this component of the mining equipment will contact the seabed while heave compensation on the vessel is applied.

Although the wave climate is particularly harsh, winds are not. Figure 17 summarises the wind environment for the Chatham Rise. However, the mining vessel must have sufficient power and manoeuvrability to keep the mining drag-head within the required mining tracks in the predicted wind environment. The vessel will have a dynamic positioning system, including retractable azimuth thrusters[15] and its main propulsion system, to provide the required stability. The thrusters will allow the vessel to maintain the heading.

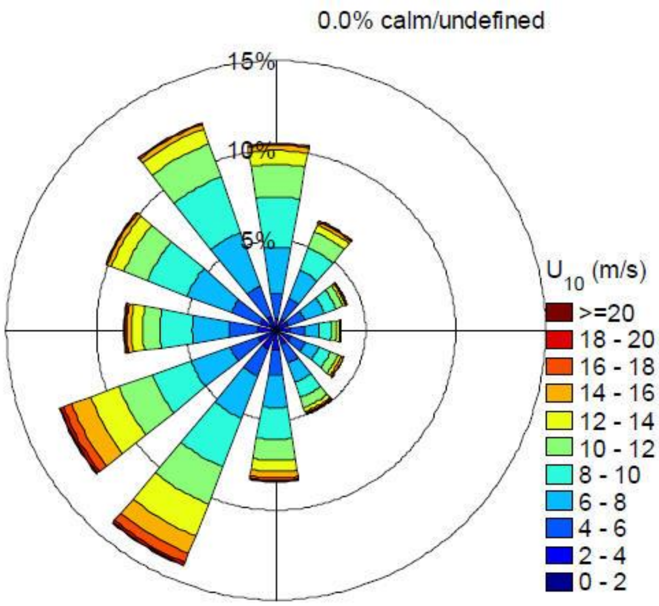

Figure 17: Wind rose showing year-averaged speed and direction (source: NOAA NWW3 model data 43.0°S 180°E, 1997-2010). Winds tend to be from the west but do not show the same predominant southwest orientation as the swell direction.

4.4 The Mining Approach

4.4.1 Seabed conditions and environmental constraints

Physical conditions at the seabed influence the design of the mining system because the drag-head and riser system rely on loosening the surface sediment layers, a process that depends on the physical properties of the sediments. During the 2012 Dorado Discovery surveys, a substantial amount of data was gathered about the shape and nature of the seabed that has provided fundamental input to the mining design. Factors that will constrain mining operations, and therefore determine areas that will generally not be mined, are primarily associated with areas of rock outcrops. Within the mining permit area, large rock outcrops are not common, but large areas of basement rock have been mapped elsewhere in the marine consent area.

Environmental factors that have been incorporated into the overall mining approach and design include:

- Minimisation of disturbance of seabed and the nodule bearing sediments during mining.
- Minimisation of the dispersion of fine material during return of processed sediment to the seabed by the sinker and diffuser design and management of their height above seabed.

[15] Azimuth thrusters are a configuration of propellers (i.e., generally in pods) which can be rotated in any horizontal direction. They provide a vessel with better manoeuvrability than that provided by fixed propeller and rudder system alone.

- Setting aside areas of particular scientific or conservation sensitivity and values as mining exclusion areas (Figure 18), identified through a marine spatial planning exercise (refer to Section 8.6.6.4 and Appendix 32).

The proposed mining exclusion areas (Figure 18) cover a total area of 1,822 km^2, approximately 18 % of the marine consent area.

If further research undertaken by CRP within its prospecting areas identifies other areas associated with specific values (e.g., high resolution bathymetry identifies significant iceberg furrows not previously identified), then CRP will consult with the proposed Environmental Reference Group (ERG) about including these in the mining exclusion areas (Section 11.4 contains proposed marine consent conditions reflecting this requirement).

4.4.2 Mining concept

4.4.2.1 First five years

As outlined previously, CRP expects to mine about 30 km^2 each year to meet its initial annual production target of 1.5 Mt of phosphate. To improve mining efficiency by minimising the amount of time spent turning the mining vessel, mining operations will focus on 10 km^2 blocks (5 by 2 km). Each year CRP expects to mine about three 10 km^2 mining blocks.

The mining blocks are oriented northeast-southwest (Figure 19) as that is the dominant swell direction and vessel operations will be easier if the vessel travels with or into the swell. To also improve mining efficiency, the mining block boundaries may be shifted slightly and the mining operations adapted to accommodate factors such as the mining permit boundary (or future mining permit boundaries) and mining exclusion areas.

A possible sequence of mining blocks, for the first five years of mining operations is described below. Factors that have controlled the order of the mining blocks include:

- **Large amount of existing data in the mining block**. Mining blocks with extensive sampling, CPT measurements, and ROV video and other data will be preferred.
- **Determine mining characteristics across the mining permit area.** Mining blocks will be mined from representative areas throughout the mining permit area so as to determine how variations in the physical properties of the seabed affect mining operations. This will enable the identification of changes that can be made, if any, to processes, procedures and technology to maximise efficiency and minimise impacts.
- **Maximise the potential for recolonisation of mined blocks**. The sequence of mining will be planned to distribute spatial and temporal effects of mining and to minimise deposition of the return of non-phosphatic material in previously mined blocks. Once operations become routine then adjacent mining blocks will be mined from the northwest to the southeast unless other operational factors dictate a different sequence (modelling predicts that the returns will be preferentially distributed to the northwest).
- **Maximising economic returns in the early years of the project**. Mining blocks estimated to have large concentrations of phosphate will be preferred during these early years.

Figure 20 shows a concept scheme for mining 15 blocks in the first five years of operations on the Chatham Rise.

In addition to the mining operations, in the first two years of operations CRP will complete the multi-beam swath mapping of the mining permit area and collect and analyse sufficient other data (e.g., video transects, bottom samples) to model the phosphate resource and benthic habitats throughout the area. Similar investigations will also occur in a staged manner within CRP's prospecting areas.

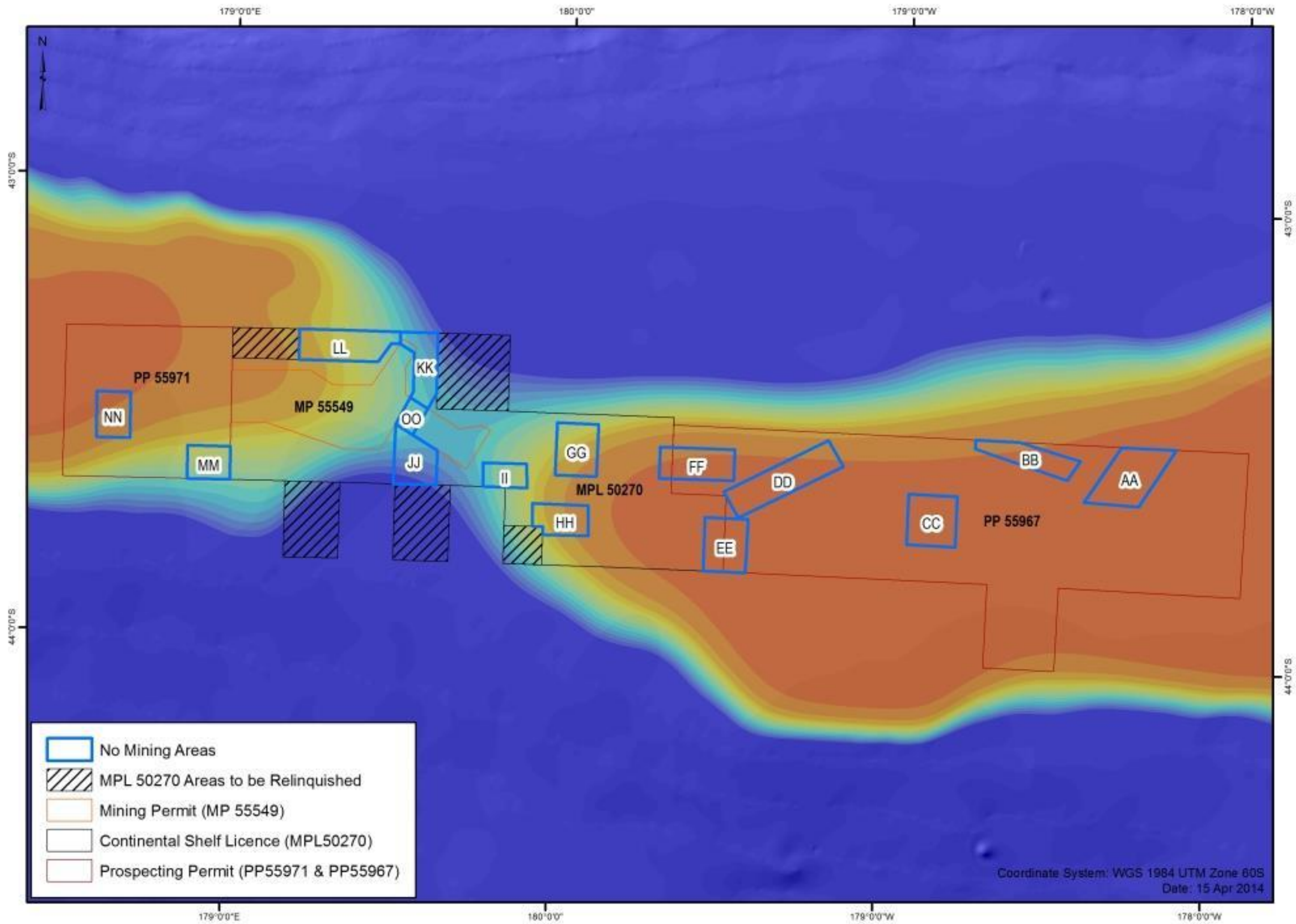

Figure 18: Map showing CRP's proposed mining exclusion areas inside the proposed marine consent area. The areas were defined using the results of Zonation, a spatial planning software tool, and were chosen to preserve biodiversity and represent habitats across the entire marine consent area.

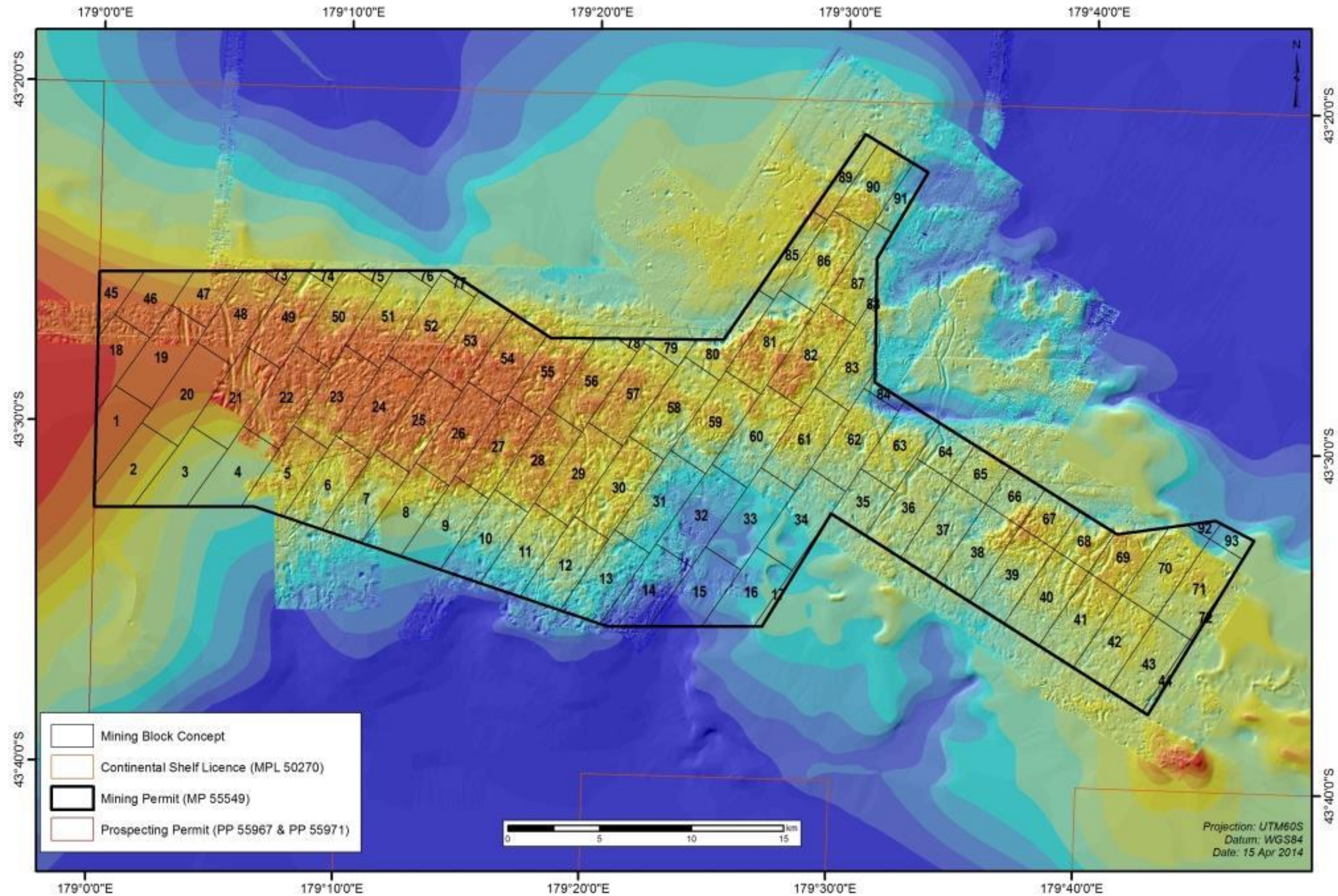

Figure 19: Mining block concept – each full mining block is 5 by 2 km. Small areas would be mined in conjunction with adjacent blocks for efficiency. The mining blocks location may be revised to accommodate the mining exclusion areas.

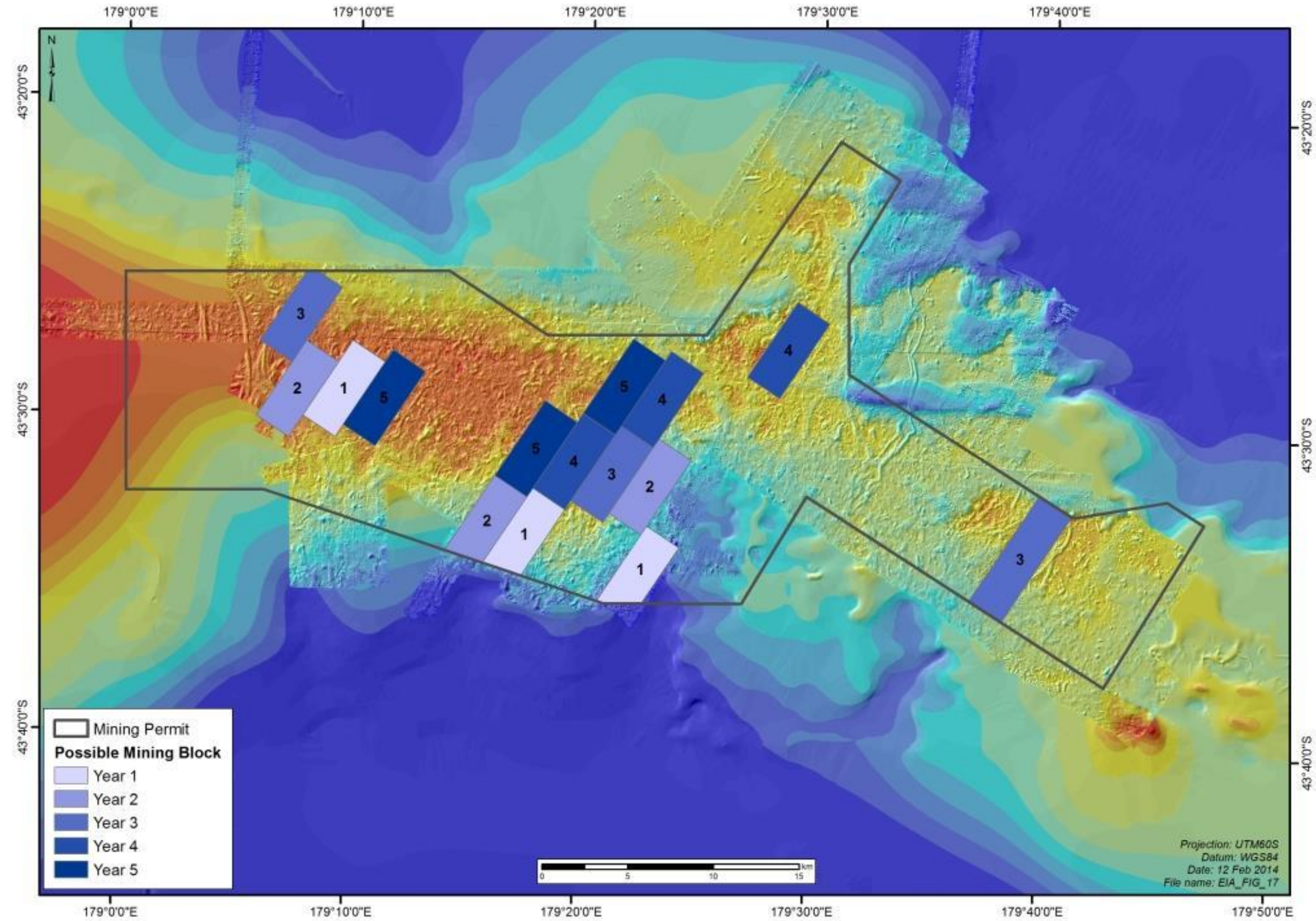

Figure 20: Possible concept 5 year mining plan. The mining blocks are colour-coded and labelled with the proposed mining year. The blocks are chosen to minimise overlapping effects and test seabed properties of the mining permit area.

4.4.2.2 Beyond the first five years

CRP expects to mine about 30 km^2 each year to meet its annual production target of 1.5 Mt of phosphate for the duration of its mining permit/s and marine consent, or until the economic resource is exhausted. This production target will remain the same, regardless of the outcome of the prospecting activities in the marine consent area beyond the existing mining permit area. If mining were to take place throughout the proposed 35 year consent term, then approximately 1,050 km^2 of the seabed will be mined (approximately 10 % of the marine consent area).

Within the existing mining permit area, the adaptive management process will be used to apply experience from the first five years of mining to adjust, if necessary, the mining plan, mining operations and the sequence of mining blocks to continue to maximise mining efficiency and minimise environmental impacts. Development of commercially viable resources outside the existing mining permit would offer opportunities to spread the mining effort spatially and temporally, an option that might increase the rate of recolonisation and recovery of mined blocks.

If commercially viable resources are discovered in the prospecting areas and if CRP has met the adaptive management conditions outlined in Section 11.4, then it may begin mining in those areas (subject to obtaining a mining permit). The adaptive management conditions proposed by CRP stipulate that permission to mine areas beyond the existing mining permit area will be based on the outcomes of the monitoring and research that have been undertaken and reported to the EPA. If a mining permit is also granted then CRP will be able to move its mining effort geographically, but it will not increase the annual production target. In that respect, precisely the same mining activity will continue, with the only difference being that mining will be carried out in identified areas of the wider marine consent area beyond the existing mining permit area. As such, CRP considers that it is in a position to predict with effectively the same level of certainty the likely impacts of mining activity in any new mining areas.

There is already a very good base of information about the wider marine consent area which enables CRP to assess the likely impacts of any mining activity there. In addition, the physical and environmental properties of every new mining area, if any such areas are found, will have been comprehensively surveyed as part of the exploration programme and the proposed conditions of the marine consent (refer to Sections 11.3 and 11.4). Largely through these processes, the characteristics of the new mining areas will be known and analysed to at least the same level of detail as known within the existing mining permit area. The surveys and associated research will map the seabed at a similar resolution to that in the existing mining permit area, and collect samples and photographs of the seabed to determine the distribution of the phosphorite resource, the physical properties of the sediments and the nature of benthic habitats and communities. These data will provide ground-truthing for the predictive benthic community habitat mapping discussed in Section 6.3, and through their refinement as part of the adaptive management process support on-going decisions balancing economic and conservation values. Baseline seabed and oceanographic data will also be collected to help predict spatial changes in benthic habitats and the marine environment, and to support mine planning decisions and the regulation of mining activities.

As for the first five years, each year CRP expects to mine about three 10 km^2 mining blocks. The area outside the existing mining permit will be subject to the same metocean conditions, and the mine plan and mining operations will be the same as or very similar to those planned for the first five years.

Mining exclusion zones identified through the spatial planning exercise as described in Sections 4.4.1 and 8.6.6.4, or through any another process, are included in the proposed conditions of CRP's marine consent, and they will not be mined (whether they are in the mining permit area or prospecting permit / licence areas). Mining operations will be designed to minimise environmental impacts on these areas.

Factors that will control the on-going selection of mining blocks will be similar to those for the first five years of mining and include:

- **Large amount of existing data in the mining block**. Mining blocks with extensive sampling, CPT measurements, and ROV video and other data will be preferred. As a consequence of the exploration programme, it is likely that some areas will be identified as more prospective than others and will consequently be the target of more intense and varied data collection. All factors being equal, these areas will be high priority mining blocks.
- **Determine mining characteristics across the mining area.** Experience from the first five years of mining will give insight into what adjustments, if any, are needed in response to changing seabed conditions to continue to maximise mining efficiency and minimise environmental impacts. This insight will be used to guide the choice and sequence of mining blocks outside the existing mining permit area.
- **Maximise the potential for recolonisation of mined blocks.** Experience from the first five years of mining will give insight into what effects the sequence of mining may have on recolonisation. This insight will be used to guide the choice and sequence of mining blocks outside the current mining licence area.
- **Maximising economic returns.** All other factors being equal, mining blocks estimated to have large concentrations of phosphate will be given a high priority.

4.4.3 Vessel requirements

The vessel design and size are dictated by Chatham Rise sea conditions, required hopper volume and tonnage requirements for the storage of phosphorite nodules, and the space required for on-board processing of dredged seabed material.

The proposed seabed mining operation requires precise positioning and movement of the drag-head to accurately follow the mining plan. The position of the vessel and drag-head will be primarily controlled by two electrically driven and retractable azimuth thrusters. With this propulsion mechanism, in conjunction with a dynamic positioning (DP) and tracking system (DT), the manoeuvrability and navigation are sufficient to achieve the required degree of accuracy.

The dredging unit consists of a pumping unit and a suction pipe with drag-head. The total calculated pump power for suction operation and discharge via the riser to the ship is 10 to 12 MW. This pumping power is divided over two or three electrically driven pumps, which will be used in series. The dredge pumps are of common design and have a high efficiency.

The electro-motors used for driving the pumps will be modified from an existing design for high voltage use. To compensate for the pressure of the water depth, the motor compartment is oil filled and pressure compensated. This is also a commonly used system for underwater dredge pump motors. The pumping unit is likely to be equipped with hydraulically driven thrusters and the drag-head with a single thruster. These thrusters will, in conjunction with the vessel positioning system, be able to position the frame and the attached suction pipe onto the desired mining track. For these thrusters and some other small system components, the pump-frame will be equipped with a hydraulic power pack.

The total weight of the pump-frame will be approximately 300 tons and the drag-head will weigh between 30 to 50 tons. At this conceptual design phase, the suction pipe consists of a 750 mm (internal diameter) suction pipe and a drag-head at the end. The suction pipe is connected to the pump-frame with a cardanic connection with a rubber hose in between. On top of the suction pipe a jet pipeline is installed to feed jet-water to the drag-head for seabed fluidisation. Dependent on final design, the water jets could possibly be assisted by cutting teeth incorporated into the drag-head as a means of loosening the seabed material. A screen on the drag-head will ensure that material greater than 150 mm is not taken by the drag-head (although disturbed, it is left on the seabed). On the suction pipe, a hydraulic operated vacuum relieve valve is installed to avoid excessive vacuum levels in the suction system which would lead to process disturbances including efficiency losses and material spillage. This vacuum relieve valve is a commonly used tool for suction hopper dredgers.

The pump-frame and the suction pipe are suspended from the ship on four steel wires.

- Two hoisting wires are connected to the pump-frame and carry the weight of the pump-frame and part of the suction pipe.
- One hoisting wire is connected to the end of the suction pipe and carries the weight of the drag-head and part of the suction pipe. This wire is led through a hydraulically operated passive heave compensator which is capable of compensating depth variations by automated rapid wire length adjustment.
- One long forward tow-wire is used as an active pulling wire and is connected between the front of the pump frame and the bow of the vessel. The active system is capable of compensating for speed variations caused by wave-induced variations in the motion of the ship.
- The winch system will have sufficient power to bring the suction unit from the seabed onto the vessel within approximately 15 minutes. Lowering the unit to the seabed also takes approximately 15 minutes.

Hydraulic transport of the material from the pump unit to the surface vessel will be through a flexible hose. The concept design has this sized at 750 mm (internal diameter). This 'riser' is composed of 20 m long sections connected by bolted flanges. It is operated from a single layer reel that can store 450 m of hose, equipped with a swivel connection at the rotating point.

A similar configuration of hoses and reel will be used for the sinker return system (refer Section 4.4.6). Between the couplings of the last five 20 m hose sections a de-aerator will be installed to release the air from the hose. At the end of the return hose, a special steel diffuser with an approximate diameter of 2 m will be installed. The diffuser will be designed to ensure that the outlet velocity of the mixture flow is reduced as much as possible. Ballast weight of around 20 tons will be added to the return system to stabilise the diffuser.

4.4.4 Mining operations

The Boskalis mining concept consists of a dredge pump and pump drive on a frame near the seabed (Figure 13). A mixture of seabed sediment (including the phosphorite nodules) and water is pumped up through the riser to the surface vessel. The seabed sediment is loosened by high pressure water jets (possibly assisted by cutting teeth incorporated into the drag-head) and collected by a drag-head pulled (trailed) over the bed.

The drag-head is designed to efficiently collect phosphorite nodules from a layer that varies in thickness from 0 to 50 cm, 35 cm in average, and to avoid dredging the underlying chalk/ooze layer. Where the phosphorite-bearing sediment is thicker than 50 cm the drag-head will not be able to mine the entire layer and will therefore leave some of the nodules behind unless a second 'run' over areas with economic volumes of phosphorite nodules is undertaken. The basic concept of a drag-head suitable for this material is shown in Figure 21. The CRP drag-head is a modified version of this concept.

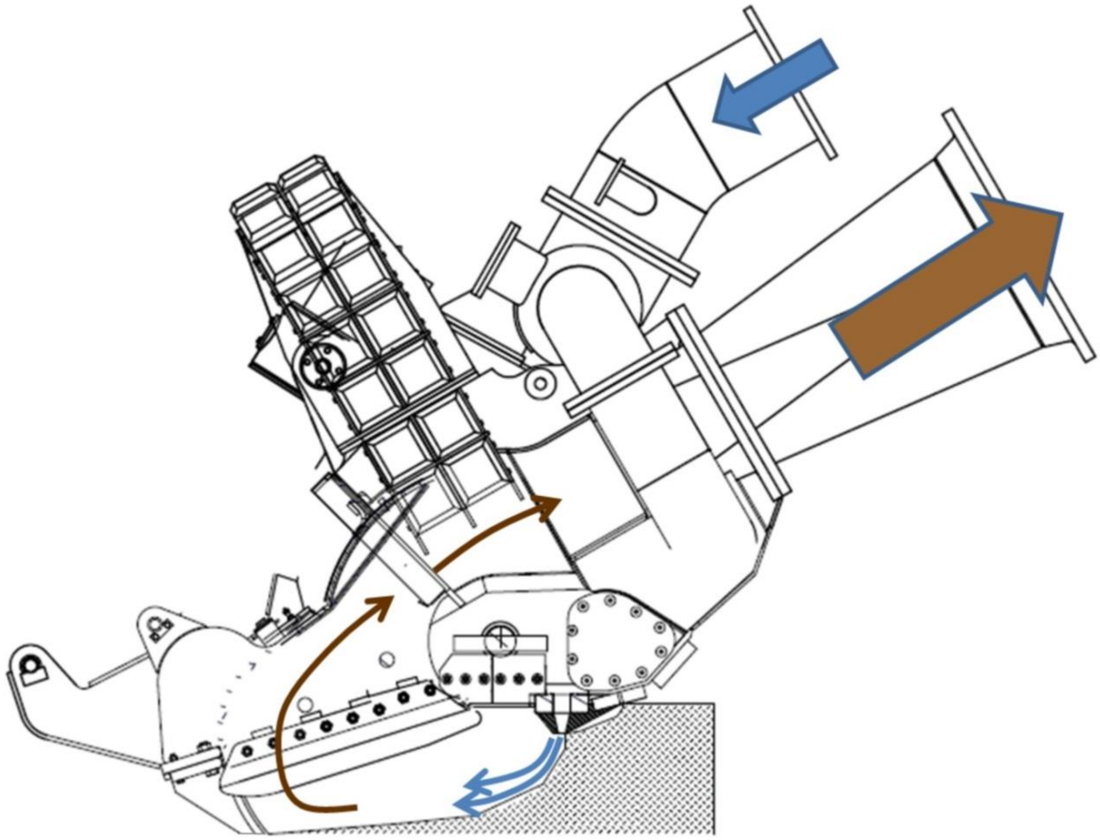

Figure 21: Conventional drag-head concept. The drag-head moves to the right in this illustration. Water jets fluidise the seabed sediment (blue arrows) and pumps lift the sediment and water mixture to the riser and onto the mining vessel (brown arrows).

Accurate positioning of the drag-head while mining is important for two reasons.

Firstly, lateral control determines the ability to follow a predetermined track, making one pass next to another with or without overlap. The amount of overlap directly affects the efficiency of the system, including the possibility of leaving minable resource material on the seabed. Boskalis are continuing to undertake design work to optimise the control of this sideways movement, in combination with variations in longitudinal movement as control of longitudinal movement also influences the sideways movement.

Secondly, longitudinal movement variations (i.e., slower or faster movement forward) are primarily affected by the speed of the vessel. To cope with variable seabed conditions and the need for the drag-head to collect thinner or thicker layers as the depth of the resource changes, the design ideally requires improved reaction time for accelerating and decelerating the drag-arm, independent of the vessel speed. This will be achieved using the main forward pulling tow-wire control which will ensure that forward speed is maintained.

Lights and cameras may be attached to the drag-head to observe the performance of the unit, but this will be part of the research plan to improve drag-head performance and will not be part of routine mining operations. These observations will be more common in the first few years of operations. It is anticipated that observations will typically last between 1 to 8 hours, depending on the process or equipment being observed. Over any mining cycle the total length of observations is not expected to be more than a day or two. The light beam will be narrow, between 60 and 90°. The expected range of the light and camera system will be sufficient only to see the immediate area around the drag-head, which is approximately 5 m. The precise system is yet to be confirmed but it is likely to be similar to that used on the ROV during the 2012 environmental survey.

4.4.5 On-board processing of mined material

After being lifted to the mining vessel all seabed material will be mechanically processed on-board – that is, no chemicals are involved in the separation process. The nodule separation plant will be located in an area on the vessel that is safely accessible for those operating the plant, and as close as possible to the vessel's centre of gravity. The processing plant contains four parallel processing streams for the coarse fraction (>8 mm) separation and two to four processing streams for the finer (2 to 8 mm) fraction separation (Figure 22). The transport within processing streams is based on gravity.

In the design phase it was found that 'logwashers'[16] are predicted to significantly improve the performance of the separation system so they are included in the concept.

During this design phase, work was also undertaken to assess the implication on the percentage of nodules retained as a result of the different fraction separation options. An evaluation of whether a 1 or 2 mm cut-off should be utilised to extract the phosphorite from the mined material demonstrated that at 2 mm the highest overall efficiency could be achieved. The 2 mm cut-off means that all sand sized material and smaller is returned to the seabed. The 2 mm cut-off is used as the basis in all modelling of sediment dispersion.

4.4.6 Disposal of the non-phosphatic material

Processed sediment less than 2 mm in size will be returned to the seabed via a flexible sinker hose and a diffuser that will release the material at or near to the seabed (Figure 23). This decision was made following numerical modelling that showed dispersion of sediment plumes was minimised when the material was released at or close to the seabed. The current plan is to release the material 10 m, on average, above the seabed.

The diffuser will be specially designed to create a horizontal outflow velocity similar to the forward velocity of the diffuser, but in the opposite direction. This design will result in deposition of the returns at close to zero velocity relative to the seabed, giving the highest depositional efficiency and lowest turbidity/plume generation.

4.4.7 Environmental surveying and monitoring

4.4.7.1 Overview

CRP will continue to collect data on the nature of the seabed and ecology of areas of the Chatham Rise relevant to its activities. The focus of this research will be on the areas both inside and outside of the mining permit area. These surveys will be undertaken firstly as part of the environmental monitoring of the impacts of mining operations and secondly as part of an on-going exploration effort. Surveying for the exploration effort will include the assessment of the resource distribution and seabed characteristics throughout the marine consent area to inform mine planning decisions.

CRP is required to undertake environmental (and resource) surveys and associated research as a condition of MPL 50270, and such work will also be required by the proposed prospecting permits if approved. These surveys are similar to those undertaken to support the application for the existing mining permit (MP 55549). They will collect samples of the seabed to determine the distribution of the phosphorite resource and the physical properties of the sediments, and confirm the nature of the benthic communities in the prospecting licence / permit areas. In addition, a broad spectrum of baseline seabed and oceanographic data will also be collected to identify spatial changes in benthic habitats and the marine environment as well as measurements relevant for mine planning purposes and regulation of mining activities. The research and surveys associated with mine planning decisions are described below and in Section 11.3.2.

[16] A logwasher is a type of rotating washing plant which effectively consists of a screw type set centred on a central pivot point. The material moves along the 'screw' and is broken up.

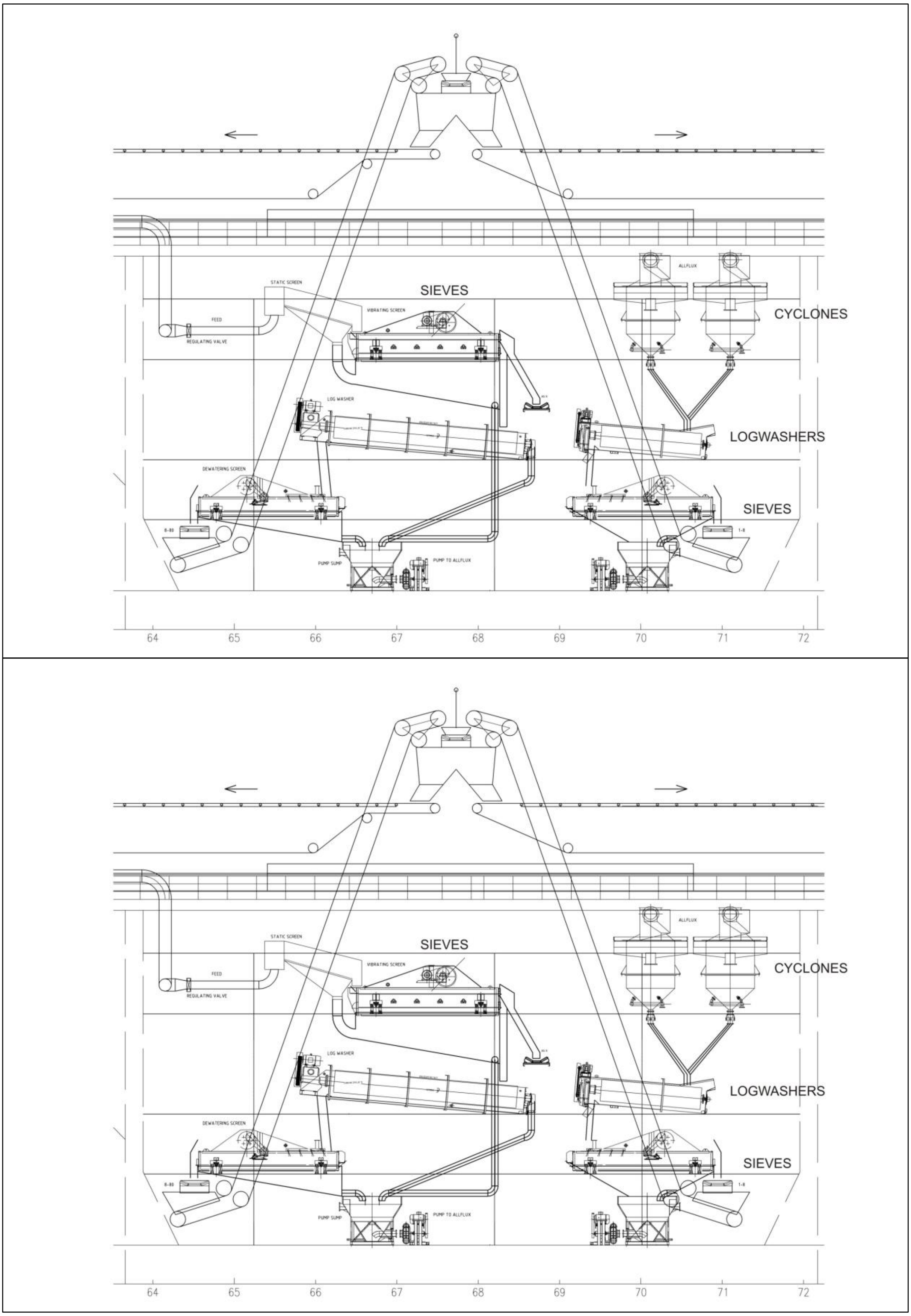

Figure 22: Separation plant concept. Sediment is processed through sieves, logwashers and cyclones. No chemicals are used.

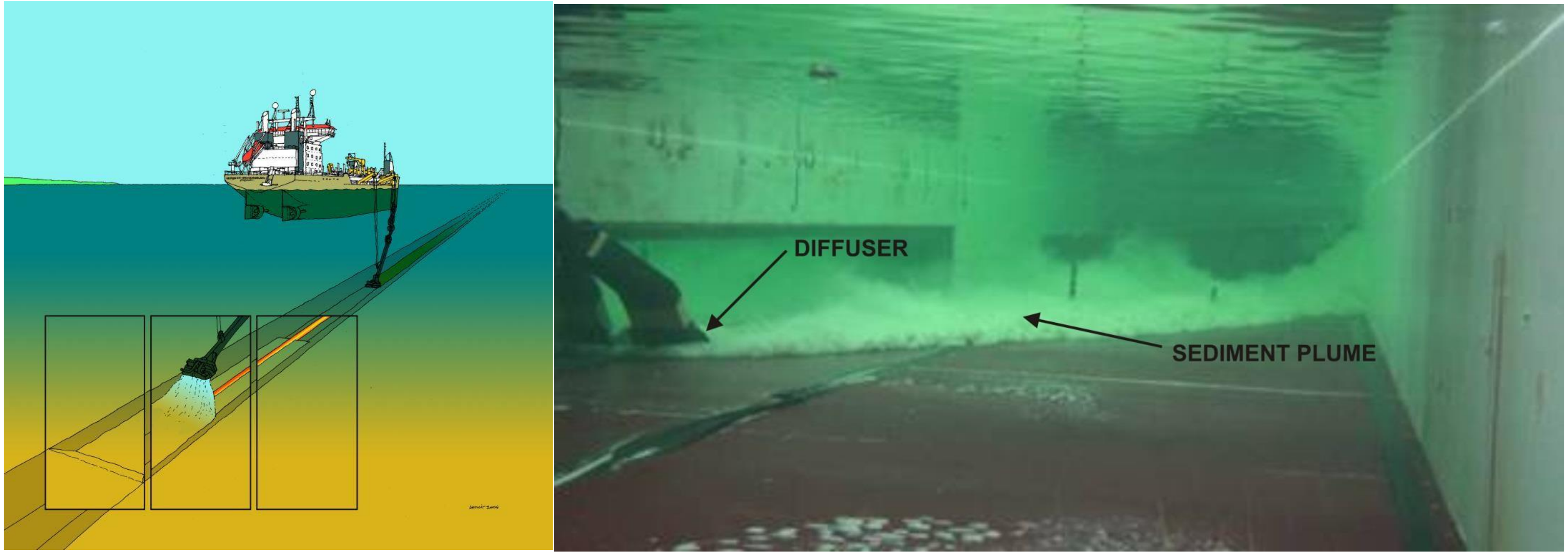

Figure 23: Return disposal design studies. (Left) An illustration showing trench backfilling, the basis for the diffuser design for this project. (Right) Tank test of a diffuser at the seabed.

The proposed monitoring programme associated with the mining operations is described in Section 11.3.3. The programme framework is also contained in the draft EMMP (Appendix 35(i)), which under the proposed consent conditions provided in Section 11.4 will be fully developed and provided to EPA for review prior to mining activities commencing on the Chatham Rise.

Some elements of the environmental surveying and monitoring programme are permitted activities under the EEZ Act (section 5 of the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013 provides for *"marine scientific research, prospecting and exploration"* as permitted activities*).* If these Regulations were not in place, the placement of the structures (the mooring landers), the disturbance of the seabed (seabed samples) and the deposition of hard substrate on the seabed (recolonisation trials and possible subsequent habitat creation) would also trigger the need to seek a marine consent under sections 20(2)(a), (e) to (g) of the EEZ Act.

It is appropriate to include the environmental surveying and monitoring activities as part of the marine consent being sought for CRP's mining operations because the permitted activities under the EEZ Act require similar administrative oversight (the preparation and lodgement of initial environmental assessments and sensitive environment contingency plans, log-books and a post-activity report) and it is operationally and administratively more efficient to include them in the marine consent. Therefore these aspects of the environmental monitoring and surveying programme are described in more detail below even though their impacts are minor, especially when considered in the context of the mining activity itself.

In addition to the CRP-led research outlined above, CRP proposes to support research led by other parties through its environmental compensation package (refer to Section 10.5).

4.4.7.2 Mooring landers

A broad spectrum of baseline oceanographic data will be collected to identify natural variations in the marine environment.

These data will be collected by moorings deployed at no more than four monitoring sites chosen to adequately sample the oceanographic conditions in the marine consent area. The moorings will use standard sensors and be a conventional design. The sensors will be attached to a cable tethered to an anchor weight that sits on the seabed (typically a railway wheel or something similar) and a float, usually a few tens of metres above the seabed. The environmental impact of the moorings is only associated with the anchor, and will probably be about 1 m^2.

The mooring will include instruments to monitor turbidity, current speed and direction, temperature, conductivity, and pressure. The instruments will be chosen and deployed to provide detailed information about the lower part of the water column (within about 50 m above the seabed) and less detailed information about the remainder of the water column. The instruments will be deployed before mining begins and will be maintained throughout the life of the project. It is expected that the moorings and instruments will be serviced every 6 months.

4.4.7.3 Seabed surveys, including seabed sampling

Seabed surveys will be carried out as part of three phases of the project: pre- and post-mining surveys, prospecting surveys, and environmental monitoring surveys. These surveys will collect a broad spectrum of data, including photographs and samples of the seabed.

The photographs and other sensor data will be collected using an autonomous underwater vehicle (AUV), or similar towed or tethered equipment. The photographs and/or videos of the seabed, taken along a transect, will be used to identify changes in the nature of the seabed and the seabed organisms. In addition to photographs, it is likely that the system will collect oceanographic measurements and high resolution bathymetry data along the seabed transects. The AUV or towed system will take its measurements and observations at a height of a few metres above the seabed.

In addition to the photographs and other sensor measurements, seabed samples will also be collected using appropriate sampling equipment, for example a box-corer, piston-corer or similar device. The samples will be collected at sites representative of the survey area, with the restriction that the sampling devices are not suited to sample areas of hard substrate. At each sample site, the area of disturbance will be no more than 1 m^3 in volume (maximum of 2 m^2 in area and 0.5 m in depth). Samples will be analysed to identify the physical properties of the sediments and the organisms living in them. Other seabed sampling associated with prospecting or resource surveys may include a cone penetrometer to test the physical properties of the seabed. The cone penetrometer pushes a rod into the seabed to measure resistance, and will disturb no more than 1 m^2 of seabed per sample.

The pre- and post-mining surveys will systematically cover the mining blocks to identify rich and barren areas and areas unsuitable for mining (e.g., high conservation values, unsuitable for drag-head operations), and to assess the efficiency of the mining process. The results of these surveys will be used to adapt mining operations to improve productivity and to reduce environmental impacts, if possible. These surveys will also provide the baseline for subsequent surveys that observe recolonisation of the mining blocks.

The prospecting surveys will be designed to efficiently determine if there are areas of high concentrations of phosphorite in the marine consent area. These surveys will include comprehensive mapping of the seabed at a resolution similar to that in the existing mining permit, seabed sampling to determine the distribution of the phosphorite resource and benthic organisms, tests of the physical properties of the seabed, and photographs and/or videos of the seabed to determine spatial changes in benthic habitats and communities.

The environmental surveys are planned to monitor the impacts of sedimentation beyond the mining blocks, and recolonisation inside the mining blocks. They will collect similar data to the prospecting surveys, but the data will be collected on transects radial to and within the mining blocks. The surveys will also collect information on the water column, including turbidity. The radial transects will extend to a distance sufficient to ensure the impacts of sedimentation from the mining returns have been observed.

4.4.7.4 Hard substrate recolonisation trials and possible subsequent habitat creation

The hard substrate trials will assess the viability and value, in terms of enhancing recolonisation opportunities, of placing hard substrate within the marine consent area. The nature and volume of the material for the trial and locations of the trial will be determined in consultation with the ERG. If the trials show that there are benefits in creating further areas of hard substrate and a cost-effective technique is identified for placing the hard substrate, then CRP proposes to create hard substrate habitat according to protocols developed in conjunction with the ERG. This aspect of the environmental monitoring programme is positive in terms of potential impacts on the environment.

The protocols are yet to be developed, but it is likely that the trials will involve depositing clean rocks similar to those found on the Chatham Rise at no more than four areas characterised by soft-sediments. The trials will probably utilise a range of sizes of hard substrate. The total volume of each trial will be no more than 10 m^3.

If the trials identify that habitat creation is viable, CRP will proceed with creating habitat within mined mining blocks. To provide sufficient areas for recolonisation, the volume of material put on the seabed will be substantially greater than the trials. The exact amount, type and distribution of material will be determined by the trials and in consultation with the ERG. A scenario that is likely to be similar in magnitude to an acceptable solution is the creation of patches and / or 'reefs' similar in dimensions to existing areas of hard substrate. These patches and / or reefs will be formed in mined areas, and are likely to require an average annual placement of about 1,000 to 2,000 m^3 of clean rock or similar material.

4.4.8 Elements of the mining operations relevant to impact assessment

Not all aspects of the proposed mining operations have the potential to impact on the environment. Of relevance to the assessment in Sections 8 and 9, the following elements of the mining operations are directly connected to potential impacts on the environment:

- The removal of seabed through the drag-head (i.e., loss of habitat and fauna) and localised seabed disturbance around the drag-head.
- The return of the non-phosphatic material and associated sedimentation and plume generation.
- Some specific vessel operations, including noise generation (including from mining), vessel lighting, waste discharges, biosecurity issues and general operational related risks. These are assessed in Sections 8.7 to 8.11.

The elements of the mining operations not listed above are not considered to significantly influence or impact the environment. This includes the mooring landers, the collection of seabed samples and the recolonisation trials and possible subsequent habitat creation that form part of the environmental surveying and monitoring activities associated with the project.

4.5 Shipping Route/s and Port

This EIA does not provide information on the port related operations. At the early stages of the project the suitability of every port in New Zealand that could receive a vessel of the size of the "Queen of the Netherlands" or the "Black Marlin" was considered. A short list of ports has been determined based on distance to the mining site, access, port water depth, berthage and the ability to handle and store the product for delivery to national and international destinations. CRP has not yet confirmed the port/s that will be used and therefore a port is not identified in the EIA. The vessel route will depend on the port the vessel will use.

It is expected that the port will be located on the east coast of the mainland.

It is anticipated that the selected port will already have the necessary 'permissions' under the RMA in place. Therefore, as with any vessel utilising the port, CRP's land-based port operations will be required to comply with any controls or restrictions that arise out of any such permission.

4.6 Seabed Mining Plan

Although the exact operating limits are still to be defined, it is conservatively assumed that the system will only be mining in swells up to 4 m coming from the forward and aft quartering sectors. For the Chatham Rise operation, this means that the preferential orientation of the mining tracks will be southwest to northeast.

Key factors influencing the consideration of the seabed mining patterns were:

- The width that will be covered with return of the processed non-phosphatic material.
- The vessel's turning circle and time.

Based on numerical modelling studies of diffuser performance it is predicted that the majority of the sand component, and a portion of the finer sediment, will settle in a strip about 20 m wide at the seabed (refer to Section 8.4). The distance between the centre of the drag-head track and the centre of the diffuser track will be in the order of 20 to 45 m, depending on the mining vessel selected and whether the drag-head is lowered from the side or centre of the vessel, so there is little chance that the drag-head will recover substantial amounts of previously deposited material.

Mining will be in long parallel tracks, with a 180 degrees turn at the end to continue mining in the opposite direction.

With this concept, a mining pattern of long stretched loops develops, as shown in Figure 24.

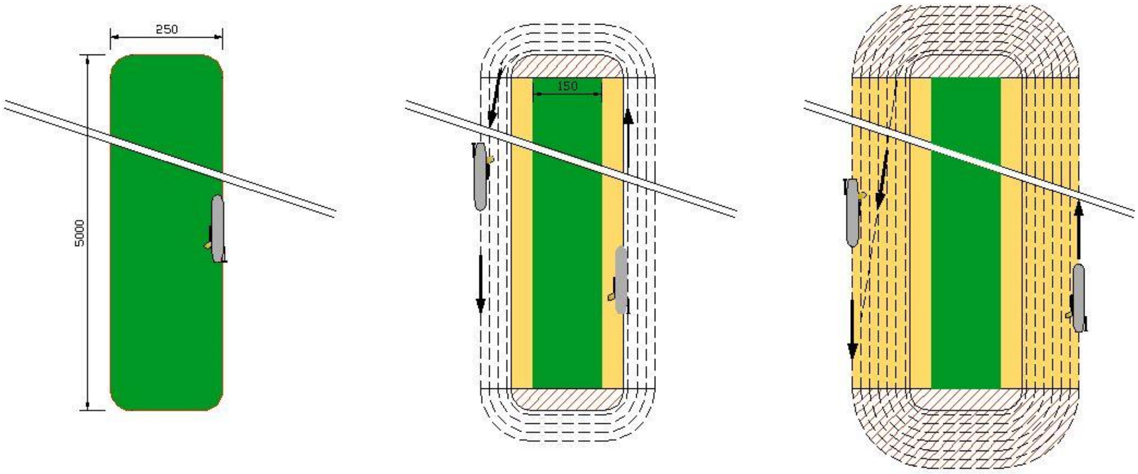

Figure 24: Mining pattern – 'spiralling out'. The green areas have not been mined and the yellow areas have been mined. Mining blocks are about 5 by 2 km when completed. Central area will not have been mined but it will be covered by some sediment from the returns.

The time required to turn the vessel, determined by its length, draft, displacement (and added mass), lateral area (drag surface and length), wind and Metocean conditions, and the thrust from the two Azimuth thrusters, is expected to be about 7 minutes. If the vessel maintains its forward speed (average trailing speed of approximately 1 kn) then the vessel's path will be half a circle of at least 125 m diameter. Consideration of active dredging times, unproductive turning times in relation to the total cycle of mining, and transferring the mined product to a shore location indicated that mining in strips at least 5 km long would be optimal.

By systematically working along this pattern an ever wider spiral will be made. When the spiral becomes wider than 2 km the increased turning times make the system too inefficient to continue. For this reason the optimal block width is 2 km.

4.7 Vessel Operational Matters

4.7.1 Vessel activity cycle

Generally the mining vessel, dependent on its final configuration, will operate on about a 10 day cycle:

- A mining, processing and hopper filling phase (4 to 5 days).
- Transit to port (1.5 days).
- Offloading and re-provisioning (3 days).
- Transit to Chatham Rise to commence the next mining cycle (1.5 days).

4.7.2 Crew and quarters

Accommodation, meeting requisite standards, for at least 50 people will be provided. The accommodation will have about 50 rooms, 20 single cabins and 30 cabins with the option for two beds. This provides accommodation for a maximum of 80 people in the start-up phase of the project, or during periods of special activities. Under normal operational conditions about 50 people will be working on the mining vessel.

The accommodation also includes a mess room and galley. Three cold stores, sports room, leisure facilities, laundry room, meeting room, hospital, dock office and all modern communication and TV systems will also be on the vessel.

4.7.3 Vessel lighting

Vessel lighting will be as is standard on all Boskalis ocean going work vessels, with special attention to measures to reduce the attraction of birds to the vessel.

Minimising the potential for seabird strike (i.e., seabirds being injured or dying as a consequence of striking the vessel) will be undertaken via a Vessel Lighting Management Plan (LMP). This is discussed in more detail in Section 8.8.

4.7.4 Waste and emissions management

4.7.4.1 MARPOL

New Zealand has regulations in place that all vessel operators need to follow to minimise the risk of pollution. New Zealand is a signatory to MARPOL as discussed in Section 2 and Appendix 1 of this EIA. MARPOL has a series of annexes that cover key aspects of pollution prevention by vessels at sea:

- Annex I: Prevention of pollution by oil.
- Annex II: Control of pollution by noxious liquid substances. This annex is not relevant to CRP's proposed mining operations as it relates to discharges from bulk chemical carriers.
- Annex III: Prevention of pollution by harmful substances carried in packaged form.
- Annex IV: Prevention of pollution by sewage from ships (sewage and greywater from vessel crew and galleys).
- Annex V: Prevention of pollution by garbage (garbage, such as food scraps from ships' galleys, paper waste etc.).
- Annex VI: Prevention of air pollution from ships.

New Zealand law (the MT Act and associated Marine Protection Rules) currently gives effect to Annexes I to III and Annex V within the EEZ, and as such regulates the discharge of oil, chemicals, marine pollutants (in packaged form), and garbage. CRP's plans to meet these requirements as discussed below. As well, CRP and Boskalis will also meet the requirements of Annex VI even though it is not yet in force in New Zealand.

4.7.4.2 Oily waste

Part 120 of the Marine Protection Rules, derived from Annex 1(i) of MARPOL, deals with the discharge of oily wastes from vessels. The discharge regime established under these Rules prohibits a number of specific discharges (including in defined special areas) and imposes controls on the flow, concentration and quantity of discharges in other areas.

The Regulations allow discharges to occur provided that:

- The ship is proceeding en route.
- The oil content of the discharge, without dilution, does not exceed 15 parts per million (mg/L).
- The ship has the appropriate oil filtering equipment, for that ship, in operation as required by Rule 122.4 of the Rules.

CRP's mining vessel will comply with the relevant requirements of the Marine Protection Rules as well as MARPOL, and accordingly will hold an International Oil Pollution Prevention Certificate (IOPPC), appropriate certificates of insurance and will have in place a Shipboard Oil Pollution Emergency Plan (SOPEP).

4.7.4.3 Hazardous substances

The processing of material dredged from the seabed on-board the vessel does not involve chemicals. As such there will be no bulk chemicals on-board.

However, there will be a range of 'chemicals' on-board. Many of these are household products and typical of those present on any vessel within New Zealand coastal waters. These include, but are not limited to, cleaning products and foodstuffs such as oils. The vessel will hold material safety data sheets for all materials that are required to be managed under the New Zealand Hazardous Substances and New Organisms Regulations.

4.7.4.4 Wastewater

Within New Zealand waters, the Resource Management (Marine Pollution Regulations) 1998 outlines treatment standards that specify where wastewater can be discharged. These Regulations restrict the disposal of untreated wastewater near marine farms, mataitai, or marine reserves. The Marine Pollution Regulations, although only applying within New Zealand's Territorial Sea, are a good basis for managing wastewater on-board the mining vessel.

Systems that treat wastewater to the Grade A standard, outlined in Schedule 6 of the Regulations, are found on many ships. These systems often include a bacterial breakdown and disinfection stage prior to the discharge of treated wastewater. A list of certified systems is contained in Schedule 5 of the Regulations.

The proposed mining vessel will include and operate a wastewater treatment facility that meets the requirements of Schedule 6 of the Marine Pollution Regulations, and will therefore also hold an International Sewage Pollution Prevention Certificate.

4.7.4.5 Garbage (solid waste)

All vessel waste management will be carried out in a manner that is compliant with the requirements of Annex V of MARPOL and New Zealand legislative and regulatory requirements. Under these requirements, garbage disposal at sea is generally prohibited and therefore will not occur. All vessel garbage, except that which is permitted to be discharged (i.e., only ground or comminuted food waste) will be returned to New Zealand for disposal in appropriate facilities (via the solid waste reception facilities available at every New Zealand port). In addition, a Vessel Solid Waste Management Plan (WMP) and Garbage Record Book will be maintained by the mining vessel. This Plan is discussed further in Section 8.9 and a draft WMP is contained in Appendix 35(iii).

Boskalis, as operator of the mining vessel for CRP, will also ensure that they comply with its internal environmental policy that requires continuous reduction of vessel garbage volumes and evaluation of options to improve waste recycling.

Recycling facilities exist throughout New Zealand. As long as the following recyclable waste is separated from other materials it is likely to be accepted for recycling:

- Paper and cardboard.
- Glass bottles – all green, brown, blue, frosted and clear glass bottles and jars.
- Plastic – grades 1 and 2 (and others as identified in the local Council recycle system).
- Aluminium, tin and steel cans.

4.7.4.6 Emissions to air

As outlined in Appendix 1, Annex VI (Prevention of Air Pollution from Ships) of MARPOL sets limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances. In designated emission control areas (NZ not being part), more stringent standards for sulphur oxide, nitrogen oxide and particulate matter are established. In 2011, ground-breaking mandatory technical and operational energy efficiency measures which aim to significantly reduce the amount of greenhouse gas emissions from ships were also adopted as an amendment to the Annex. These came into force on 1 January 2013. Despite the fact the New Zealand has not yet ratified this Annex, CRP will ensure that its vessel meets all of the requirements of this Annex.

In relation to sulphur oxide, it is noted that emissions are fuel dependent. Presently heavy fuel oil with 3 % sulphur oxide is allowed to be used in most parts of the world although in designated emission control areas (NZ not being part) there are also requirements for 1 % or 0.1 %, although these fuels are not always readily available. The fuel type used by CRP's mining vessel will depend on what fuel is available in New Zealand ports.

4.7.5 Ballasting

When loading and unloading the ship the ballast water system will take care of the proportional distribution of the bending moments in the ship's construction. Depending on the choice of vessel for this project, an extra investment in a ballast pumping and treatment system may be necessary.

Biosecurity activity will be undertaken in accordance with New Zealand's Import Health Standard for Importing Ballast Water from All Countries (www.biosecurity.govt.nz) and international treaties and agreements that New Zealand has signed as already overviewed in Section 2.4.2 and Appendix 1.

To summarise, ballast water loaded in another country's waters must not be discharged inside New Zealand territorial waters without permission. Before arrival in New Zealand, MPI will either grant permission if it has been shown that ballast was appropriately treated or otherwise exchanged adequately with mid-ocean water, or if it can be shown that an exchange of ballast water could not be undertaken safely in mid-ocean. No exemptions are available to discharge un-exchanged water from stipulated high risk areas. Vessels entering New Zealand waters are required to complete a Ballast Water Declaration[17].

Mid-ocean ballast water exchange significantly reduces the chance of introducing unwanted marine organisms to New Zealand waters. Exchange must be carried out with ocean water at least 200 nautical miles offshore and should replace at least 95 % of the volume of water in the tank.

[17] Available online at http://www.biosecurity.govt.nz/enter/ships/ballast

The uptake of harmful aquatic organisms can be minimised by not loading ballast water in:

- High risk areas (e.g., the closest are at Port Phillip Bay and Tasmania in Australia).
- Very shallow water.
- Locations where propellers may stir up sediment.
- Locations where diseases such as cholera are known to be present in the water.

Before first arriving in New Zealand, the mining vessel will ensure that the above requirements are met by re-ballasting enroute (e.g., mid-Tasman Sea if that is the route followed). Once the vessel is operating in New Zealand (provided it remains within New Zealand waters), there is no ballast biosecurity issue as the vessel will be ballasting at New Zealand ports and then discharging this water on the Chatham Rise as the vessel fills up with phosphorite. Only if the vessel proceeds overseas, for example for regular inspections and dry docking, will the requirement for ballasting water need to be met again.

4.7.6 Hull biofouling

As outlined in Section 2.4.2, under the Biosecurity Act 1993 the vessel owner/operator is required to ensure that the hull is clean of any visible biofouling (apart from a slime layer) and that the hull of any vessel, upon arrival in New Zealand, is clean. These requirements will be complied with. This requirement will also need to complied with if the vessel goes overseas again (i.e., for inspection or dry docking etc.)

Once the vessel is operating in New Zealand, and provided it is going in and out of the same port then there is no biosecurity issue. If the vessel does go to more than one port, and one of those ports is infested with an unwanted marine organism new to New Zealand or a marine pest with limited distribution in New Zealand (for example, the sea squirt *Didemnum vexilum*) and the other port is not, then CRP and Boskalis will ensure that appropriate hull cleaning occurs.

4.8 Summary

Mining of the phosphorite nodules on the seabed on the crest of Chatham Rise will be carried out by a specially built or modified mining vessel, currently being designed by Boskalis. The mining vessel will be sufficiently large to accommodate the equipment that will be lowered to the seabed, the on-board mechanical separation plant and the storage of the phosphorite nodules.

The mining vessel will be designed to operate in the climatic and oceanographic conditions within the mining area. The mining plan is also designed to ensure safe and reliable operations in these conditions. Weather downtime is estimated to be on average 15 % of the time that the vessel is on site.

The core elements of the mining operations include:

- Mining approximately 30 km^2 each year to retrieve at least 1.5 Mt of phosphorite each year.
- The use of a trailing drag-arm carrying the drag-head which is suspended from the vessel by wires.
- The trailing suction drag-head will suck up, on average, the top 0.3 m of seabed.
- Pumping of mined sediment through a flexible riser to the mining vessel.
- On-board physical separation of the recovered material to separate and retain phosphorite

nodules larger than 2 mm in the vessel's hold/s.

- Controlled disposal of unwanted sediment near the seabed through a flexible sinker hose and diffuser attached to the opposite side of the vessel from the drag-arm.

There are areas within the mining area that will not be mined. These include large areas of rocky outcrops (none are known in the mining permit area) and the mining exclusion areas identified through a marine spatial planning exercise.

Mining operations are expected to proceed on a 10 day cycle. Once the holds are full, the mining vessel will transit to port for unloading before returning to the Chatham Rise. Under normal operational conditions the vessel will have a crew of approximately 50 people. Waste and emissions from the vessel, as well as ballasting and hull biofouling, will be managed to ensure that the requirements of MARPOL and relevant New Zealand legislation and regulations are met.

5. The Chatham Rise – Physical Environment

KEY ELEMENTS

- The Chatham Rise extends east from Banks Peninsula for more than 1,000 km to beyond the Chatham Islands. The crest of the Rise is 200 to 500 m deep and the flanks of the Rise deepen to more than 2,000 m to the north and south.
- The Chatham Rise formed more than 60 million years ago and it has affected the geologic and oceanographic processes in the region since that time.
- The geology of the Chatham Rise is well understood as is the history of sedimentation and tectonic deformation. Exposure of 5 million year old rocks on the crest of the Chatham Rise means that modern sedimentation rates are low with sedimentation primarily occurring on the flanks of the Rise.
- Significant seabed deposits of phosphorite and other potentially valuable minerals are found on the crest of the Chatham Rise. However, some details on the distribution of the phosphorite are still not understood.
- The Chatham Rise phosphorite deposits formed about 5 million years ago and occur as irregularly shaped grains and nodules, 0.5 to 350 mm in diameter, on and within the uppermost sedimentary layer of the seabed. These sediments (including the phosphorite) are the erosional remnant of chalk and limestone rocks deposited and chemically altered over the last 25 million years. Fossilised marine mammal bones are also found on the Rise.
- Geomorphological features on the Chatham Rise include shallow banks and seamounts, furrows created by icebergs during periods of low sea level in the last several million years and pockmarks associated with methane release from the seabed. Furrows and circular features are widespread on the seabed along the Chatham Rise.
- The Subtropical Front, the boundary between warm, saline subtropical waters to the north and cooler, less saline sub-Antarctic water to the south, lies along the crest of the Chatham Rise. From late spring to early autumn this can result in relatively thermally stratified ocean water conditions. Upwelling and mixing of these waters in conjunction with high dissolved oxygen concentrations provides increased nutrient content, making the Chatham Rise very productive.
- The large-scale flow of water on the Chatham Rise is west to east, but there are also local surface currents associated with eddies that form at the Subtropical Front. Seabed currents are driven by similar processes, but at some times of the year they are effectively decoupled from the surface currents. Modelling predicts that seabed currents are likely to trend predominantly to the northwest at velocities of up to 40 cm/s.
- Seabed currents are capable of some resuspension of sediments along the crest of the Chatham Rise. Background turbidity levels near the seabed are estimated to range from approximately 0.1 to 1 mg/L.

5.1 Introduction

The Chatham Rise is a significant physical feature within New Zealand's EEZ, extending east from Banks Peninsula (near Christchurch) to beyond the Chatham Islands. The Rise has a broad crest approximately 150 km wide and more than 1,000 km long, bounded to the north by the Hikurangi

Trough and to the south by the Bounty Trough. East of the Chatham Islands the Rise gives way to the deep ocean floor. At its western end, the Rise is separated from the New Zealand mainland by the Mernoo Gap.

This section of the EIA describes the nature of the physical environment of the Chatham Rise including:

- Bathymetry.
- Regional geology and fossils.
- Regional geomorphology.
- Regional oceanography.
- Seabed sediments and their chemistry.
- Water properties and chemistry.

This section of the EIA identifies the background physical characteristics of the area broadly associated with CRP's proposed mining operations for the impact assessment contained in Section 8 of this EIA.

The information provided in this section of the EIA is supported by a series of technical documents appended to this EIA:

- A summary of information defining the nature of the seabed physical environment within the mining permit area. This was undertaken as part of benthic studies described in Section 6 (Nodder et al. 2013) (Appendix 9).
- A review of the physical oceanography of the Chatham Rise (Chiswell 2013) (Appendix 8).
- An assessment of oceanographic data used for modelling plume dispersion on the Chatham Rise (Deltares 2014a) (Appendix 10).
- A summary and analysis of site investigation information (seabed sediment textures) (Boskalis 2013b) (Appendix 4).
- An examination of the geochemistry and environmental chemistry of sediments on the Chatham Rise (Golder 2014a) (Appendix 11).
- A review of the natural sedimentation and particulate matter concentrations (Nodder 2013) (Appendix 12).

To set the scene for the description that follows within this section of the EIA, Nodder et al. (2013) (Appendix 9) describes four key sets of data that have been used to understand the seabed environment in the mining permit area:

- Multi-beam echo-sounder bathymetric data collected using both shipboard (50 kHz) and ROV mounted (400 kHz) instruments.
- Sidescan sonar data.
- On-board ROV video logging of seabed substrate followed by post cruise analyses of the data.
- Sediment grain size data from cores, and grab samples.

Subsequent to the preparation of Nodder (2013), similar data were collected at locations adjacent to the mining permit area during a NIWA OS20/20 cruise in June 2013 (refer Section 3.6.3) and analysed to determine benthic habitats and communities. Rowden et al. (2014a) (Appendix 16) summarises seabed characteristics of the wider marine consent area as part of benthic ecological studies described in Section 6.3.

The historical and modern interest in phosphorite and the importance of the Chatham Rise to New Zealand's fisheries, the seabed and oceanographic conditions in and around the marine consent area are among the best known, if not the best known, in New Zealand's EEZ. The level of information about the shape of the seabed, the nature and properties of the sediments, and the oceanographic conditions is greatest in the existing marine permit area, but there is adequate information throughout the marine consent area and the surrounding region to understand and predict the major seabed features, the likely distribution of the sediments and the large-scale oceanographic properties of the water column.

Figure 25 summarises the extent of seabed samples collected by CRP, NIWA and by the earlier Valdivia and Sonne cruises.

5.2 Bathymetry

Over the Chatham Rise there are four banks shallower than 250 m: Mernoo, Veryan, and Reserve Banks at the western end of the Rise, and Matheson Bank near the Chatham Islands. Physical features of note on the Chatham Rise include numerous seamounts (volcanic features) located off the crest of the Rise (Rowden et al. 2005) at depths of about 1,000 m. Between the Mernoo Gap and the Chatham Islands the crest of the Rise has low relief with the seabed lying between 200 and 400 m (Figure 26).

Seamounts are features with elevations of 100 m or more above the surrounding seabed. The Graveyard Seamount Complex is closest to the mining area, approximately 50 km to the north. The seamounts are 50 to 300 m shallower than the surrounding water depths of 1,000 to 1,600 m. The majority of Chatham Rise seamounts are 100 to 500 m (Rowden et al. 2005).

The water depths in the proposed mining area are generally 350 to 450 m, although some parts of the proposed eastern prospecting permit are shallower at between 250 and 350 m deep (Figure 27). Approximately 39,000 km^2 of the Chatham Rise lies at water depths of between 350 to 450 m and about 25 % of this area is located within the marine consent area.

Detailed bathymetry within the mining permit area is shown in Figure 28 . The Dorado Discovery mapped more than 1,100 km^2 of the seabed with multi-beam swath bathymetry data (25 m horizontal resolution), and collected additional regional and high resolution bathymetry data (up to 10 cm horizontal resolution for the ROV data). These high resolution bathymetric data provides a greater understanding of seabed relief and slope, both important factors for the mining plan.

5.3 Regional Geology and Fossils

5.3.1 Geology

The basement rock of the Chatham Rise consists of Paleozoic-Mesozoic (200 to 300 Ma) greywacke, argillite and associated metamorphic rocks (e.g., schist), overlain by Upper Cretaceous and younger sediments (Wood et al. 1989, Barnes 1994, Stilwell et al. 2006, Kenex 2010 – Appendix 2). The seabed of the Chatham Rise is punctuated by volcanic intrusions ranging in age from Cretaceous to Neogene (Wood et al. 1989).

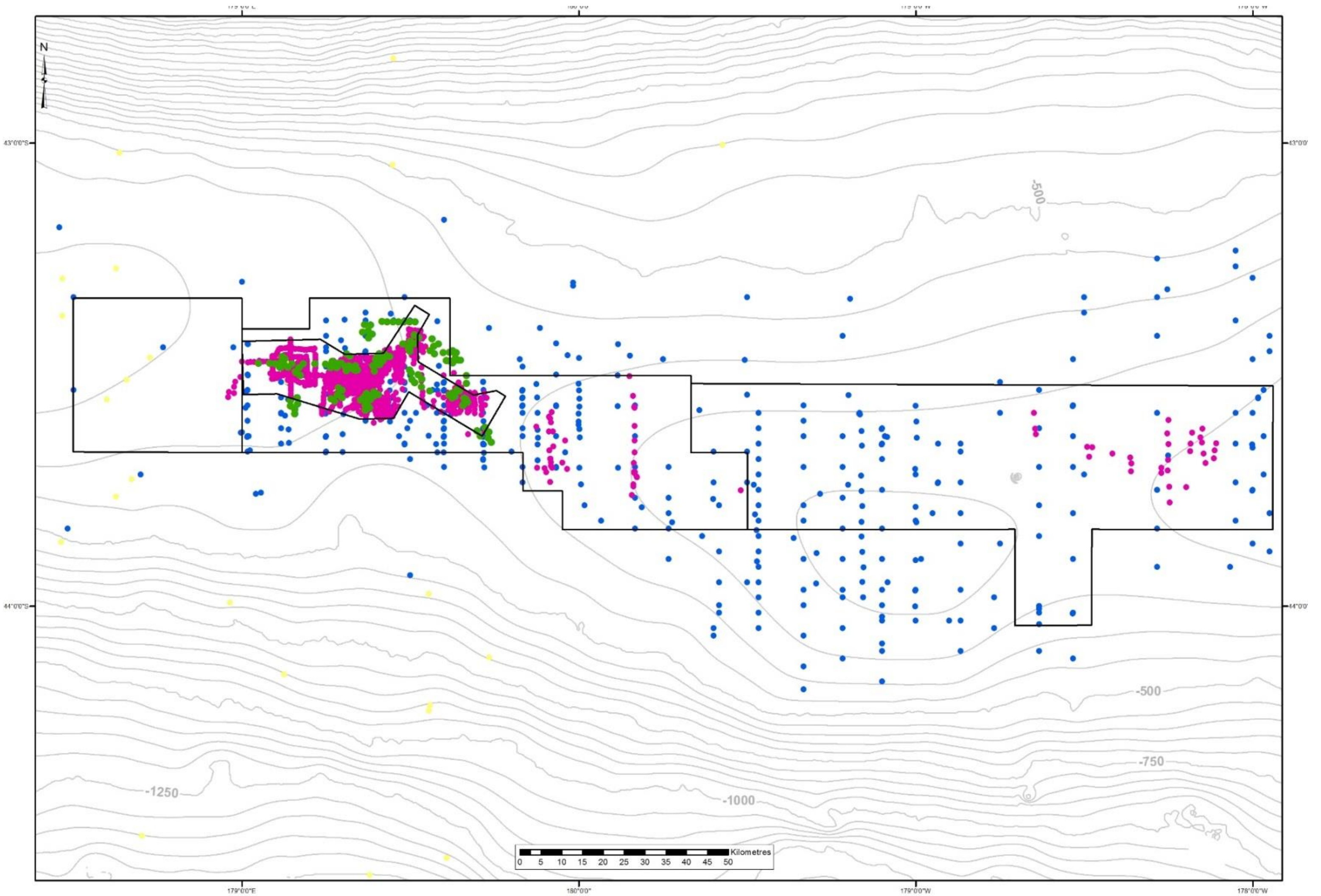

Figure 25: Map showing CRP's marine consent area and seabed sample locations. Reconnaissance data from the 1950s are shown as blue dots, data from Valdivia and Sonne as pink dots, and data from CRP's 2011 and 2012 voyages as green dots. Bathymetry shown as 50 m contours.

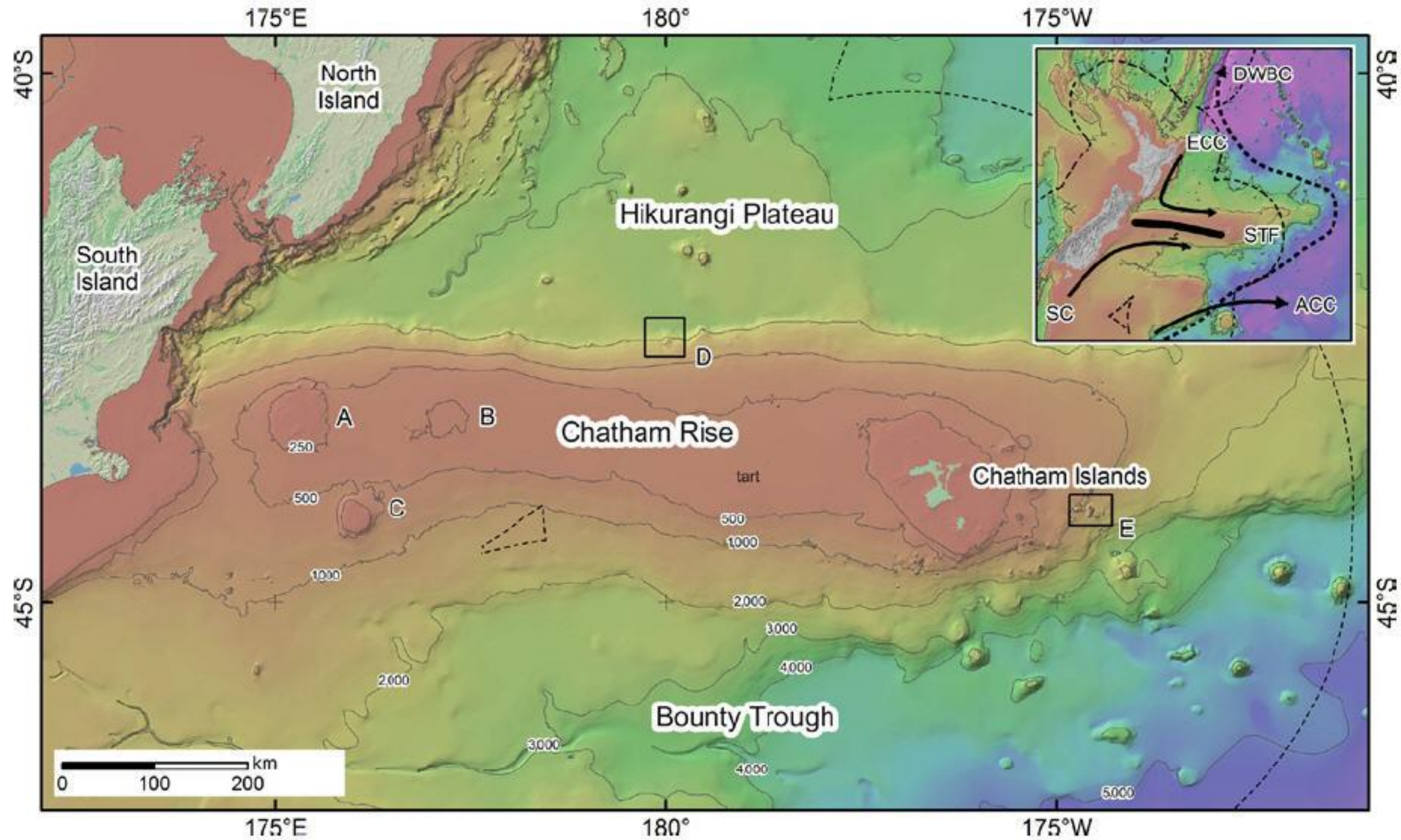

Figure 26: The Chatham Rise showing the location of the (A) Mernoo Bank; (B) Reserve Bank; (C) Veryan Bank; (D) Graveyard seamounts complex; (E) Andes seamounts complex. Inset shows the approximate position of the Subtropical Front (STF, black bar) formed by convergence of the Southland Current (SC, lower arrow) and East Cape Current (ECC, upper arrow). The Antarctic Circumpolar Current (ACC) and Deep Western Boundary Current (DWBC, thick dashed line) are also shown. Bathymetric contours are in metres. The narrow dashed lines show the extent of the New Zealand 200-nautical-mile Exclusive Economic Zone (from Nodder et al. 2012).

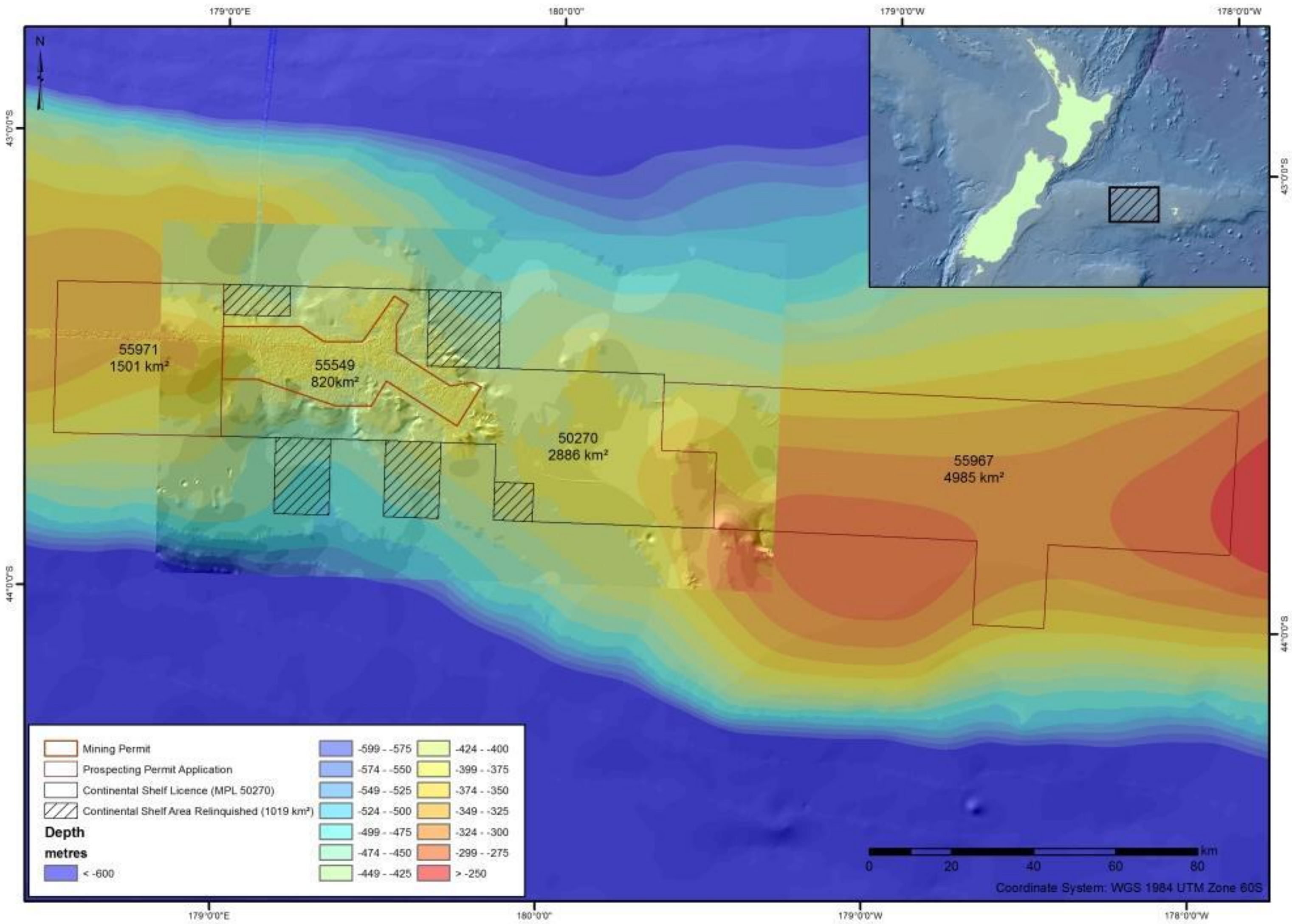

Figure 27: Bathymetry of the area associated with CRP's proposed marine consent area. More detailed bathymetry gathered by CRP is shown in the areas associated with MPL 50270 and MP 55549.

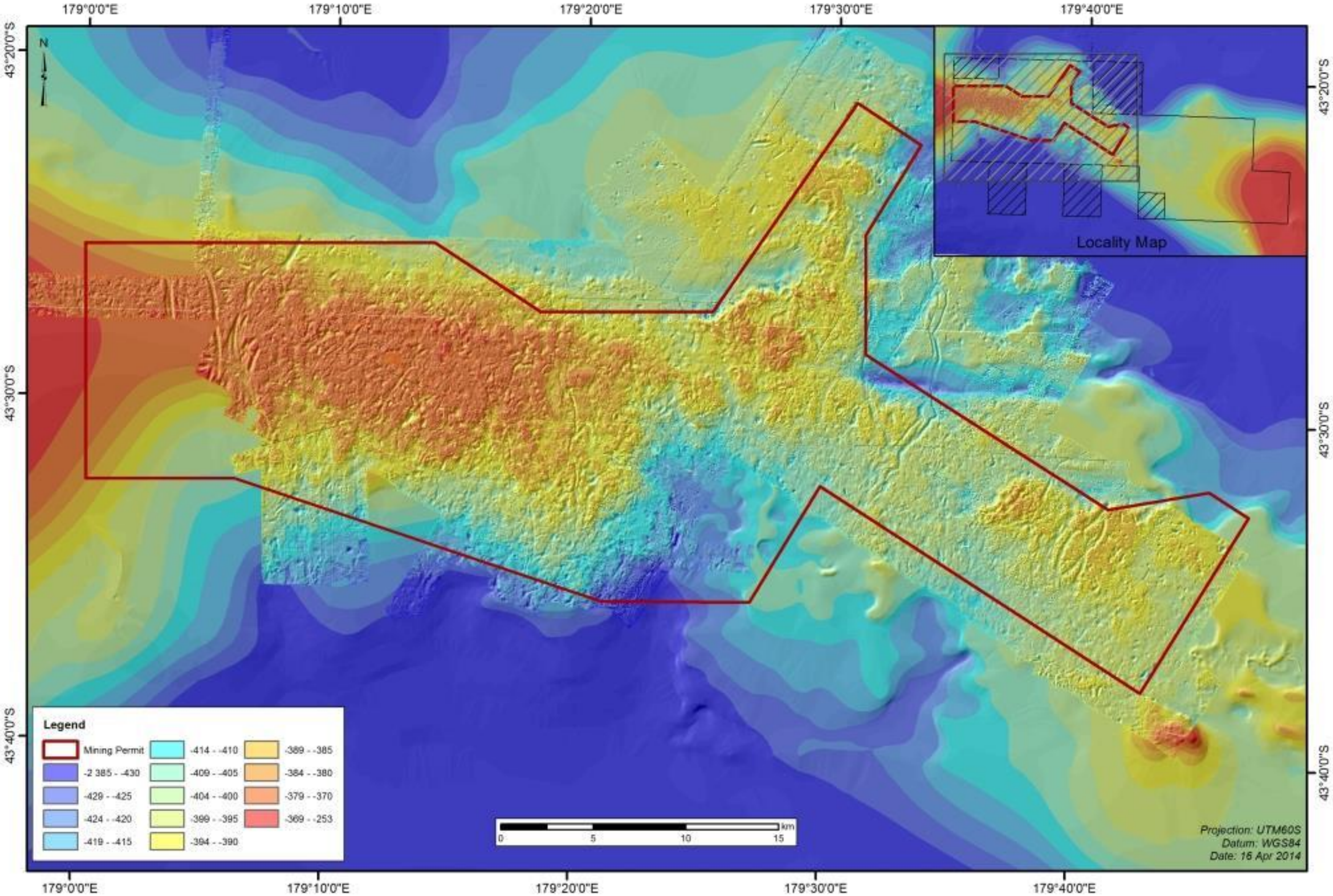

Figure 28: Bathymetry of the CRP mining permit area. Note the linear iceberg furrows and circular features possibly also formed by icebergs.

During the Cretaceous, faulting, warping and uplift created grabens and half-grabens, which were filled by marine sediments (Wood et al. 1989, Kudrass & von Rad 1984a). Sedimentation rates in the Tertiary period were dependent on ocean productivity. During warmer and more productive periods, sedimentation rates increased as more organic matter was produced. Following a period of cooling and sea-ice formation in the Oligocene, sedimentation rates decreased (Burns 1984). The complete absence of late Oligocene sediments may reflect exposure and erosion following a fall in sea-level. After this hiatus, sedimentation of pelagic nanno-ooze resumed through the Miocene (Wood et al. 1989, Kudrass & von Rad 1984a).

The formation of phosphorite in Oligocene and Miocene chalk layers occurred during the late Miocene (<10 Ma). Sediments from the Pliocene include glacial debris and ash falls. In the Pleistocene, gouging by icebergs led to a redistribution of phosphorite nodules across the Chatham Rise. On the central part of the Rise, these unconsolidated sediments typically make up a layer approximately 0.4 to 0.6 m thick overlying the chalk deposit (Lawless 2012).

Exposure of Miocene and older rocks at the seabed along the crest of the Chatham Rise indicate that modern deposition is primarily occurring along the flanks of the Rise. This conclusion is supported by the interpretation of seismic reflection data from the region. Erosion of the phosphatised chalk and limestone layer and filling in of iceberg furrows are interpreted as evidence for reworking of the surface sediments on the crest of the Chatham Rise, either through resuspension or as bed load (e.g., Kudrass and von Rad 1984a).

Phosphorite samples have been recovered from large areas of the crest of the Chatham Rise, primarily within the area covered by the marine consent area (Figure 7). From the research that has been carried, it is known that the mining permit area contains a commercial deposit. At present there are too few high quality samples to reliably estimate the distribution and grade of the phosphorite within the broader marine consent area.

Extensive deposits of glauconite also occur on the crest of the Chatham Rise, primarily west of the phosphorite deposits (Lawless 2012).

Examination of the seabed also shows the presence of isolated rocks and boulders. In many cases these are rock types associated with outcrops in Antarctica rather than the Chatham Rise. Cullen (1962) postulated that the suite of rocks dredged from the Chatham Rise were dropped by icebergs passing over the Chatham Rise. This is described further in the following section.

5.3.2 Fossilised whale bones

Fossilised whale bones have been recovered in trawls from the Chatham Rise. Fordyce (1984) describes phosphatised cetacean ear bones and teeth from dolphins and toothed whales (e.g., pygmy sperm whale, beaked whales) from phosphatised sediments in the central Chatham Rise. Whale bones are also brought to the surface by trawling (Horn 1994). The sediments of the Chatham Rise contain a range of shark and ray teeth (Pfeil 1984) (of late Oligocene to early Miocene age, similar to those found in the Burnside quarry near Dunedin).

The bones often have molluscs associated with them and many of these are unique to the fossilised whale bones (refer Museum of New Zealand - Te Papa) as they were associated with the unique ecosystem that develops when whales decompose on the seabed ('whale falls' - see Smith & Baco 2003). In these cases the molluscs attached to the bones became fossilised along with the whale bones.

The fossilised fauna were considered by Fordyce (1984) to be similar to the temperate dolphin and whale community found today.

5.4 Geomorphology

5.4.1 Geomorphological features

Nodder et al. (2012) provided an overview of the key geomorphological features of the Chatham Rise. The crest of the Rise is relatively flat (at a large scale) and lies between 350 and 450 m. To the east, the Chatham Islands emerge from the Rise. There are also several banks and seamounts in the area.

Nodder et al. (2013) (Appendix 9) provides a more detailed evaluation of a range of geomorphological features within the mining permit area, based on analysis of the high resolution bathymetry data (Figure 29).

This evaluation by Nodder et al. (2013) provided information on seabed morphology including a variety of bathymetric measures including slope, aspect and ruggedness. The results highlight ridges, crests, slopes, depressions and troughs that reflect both regional features and the local effects of iceberg furrows.

5.4.2 Iceberg furrows

Figure 30 shows iceberg furrows on the Chatham Rise from data collected by the Dorado Discovery in 2011 and 2012. Iceberg furrows were reported by Kudrass & von Rad (1984b) and more recently by NIWA, who identified them from multi-beam surveys of the Chatham Rise during the OS20/20 research programme in November 2006. Some of the furrows are large, up to 25 km long, 200 m across and 10 m deep. The furrows were caused by icebergs that carved off the decaying Antarctic ice-sheet at the end of the five extreme glacial periods in the Pleistocene. Figure 30 shows one of the largest furrows within the mining permit area. The right hand part of the figure shows the slope of the seabed, and illustrates grooves and circular marks that are likely to have been caused by icebergs, possibly including pivot points or impacts with the seabed when the icebergs overturned.

5.4.3 Pockmarks

Features similar to the circular seabed marks on the multi-beam swath bathymetry data in Figure 29 are seen elsewhere on the Chatham Rise, but they are thought to have a different origin.

In 2007, 'pockmark' fields (2 to 5 m deep) were found on the Chatham Rise at a water depth of 500 to 600 m south of the Mernoo Bank. These were considered to indicate fluid or methane hydrate gas escape in the geologic past (Nodder et al. 2012). Collins et al (2011) describe pockmarks on the southern flanks of the Chatham Rise near the Urry Knolls. Further survey work on the southern flanks of the Chatham Rise in 2013 identified pockmarks at 500 to 700 m water depths (150 m diameter, 4 to 8 m deep) and much larger pockmarks (i.e., 1 to 5 km across and 50 to 150 m deep) at a water depth of about 800 to 1,000 m on the flanks of the Chatham Rise (Davy et al. 2010). The pockmarks are assumed to be the remnants of seabed degassing and no evidence of current gas emissions was identified (Pecher et al. 2013[18]). The pockmarks are considered to be part of a very large field of thousands of pockmarks that extends over a very large area of seabed.

[18] Refer to - http://www.nrl.navy.mil/media/news-releases/2013/nrl-geochemistry-survey-at-chatham-rise-reveals-absence-of-modern-day-greenhouse-gas-emissions

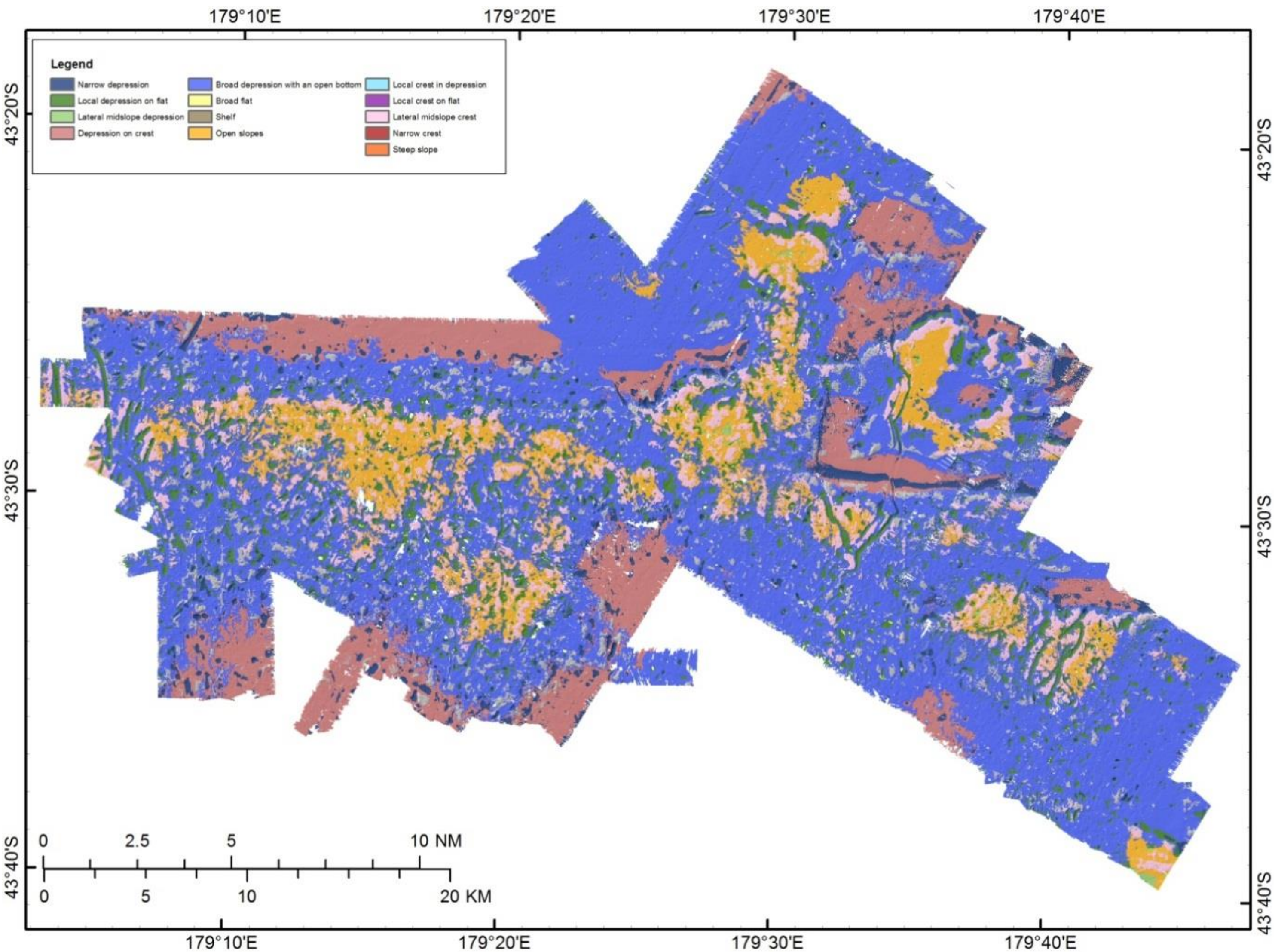

Figure 29: Benthic Terrain Modeller geomorphologic zones from the CRP survey area, derived from MBES bathymetric data collected using a shipboard Reson 8160 by CRP in 2012 (from Nodder et al. 2013). The zones reflect both the iceberg features and older, broader aspects of the morphology related to the tectonic history of the Chatham Rise.

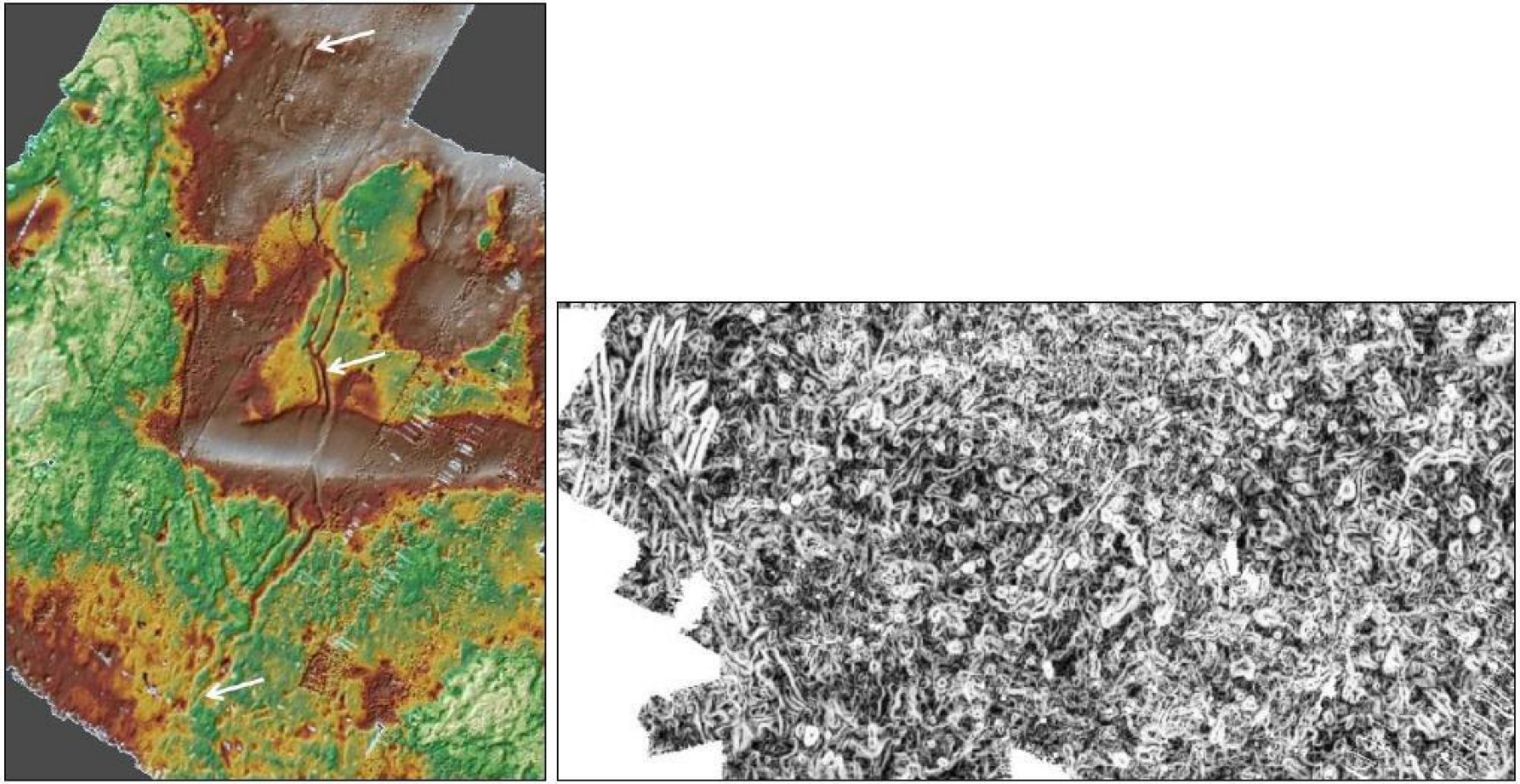

Figure 30: Detailed bathymetry of part of the mining permit area showing a large, long iceberg furrow on the seabed, indicated by arrows (left, deeper areas are red, shallower green). Circular and oval seabed depressions are highlighted on a map of seabed slope (right, steep slopes are white) (the scale of both images is about 20 km across).

5.5 Physical Oceanography

5.5.1 Introduction

This section of the EIA provides an overview of the physical oceanography of the Chatham Rise and the information (especially currents above the Rise) used to model the likely dispersion of sediment discharged back to the seabed following the processing of mined seabed material.

Extensive published scientific information is available on the oceanography of the waters on and adjacent to the Chatham Rise. Data include those generated from current meter deployments, including a current meter deployed in 2011 as a part of this study. This information has been supplemented with modelled data to develop an understanding of the water mass on the Chatham Rise.

5.5.2 Regional water masses and circulation

Chiswell (2013) provides an overview of all readily available data on the physical oceanography of the Chatham Rise. Deltares (2014a) provides an evaluation of specific information for the Chatham Rise that was used for detailed plume dispersion modelling described in Section 8.

At latitudes between 35° to 45°S there is a transition between warm, saline subtropical waters (STW) to the north and cooler, less saline sub-Antarctic water (SAW) to the south. The boundary between them is referred to as the Subtropical Convergence or Subtropical Front (STF) (Figure 31).

In the open ocean this front is typically 400 to 500 km wide (Hadfield et al. 2007). The STF curves under the South Island south of Stewart Island before running up the eastern margin of the South Island and east along the Chatham Rise (Boyd et al. 1999). Over the Chatham Rise, the STF is relatively narrow (c. 150 km) and limited vertically by the shallow bathymetry (Gilmour & Cole 1979; Heath 1984; Sutton 2001; Chiswell 2002).

5.5.3 Meteorology and Waves

Weather could affect vessel operations and the ability to undertake seabed mining (refer Section 4.3). Wind and wave data have been summarised for this project (Deltares 2014a – Appendix 10).

There is no database of measured wind and wave information within the proposed marine consent area. There is wind information for airports and other shore locations around the New Zealand coast and the Chatham Islands. As a result, the wind and waves are assessed indirectly. ERA-interim wind and wave reanalysis data (ECMWF Re-Analysis, the European Centre for Medium Range Weather Forecast (ECMWF) global wind and wave reanalysis dataset with a resolution of 1°x1°) near the acoustic Doppler current profiler (ADCP) measurement location for January 1979 to December 2012 were downloaded and processed using Deltares' in-house metocean data analysis package "ORCA" (Deltares 2014a). The wave model used in the reanalysis is the third generation WAM model, which is coupled with the atmospheric model. Data can be downloaded from the ECMWF website[19]. Monthly mean wind speed is shown in Figure 5.1 and monthly mean wave height in Figure 5.2 of Deltares (2014a) (Appendix 10).

The wind and wave data show that the main wind and wave directions are from the southwest, with mean monthly wind speeds up to 13.8 m/s (Beaufort 6). Mean monthly wave heights reach about 5 m with periods over 12 s (Figure 5.3, Figure 5.4 and Figure 5.5, Deltares 2014a - Appendix 10). Figure 32 illustrates monthly data for wave height and direction. There is no strong seasonal effect in wind and waves, other than the period between May and July when the northern component of the wind is small.

[19] http://dataportal.ecmwf.int/data/d/interim_daily

The wind and wave conditions on the crest of the Chatham Rise do not impact the seabed since the water motion below about half the wave length is negligible.

The water depths are too deep in the marine consent area (deeper than 350 m) for the seabed to be impacted by water movements associated with storm events. However, storms may impact on mining vessels operations.

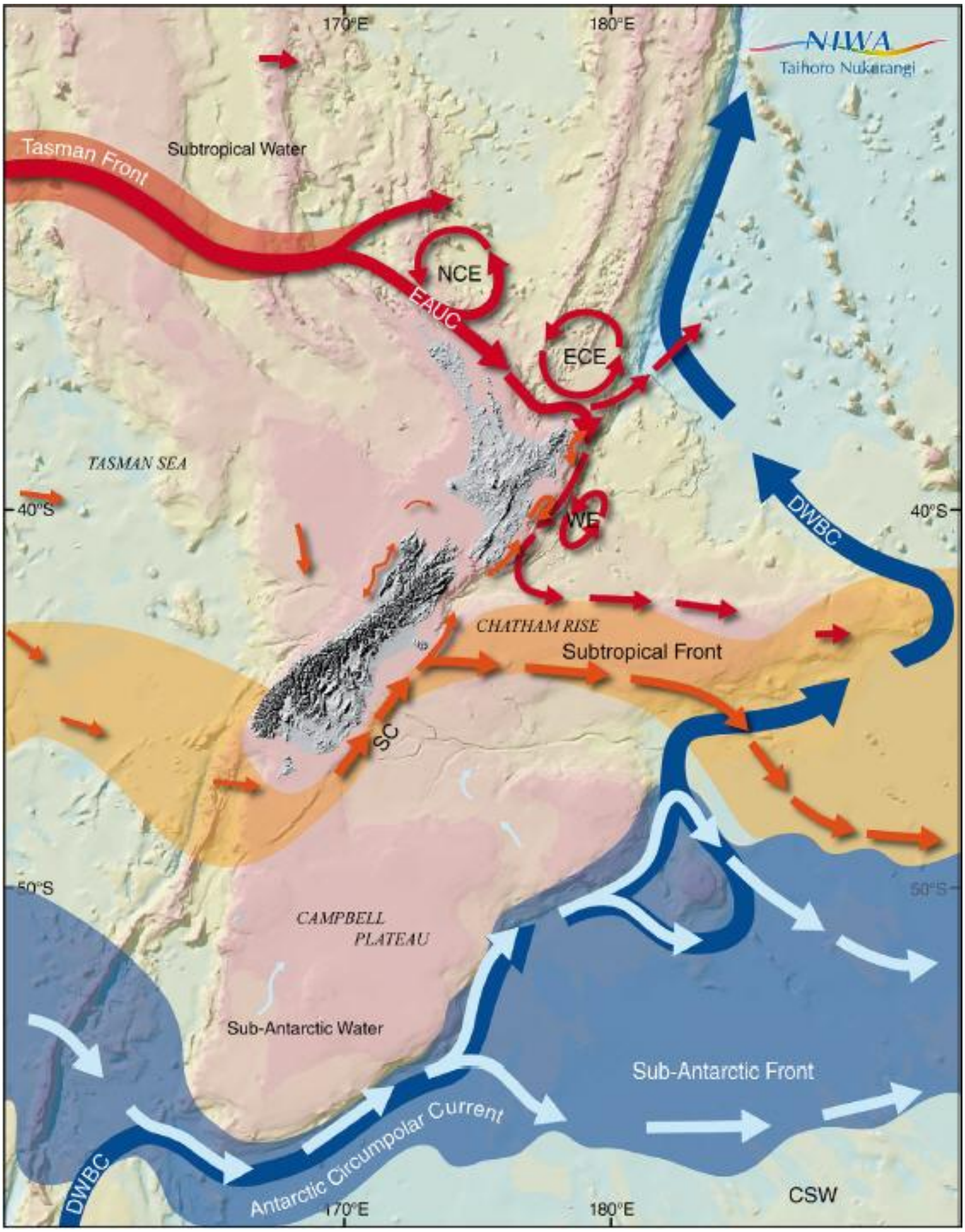

Figure 31: Ocean current circulation patterns in the New Zealand region, showing the major fronts and eddy features. EAUC, East Auckland Current; ECC, East Cape Current; NCC, North Cape Current; SC, Southland Current; WE, Wairarapa Eddy; DWBC, Deep Western Boundary Current (from Gordon et al. 2010).

5.5.4 Tides and currents

5.5.4.1 Introduction

Hadfield et al. (2007) describes the ocean circulation patterns on the Chatham Rise. Typically the currents on the crest of the Chatham Rise are weaker than on the flanks (Chiswell 2013).

Chiswell (2013) (Appendix 8) reported that there have been 41 current meter deployments on the Chatham Rise between 1981 and 1999 (refer Figure 5 in Chiswell 2013 – Appendix 8). Chiswell (2013) also reported that NIWA had undertaken 24 cruises between May 1996 and May 2010 on which an ADCP had collected current data.

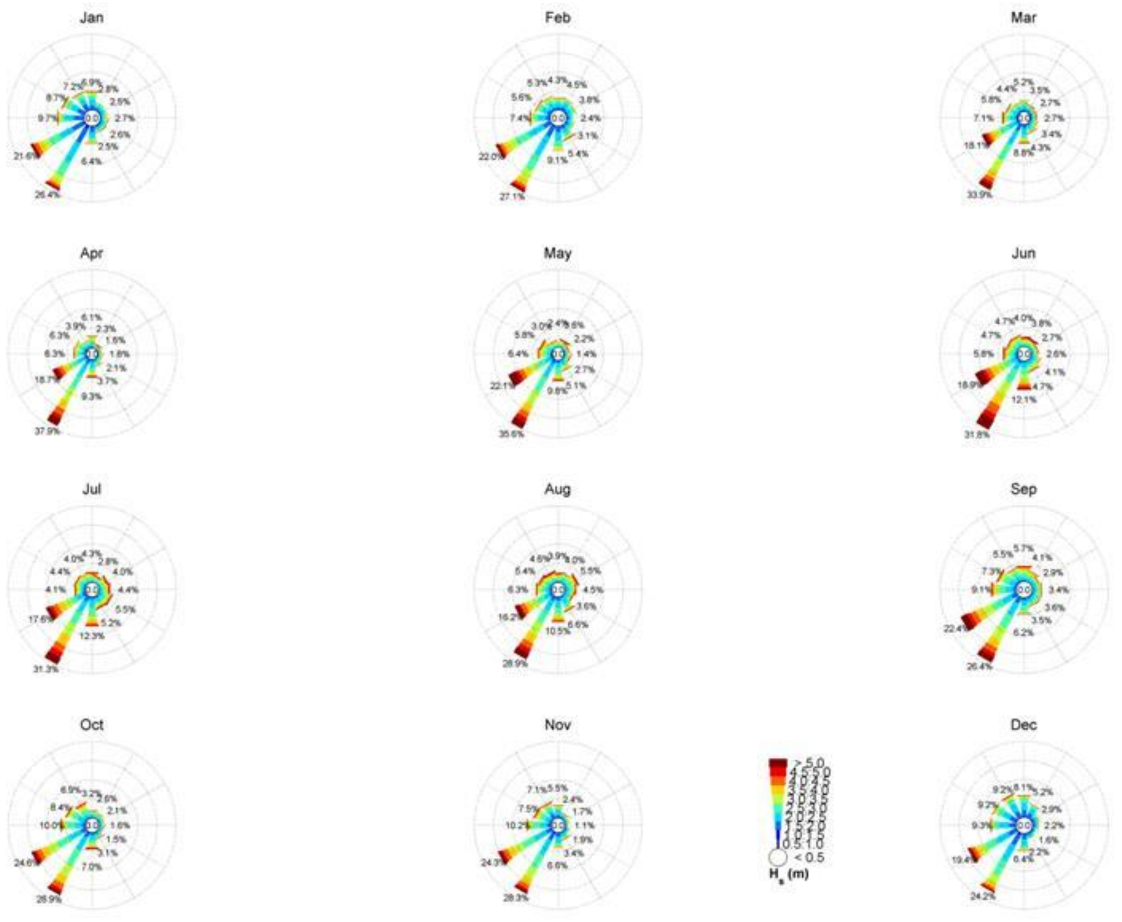

Figure 32: Significant wave height roses for each month of the year on the Chatham Rise (From Deltares 2014a, Figure 5.4). Note that waves from the southwest dominate.

5.5.4.2 Historical current meter deployments

As part of the 1981 Sonne cruise (SO 17) to the Chatham Rise, three Aanderaa current meters were moored at 43°34.3'S, 179°26.9'E from 20 April to 24 May 1981, in 410 m of water on the crest of the Rise. Over the 34-day recording period the maximum recorded current speeds were 42.9, 32.6 and 24.2 cm/s at 43, 193, and 393 m depth respectively.

A cruise in 1991 to the region used an ADCP to measure the spatial variability in the tidal and mean flows along a north to south transect at 179°E (Chiswell 1993) over the Chatham Rise. Current meter moorings were deployed along the transect in 350 m of water, and on the northern and southern flanks at a depth of 750 m. Current meters were installed at a depth of 150 m on all three moorings, and 50 m above the bottom on the central mooring.

During both May 1996 and October 1997 hydrographic sections were made across the STF along the 178°30'E meridian. A mooring was deployed at a depth of 1,500 m on the north flank of the Chatham Rise from September 1996 to May 1997. The mooring had meters at nominal depths of 250 and 1,000 m, although data recovery was limited at 1,000 m.

A similar mooring was deployed on the southern flank from May 1996 to May 1997. A crest array was centred at 178°30'E, 43°10'S in 380 m of water. The nominal distance between apex moorings was 15 nm (27 km). Each mooring had two vector-averaging current meters at nominal depths of 150 and 250 m, respectively. The array was deployed for two separate one month periods in May 1996 and October 1997. During the second of these deployments an additional central mooring was added so that the minimum spacing between moorings became 18 km.

A longer deployment of the southern and central moorings within the array was made from April to November 1999, but biofouling restricted the collection of useful data from this deployment to 118 days. Thus, the study obtained five data sets, referred to here as northern and southern flanks (261 days each) and consisting of May 1996 (26 days), October 1997 (29 days) and April to August 1999 (118 days) crest deployments. Mean current direction over eight months was to the east with currents being stronger south of the Rise. Mean speeds south of the Rise were as high as 15 cm/s compared to 4.5 cm/s north of the Rise. Tidal flows were the strongest currents, with magnitudes between 10 and 40 cm/s and with a fortnightly spring-neap variation. Tidal currents changed speed over a tidal cycle and the direction of the flow rotated anti-clockwise.

5.5.4.3 2011 current meter deployment

As part of the CRP investigations for this project, current and tidal information were obtained from a current meter and a moored ADCP deployed on the Chatham Rise from 21 May to 13 November 2011 (referred to as the IX Survey).

Two moorings were deployed on the Chatham Rise, about 80 m apart in 380 m of water on the crest of the Rise in the central part of MPL 50270. One mooring measured velocity through the water column with a current profiler (a RDI Workhorse ADCP). Velocities were measured in 5 m bins (depth layers) with the centre of the first bin 30.5 m above bottom and the last at 345.5 m. The ADCP also measured pressure, a proxy for water level. A single current meter (Aquadopp) measured horizontal velocity 8 m above bottom (from 21 May 2011 to 11 December 2011). The second mooring had two instruments measuring turbidity and temperature 7 and 21 m above seabed (Aqualogger sensor) from 19 July to 10 December 2011.

5.5.4.4 Model data

As part of the detailed plume modelling undertaken for this EIA, data were obtained from HYCOM (Hybrid Coordinate Ocean Model – refer Section 2.2 in Deltares 2014a (Appendix 10)). HYCOM data are used to model three-dimensional temperature, salinity and current structures, and to depict the location of meso-scale hydrodynamic features such as oceanic eddies and fronts. The US Navy Coupled Ocean Data Assimilation (NCODA) system was used to assimilate the HYCOM data with satellite altimeter observations and in-situ sea surface temperature (SST) measurements, as well as in-situ vertical temperature and salinity profiles (from a variety of sources – Appendix 10).

Data were also derived from the TPXO.7.2 ocean model. This model computes the major tidal constituent (amplitude and phase) around the world. The model uses inverse theory to find the optimal balance between the modelled hydrodynamics and observations from satellite observations and tide gauges. The satellite observations used in TPXO are part of the Topex/Poseidon satellite mission, launched in 1992 to map ocean surface topography. The version (7.2) of the model used by Deltares (2014a) (Appendix 10) is the latest version available and contains output on a 0.25 by 0.25 degree grid. In addition, data were obtained from ERA-interim, a modelling system for waves and wind developed and run operationally by the ECMWF. ERA-interim produces a global wind and wave reanalysed data set with a spatial resolution of one degree, starting from January 1979. The wave model used in the reanalysis is the third generation WAM model, which is coupled with an atmospheric model. The quality of the ERA-interim wind and offshore wave data is high, even higher than that of the ECMWF operational model, for data up to 2005.

5.5.4.5 Current and tide velocities

Tides (barotropic flow) play a distinct role in the hydrodynamics on the Chatham Rise (e.g., Heath 1985 or Chiswell 2001). Evaluation of the 2011 IX Survey mooring data showed that maximum velocities were about 45 cm/s near the seabed (Figure 33, Figure 34). The strongest flows measured at the site were associated with tides.

Tides account for more than 70 % of the total variance of the flows at the mooring. Tidal velocities range from 10 cm/s near bottom (30 m (blue) in Figure 35) to 40 cm/s near the surface (cyan in Figure 35), and show a fortnightly spring-neap cycle due to the difference in the lunar and solar semi-diurnal tidal period. Tidal currents changed direction every semi-diurnal tidal cycle (approximately twice a day). The direction of the flow moved anti-clockwise and changed in magnitude every tidal cycle.

Once tidal flows were removed from the velocities, the subtidal flows were typically less than 10 cm/s and varied in direction about every 15 to 20 days. Often the subtidal flows were in the same direction throughout the water column. However, during the last month of the deployment and in several earlier instances subtidal flows were in opposing directions with depth. Subtidal flows were more directional than tidal flows with a tendency for flows 40 degrees north of west. Unlike the tidal flows, the subtidal flows did not always have a periodicity associated with their direction nor did they periodically trace out an ellipse.

Overall, the analysis of the ADCP data collected in 2011 indicated the most important processes for sediment plume dispersion (considered in Section 8) are related to tides, residual flow and internal tides. The ADCP measurements show that near the bed, velocities rarely exceed 40 cm/s. The tidal part of the flow shows maxima of approximately 32 cm/s near the bed. The residual flow has maxima of 0.07 m/s (7 cm/s). Hence, the major part of the flow is determined by the tide (important for (re)suspension of sediments). Residual flow velocities vary between 2 to 7 cm/s and have a dominant northwesterly direction (varying between 270° and 90° nautical) in the lowest 100 m of the water column (Figure 36). This implies that dispersion of any suspended sediment plume will generally be oriented towards the northwest, and less frequently to the southwest and southeast (discussed further in Section 8).

The residual signal in the ADCP observations revealed the passage of an eddy with a period of approximately three months in the top 200 m of the water column.

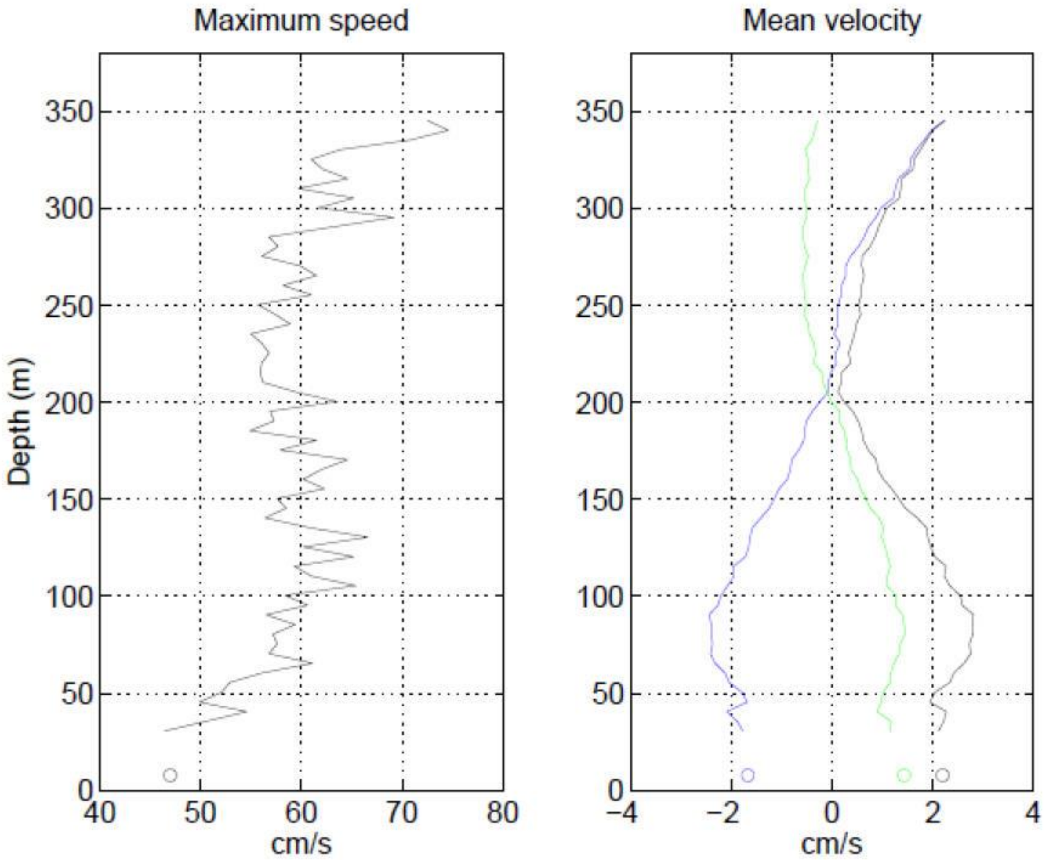

Figure 33: (left) The magnitude of the maximum velocity measured by the current profiler (line) and single current meter (circle) over the deployment period . (right) The mean east-west velocity (blue, positive east) and north-south (green, positive north) and magnitude of the mean (black) from the current profiler (lines) and current meter (circle) (note 0 cm is seabed).

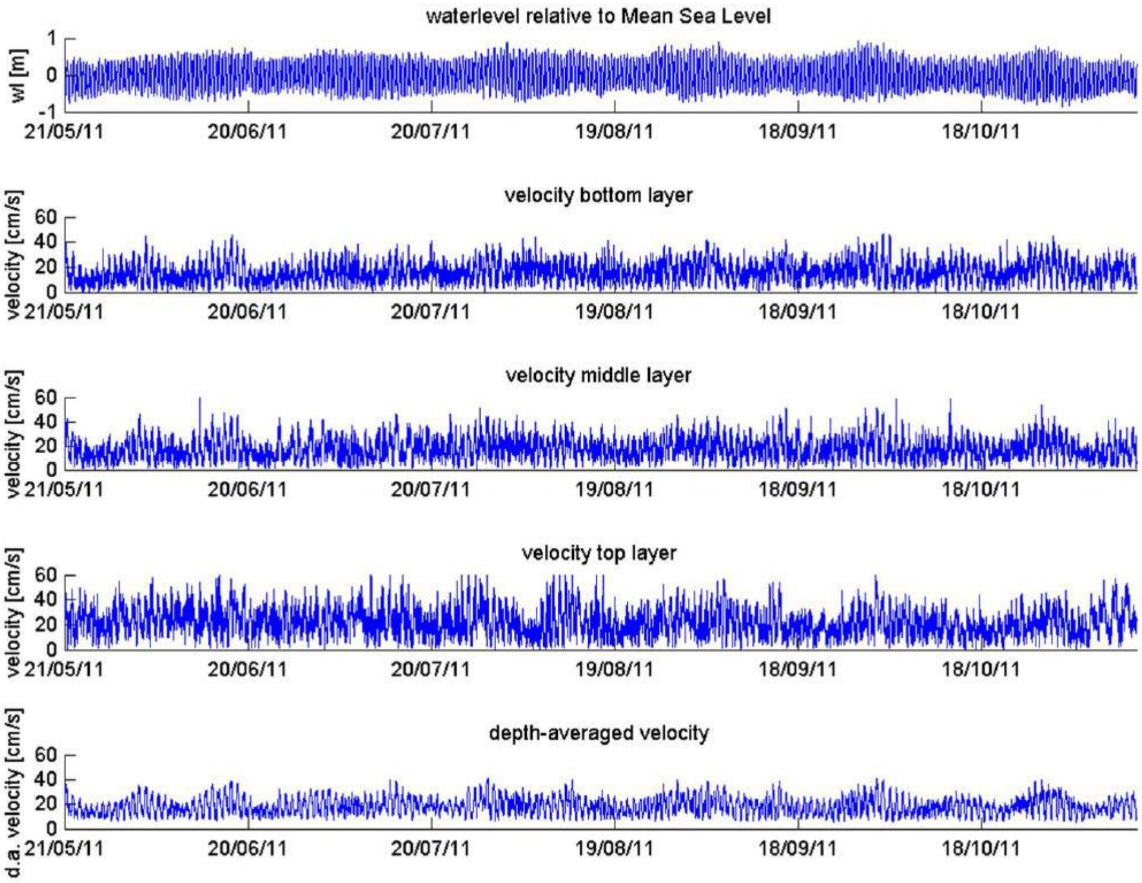

Figure 34: Time series derived from the RDI ADCP measurements (from top to bottom): pressure (m) and velocities for the bottom, middle and top layers, and depth averaged-velocities (cm/s).

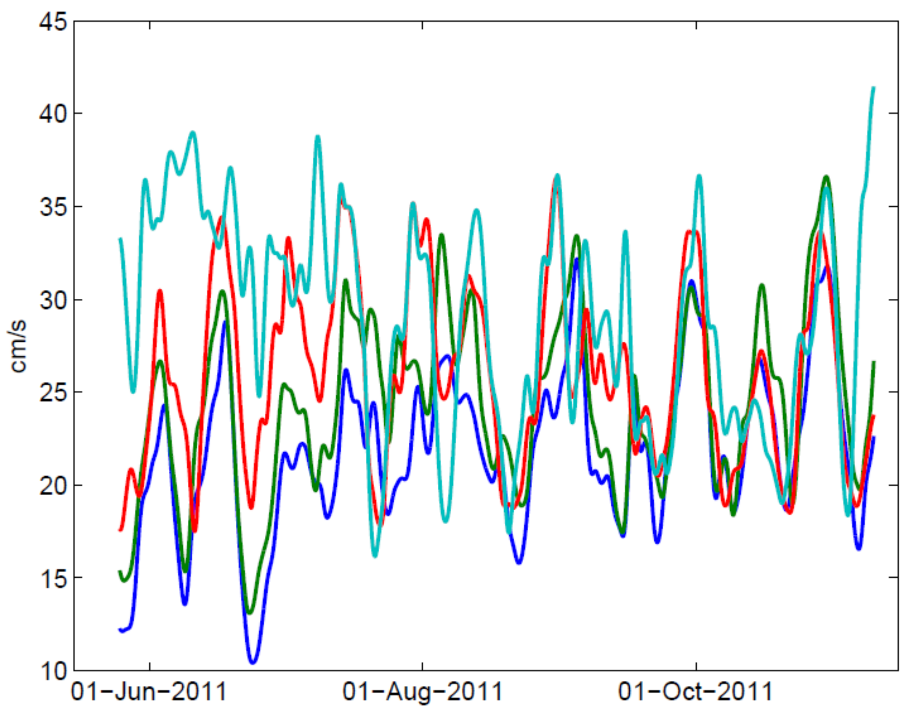

Figure 35: Amplitude of the high-passed filtered velocities at 30 m (blue), 100 m (green), 250 m (red) and 325 m (cyan) above the seabed. These are predominantly tides, but include contributions from other motions with periods of a day or less.

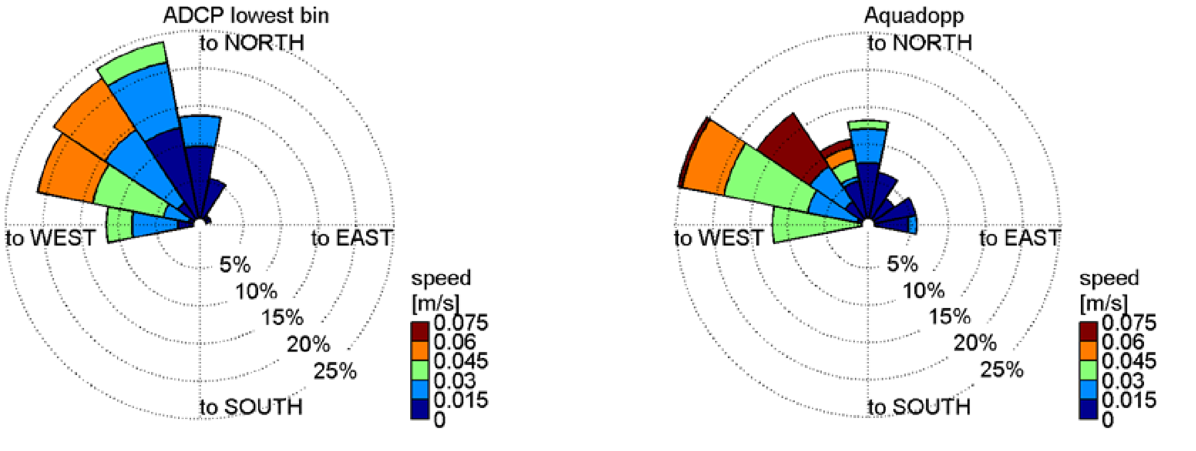

Figure 36: Current roses of near bed residual currents measured with Aquadopp (right) and ADCP (left - lowest bin).

Internal (baroclinic) tides are associated with the vertical movement of density surfaces, the pycnocline in particular, within the water column. Similar to surface (barotropic) tides, internal tides may be broken into higher modes (higher harmonics), each with a distinct vertical distribution of horizontal velocities that often extend to the seabed. Heath (1984) observed internal tides on the crest of the Chatham Rise with a M2 baroclinic signal accounting for about a quarter of the M2 tidal variance.

The ADCP measurements revealed the presence of internal tides. The magnitude of horizontal velocities associated with the mode-1 internal tide can amount to 20 cm/s, which is substantial given the tidal velocities of 30 to 40 cm/s. Vertical velocities can typically approximate 1/10th of the magnitude of horizontal baroclinic velocities near sloping beds and around the thermocline. This implies vertical velocities in the order of 1 to 2 cm/s, large compared to settling velocities of sediment.

The ADCP measurements were carried out during relatively weakly-stratified conditions. During the stratified conditions of late spring, summer and early autumn, the internal tides are likely to be stronger. Hence, internal tides are potentially important for re-suspension and dispersion of sediments over sloping parts of the bottom (refer Section 8).

5.6 Geological and Geochemical Seabed Environment

5.6.1 Introduction

This section of the EIA provides an overview of the geological and geochemical nature of the seabed on the Chatham Rise. The appearance and properties of the present day seabed are influenced by both geological and oceanographic factors.

The information presented is this section is supported by the following reports and appendices.

- A discussion of the genesis of the Chatham Rise deposits (Kenex 2010) (Appendix 2).
- A summary and analysis of site investigation information (sediment textures) (Boskalis 2013b) (Appendix 4).
- An examination of the geochemistry and environmental chemistry of sediments on the Chatham Rise (Golder 2014a) (Appendix 11).

5.6.2 Sediment evolution characteristics

Kudrass & von Rad (1984a) summarised the evolution of Chatham Rise surface sediments (Figure 37), and Cullen (1978a) developed a conceptual diagram of Chatham Rise surface sediment distribution (Figure 38). Excluding weathered schist material, the chalk layers constitute the oldest components of the surface sediments and provided the source material for the genesis of the phosphorite nodules (refer below). The deposition of glauconite occurred after phosphatisation ceased, and accumulated as the host Miocene chalks were eroded. The erosion of these host chalks also exposed phosphorite at the water-sediment interface, which led to the formation of glauconitic coatings on these nodules.

In addition, most of the sediments on the crest of the Chatham Rise have been physically disturbed by the passage of icebergs during the Pliocene and Pleistocene.

5.6.3 Sediment physical characteristics

McDougall (1982) mapped the sediments of the Chatham Rise at a 1:1 million scale, providing regional indications of the nature of surface sediments in the area between the South Island and Chatham Islands. Sediments on the Chatham Rise were also mapped and described by Norris (1964).

Norris (1964) divided the materials in the largely unconsolidated surficial sediments on the Chatham Rise into five categories:

- Rock fragments.
- Authigenic minerals (e.g., phosphorite and glauconite).
- Residual biological material (e.g., forminifera skeletons, shell fragments).
- Faecal pellets.
- Dust particles and monomineralic grains.

Nodder (2013) (Appendix 12) also describe sources of sedimentary material and discuss natural sedimentary processes.

Information on the physical characteristics (grain size and other physical characteristics) of sediments on the Chatham Rise has been gathered over the last 50 years. Surveys have collected grab samples, box cores, piston cores, and vibro-cores, and information about the physical properties of the sediments has been obtained from cone penetrometer testing (CPT).

The surface sediments of the Chatham Rise are predominantly an unconsolidated mixture of greenish-grey muddy sands and sandy muds. In the marine consent area, granule to cobble sized phosphorite nodules (1 mm to >150 mm) are dispersed through this mixture. Along with the phosphorite nodules, the major components of the matrix include Miocene chalks, glauconite granules (0.125 to 0.5 mm), volcanic glass shards and fragments derived from exposed schist outcrops.

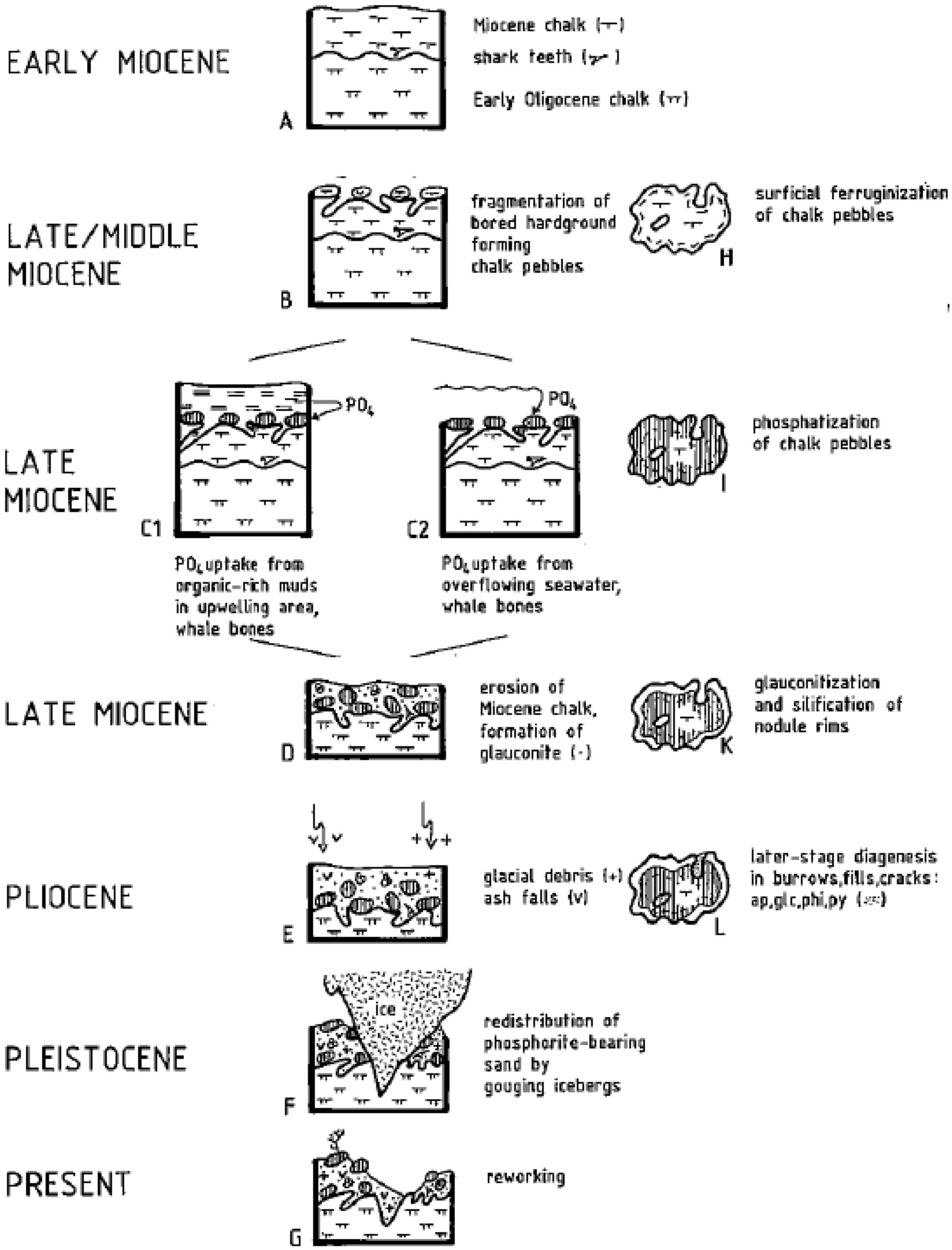

Figure 37: Interpretation of the evolution of Chatham Rise sediments from the Early Miocene (~23 Ma) to the Present (from Kudrass & von Rad 1984a).

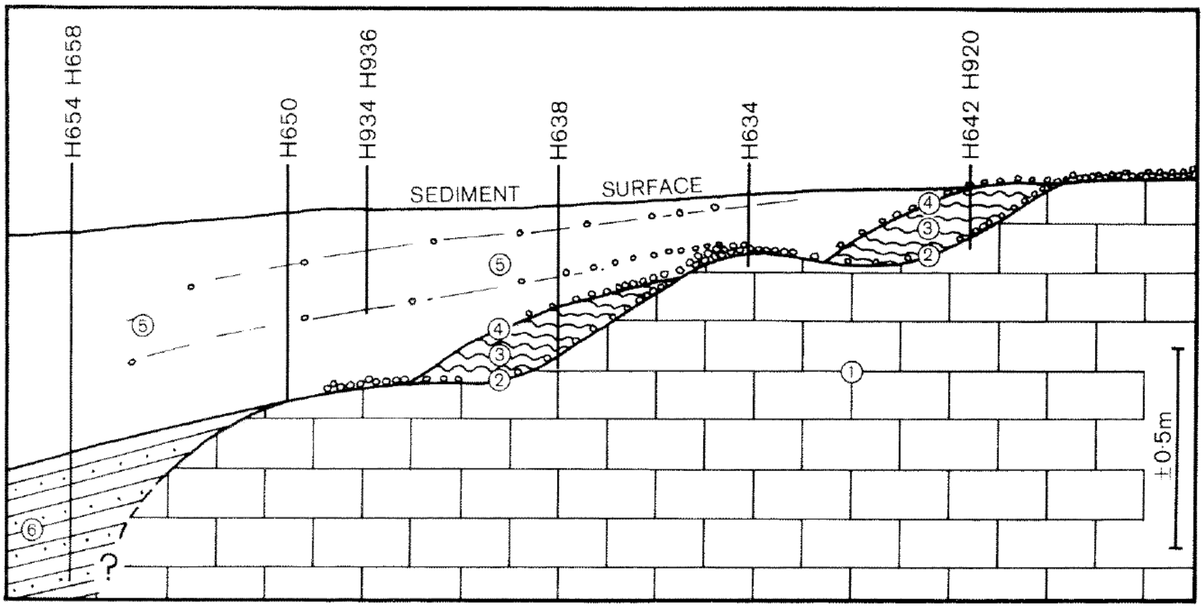

Figure 38: Model of the distribution and evolution of surface sediments on the Chatham Rise. 1: Miocene/Oligocene chalks; 2: Basal phosphorites; 3: Foraminiferal ooze; 4: Upper phosphorites; 5: Reworked glauconitic muddy-sand; 6: sandy muds and ash. (Figure adapted from Cullen 1978a).

Surface sediments of the central Chatham Rise are dominated by phosphorite bearing, glauconitic, fine to medium grained sandy muds and muddy sands (Norris 1964; Pasho 1976; Kudrass & Cullen 1982; von Rad & Rösch 1984; Grove et al. 2006; Nodder et al. 2011; Lawless 2012; Nodder et al. 2012). The average thickness of phosphatic sediment measured during the Valdivia and Sonne cruises was between 0.17 to 0.27 m (Kudrass & Cullen 1982). Sand percentages are greatest towards the Chatham Islands, and muds become more dominant towards New Zealand (Nodder & Northcote 2001). Compared to sedimentation rates of previous eras, modern sedimentation rates are relatively slow (Nodder et al. 2012). Lawless (2012) reported medium to fine sands are limited to water depths less than 500 m, whereas very fine sands to medium silts extend to depths greater than 500 m. Based on Folk's (1968) textural classes, sand dominates only the shallowest (<300 m) portions of the Chatham Rise on Reserve Bank, silty sand dominates in <500 m water depths and sandy silt in the deeper (>500 m) areas of central Chatham Rise.

Nodder et al. (2013 – Appendix 9) and Rowden et al. (2014a – Appendix 16) summarised sample data for mud, sand and gravel fraction in the mining permit and marine consent areas, respectively. These reports illustrate the patchy nature and high spatial variability of surficial sediments on the Chatham Rise. Gravel percentage across the study area range from <10 % to >70 %. The distribution of gravel is affected markedly by sample location, resulting in apparent 'hot-spots' of gravel accumulation, often driven by single samples with very high gravel percentages. Moderate levels (>30 %) of gravel are found consistently across the western and through the central parts of the study area, with more isolated, sporadic patches in the east, especially in areas of reasonably flat-lying seabed. Sand percentages are typically greater than 30 % across the marine consent area, increasing to greater than 70 % sand in the western and south-central areas. Mud percentage mirrors the sane percentages, with low percentages less than 40 % in the western and south-central areas and higher percentages (>50%) to the east and north.

The results of sediment grain size data obtained from surface, subsurface and chalk samples during the Dorado Discovery Leg 3 cruise in 2012 are summarised in Golder (2014a) in Appendix 11. The sediments had variable textures but surface samples typically had about 41 % mud, 56 % sand and 3 % gravel sized material. Subsurface samples had similar proportions of mud, a lower sand percentage and higher amount of gravel. Chalk samples were on average finer (66 % mud) with less sand than non-chalk sediment (Golder 2014a). Figure 39 illustrates examples of the sediment grain size distribution for material less than 2 mm in size from the grab samples collected during the Dorado Discovery survey in February 2012. This information is used in numerical models to predict the behaviour of the fine-grained material returned to the seabed after processing of the mined seabed sediment.

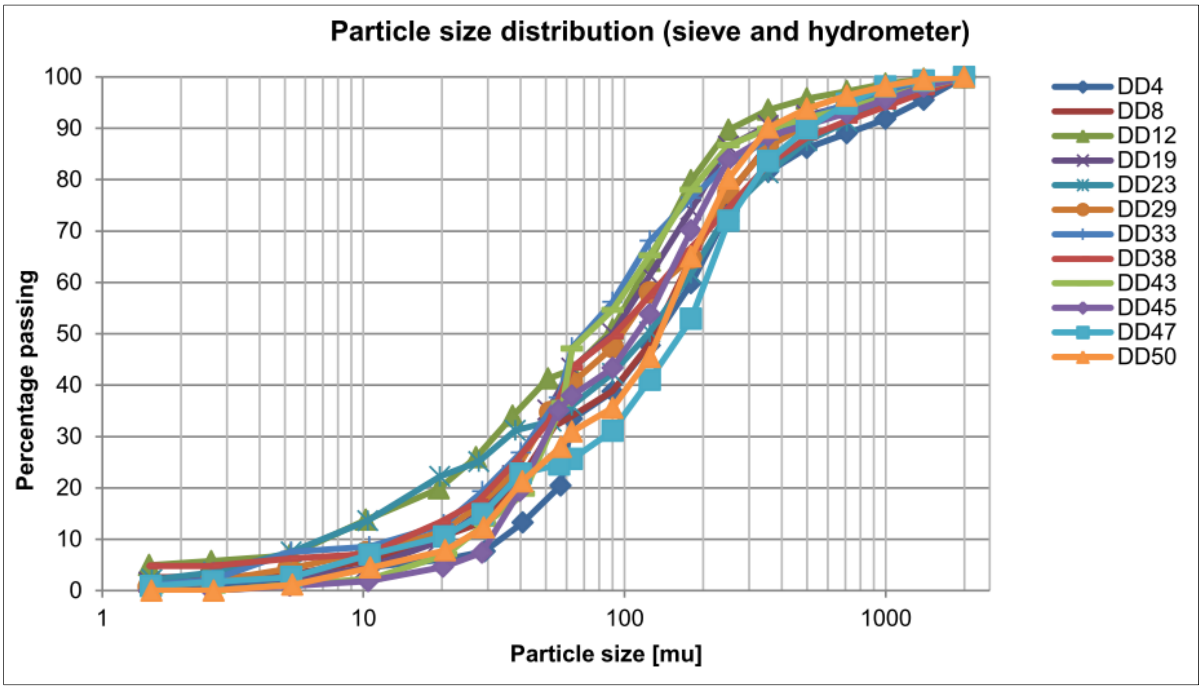

Figure 39: Selection of sediment particle size distributions (for material <2 mm in size) from 12 sediment grab samples (from Boskalis 2013b).

5.6.4 Sediment mineralogy

Phosphorite nodules are predominantly a mix of carbonate-bearing apatites derived from fluorapatite ($Ca_5(PO_4)_3F$) and hydroxyapatite ($Ca_5(PO_4)_3OH$) (Ames 1959; Piper & Codispoti 1975; Kenex 2010 – Appendix 2). Phosphorites on the Chatham Rise are also associated with glauconite plus minor amounts of goethite (iron oxides); the nodules contain 3 to 10 %, by weight, of iron (Fe). Quartz, opal and organic carbon are also relatively enriched (von Rad & Rösch 1984).

Lawless (2012) described the bulk sediment mineralogy for the central Chatham Rise, and identified chlorite, illite, and smectite in the clay matrices, with the clays being similar throughout the central Chatham Rise. The chalk is predominantly low-Mg calcite (calcium carbonate) derived from coccolith plates and fragments, interspersed with siliceous silt and clay debris.

The glauconites on the Chatham Rise typically contain about 7 % by weight of potassium oxide (K_2O). Active smectite layers typically make up <20 % of the mica dominated glauconaceous material (Lawless 2012).

5.6.5 Sediment composition - major components

5.6.5.1 Carbonates

Calcium carbonate is a key component of Chatham Rise sediments with abundances of typically 30 to 40 %. Forty-nine samples collected in 2012 had a mean carbonate content of 41 % (Golder 2014a – Appendix 11). Boskalis (2013b) (Appendix 4) also reported a mean carbonate abundance of 37 % from 12 grab samples. Lawless (2012) reported a mean calcium carbonate content of 29 % (range 13 to 47 %) for 10 samples and a median carbonate content of 82 % for the Oligocene chalks on the Rise .

5.6.5.2 Organic matter

Golder (2014a) (Appendix 11) reported an average total organic carbon content of surface sediments from the Chatham Rise of 0.6 %. Total nitrogen abundances were low, with samples containing less than 0.13 %. The organic matter found in Chatham Rise sediments is derived from in-situ carbon generated by organisms living within the sediments (e.g., bacteria, benthic infauna) and from biological activity in the water column above and upstream of the Chatham Rise. These contributions include the precipitation of dead phytoplankton, other small pelagic organisms, larger biota (e.g., cephalopods and fish), and faecal pellets.

The labile, or 'fresh', component of organic material in these surficial sediments, as estimated by algal pigment chlorophyll-*a* (chl-*a*) concentrations, varies from 0.06 to 0.10 ng chl-*a*/mg dry sediment (Grove et al. 2006; Nodder et al. 2007; Berkenbusch et al. 2011). The organic matter content of Chatham Rise sediments is enhanced on the crest of the Rise compared to the upper northern and southern flanks, reflecting the seasonal algal production and subsequent deposition within the waters associated with the STF on the Rise crest (e.g., Murphy et al. 2001). Seasonal deposition of algal material from near-surface phytoplankton blooms, especially on the southern flank, can distort this distribution, resulting in organic-rich material being deposited to the seabed, especially on the upper slopes (Nodder & Northcote 2001; Nodder et al. 2007). Nodder et al. (2012) presented an example of the accumulation of phytodetritus around a large erratic (iceberg sourced rock) on the southern flank of the Chatham Rise.

5.6.5.3 Bulk sediment chemistry

The major element chemistry of Rise sediments is a function of their mineralogy, geochemistry and geological provenance. For the sediments relevant to CRP's project, the major elements chemistry reflects the proportions of limestone (chalk), glauconite sand, phosphorite, in-situ biological (e.g., generation of shell material), and the geochemical processes that have formed or altered these components.

Lawless (2012) provided a summary of major element oxide abundances in key sediment facies groups (sandy to finer sediments). Changes associated with particle sizes in sediments were often related to changes in the proportions of more significant components, such as fine phosphorite nodules, glauconite grains, and carbonates (Figure 40).

Analysis of phosphorite nodules collected on the Valdivia and Sonne cruises provided information on phosphorite major element chemistry. Consistent with data from elsewhere, phosphorite nodules on the Chatham Rise are predominantly composed of calcium, phosphorus and carbon, as is expected given apatite is the predominant host mineral (Table 4). In comparison, host sediments are dominated by silicate and carbonaceous minerals and contain <5 % phosphorus (as P_2O_5).

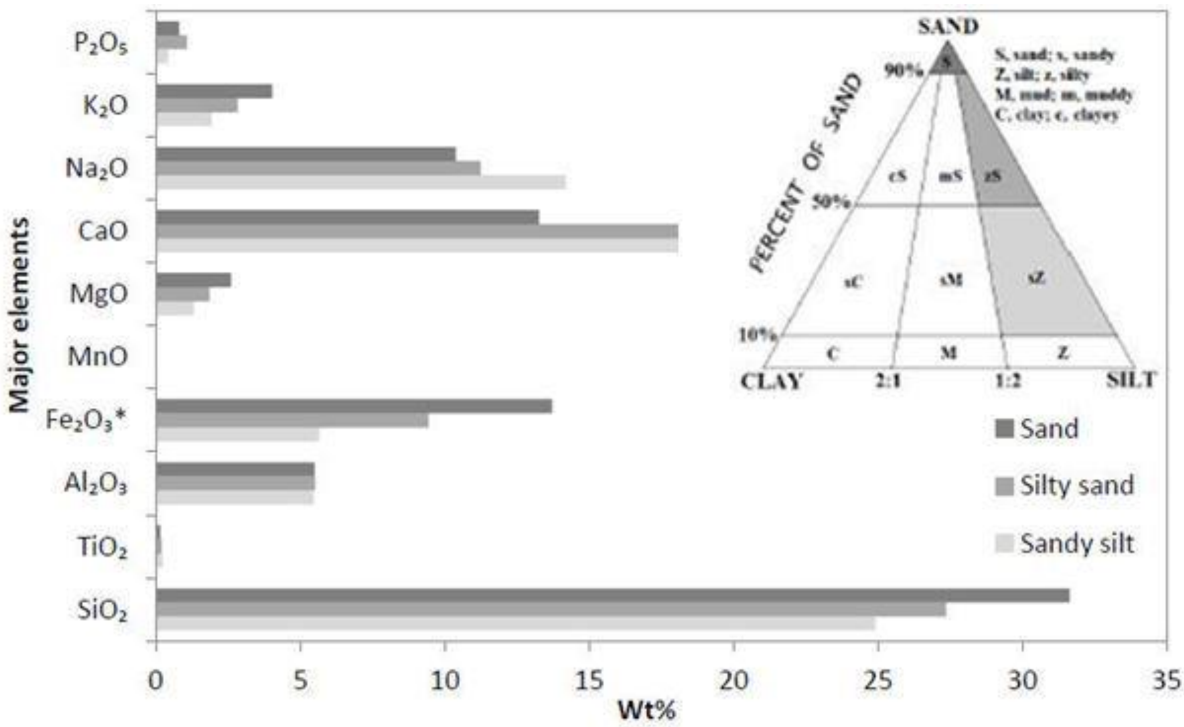

Figure 40: Major element abundances for three key textural classes in sediments on the Chatham Rise (from Lawless 2012).

5.6.6 Major and trace elements

5.6.6.1 Bulk host sediments

Analysis of trace elements in samples collected by Lawless (2012) showed that elements such as chromium and vanadium were enriched in the sand fraction and elements like strontium and barium were associated with the silty siliceous and carbonaceous materials in the sediment. An analysis of data collected by the Dorado Discovery in 2012 by Principal Component Analysis (PCA) indicated approximately 50 % of the variance in trace element abundances could be explained by a single principal component (Golder 2014a – Appendix 11). This component was strongly associated with the proportion of mud in the samples.

The major elements present in the seabed, as well as the phosphorite nodules, are shown in Table 4. Data are reported as elemental oxides (i.e., of iron, phosphorus, silicon, titanium, aluminium, magnesium, calcium, sodium, potassium, sulfur and carbon).

Table 4: Major element data for Chatham Rise phosphorite and bed sediments.

Parameter	Phosphorite nodules			Bulk host sediments	
	Valdivia	Sonne[2]	DD-4[3]	Tangaroa[4]	DD-4[5]
Fe_2O_3	5.39	3.1 ± 0.4	3.2 ± 0.4	9.4-13	9.2 ± 1.3
P_2O_5	21.97	21 ± 1	19 ± 1	2.1-4.3	2.8 ± 0.8
SiO_2	9.83	6.7 ± 1.1	5.0 ± 0.6	38-41	-
TiO_2	-	0.026 ± 0.004	-	0.18-0.23	-
Al_2O_3	1.11	0.96 ± 0.18	0.66 ± 0.12	6.8-7.3	-
MgO	-	0.63 ± 0.08	0.72 ± 0.05	2.0-2.7	-

Parameter	Phosphorite nodules			Bulk host sediments	
	Valdivia	Sonne[2]	DD-4[3]	Tangaroa[4]	DD-4[5]
CaO	42.33	45 ± 1	47 ± 1	15-20	-
Na_2O	0.73	0.99 ± 0.04	0.42 ± 0.02	1.3-1.3	-
K_2O	1.48	0.89 ± 0.14	0.17 ± 0.05	3.6-4.7	-
SO_3	1.21	1.5 ± 0.1	1.4 ± 0.1	-	-
LOI (Loss of Ignition)	12.19	18 ± 1	19 ± 1	11-17	-

Notes: All units % wt and measured by XRF unless otherwise stated; phosphorite data for nodules >0.8 mm [1]Mean data, n not reported, Kudrass & Cullen (1982); [2]Mean data ± 95 % confidence intervals, von Rad & Rösch (1984); n=78;[3]Mean data ± 95 % confidence intervals, n=44. [4]Range of data, n=2, University of Waikato (2012). [5]Bed sediments only, data measured by total recoverable digestion and analysis by ICP-MS (converted to oxide abundances).

The analysis of sediment presented in Golder (2014a) included the abundance of key environmental trace elements. The abundance of elements such as arsenic (about 6 mg/kg in sediment and <4 mg/kg in chalk) and cadmium (0.2 mg/kg in surface sediment and 0.3 mg/kg in chalk) is low in the host sediments, even though cadmium is often associated with phosphates (refer to Section 5.6.6.2 below). Mercury abundances are also low, about 0.06 mg/kg in surface sediments and about 0.04 mg/kg in chalk samples.

These results indicate that, if normalised for sediment grain-size, abundances of most elements would be expected to be similar across the Chatham Rise. However, such relationships with sediment size were not observed for cadmium, copper, molybdenum and nickel. Abundances of these elements exhibit spatial variation across the Rise that cannot be attributed to sediment particle size alone, and that may be attributed to changes in lithology along the Chatham Rise.

5.6.6.2 Phosphorite

The composition of phosphorites and other phosphate minerals is a function of their diagenesis. Phosphatic rocks from sedimentary deposits often have elevated abundances of trace elements such as cadmium, chromium, copper, nickel, lead, zinc and rare earth elements (Gnandi & Tobschall 1999). Cadmium, in particular, can be particularly elevated (up to 267 mg/kg) in phosphorite rock because cadmium may substitute for calcium in apatite matrices (Kunkel 1990, as referenced in Gnandi & Tobschall 1999).

Although the phosphorite nodules on the Chatham Rise are sedimentary in origin, cadmium abundance in the nodules is relatively low (Table 5). Phosphorite nodules from the Rise also have low lead abundances, and somewhat elevated arsenic (only in finer nodules) and uranium abundances.

5.6.6.3 Uranium

As a result of natural processes uranium is enriched in Chatham Rise sediments and nodules compared with other phosphorite deposits (Table 5). However, the nodules are not considered radioactive as specified under the New Zealand Radiation Protection Act 1965. Uranium from the Rise was not considered to present a radioactive hazard to the environment or people by Cullen (1978b) and a recent reassessment of the radioactivity of the phosphorite nodules has confirmed the findings of Cullen (1978b) (refer Appendix 11).

Cullen (1978b) identified that the uranium in phosphorites is concentrated in the carbonate fluorapatite, with tetravalent uranium substituting for calcium in the apatite and hexavalent uranium adsorbed to the surface of apatite.

Table 5: Trace element abundances in Chatham Rise sediments, phosphorite nodules and glauconite rich sands.

Parameter	Phosphorite (global)[1]	Coarse (>8 mm) Chatham Rise phosphorites[2*]	Fine (<8 mm) Chatham Rise phosphorites[2]**	Glauconite rich sands[3]	Chatham Rise sediment[4]	Chatham Rise host sediment[5]	Continental Crust[6]
Arsenic	2-23	11 (5-39)	39 (5-79)	21 (16.8-23)	10.1-11.8	6.0 (1.2-10)	1.5-5.1
Barium	-	63 (0-300)	36 (4-140)	49 (29-99)	132-211	-	550-1,100
Cadmium	0.1-510	<2[7]	<2[7]	-	-	0.20 (0.12-0.37)	0.075-0.10
Chromium	1-160	0 (0-30)	9 (0-24)	267 (233-283)	127-164	43 (9-55)	35-110
Cobalt	0.37-385	14 (0-26)	15 (1-33)	22 (<15-36)	24-25	-	12-19
Copper	5.5-130	10 (5-85)	7 (5-69)	<0.7	2-3.7	6.1 (4.0-8.6)	14-32
Lead	50	7.0 (5.0-16)	15 (5-24)	7.9 (6.9-9.3)	10-10.1	3.6 (1.4-4.7)	17-18
Molybdenum	-	6.0 (3.0-17)	7.0 (3.0-10)	1.4 (1.1-1.7)	1.7-2.2	0.46 (0.11-1.0)	0.78-1.5
Nickel	2-120	15 (6-37)	30 (14-59)	41 (36-48)	27-33	20 (17-24)	19-60
Rubidium	-	16 (5-27)	52 (8-64)	179 (171-185)	108-132	-	82-110
Strontium	-	1,600 (1,400-1,800)	1,300 (1,200-1,700)	155 (99-196)	447-529	630 (330-1,100)	270-380
Thallium	-	12 (9-19)	11 (6-15)	<0.7	1.5-1.9	-	8.6-11
Uranium	64-140	240 (20-480)	170 (120-310)	25 (17-33)	24-31	8.6 (2.7-21)	1.5-2.7
Vanadium	-	56 (0-140)	74 (61-91)	156 (142-168)	69-90	-	53-110
Yttrium	-	25 (19-54)	49 (23-91)	62 (44-80)	58-80	-	17-24
Zinc	6-520	11 (5-30)	22 (9-80)	74 (66-84)	61-78	27 (15-31)	52-71
Zirconium	-	5.0 (5.0-14)	12 (5-23)	38 (33-45)	90-94	-	160-240

Notes: All units mg/kg dry weight; [1]Aydin et al. (2010) except cadmium (Mar & Okazaki 2012), arsenic and uranium (Syers et al. 1986); [2]Data from Sonne survey, median data with range in parentheses; [3]Glauconite magnetically concentrated (n=10); [4]whole sediments (n=2) (Analysis by University of Waikato); [5]Golder (2014a) (excluding chalk samples, median data with range in parentheses; n=19); [6]Rudnick & Gao (2003);[7]DD-4 datamedian data with range in parentheses, n=13.*n=46, **n=31.

Burnett & Veeh (1977) showed that tetravalent uranium comprised some 80 % of the uranium in Chatham Rise phosphorite. Cullen (1978b) provided results for the uranium concentration in nodular phosphorites (mean 188 mg/kg, values up to 435 mg/kg), phosphatised limestones (up to 357 mg/kg) and cetacean bones (up to 369 mg/kg). Concentrations measured in phosphorite bearing material collected during the Sonne voyage were comparable (mean 240 mg/kg and 170 mg/kg for fine and course nodules respectively (Table 5)) (von Rad & Rösch 1984). Cullen (1978b) noted uranium enrichment was limited to phosphorite nodules. The glauconitic material on the Chatham Rise does not have elevated uranium content. Further discussion of uranium in phosphorite and sediment can be found in Golder (2014a) (Appendix 11).

5.7 Water

5.7.1 Introduction

As described in Section 5.5, the key oceanographic feature of the Chatham Rise is the subtropical front (STF). The STF is the meeting point of two major oceanic water masses that have different physical properties and chemical signatures. In addition to the influence that these water masses have on water chemistry and biogeochemistry over the Chatham Rise, the water depth on the Rise also has an influence on vertical water properties (light, temperature, particulates) and biogeochemistry (salinity, dissolved oxygen, chlorophyll-a, etc.).

This section of the EIA provides an overview of general water properties and chemistry of the Chatham Rise and is supported by the following reports:

- A review of the physical oceanography of the Chatham Rise (Chiswell 2013) (Appendix 8)
- An assessment of natural sedimentation on the Chatham Rise (Nodder 2013) (Appendix 12)

5.7.2 Water temperature/salinity relationships

Historical sea surface and subsurface temperature data have been collected by numerous vessels on the Chatham Rise. Figure 41 illustrates the CTD (conductivity, temperature and depth) profiles made on and around the Chatham Rise since 1987. Casts along the 178.5°E meridian were collected by scientific research regarding biogeochemical processes associated with the STF (Nodder et al. 2005).

Waters on the Chatham Rise and its flanks are stratified. Stratification is strongest at the base of the mixed layer (Figure 42). Temperature decreases with depth and varies seasonally. The temperature characteristics found in the December 2011 survey (Bowen 2012) are similar (accounting for the seasonal changes in temperature) to other CTD casts made on the Chatham Rise. Both temperature and salinity display seasonal changes with water depth. Surface and bottom temperature data have been collected as part of ongoing fishery surveys on the Rise (e.g., Stevens et al. 2011). Temperatures measured reflect those shown in Figure 42 at the depths corresponding to the top of the Rise.

Figure 42 summarises vertical changes in temperature from the sea surface to deep water either side of the Chatham Rise. Sea surface temperature varies seasonally on either side of the Chatham Rise with higher temperatures on the north side compared to the south (by 2°C). The casts typically showed a sharp decrease in temperature at about 100 m followed by a steady decrease with depth. By 400 m on both sides of the Chatham Rise temperatures have decreased to about 5°C, depending on the time of year. The CTD casts made in the proposed mining area in December 2011 measured surface water temperatures of 13°C and seabed temperatures of just under 8°C.

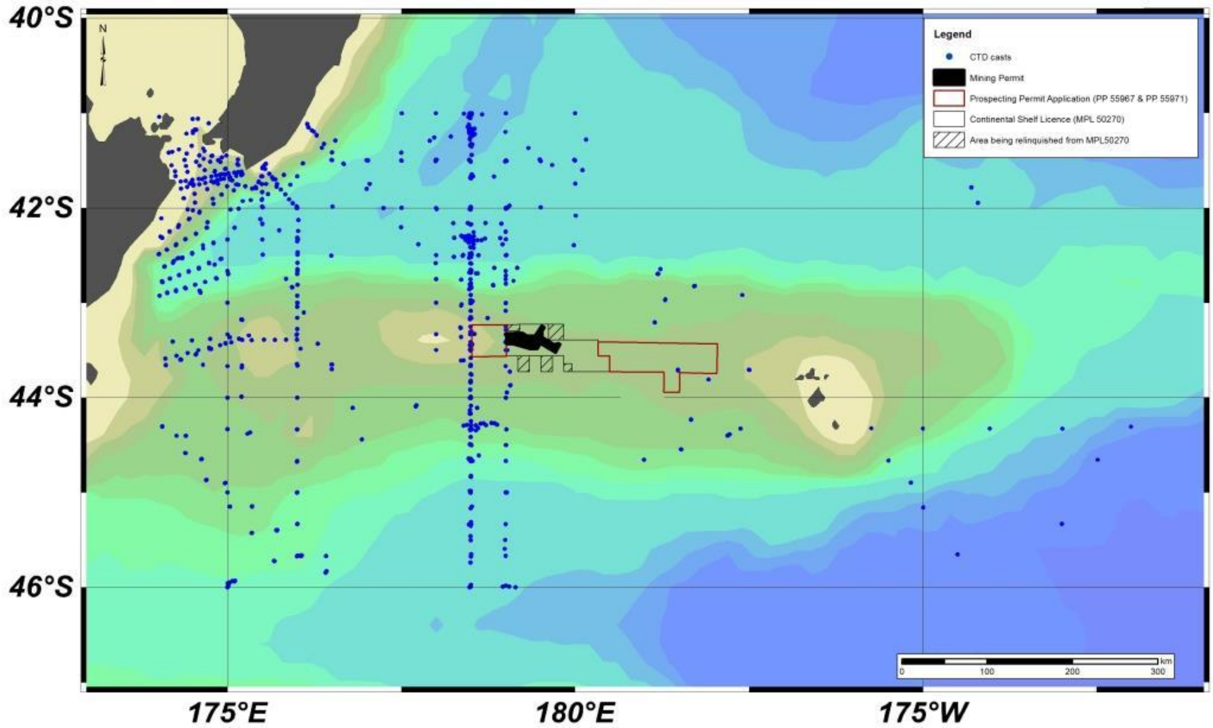

Figure 41: CTD casts made near the Chatham Rise since 1987 (from Chiswell 2013). These data are used to determine the vertical changes in salinity and temperature of the ocean.

Since the 1980s, satellites have been used to collect sea surface data. These data provide information on regional sea surface temperatures that reflect the regional patterns of water circulation and movement. Although temperatures vary through the year, surface temperatures reflect the influence of two water masses. They are the warmer (and more saline) waters associated with the East Cape current that flows along the northern side of the Chatham Rise after moving south along the east coast of the North Island, and the colder sub-Antarctic water that flows up the east coast of the South Island (where it is locally known as the Southland current). Figure 43 illustrates the temperature differences commonly seen either side of the Chatham Rise. Chiswell (2013) (Appendix 8) discusses this in more detail.

Near surface water column properties and behaviour are determined by factors including the mixing created by surface waves and stratification. Hadfield et al. (2007) discuss mixed layer depths, the depth to which turbulent mixing extends at sites either side of the Chatham Rise (41 and 46°S at 178.5°E). This depth is where the potential density[20] first exceeds a near surface reference value by 0.1 kg/m^3. In summer, the mixed layer depth was similar at the two sites, 20 to 25 m, but in winter the mixed layer depth was much deeper at the northern site than at the southern site (320 m and 120 m, respectively). The deeper values at the northern site may be related to the bowing down of water densities (isopycnals) as a result of the currents associated with the Wairarapa Eddy (Heath 1984).

[20] Density of a fluid if adiabatically transferred to a reference value (typically 1 bar).

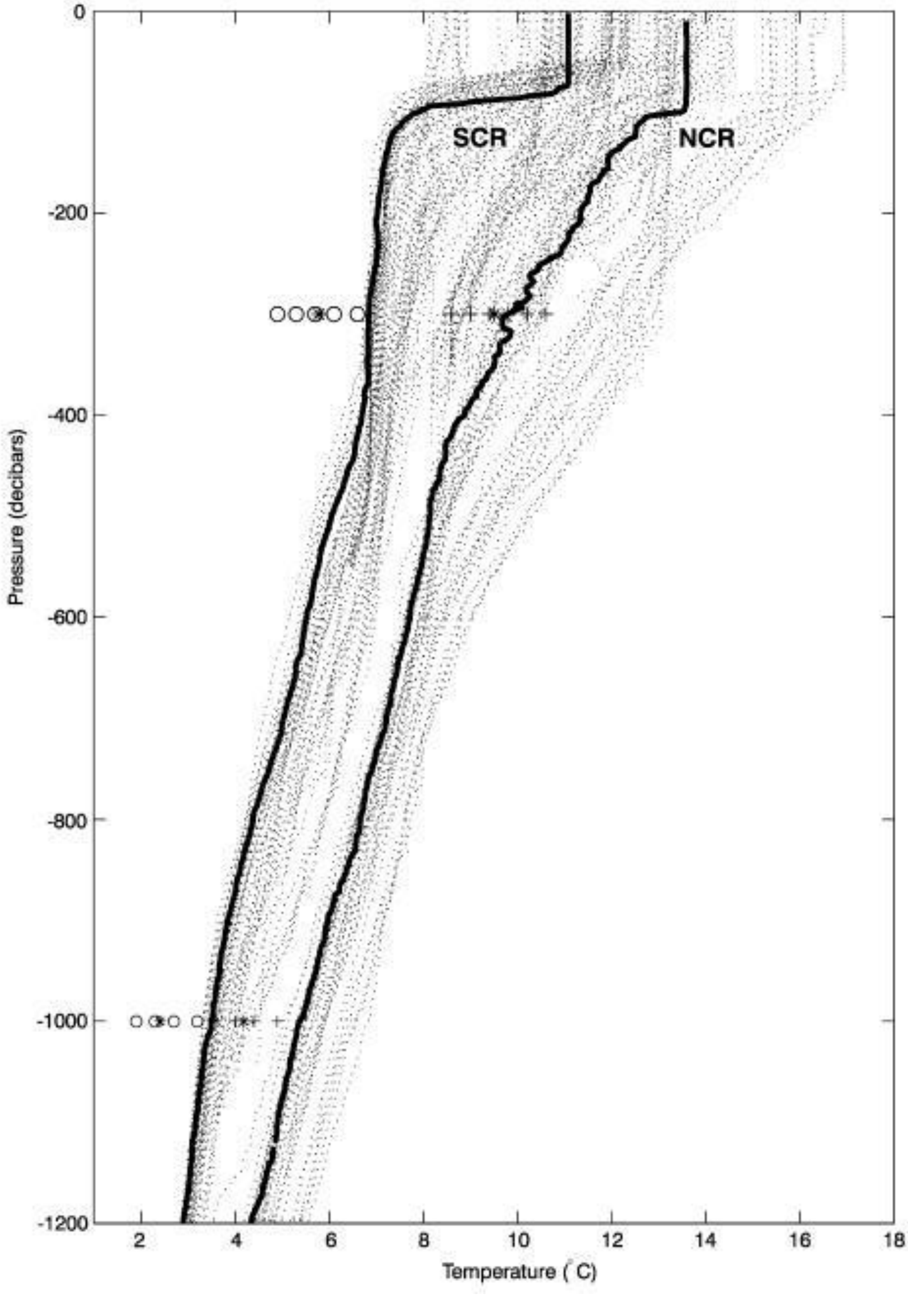

Figure 42: Temperature profiles from CTD casts made by NIWA at two stations (used for deep ocean sediment traps) in deep water north (NCR) and south (SCR) of the Chatham Rise. Open circles and crosses identify additional data from temperature sensors on traps (from Nodder & Northcote 2001).

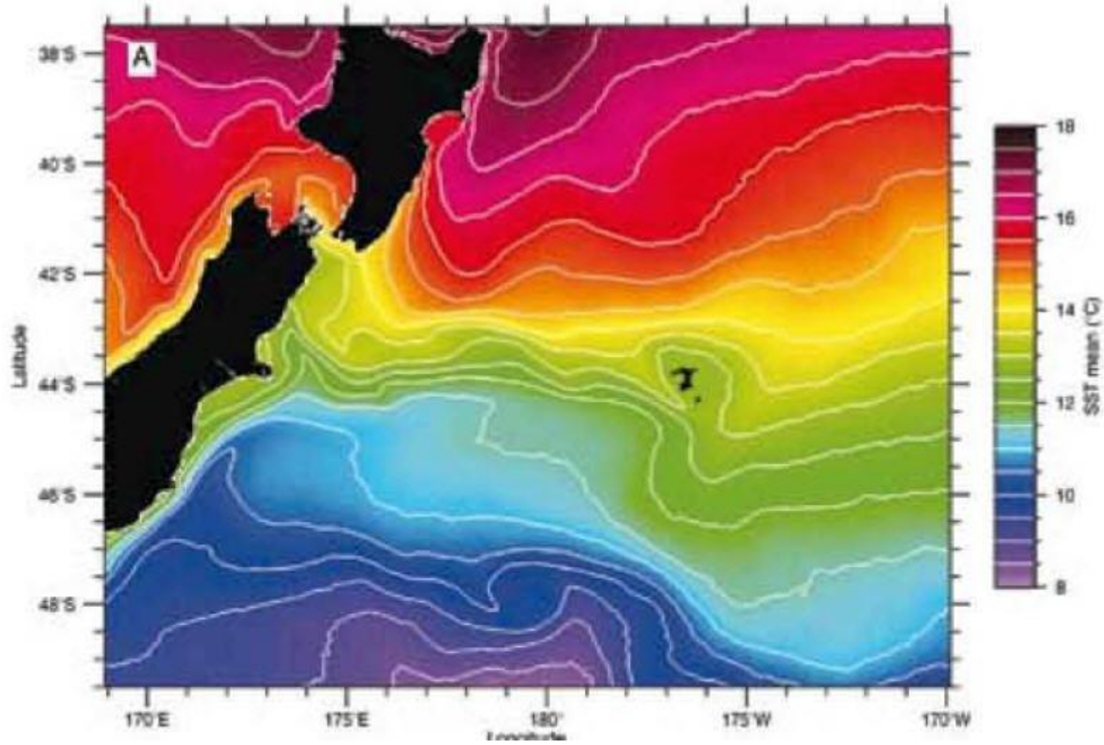

Figure 43: Sea surface temperature statistics from a harmonic analysis of NSA monthly composites, 1993-2002. Annual mean temperature (°C) (from Hadfield et al. (2007)).

Results of the HYCOM model clearly show the STF over the Chatham Rise and its seasonal dynamics. Daily snapshots of assimilated HYCOM data near the location of the mooring deployed in 2011 revealed distinct variations (which relate to either which water mass is at the location or the season) and vertical gradients in salinity (34.2 to 35.1 PSU), temperature (7 to 18°C) and water density (≈1025 to 1028 kg/m^3). The strongest gradients occur in the first 100 m below the water surface. Assuming that HYCOM is a good approximation of the conditions on the Chatham Rise, then relatively stratified conditions are likely to prevail in the marine consent area during late spring, summer and early autumn (i.e., from November until May). Weakly-stratified conditions are likely to prevail during late autumn, winter and early spring (i.e., May until November). These differences in stratification are associated with differences in the near-surface (top 100 m) currents (i.e., strongest velocities prevail during the strongly stratified 'summer plus' period). Near-bed flows tended to be stronger during the weakly-stratified 'winter plus' period.

5.7.3 Water clarity

5.7.3.1 Introduction

Water clarity and particulate concentrations near the seabed on the crest of the Chatham Rise are a function of the downward movement of particulates from the sea surface. Particulate concentrations are also affected by resuspension from the seabed.

Nodder (2013) (Appendix 12) provides a summary of sediment trap deployments on and adjacent to the Chatham Rise. Downward vertical fluxes of material on the crest of the Chatham Rise within the STF are generally elevated compared to fluxes in the water masses on either side of the Rise, reflecting the high productivity of the frontal zone. Vertical fluxes on the Chatham Rise are in the order of 0.18 to 0.5 g/m^2/d, but have been measured as high as 1.8 g/m^2/d close to the seabed. Nodder (2013) observes that vertical fluxes on the Chatham Rise are similar in magnitude to other temperate, continental margin and open ocean environments.

Lithogenic material is a natural component in particle fluxes on the Chatham Rise (0.1 to 0.3 $g/m^2/y$; Nodder & Northcote 2001), and resuspended material is apparent in near-bottom sediment traps (e.g., mineral grains and glauconite pellets observed in traps deployed 40 to 70 m above the seabed (Nodder & Alexander 1998). Increases in flux with increasing water depth are ascribed to resuspension and/or lateral advection (Nodder 1997; Nodder & Gall 1998; Nodder & Northcote 2001), indicating that natural volumes of particles in the Chatham Rise area are affected by dynamic vertical and horizontal processes. Recent studies suggest that currents are occasionally strong enough to resuspend and transport sediment laterally on the Chatham Rise, perhaps on tidal time-scales (e.g., Nodder et al. 2007).

5.7.3.2 Water column particulates

Measurements of total suspended solids on the Chatham Rise demonstrate that the suspended particle concentrations in the vicinity of the crest are highly variable. They are elevated relative to surrounding waters (e.g., McCave and Carter, 1997), but are generally less than 1 mg/L. Bottom nepheloid layers on the crest have particle concentrations that are 1.5 to 2 times higher than surface concentrations.

McCave & Carter (1997) examined large scale sedimentation processes associated with the Deep Western Boundary Current that runs around the Chatham Rise (from the south) and north across the Hikurangi Plateau to the Kermadec Trench. They presented a series of nephelometer profiles extending northwards along a transect from near the base of the northern flank of the Chatham Rise. They showed that total suspended solids (TSS) concentrations at water depths greater than 2,500 m were typically <0.065 mg/L and that the presence of bottom nepheloid layers attributed to resuspension of seabed sediment.

Nephelometer profiles and suspended particulate matter measurements collected at a station on the crest of the Chatham Rise (NIWA station U942, 43° 20.32’S 179° 00.03’E) indicate the presence of near-bed particle concentration maxima at 150 m above the seabed, with measured concentrations of approximately 0.55 mg/L (Nodder 1997) (refer Figure 4-1, Figure 4-2 in Nodder (2013) – Appendix 12). Mid-water particle concentrations at 300 m depth on the northern slope also varied five fold over a 12-hour sampling period from 0.05 to 0.25 mg/L (stations U946-U949, 42° 42.00’S 179° 00.00’E).

A compilation of beam transmissivity data collected over a 12 year period (1999 to 2011) indicated near-bed particle concentration maxima were apparent on most CTD casts conducted on the Chatham Rise crest in the vicinity of CRP’s proposed mining area (Nodder 2013 – Appendix 12). However, Nodder (2013) noted that most of these data were not calibrated by in-situ measurements of suspended particulate matter concentration, but they did show that there were persistently relative elevated particle concentrations within as much as 80 to 100 m above the seabed. These increases in particle concentrations were matched by near-bed increases in fluorescence, suggesting that photosynthetic material (phytodetritus) was being resuspended (e.g., Nodder et al. 2007).

5.7.3.3 IX Survey 2011

Turbidity data were collected from two moorings deployed for a seven month period in 2011 (May to December) on the Chatham Rise crest (43° 29. 003’S 179° 20.099’E) (IX Survey 2012). The monitoring equipment included an upward looking ADCP moored 8 m above the seabed and two Aqualogger turbidity sensors moored 7 and 21 m above the bed. The data collected by the seabed instrumentation were reported and analysed by IX Survey (2012), Bowen (2012), Nodder (2013) (Appendix 12) and Deltares (2014c) (Appendix 26). The instrumentation also included current meters.

The Aquatec Aquadopp current meter data at 10 m above the seabed indicate that flows at the start of the time-series were predominantly 10 to 15 cm/s (IX Survey, 2012). Over the 7 month deployment period (May to December 2011), there was an overall increase in current speed to 15 to 25 cm/s, and sporadically as high as 40 cm/s, for the last five months of the deployment.

Turbidity measurements obtained during the IX Survey are described in detail in Bowen (2012) and Deltares (2014c) (Appendix 26). The abundance of upper water column particulate material may be influenced by phytoplankton near the surface and diurnal cycles of planktonic and other organisms in the mid and lower water columns. Examination of the data collected by the ADCP turbidity logger indicated that the majority of the turbidity readings were low (e.g., 0.5 to 1 NTU), but there were a few higher turbidity readings (i.e., >1 NTU). Figure 44 illustrates turbidity in the bins closest to the surface (Bin 64 - near sea surface) and seabed (Bin 1). Figure 45 shows turbidity data collected from the Aqualoggers at 7 and 21 m above the bed (data in FTU).

The elevated turbidity observed at the lower sensor may be due to the resuspension and transport of bottom sediments by strong bottom currents, probably at least >10 cm/s to suspend fine, organic-rich material (e.g., Nodder et al. 2007) and as much as 20 to 30 cm/s for sand-sized particles (e.g., Heath 1984). Nodder (2013) (Appendix 12) notes that although the turbidity data provided by the IX Survey moorings are useful in a relative sense, it is impossible to relate the measurements to actual TSS concentrations because no water samples were collected to calibrate the turbidity data (e.g., Nodder 1997). Furthermore, direct comparisons between the two different instruments used on the IX survey mooring are not possible because the turbidity units are in derived NTU for the ADCP and in FTU for the Aqualoggers.

Although the increased turbidity at the lower sensor was not matched by contemporaneous heightened activity at the upper sensor, it should be noted that neither sensor was ‘at the seabed’. Therefore, it is possible that some resuspension at the bed may not have reached the upper sensor at the survey location. Further turbidity data will be collected prior to mining to improve the understanding of at and near seabed particulate concentrations.

5.7.4 Dissolved oxygen

Dissolved oxygen (DO) is present at concentrations that typically reach saturation point at the surface and near-surface waters. Concentrations typically decline towards the thermocline where minimum concentrations can be observed.

Golder (2014a) (Appendix 11) summarises DO information obtained on the Chatham Rise. The data shows high DO concentrations at the surface (between 7 to 9 mg/L), with DO concentrations progressively decreasing with water depth to concentrations around 7 to 8 mg/L at the seabed.

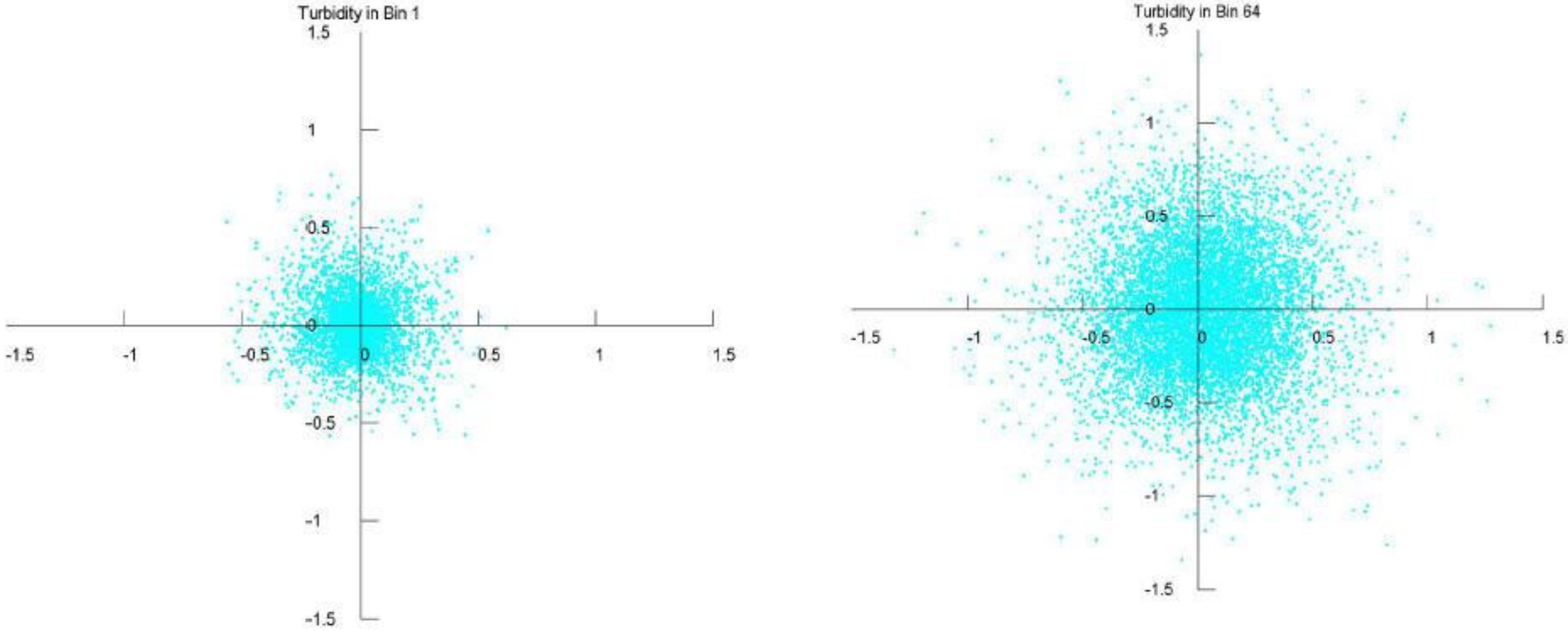

Figure 44: Direction dependent turbidity scatter plots for Bin 1 (30 m above the bed) and Bin 64 (near-sea surface) for ADCP on Chatham Rise, 2011 (from Deltares 2014c, refer to Appendix 26 for more detail). The plots show that turbidity increases at shallow depths, and that there is no dominant flux direction associated with the turbidity values throughout the water column. The turbidity data are in natural turbidity units (NTU).

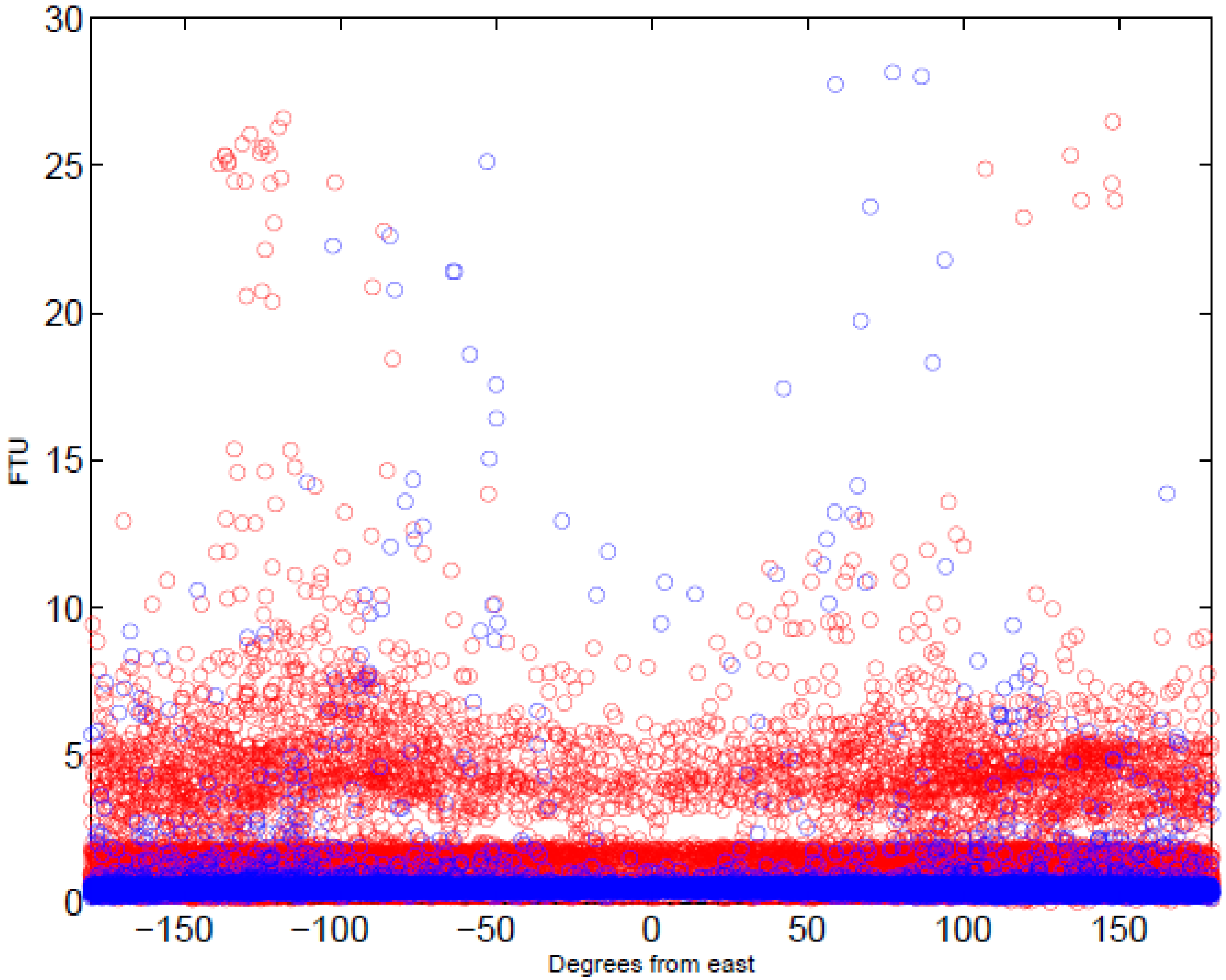

Figure 45: Turbidity from Aqualogger sensors at 7 and 21 m above seabed deployed in 2011, red circles measured at 7 m, blue circles at 21 m (from Bowen 2012). The elevated turbidity at the lower sensor may be due to resuspension of sediments by near-bottom currents.

5.7.5 Nutrients

Regional estimates of nutrients in the ocean show the contrast between high-nutrient sub-Antarctic waters over Campbell Plateau and Bounty Trough and low-nutrient subtropical waters north of the Chatham Rise. The Chatham Rise is highly productive compared to the surrounding waters (Bradford & Roberts 1978).

Differences in chemistry between STW, SAW and the STF were described in Boyd et al (1999), and are summarised in Table 6. Chemically, one of the major differences between STW and SAW is that concentrations of nutrients in the STW are at balance with plankton growth, whereas the SAW contains excess nutrients. There is an excess of nutrients in the SAW because planktonic growth is typically limited by micro-nutrients such as iron (Boyd et al. 2000). In the STF, where the water from the south meets the subtropical waters, there is no micro-nutrient limitation in the surface waters.

Table 6: Water quality of neighbouring water masses and their convergence (from Boyd et al. 1999).

Parameter	Subtropical	Sub-Antarctic	Convergence
Silicon	48 ± 4 (1.7)	76 ± 20 (2.7)	65 ± 19 (2.3)
Nitrate as nitrogen	39 ± 14 (2.8)	180 ± 25 (13)	89 ± 17 (6.3)
Phosphate as phosphorus	8.8 ± 2.7 (0.28)	35 ± 6 (1.1)	17 ± 4 (0.54)[A]
Iron	0.13 ± 0.04 (0.0023)	0.050 ± 0.016 (0.0009)	0.04 ± 0.03 (0.0007)

Units are mg/m^3 with data in µM reported in parentheses; n=4 unless otherwise stated; [A]n=3; [B]n=2.

Several studies have reported the concentrations of nitrogen, phosphorus and other nutrients (e.g., silicate) in waters across the STF. Sampling has been carried out principally in support of phytoplankton studies on and adjacent to the Rise. These studies include very early data reported in Bradford and Roberts (1978), and studies on phytoplankton assemblages (Bradford-Grieve et al. 1997; Chang & Gall 1998)

Hadfield (2011) reported estimates of macronutrient concentrations from the World Ocean Atlas 2005 (Garcia et al. 2006). This information (Figure 46) provides a generalised picture of probable nutrient concentrations across this region and is similar to southern hemisphere data for nitrate and silicate recently published by Bostock et al. (2013). As Hadfield (2011) notes, the reliability of this type of data is limited by the amount of real data on which it is based.

Chlorophyll fluorescence data collected along a vessel track (RV Akademik MA Lavrentynev) across the Chatham Rise is shown in Figure 47.

Over the last two decades, chlorophyll data have been obtained from satellite data. An example of these data is presented in Figure 48, which shows the increased intensity of satellite chlorophyll measurements along the Chatham Rise for four month period over a summer. Chiswell (2013) (Appendix 8) presents similar data for December 2009 (summer).

5.7.6 Trace elements

Trace element concentrations in waters on the Chatham Rise are low as the waters are remote from terrestrial and atmospheric sources of contaminants. Concentrations follow spatial and vertical patterns that reflect the boundary between the two water masses along the STF, and temporal patterns that are linked to biogeochemical cycles and seasons.

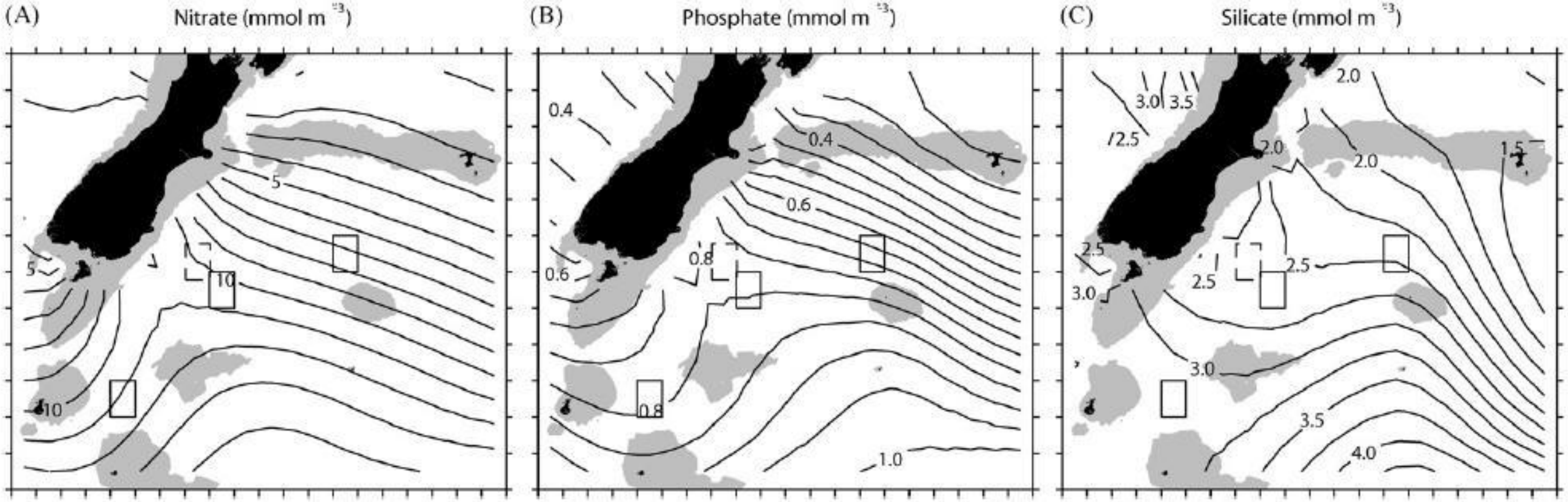

Figure 46: Annual mean nutrient concentrations (at 10 m from the World Ocean Atlas 2005 climatology showing (A) nitrate (contours 0.07-0.14 mg/m^3 nitrate-N), (B) phosphate (0.012-0.031 mg/m^3 as P), (C) silicate (0.056-0.112 mg/m^3 as Si). Adapted from Hadfield 2011.

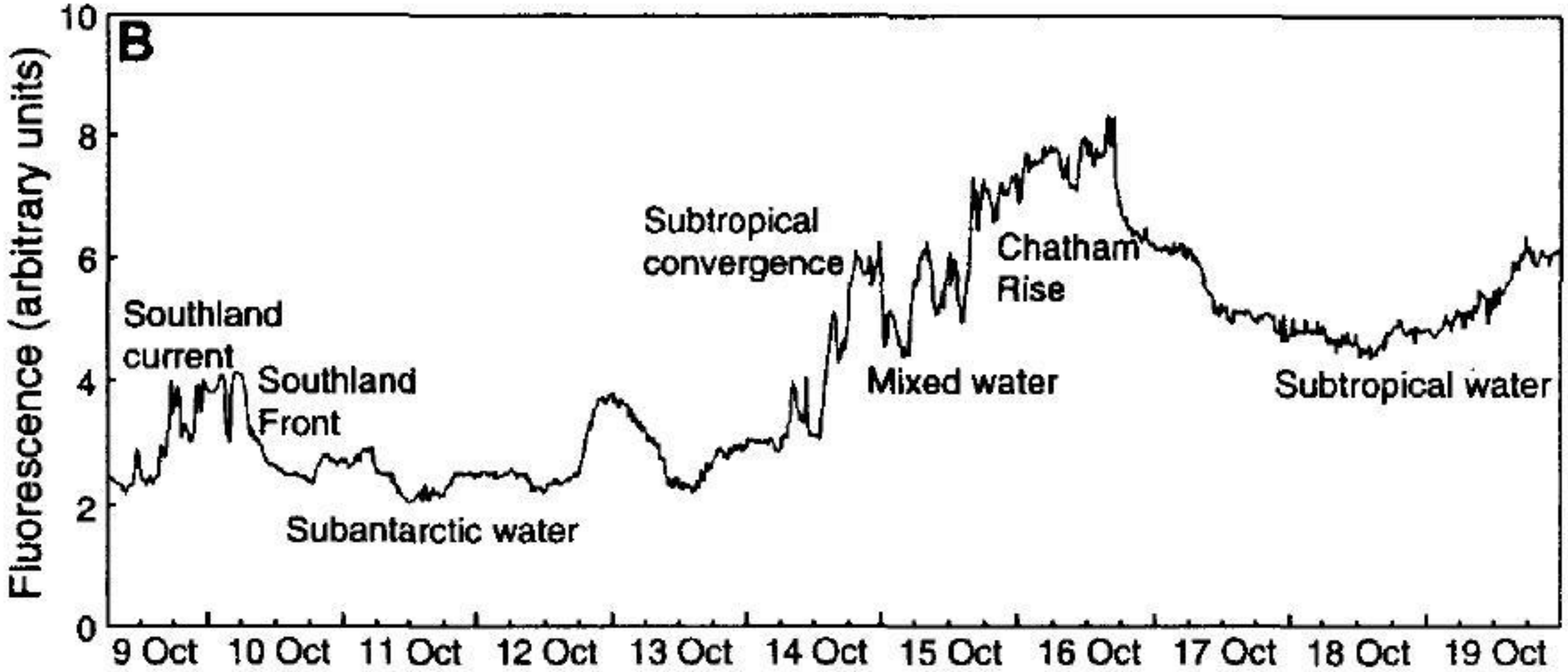

Figure 47: Chlorophyll fluorescence measurements made on a transect across the Chatham Rise, 9 to 19 October 1993 (from Bradford-Grieve et al. 1997). South is to the left, north to the right. Note the elevated levels of chlorophyll over the Chatham Rise.

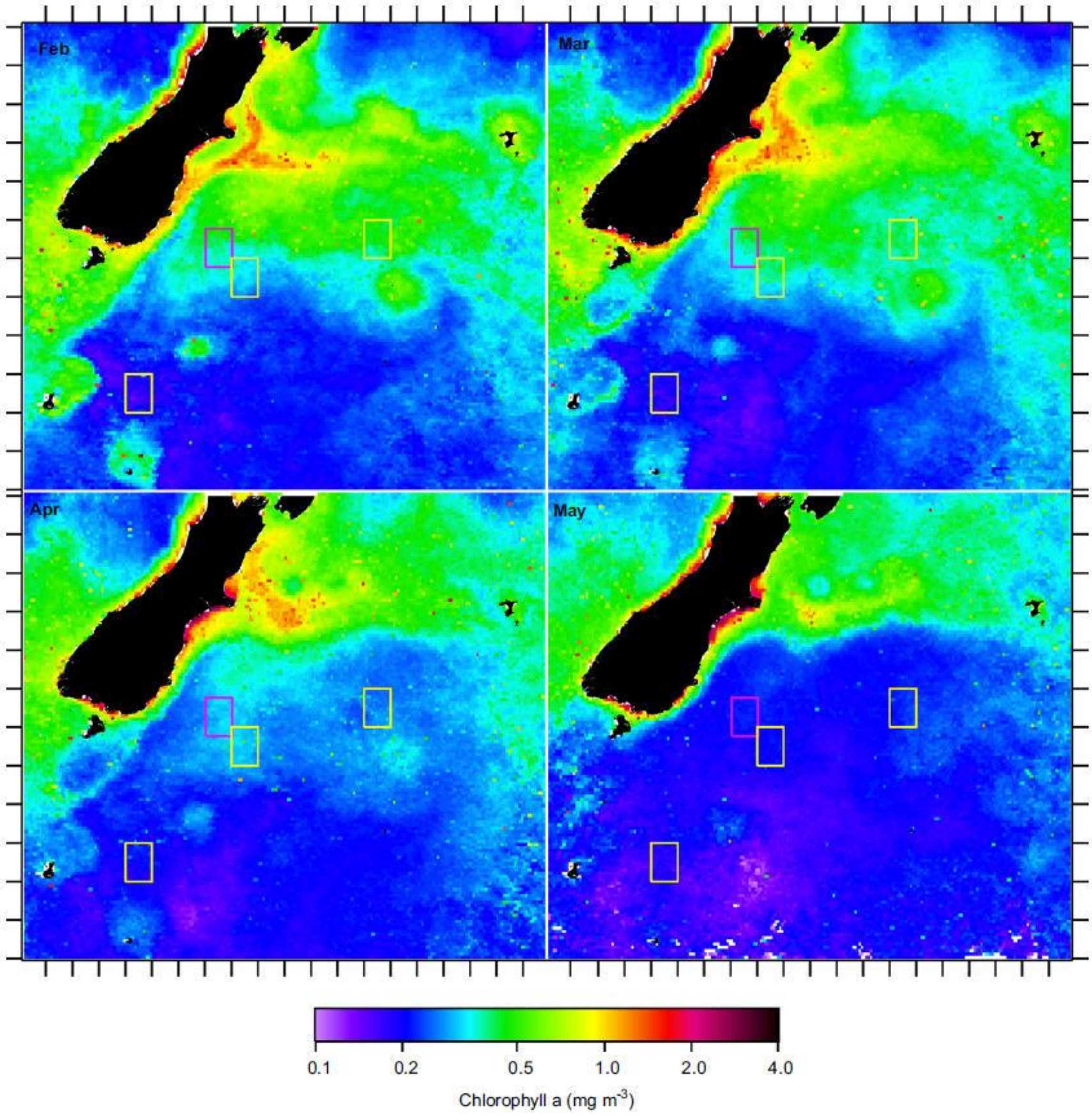

Figure 48: Mean surface chlorophyll concentrations for February through May from SeaWIFS monthly climatology (Figure from Hadfield 2011, shows SAGE iron release and study areas).

No trace element sampling has been undertaken of waters on the Rise specifically for this project as there is no indication that trace element release and mobilisation is a concern associated with mining of seabed sediments (refer Golder 2014a – Appendix 11).

The South Pacific is considered to receive lower fluxes of fluvial and atmospheric derived trace element bearing material compared to the North Pacific or the Atlantic (Donat & Bruland 1995). Input fluxes into the Southern Ocean are lower again. Therefore, although upwelling at the Chatham Rise might slightly increase trace element concentrations relative to the surrounding waters they are still relatively low compared to global ocean concentrations.

In the wider ocean, trace elements concentrations are typically studied to understand natural concentrations or to understand bio-geochemical cycles. In the Southern Ocean (south of the Chatham Rise) several trace element and seawater geochemistry studies have been undertaken. Biogeochemistry studies undertaken across the STF include studies of arsenic and antimony (Ellwood & Maher 2002), germanium cycling (Ellwood & Maher 2003), cadmium-phosphorus cycling (Frew & Hunter 1995) and organic iron speciation (Tian et al. 2006).

Figure 49 illustrates changes in metal and key constituent concentrations from water samples collected along a north-south transect across the Chatham Rise. Values for the key elements[21] on the crest of the Chatham Rise are 0.00065 to 0.0163 mg/m^3 for zinc, 0.011 to 0.022 mg/m^3 for iron, 0.0011 to 0.0067 mg/m^3 for cadmium, 0.032 to 0.052 mg/m^3 for copper, 0.13 to 0.22 mg/m^3 for nickel, 7.7 to 31 mg/m^3 for phosphorus, and 28 to 42 mg/m^3 for silicon.

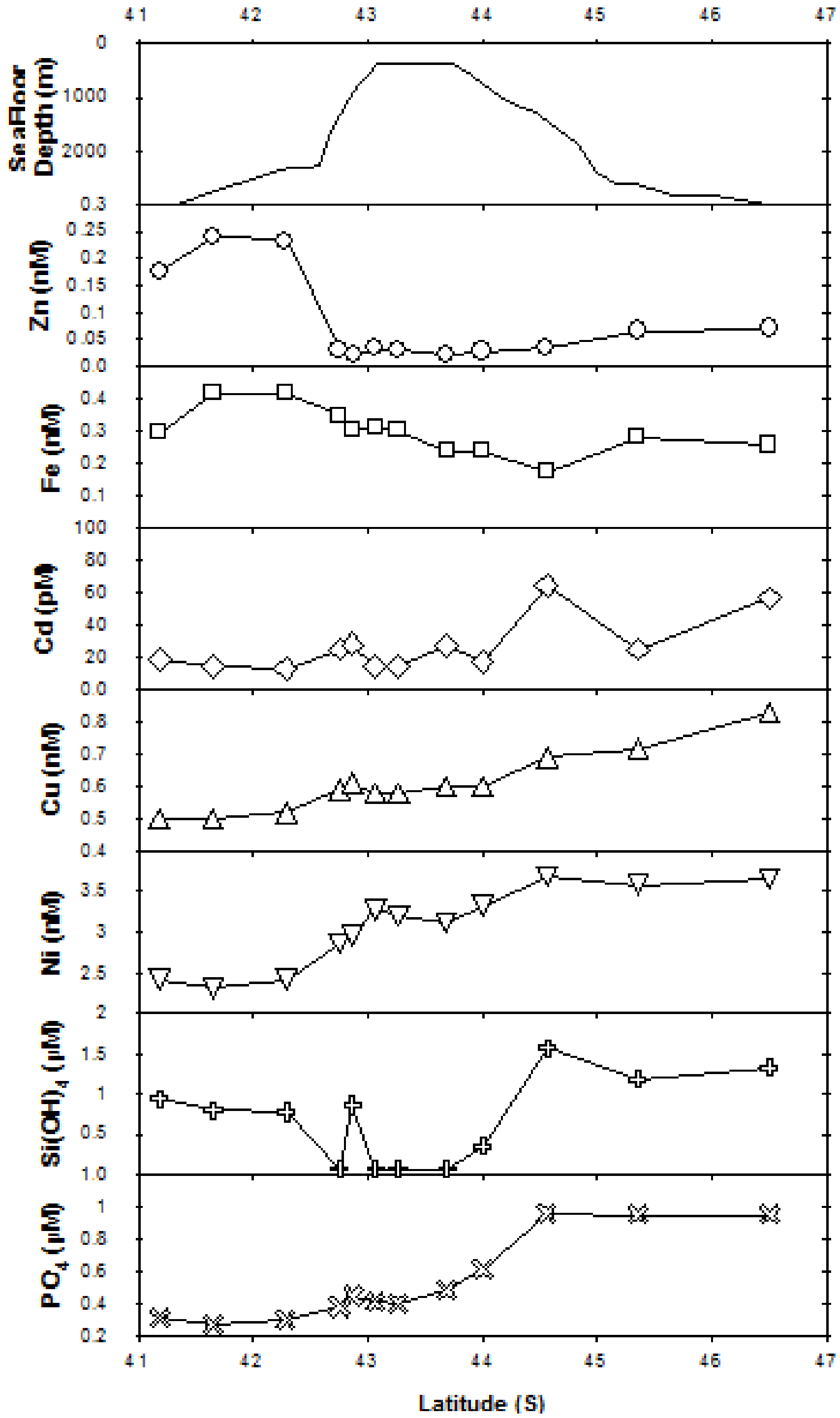

Figure 49: Trace metal results from water samples collected across the STF on the Chatham Rise (data courtesy of NIWA). North is to the left, south to the right.

[21] For the purpose of the overview that follows in this paragraph, the units used in the Figure 49 have been converted to mg/m^3.

5.8 Summary

The marine consent area associated with CRP's mining proposal lies on the crest of the Chatham Rise at a depth of 350 to 450 m. There is a broad saddle in the eastern prospecting area which is about 50 to 100 m shallower. The flanks of the Rise, to the north and south of the marine consent area, are more than 2,000 m deep.

The Chatham Rise phosphorite deposits, formed about 5 million years ago as a result of sedimentary processes, are known to cover much of the eastern half of the Rise. Based on the data currently available, an economic deposit is present within the mining permit area.

The most significant geomorphological features in the marine consent area are furrows and circular features created by icebergs in the last several million years. These features are widespread on the crest of the Chatham Rise.

The Chatham Rise lies at the boundary between warm, saline subtropical waters to the north and cooler, less saline sub-Antarctic water to the south known as the Subtropical Convergence or Subtropical Front. Modelling predicts that the most likely direction of non-tidal component of the seabed currents will be towards the northwest, and that velocities at the seabed may be as high as 40 cm/s. Seabed currents are capable of some resuspension of sediments along the crest of the Chatham Rise.

Relatively stratified oceanic water conditions are predicted to prevail in the marine consent area from November until May. Vertical water mixing velocities near the seabed on the crest of the Rise are in the order to 1 to 2 cm/s.

The geochemistry of the seabed sediments within the marine consent area are predominantly characterised by the area's geology. Key trace elements include low levels of arsenic and cadmium. The phosphorite nodules themselves contain low levels of cadmium and lead, and slightly elevated levels of arsenic and uranium. Uranium from the Rise is not a radioactive hazard to the environment or people.

Dissolved oxygen concentrations on the crest of the Rise are high (6 to 8 mg/L). Trace element concentrations in waters on the Chatham Rise are low as the waters are remote from terrestrial and atmospheric sources of contaminants. Background turbidity levels near the seabed are predicted to be less than 1 mg/L.

6. The Chatham Rise – Biological Environment

KEY ELEMENTS

- The Chatham Rise is probably the best studied area in New Zealand's EEZ. There are still gaps in the data, but as a result of the area's high productivity and its consequent importance for commercial fishing considerable research investment, including the research undertaken by CRP, has been made to understand its benthic and pelagic environments.
- The biological environment of the Chatham Rise reflects the area's morphology and major oceanographic currents.
- The biological environment is variable over spatial scales ranging from tens of metres to hundreds of kilometres. While recognising this fact, all of the crest of the Chatham Rise is included in one benthic-optimised marine environment classification area (which is significantly different from those associated with northern and southern flanks, elevated banks and seamounts).
- Analysis of data and predictive benthic habitat modelling from samples and observation data from within the proposed marine consent area identified 13 epifaunal communities and five infaunal communities. The distribution of these communities was explained by the sea surface temperature gradient, depth, nodule content and sediment type. Habitat suitability modelling predicts that all the identified epifaunal communities could be more widespread on the Chatham Rise, including the communities dominated by the stony coral *G. dumosa*.
- Primary production on the Chatham Rise is driven by enhanced phytoplankton growth within the euphotic zone over the Chatham Rise and its adjacent waters.
- There are a number of commercial fisheries on the Chatham Rise which include hoki, hake, ling, silver warehou, orange roughy, oreos and scampi. Other fish species are also caught on the Rise. There are also important local inshore fisheries around the Chatham Islands for paua, rock lobster, blue cod, and hapuku.
- Spawning grounds and nurseries for some commercial fish species occur on the Chatham Rise, particularly the flanks.
- Most bottom trawling occurs along the flanks of the Rise, generally at least 10 to 15 km from the proposed mining area. Records show that significant long-lining occurs in CRP's eastern prospecting permit area and to the north of the mining permit area.
- Marine mammals have been observed along the Chatham Rise but there has been no systematic study of their distribution. There is some evidence that several species of cetaceans have a strong regional linkage to the environment on the south flank of the Chatham Rise. There is no indication that other marine mammals have significant dependencies on the Chatham Rise.
- There are at least three rare or endangered seabirds that nest on the Chatham Islands. These and numerous other seabird species utilise the Chatham Rise for food.

6.1 Introduction

The biological environment of the Chatham Rise has developed as a consequence of its physical and oceanographic characteristics, with past and current human activities, mainly fishing, also influencing the nature of the environment.

As described in Section 5, the Chatham Rise has several large shallow banks, slopes providing a transition to deep waters to the south and north, and seamounts scattered primarily around the edges of the Rise. The general bathymetry of the crest of the Chatham Rise varies by only about 100 m over tens of kilometres, but there are also local features such as iceberg furrows and pockmarks that provide localised, relatively small scale changes in bathymetry (refer to Section 5.2). The physical presence of the Rise between two significant ocean systems leads to regionally and seasonally high levels of primary production that supports commercially-important populations of demersal and deep water fish.

This section of the EIA describes the key features of the biological environment associated with the Chatham Rise. The information is supported by a series of technical documents appended to this EIA:

- An assessment of the macro-faunal and faunal communities on the Chatham Rise (Beaumont et al. 2013a) (Appendix 13).
- Biological and fishing data associated with the Chatham Rise (Beaumont et al. 2013b) (Appendix 14).
- Benthic communities of the Chatham Rise including the MPL 52070 (Rowden et al. 2013, 2014a) (Appendices 15 and 16).
- Information on the catchability of fish species on the Chatham Rise (Golder 2014b) (Appendix 17).
- Information on the hoki fishery on the Chatham Rise (O'Driscoll & Ballara 2014) (Appendix 18).
- Information on the ling fishery on the Chatham Rise (Baird 2014) (Appendix 19).
- Information on distribution patterns of marine mammals (cetaceans) in the area (Torres et al. 2013a) (Appendix 20).
- A summary of the Chatham Rise's seabirds (Thompson 2013) (Appendix 21).
- An ecosystem modelling assessment of the Chatham Rise (Pinkerton 2013) (Appendix 22).

The ecosystem modelling, or trophic model, contained in Pinkerton (2013 – Appendix 22) outlines the linkages and thus identifies strengths of relationships between different species within the Chatham Rise ecosystem. Within this section of the EIA the trophic importance (TI) of different species, in terms of where they are located within the food web and thus trophic levels, are identified. Section 6.13 then describes the Chatham Rise ecosystem based on this model, while Section 8.6 assessed potential trophic impacts associated with CRP's mining proposal. TI can be estimated from a single-step trophic matrix (i.e., focus on direct (first-order) predator-prey linkages, referred to as TI1) or a multi-step matrix (i.e., considers multiple interactions in the ecosystem and may incorporate higher-order effects, referred to as TI2).

As a result of the historical and modern interest in phosphorite and the importance of the Chatham Rise to New Zealand's fisheries, the benthic environment and organisms, and the oceanographic conditions affecting them, in and around the marine consent area are among the best known, if not the best known, in New Zealand's EEZ. The level of information about the benthic habitats and communities is greatest in the existing mining permit area, but there is a comparable density of environmental samples and observations throughout the marine consent area and the surrounding region, sufficient to support robust analyses of the likely distribution of these environments and communities.

6.2 Benthic Habitat

6.2.1 Overview

Benthic habitats along the Chatham Rise are observed to vary over short distances (tens of metres), but they are also influenced by regional aspects such as seabed morphology and geology and the oceanographic conditions on the Rise.

The Chatham Rise is a large feature that provides varying habitat because of its scale, varying depth and geology. The key features of the Chatham Rise are the smoothly sloping north and south facing flanks, the generally flat crest, and the local banks and isolated groups of volcanic peaks or seamounts that provide relief (refer below).

Physical habitat varies significantly between the flanks and crest of the Rise where the seabed is usually relatively smooth and soft, and the elevated banks and seamounts where hard rock substrate can be found. Both shallow depth (providing light) and hard substrate tend to support increased biodiversity. Shallow banks such as Mernoo Bank, at the western end of the Rise, are within the photic zone and support benthic macroalgae, fish, and diverse assemblages of sessile and mobile fauna normally associated with coastal rocky reef sites. Habitats of this type do not occur within or close to CRP's proposed marine consent area, which is well below the photic zone.

An interesting feature of the benthic ecosystem of the Chatham Rise is the difference between biological communities on the northern and southern slopes of the Rise (Beaumont et al. 2013a – Appendix 13, Rowden et al. 2013 – Appendix 15). These differences have been attributed to the differing quantity and quality of benthic flux generated from the water masses on either side of the STF (Probert & McKnight 1993, Nodder et al. 2007, Beaumont et al. 2013a).

Habitat types across the Chatham Rise were described by Hewitt et al. (2011) as part of the OS20/20 survey and summarised by Beaumont et al. (2013a) (Appendix 13). These are shown in Figure 50 and the habitats in and around the marine consent area are summarised in Table 7. Habitat definitions were based on variables such as water depth, sediment type, seabed roughness, currents, production, and local water column physical characteristics. The habitats B5 and B7 are most similar to those in the proposed marine consent area.

Table 7: Habitats identified along the crest of the Chatham Rise (from Hewitt et al. 2011, Beaumont et al. 2013a).

Habitat code	Depth (m)	Physical Characteristics	Biological characteristics
B5	210-682	Shallow, low roughness, muddy	Variable communities of surface bioturbators (Parapaguridae, Onuphids and Gastropods) (NB, beam trawl samples very variable)
B6	150-824	High phytodetritus	Dominated by bioturbators (Parapaguridae and Spatangidae, shrimps and 2 infaunal Gastropods)
B7	249-587	-	Dominated by bioturbators (Decapods *Munida gracilis* & *Notopandalus magnoculus*) with some habitat structure (Chaetopterids, sled data only), high epifaunal beta diversity

Habitat code	Depth (m)	Physical Characteristics	Biological characteristics
M10	100-1270	High currents, sandy, low TOM, high calcium carbonate	Dominated by anemones
M13	96-1004	-	Variable community (Polychaetes, encrusting sponges, bryozoans and anemones) with high habitat structure
M17	293	-	Mobile predator (*Astropecten*/*Lithosom*a)
M19	253	-	Anthozoa and Scaphapoda

6.2.2 Seamounts and complexes

Seamounts are an important feature on the Chatham Rise, although they are not present within the marine consent area. The biodiversity and ecology of the seamounts have been the subject of many scientific studies (e.g., Clark & Rowden 2009).

Noteworthy features on the Chatham Rise include the Graveyard seamount complex (Beaumont et al. 2013a) (Figure 26 in Section 5). The Graveyard seamount complex is about 50 km north of CRP's proposed mining area. It comprises 28 volcanic features spread across about 140 km^2, in water depths between 1,050 and 1,200 m, on the northern edge of the Chatham Rise. The seamounts are 100 to 400 m high and have in summit depths of 750 to 1,000 m (Clark et al. 2010).

The Box Hill complex is approximately 200 km east of the Graveyard seamount complex and about 100 km north-northwest of the Chatham Islands. This complex includes a main hill (up to 200 m in elevation), three small hills (approximately 50 m elevation) and a small trench area (Tracey et al. 1997). This area is close to, and possibly part of, a spawning ground for orange roughy (Beaumont et al. 2013b – Appendix 14).

6.3 Benthic Fauna

6.3.1 Introduction

Benthic fauna are those organisms directly or closely associated with the seabed. Benthic fauna on the Chatham Rise comprise meiofauna (infaunal biota in the size range 45 µm to 0.5 mm), macrofauna / macrobenthos (organisms >0.3 mm in size), and megafauna / megabethos (organisms >50 mm in size). Hyperbenthic fauna are those organisms that spend time both in the benthos and in the water layer above the seabed (<1 m).

Several studies of the Chatham Rise benthos have been made since with 1950s, including expeditions in 1954 (Knox 1960, Hurley 1961), 1981 (Dawson 1984) and 1989 (Probert et al. 1996, Probert & McKnight 1993, McKnight & Probert 1997). The locations of the seabed sampling sites from the 1954 and 1989 surveys are shown in Figure 51. Most notably, the 1954 expedition collected trawl samples along two transects through the marine consent area. The most current benthic information is presented in four reports appended to this EIA, Beaumont et al. (2013a,b) and Rowden et al. (2013, 2014a) (Appendices 13 to 16). Pinkerton (2013) (Appendix 22) provides a discussion of the benthos within the context of the wider ecosystem on the Chatham Rise.

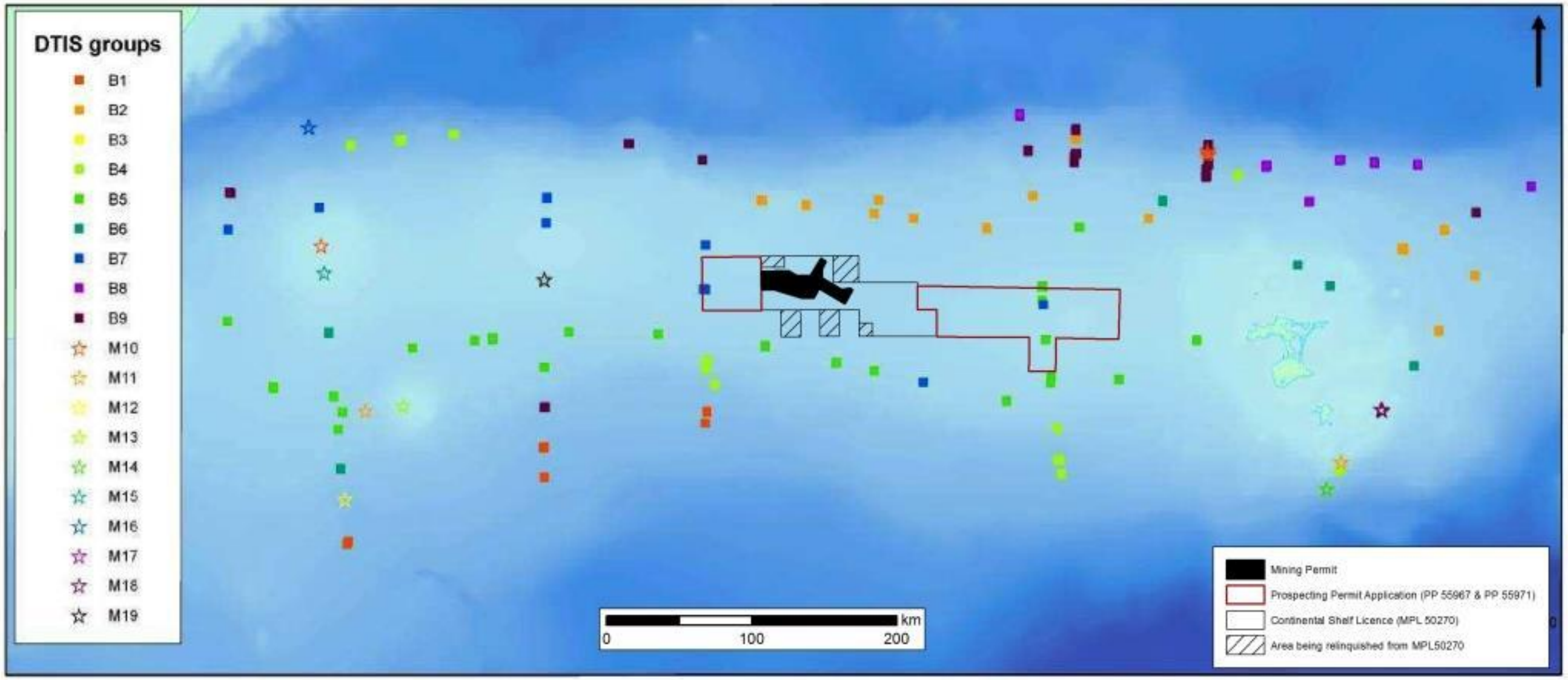

Figure 50: Biotic habitats on the Chatham Rise determined from OS20/20 survey data collected in 2007 (from Hewitt et al 2011; see also Beaumont et al. 2013a) (Note: proposed marine consent area shown in the middle of figure) (DTIS – deep towed image system).

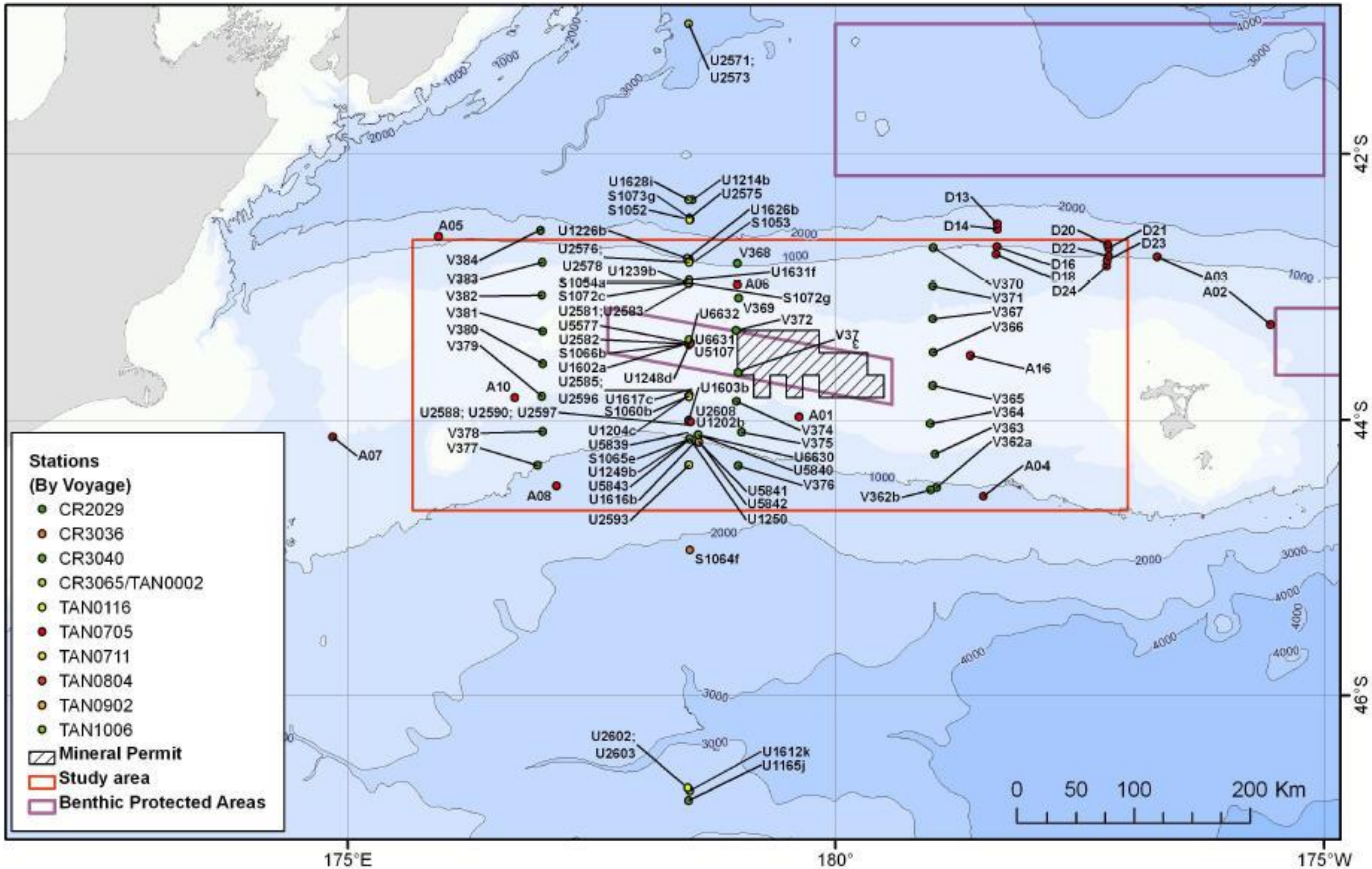

Figure 51: NIWA and NZOI benthic infaunal sampling locations on the Chatham Rise between 1989 and 2010 (From Beaumont et al. 2013a).

Within the benthic habitats, the meiofauna appear to be dominated by nematodes (Nodder et al. 2003). Macrofauna include epifauna (those organisms associated with the seabed surface) and infauna (those organisms that reside within the sediment) and is comprised of both hard-bodied animals (including ostracods, euphausiids, mysids, copepods, tanaids, cumaceans, isopods, bivalves, crabs) and soft-bodied animals (mainly polychaetes and chaetognaths). Megafauna assemblages include large mobile hyperbenthic invertebrates (e.g., decapods), sessile invertebrates (e.g., corals, sponges, crinoids), echinoderms, polychaetes, molluscs, and bottom-dwelling cephalopods.

Megabenthic decapoda on the Chatham Rise include squat lobsters (e.g., *Munida gracilis*), scampi (*Metanephrops challengeri*), shrimps (e.g., *Pasiphaea barnardi*, *Oplophorus novaezeelandiae*), crabs (e.g., *Pycnoplax victoriensis),* hermit crabs (e.g., *Sympagurus dimorphus*) and isopods (e.g., *Brucerolis* sp.) (Pinkerton 2013). The composition and distribution of these fauna are described below.

6.3.2 Studies prior to 2012

Dawson (1984) noted that the fauna communities changed as habitat changed with large deposit feeding echinoids, asteroids and gastropods associated with fine sediment, and areas of complex microhabitat such as outcrops of hard substrate and phosphorite nodules inhabited by sponges, corals, brachiopods and bivalves. Dawson (1984) also noted that 47 % of the taxa observed were carnivores, 35 % were deposit feeders and 18 % were suspension feeders. Trophic groups are further considered at the end of this section.

Probert & McKnight (1993) and Probert et al. (1993, 1997) identified three types of epibenthic communities on the crest of the Rise. The shallowest community was located on sandier sediments on the crest and shallower flanks of the Chatham Rise at depths of 237 to 602 m, the depths of CRP's proposed mining operations, and is characterised by crustaceans, and two deeper water communities characterised by echinoderms. The key fauna of this community included squat lobsters (*M. gracilis, Phylladiorhynchus pusillus*), shrimp (*Campylonotus rathbunae, Pontophilus acutirostris*) and other crustaceans (*Acutiserolis bromleyana*), brittlestars (*Amphiura lanceolata*), and bivalve molluscs (*Cuspidaria fairchildi, Euciroa galatheae*).

Beaumont et al. (2013a) noted that Dawson (1984) identified a relationship between large phosphorite nodules and branching corals such as *Goniocorella dumosa* and gorgonian corals. Nodule density also appeared to be correlated with a greater abundance of crabs, molluscs, asteroids and cidarid urchins. It was also noted that there appeared to be dense beds of sponges and brachiopods (lamp shells) in areas of dense phosphorite nodules. The relationship was considered highly likely to be due to the availability of hard substrate for attachment by sessile organisms.

Since 2001, several voyages have studied benthic invertebrate assemblages on the Chatham Rise. Figure 51 illustrates where quantitative infauna samples have been collected on the Chatham Rise by NZOI and NIWA between 1989 and 2010.

In 2007, the Chatham Rise was surveyed as part of New Zealand's OS20/20 initiative. The survey examined 100 sites distributed across eight predefined environmental strata, with seabed samples for fauna and sediment analysis collected to characterise habitat diversity and its relationship to benthic biodiversity (Bowden 2011). The primary sampling equipment used was a towed underwater camera system with video and still image cameras, and an epibenthic sled. One hundred and fifteen 1-hour video transects were collected and analysed for the presence and abundance of benthic invertebrate fauna. Epibenthic sled samples were taken at the same sites to confirm identifications of taxa seen in the video, and to generate independent estimates of abundance and diversity. At a subset of 17 sites, a multi-corer was deployed to sample infauna (bacteria, meiofauna, macrofauna) and seabed sediments.

Leduc & Pilditch (2013) examined meiofauna in core samples collected on the Chatham Rise at 345 m depth just north of MPL 50270 during a cruise in February 2011 (TAN1103). The sediments contained 362 species of nematodes from 146 genera.

Apart from the shallow banks which extend into the photic zone, the crest of the Chatham Rise consists of sediment substrates populated by mobile fauna, with conspicuous examples including scampi, squat lobsters, several crab species, quill worms (*Hyalinoecia longibranchiata*), urchins (*Parametia peloria* and other spatangids) and seastars. Sediment cover is often thin, and where rock or larger phosphorite nodules are exposed sponges, stylasterid hydrocorals, and other sessile suspension-feeding fauna occur. Most sessile fauna on the crest of the Chatham Rise are small and relatively sparsely distributed. Large (>1 m) hexactinellid sponges (*Hyalscus* sp.) are locally common in the centre and toward the western end of the Chatham Rise and have been noted within CRP's proposed marine consent area (Kudrass & Cullen 1982).

6.3.3 Recent studies

6.3.3.1 Introduction

A survey to understand the habitat and benthic ecology within CRP's mining permit area was undertaken in early 2012 using the research vessel Dorado Discovery. Rowden et al. (2013) (Appendix 15) describe the planning for the collection of habitat and ecological data on the 2012 cruise. This work consisted of:

- Recording remotely operated vehicle (ROV) video along transects about 1 nm long in 13 sampling areas (three transects in each area, a total of 39 tracks).
- Taking ROV still images every 15 seconds along each track.
- Examination of the live ROV video feed from each transect by observers and recording surface biological and geological information.
- Collecting two box core samples from each transect for physical and biological analysis (refer following sections). This yielded four to six samples per area and 74 samples in total.

This sample collection results in data describing epifauna and infauna benthic communities and species. Sample locations are shown in Figure 52.

Rowden et al. (2013) describe in detail the habitat characterisation and analyses of the seabed images collected in 2012. The results of the analysis of bathymetric data, and substrate data compiled from sediment samples taken during all surveys in the study area, are described by Nodder et al. (2013) (Appendix 9).

In June 2013, NIWA undertook another OS20/20 voyage to the Chatham Rise to determine the benthic epifaunal community structure within CRP's mining permit area and elsewhere on the crest of the central Chatham Rise, and the environmental drivers of any patterns observed, NIWA used the data to produce predictive models of the distribution of benthic epifaunal communities and also compared the structure and distribution of benthic epifaunal communities in the mining permit area and elsewhere on the crest of the central Chatham Rise with benthic epifaunal communities previously sampled elsewhere in the New Zealand region.

Three regions were selected for study by the OS20/20 survey in 2013, the Mernoo Gap ('Mernoo' region), the southern flank of the Rise ('South' region), and the Mid Chatham Rise BPA ('Crest' region). Sample locations are shown in Figure 53 for the 2013 OS20/20 voyage. Sampling within the Crest region also enabled comparisons with samples collected during the CRP research voyages (Rowden et al. 2013). Rowden et al. 2014a (Appendix 16) reports on and compares the results of the 2013 OS20/20 survey to the results of the 2012 CRP environmental survey and the 2007 OS20/20 survey. The 2013 OS20/20 survey provides environmental information about habitats on a wide area of the Rise, and context for CRP's marine consent area.

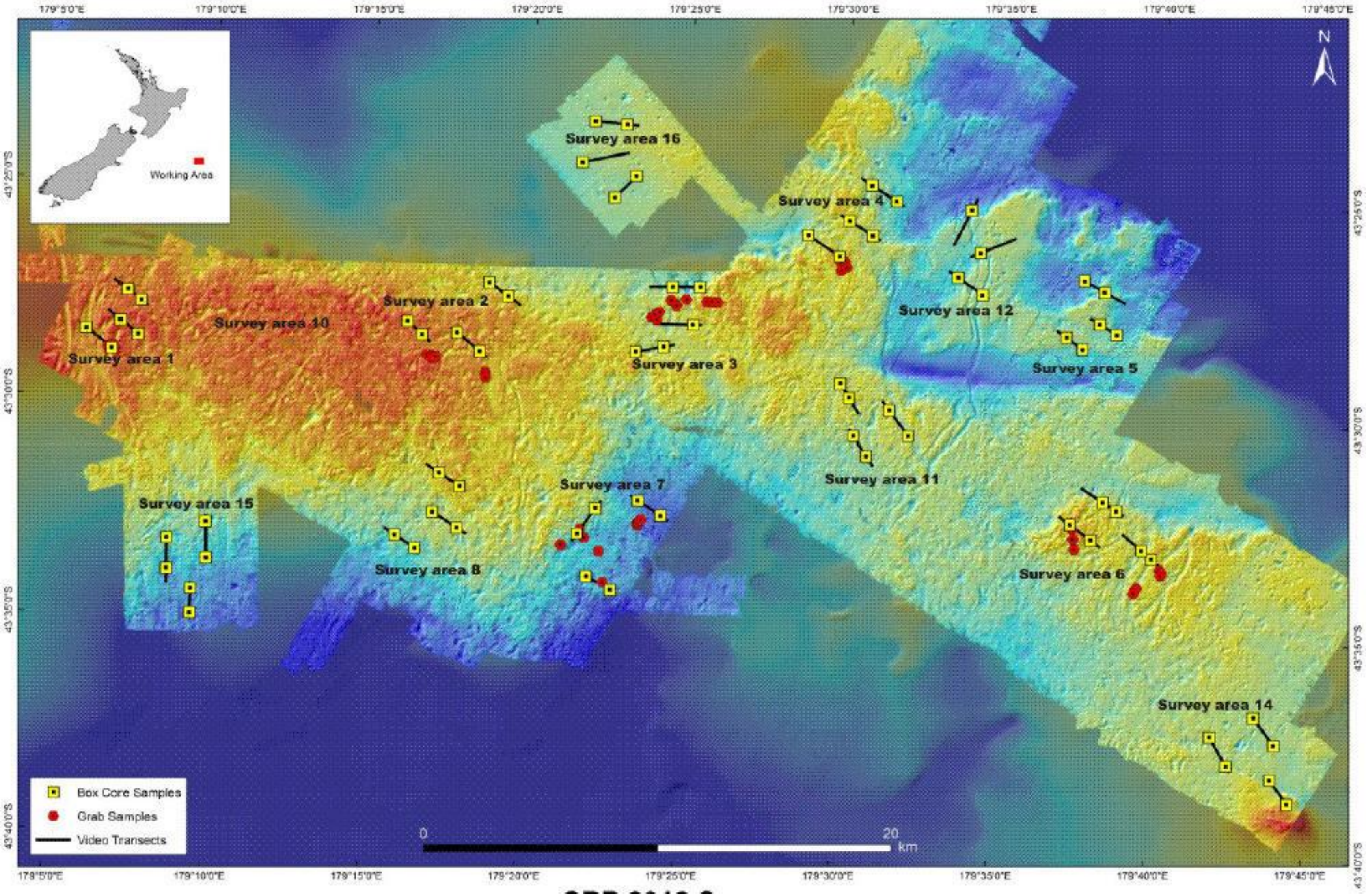

Figure 52: March 2012 Dorado Discovery survey showing environmental sampling including ROV transects, box cores and grab samples.

The integrated data used in the assessment in Rowden et al. (2014a) consisted of:

- The video and still images taken by cameras on an ROV during the CRP environmental survey (as described above and in Rowden et al. 2013).
- Video and still images taken by cameras on NIWA's Deep Towed Imaging System (DTIS) to characterise benthic habitat and to sample mega- and macrobenthic communities. DTIS transects were of 1 hour duration at a target speed of 0.25 m/s and altitude of 2.5 m above the seabed.

The analysis process for the combined 2012 CRP, 2007 OS20/20 and 2013 OS20/20 dataset was modified to accommodate variations in how the data were collected, including how species (particularly fish and cephalopods) responded to the sampling methods (ROV versus towed video) and for the variable resolution in the still images. Data were interpreted at the level of individual images and at the level of transects. Further explanation of data modifications and analysis is in Rowden et al. (2014a) (Appendix 16).

6.3.3.2 Epifauna

Key species and community composition

Epifauna described from the ROV transects included a total of 36,018 individuals belonging to 77 epifauna taxa (Rowden et al. 2014a - Appendix 16). The most diverse group was the echinoderms (28 taxa), followed by sponges (17) and cnidarians (13). The most abundant taxa were "encrusting bryozoan/sponge/ascidian" (5,714 counts), irregular urchins (2,295 counts), the stony coral *Goniocorella dumosa* (1,897 counts), lamp shells (1,361 counts), "branching bryozoan/hydroid/other" (859 counts), sea anemones (422 counts) and squat lobsters (367 counts).

The 3,908 images were classified into 13 epifaunal communities, with eight of these best describing the epibenthic fauna of the study area. The remaining 'communities' were largely comprised on a small number of images with very few or no fauna present.

Key epibenthic communities identified by Rowden et al. (2014a) were (Figure 54):

- Communities *f* and *p* – the two smallest communities had low densities of encrusting bryozoan/sponge/ascidian, irregular urchins and branching bryozoan/hydroid/other.
- Community *g* – the largest community characterised by irregular urchins in low density.
- Community *j* – dominated by sea anemones and hermit crabs (Paguridae).
- Community *m* – characterised by lamp shells.
- Community *n* – characterised mainly by a relatively high abundance of encrusting bryozoan/sponge/ascidian and the presence of *G. dumosa*.
- Community *o* – characterised by stony coral *G. dumosa* and, to a lesser extent, branching bryozoan/hydroid/other and encrusting bryozoan/sponge/ascidian.
- Community *q* – the second largest community with low density of encrusting bryozoan/sponge/ascidian.

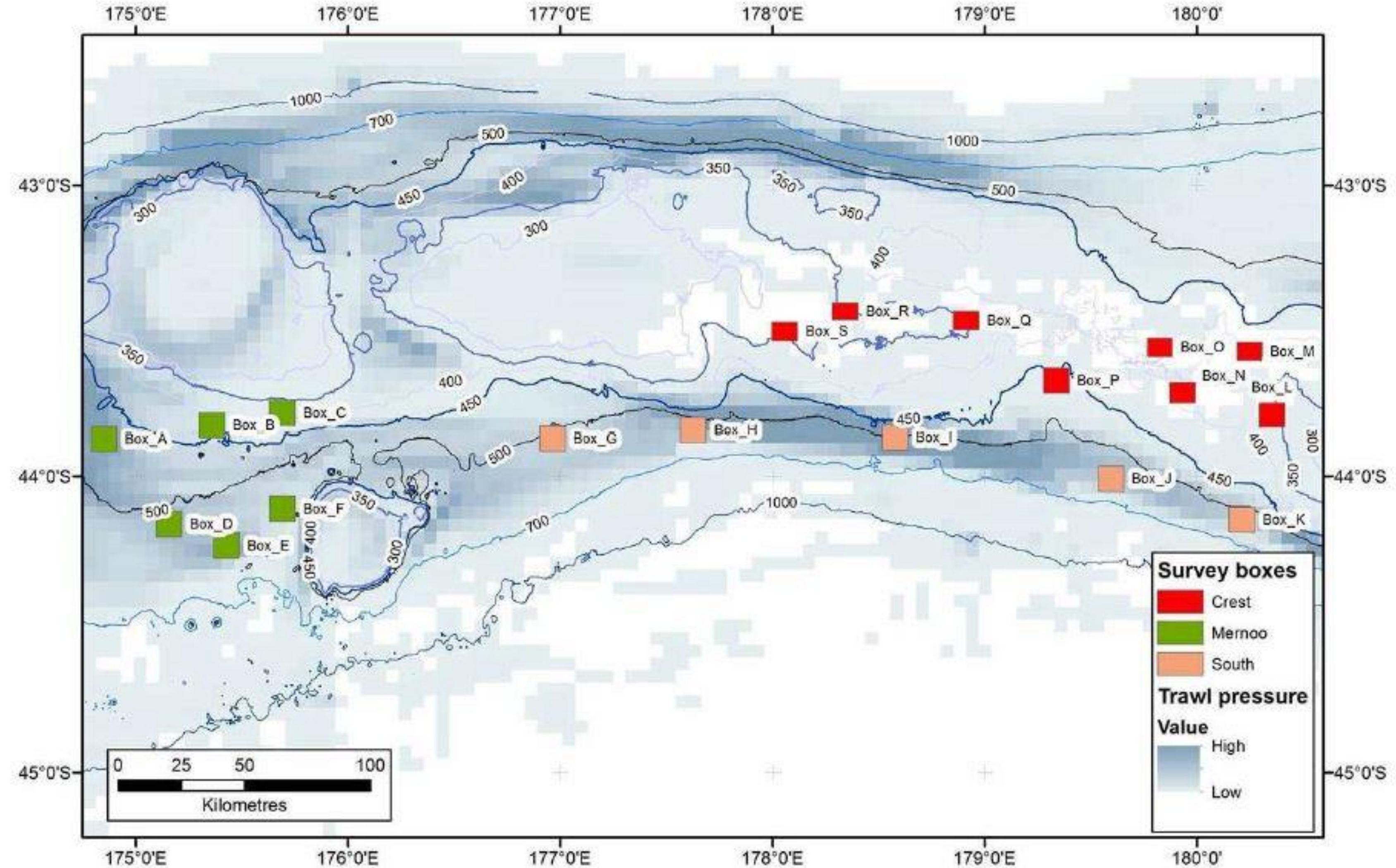

Figure 53: Chatham Rise Benthos OS20/20 2013 survey included three regions selected on trawling pressure: the Crest, Mernoo and South regions.

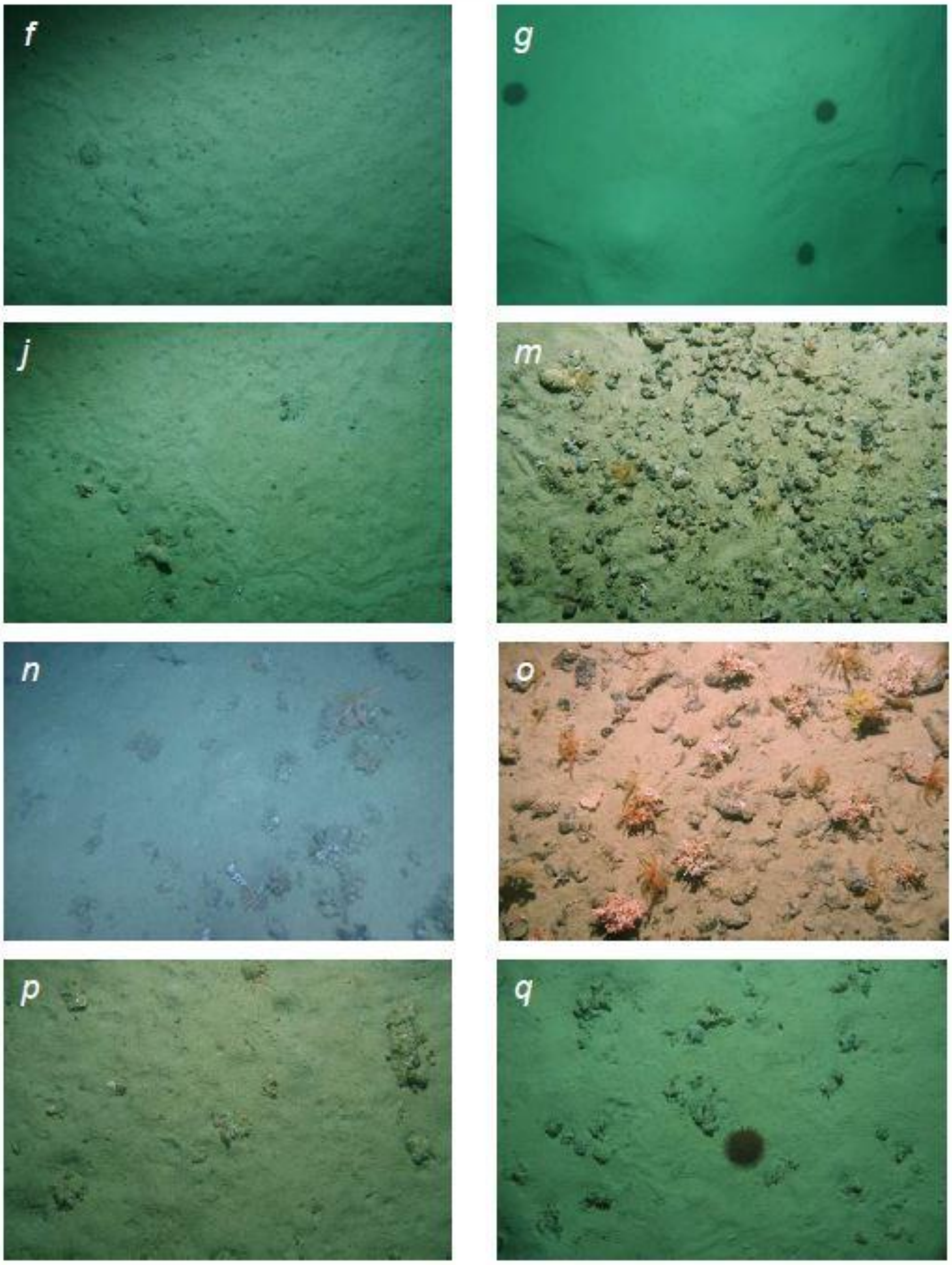

Figure 54: Seabed images representative of the epifaunal communities (image-level) identified in Rowden et al. (2014a) (Appendix 16).

Five key epifaunal communities were identified from transect-level data (Figure 55):

- Community *a* – had low faunal abundance with mostly sea anemones, squat lobsters and hermit crabs.
- Community *b* – the smallest community was characterised by low abundance of mostly irregular urchins.
- Community *d* – had moderate abundance of encrusting bryozoan/sponge/ascidian, sea anemones, lamp shells and hermit crabs.

- Community *j* – characterised by the low faunal abundance and dominated by encrusting bryozoan/sponge/ascidian, irregular urchins and branching bryozoans/hydroid/other.
- Community *l* – the largest community with high epifauna abundance, dominated by encrusting bryozoan/sponge/ascidian and *G. dumosa*.

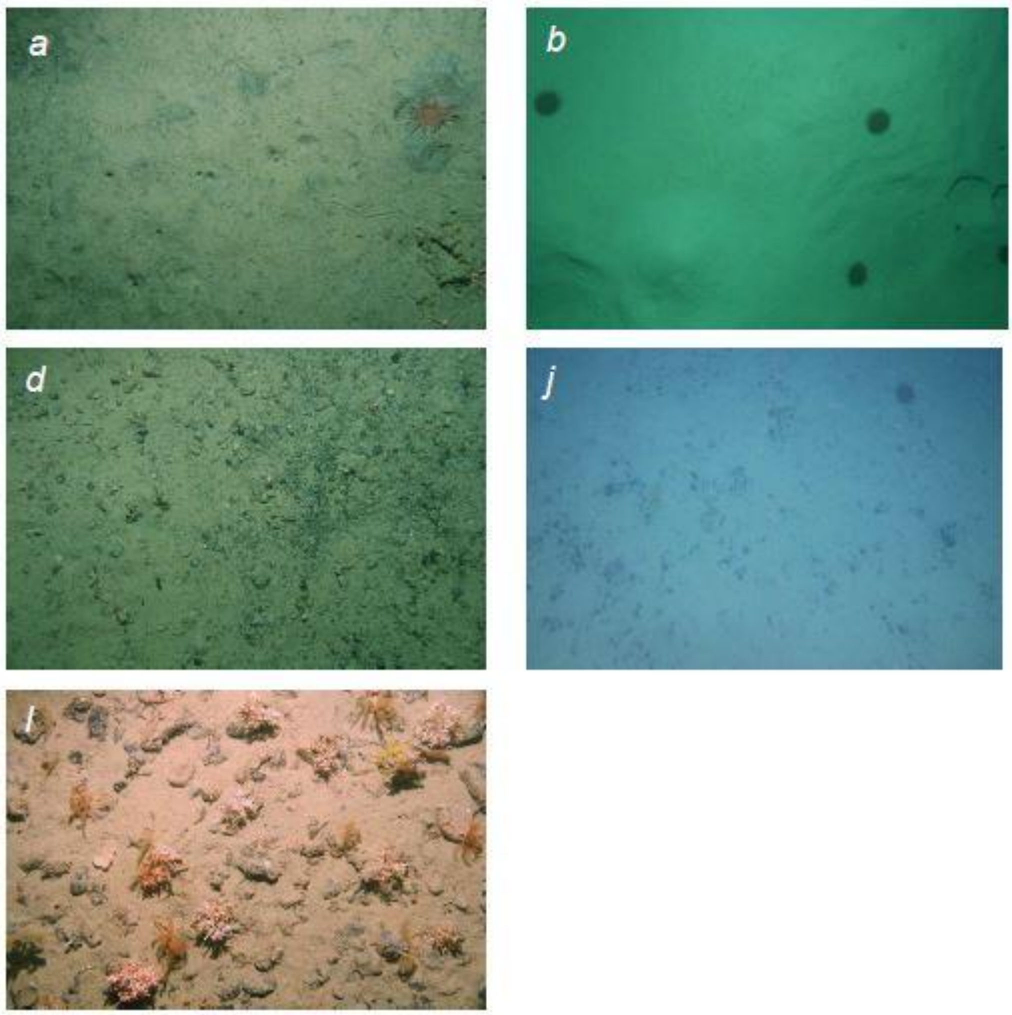

Figure 55: Seabed images representative of the epifaunal communities (transect-level) identified in Rowden et al. (2014a) (Appendix 16).

Another seven epifaunal communities identified at the transect-level (additional to those described above) were found at only one or two transects and were not described further. At the image-level analysis, Communities *n* and *o* had the most similar composition of all communities described. At the transect-level, Communities *j* and *l* were the most similar dominated by encrusting bryozoan/sponge/ascidian. The distribution of epibenthic communities determined at the transect-level is shown in Figure 56. The stony coral *Goniocorella dumosa* featured predominantly in the epibenthos and is further discussed in Section 6.3.3.3.

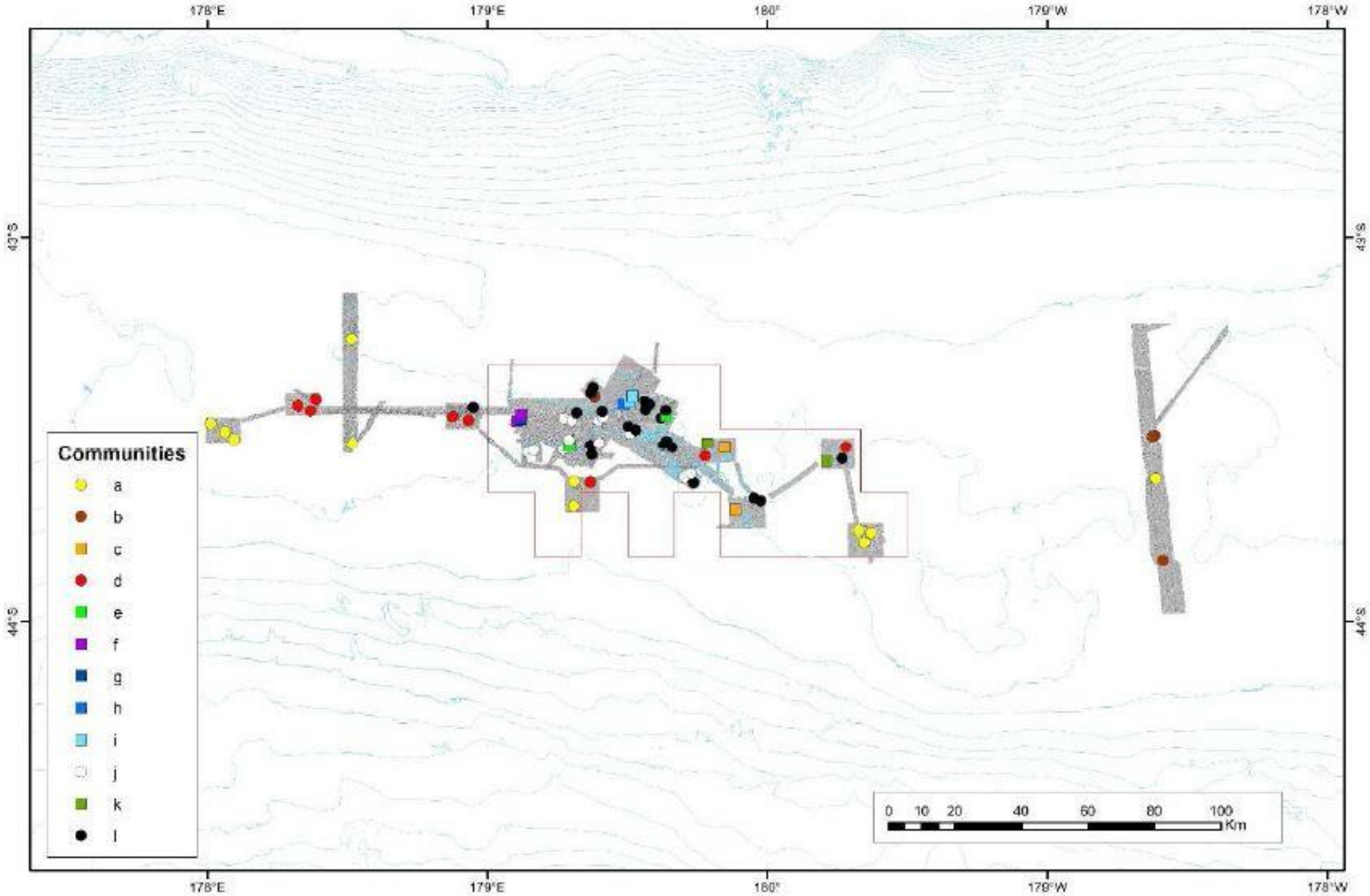

Figure 56: Distribution of epifaunal communities (transect-level) within the marine consent area (from Rowden et al. 2014a) (Appendix 16).

Modelling of epifauna relationship with seabed characteristics

Rowden et al. (2014a) (Appendix 16) examined the relationship between the epifauna data and a wide range of physical information. The modelling approach (Boosted regression trees (BRT)) allowed the interpretation of complex relationships between species or communities and their environment. BRT models of species distribution have been shown to be an effective method to understand the ecological drivers of species distribution patterns, and a reliable approach to generate predictions of species distributions across many scales (refer to Rowden et al. (2014a) (Appendix 16) for detail on the physical factors and the modelling approach used to explore the relationship between community distribution and the physical seabed environment).

Modelling of the epifaunal communities based on image-level data indicated suitable habitat for the key epifaunal communities as described above as follows:

- Community *f* - predicted to occur primarily in the western part of the study area, and in smaller areas towards the eastern side of the study area. Only small areas of high habitat suitability for this community are predicted to occur in the mining permit area, at the eastern margin of MPL 50270 and into PP 55967. Within the marine consent area, this habitat is most likely to occur in PP 55967. The distribution of suitable habitat for this community is related primarily to depth, with shallower depths (<380 m) representing more suitable habitat. Other relatively important variables for predicting habitat suitability are bottom current speed (when higher) and the nodule content of the sediment (when not very low).
- Community *g* – predicted to occur in patches almost throughout the study area (the exception being the areas predicted to be suitable habitat for Community *f* above). A relatively large part of the marine consent area is predicted to include suitable habitat for this community, predominantly within the mining permit area, some suitable habitat predicted for PP 55971 and moderate to patchy likelihood of occurrence in PP 55967. However, there is also a high likelihood of this community occurring in patches throughout the wider study area outside of the marine consent area. Twelve environmental variables were identified as relatively equally important for predicting suitable habitat for this community, with only depth and aspect each contributing >10 % to the model. Habitat suitability tended to be higher when depth was relatively deep and the aspect of the seafloor topography was between north and east.
- Community *j* – predicted to occur mainly along the deeper northern and southern flanks of study area, and at the shallowest depths of the study area to the west and east the mining permit area but very little likelihood of occurring within MPL 50270. It is possible that this community may be found in moderate, patchy distribution throughout PP 55971 and PP 55967, although key locations for this community are generally outside of the proposed marine consent area. Four environmental variables contributed >10 % to the model, and areas with relatively high and low dissolved organic matter (DOM), and low SST gradient provided the most suitable habitat.
  - Community *m* – the greatest probably of encountering this habitat occurs well to the northwest of the marine consent area but there is moderate to high probably of relatively small patches of this habitat occurring within MPL 50270 (predominantly in the mining permit area), as well as PP 55971 and PP 55967. Smaller patches of suitable habitat for this community also exist to the west and southeast of the mining permit area. The most suitable habitat occurs where SST gradient, dynamic topography and nodule content are relatively high and seabed rugosity is low.
  - Community *n* – the greatest probability of encountering this habitat occurs outside of the marine consent area, to the northwest edge of the study area. However, there is the moderate to high possibility of small, patchy habitat within MPL 50270, and specifically

within the mining permit area but low prediction for this community occurring within the proposed prospecting permit areas. The most suitable habitat occurs where SST gradient and the mud content of the substratum are relatively high.

- Community *o* – predicted to occur in a large area in the northwest part of the study area, as well as relatively large patches that wholly or partly occur in the mining permit area but with lower likelihood of occurring in the wider region of MPL 50270 and the proposed prospecting permit areas. Elsewhere the model for this community predicts only very small areas of highly suitable habitat. Depth and SST gradient are the most important contributors to the model and suitable habitat is predicted to occur in water shallower than 400 m and where the SST gradient is high.
- Community *p* – predicted to occur in light patchy distribution in areas of varying size throughout the study area, except the deepest areas. Some suitable habitat is highly likely to be found in very patchy distribution in the mining permit area, as well as smaller patches throughout the wider area of MPL 50270 and the prospecting permit areas. Suitable habitat is predicted to occur where water depth is relatively shallow and the seabed essentially flat. The nodule content of the substratum is another relatively important variable for predicting habitat suitability, with the most suitable habitat occurring where nodule content is relatively high.
- Community *q* – predicted to occur mostly in the western half of the study area. Within this area, suitable habitat mainly occurs in two strips to the north and south, as well as occupying a relatively large part of the western side of the mining permit area and within the western prospecting area. Therefore, there is high probability that some of this community will be found in the mining permit area and wider MPL 50270 area but less likely to occur in the prospecting permit areas. The most suitable habitat is predicted to occur where levels of DOM are in the middle of their range, SST gradient is high, and where the sand content of the substratum and the tidal current speed are not high.

Figure 57 to Figure 64 show the habitat associated with each of the epifaunal communities. Note that these figures use a non-linear colour scale to highlight areas where locations of relatively high habitat suitability can be found.

Analysis of the image data at the transect-level identified 13 epifaunal communities. An examination of the taxa that characterised the five most commonly identified communities and the patterns of their observed distribution revealed that the transect-level communities are equivalent to five of the eight main communities identified at the image-level (listed above). This is discussed in more detail in Rowden et al. (2013, 2014) (Appendices 15 and 16).

Overall, this pattern of spatial variation for epifaunal community structure reflects the observation that epifaunal communities are distributed with respect to soft sediment (Communities *g* and *j*) and with some patchy distribution related to hard substrate (Communities *m, n, o, p, f* and *q*). Habitat suitability modelling also revealed the importance of other environmental variables for the distribution epibenthic communities, particularly variation in seabed topography and SST gradient (related to the position of oceanographic fronts and the availability of food).

SST gradient is known to be particularly important in structuring benthic communities across a wide area of the central Chatham Rise (Nodder et al. 2007 and references within). The importance of the position of a frontal feature is particularly noticeable for Communities *m, n and o*, which are characterised by sessile taxa such as bryozoans, sponges, hydroids and ascidians. Especially notable within the proposed marine consent is the observed association between the patchy distribution of hard substrate, particularly phosphorite nodules and Communities *o and n*, characterised by the stony coral *G. dumosa*. Community *o*, in particular, has abundances of *G. dumosa* that allow areas where this community is found to be termed 'coral thickets', a type of sensitive environment (MacDiarmid et al. 2013) as defined by the EEZ Act Regulations (Rowden et al. 2014).

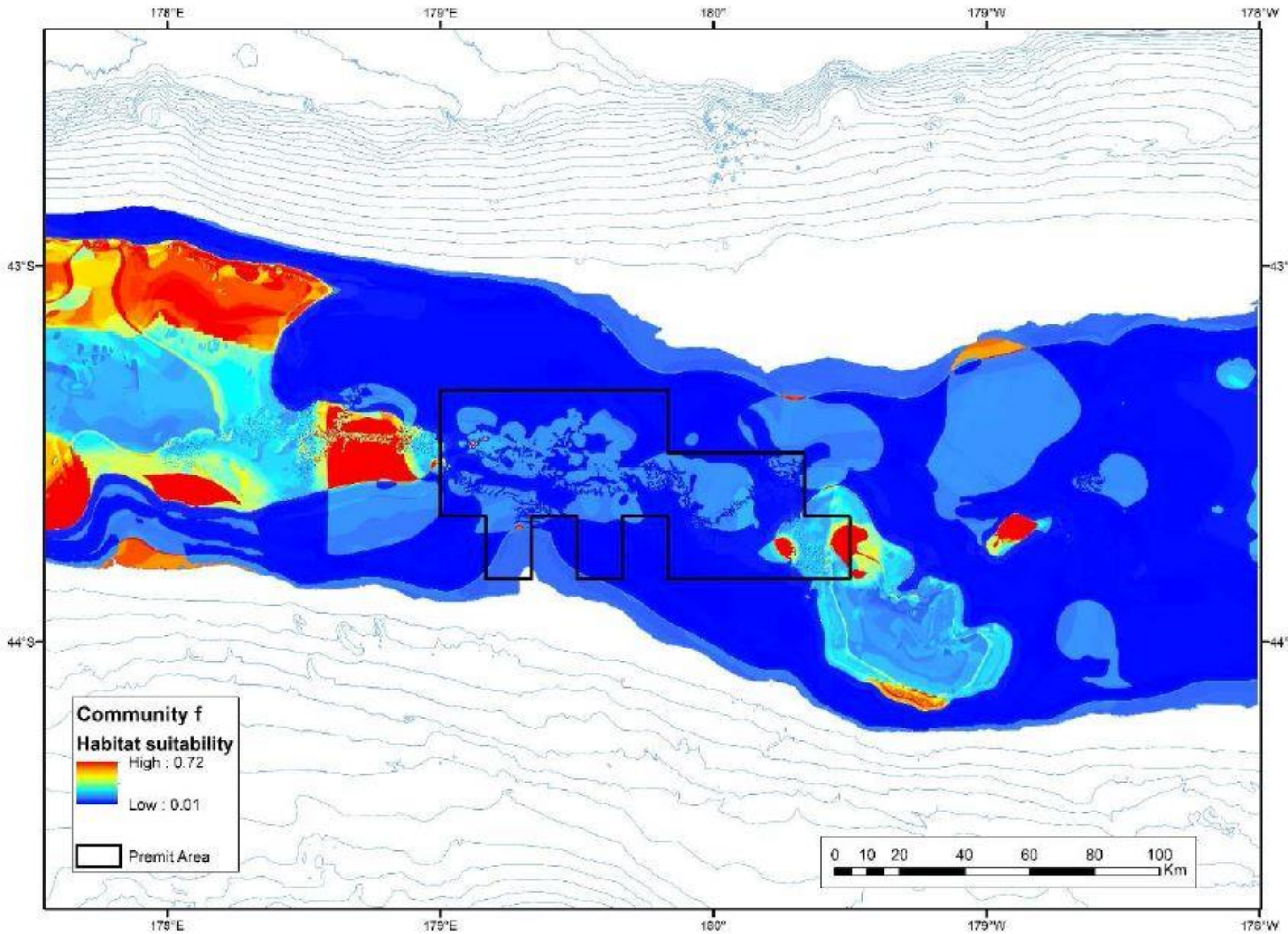

Figure 57: Predicted habitat suitability for epifaunal Community f (from Rowden et al. 2014a) (Appendix 16). Note the non-linear colour scheme.

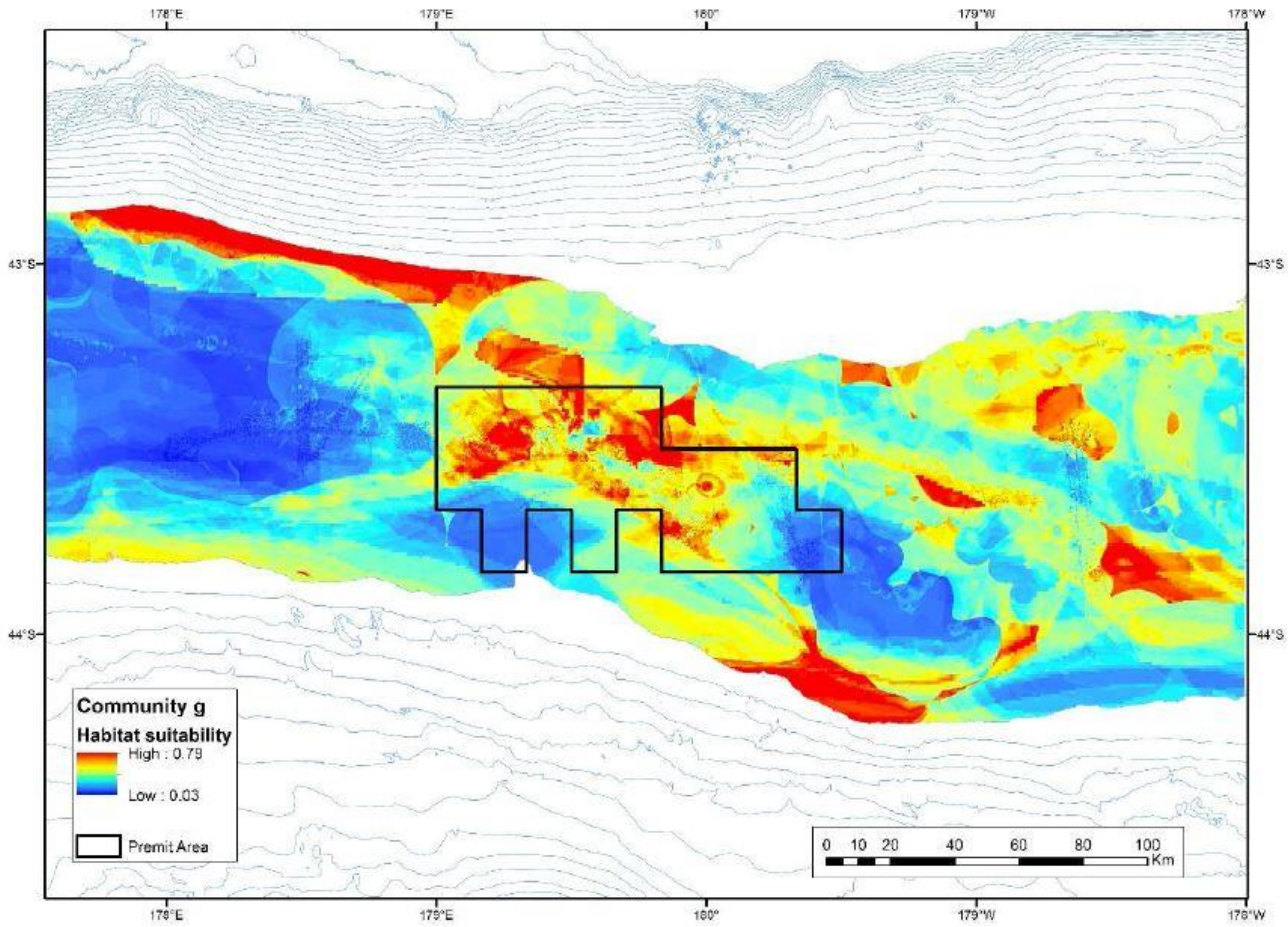

Figure 58: Predicted habitat suitability for epifaunal Community g (from Rowden et al. 2014a) (Appendix 16). Note the non-linear colour scheme.

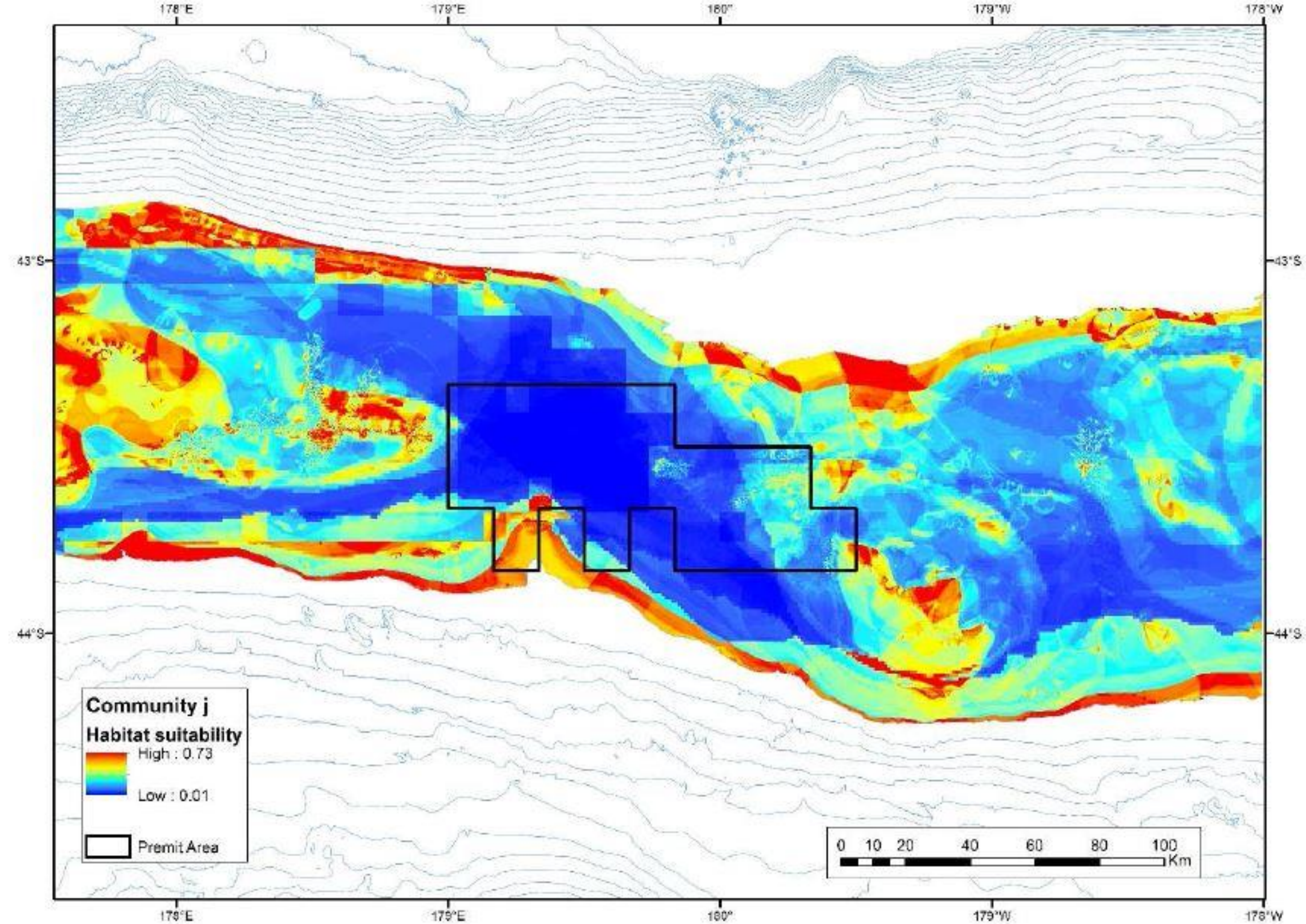

Figure 59: Predicted habitat suitability for epifaunal Community j (from Rowden et al. 2014a) (Appendix 16). Note the non-linear colour scheme.

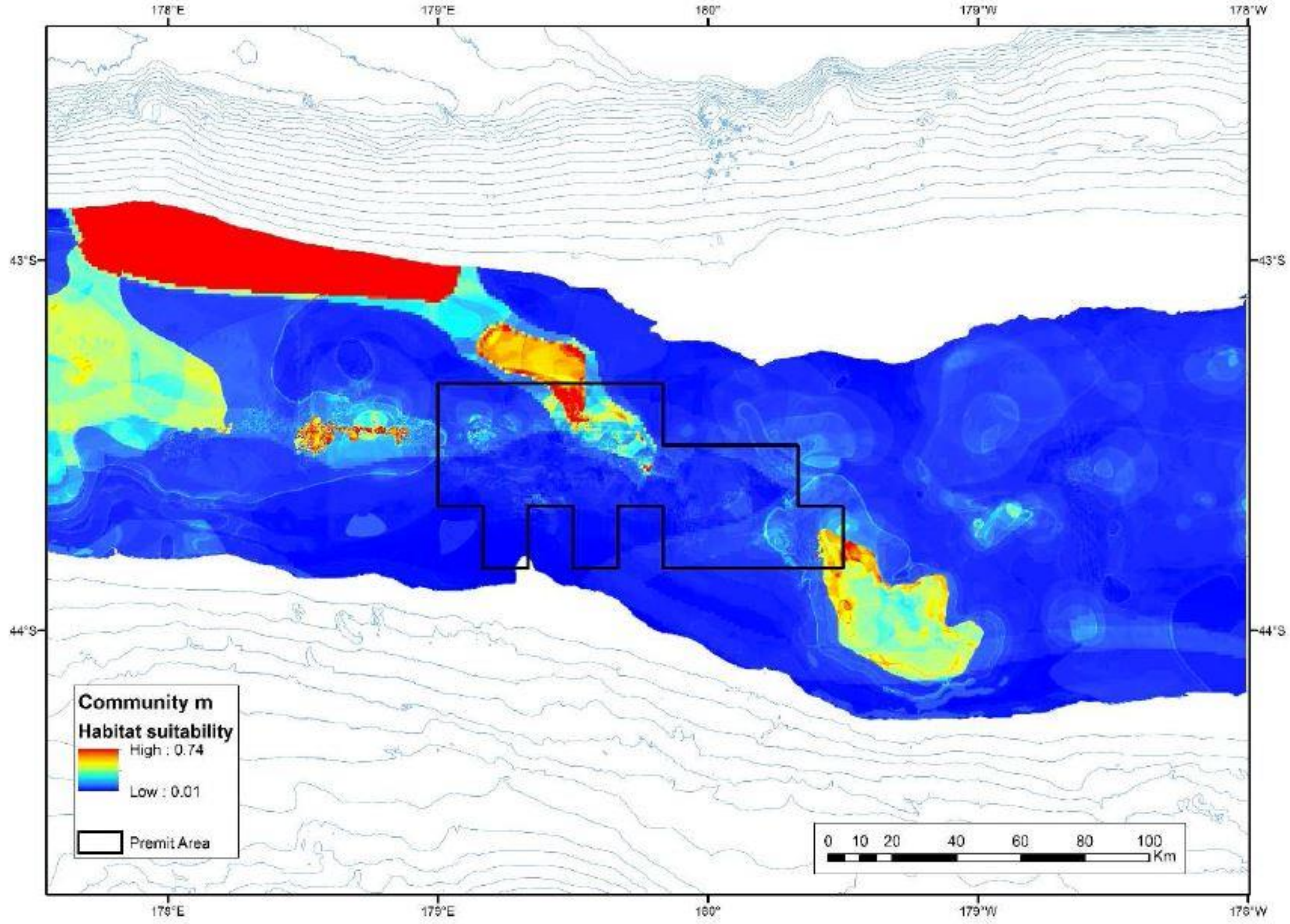

Figure 60: Predicted habitat suitability for epifaunal Community m (from Rowden et al. 2014a) (Appendix 16). Note the non-linear colour scheme.

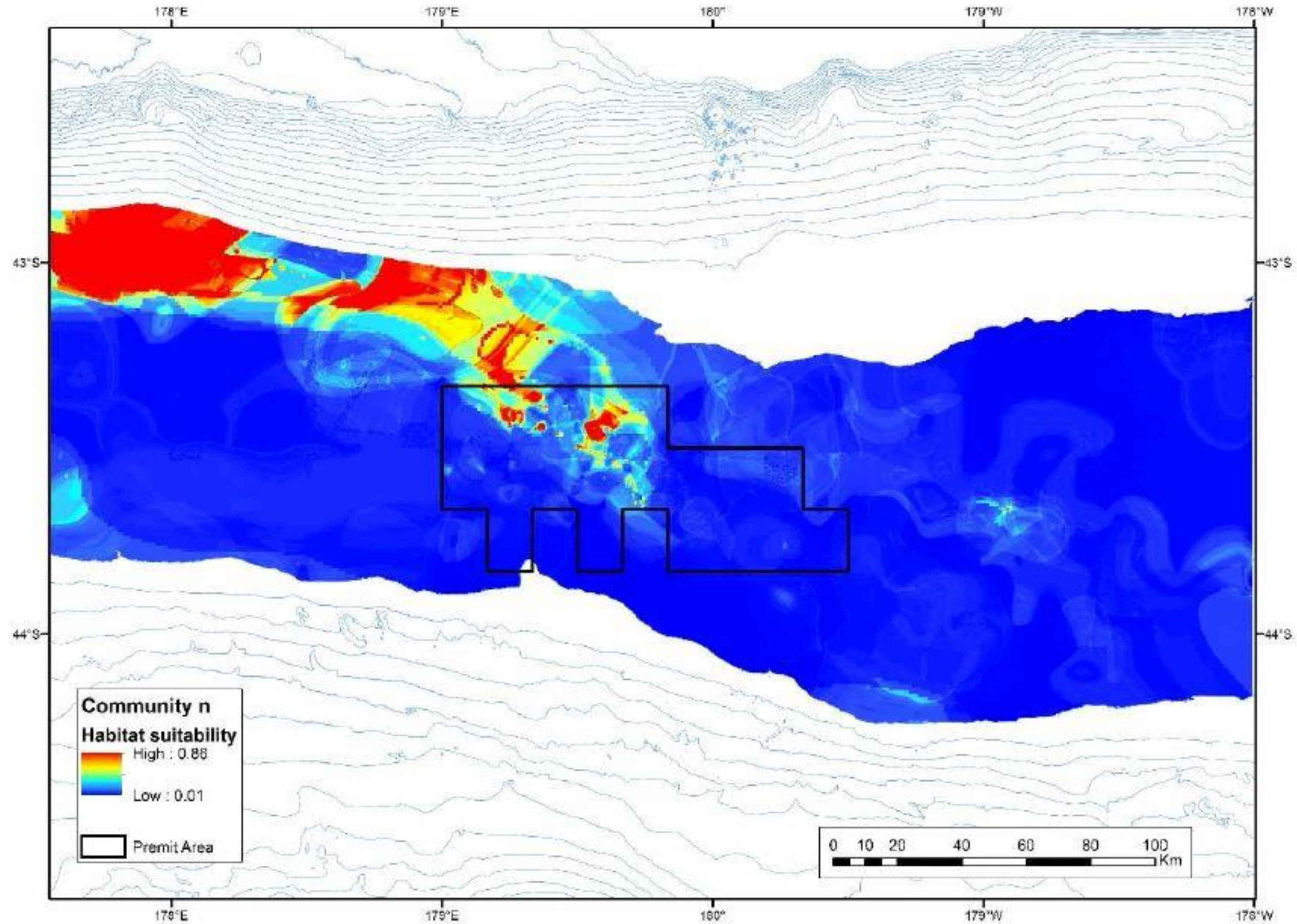

Figure 61: Predicted habitat suitability for epifaunal Community n (from Rowden et al. 2014a) (Appendix 16). Note the non-linear colour scheme.

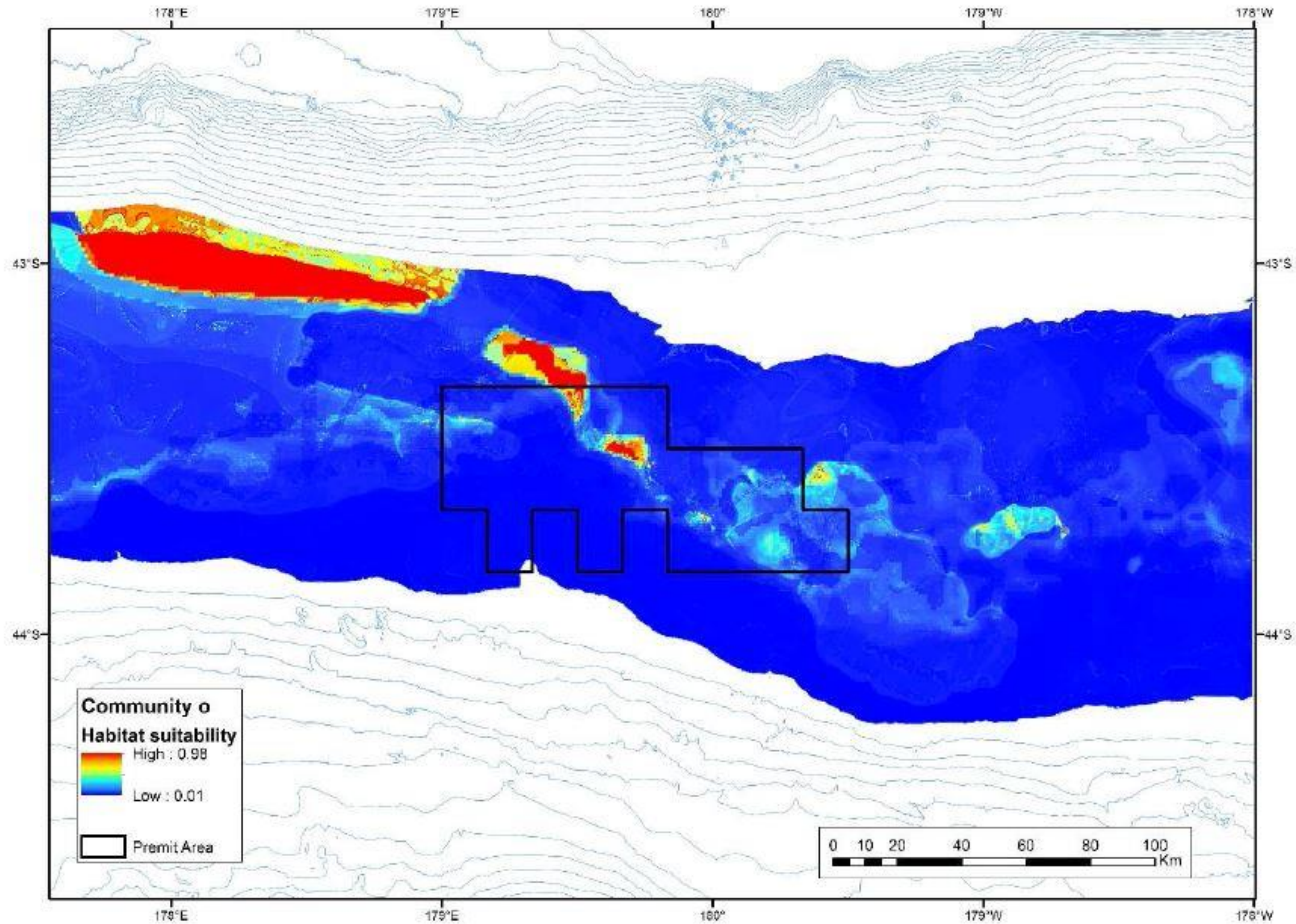

Figure 62: Predicted habitat suitability for epifaunal Community o (from Rowden et al. 2014a) (Appendix 16). Note the non-linear colour scheme.

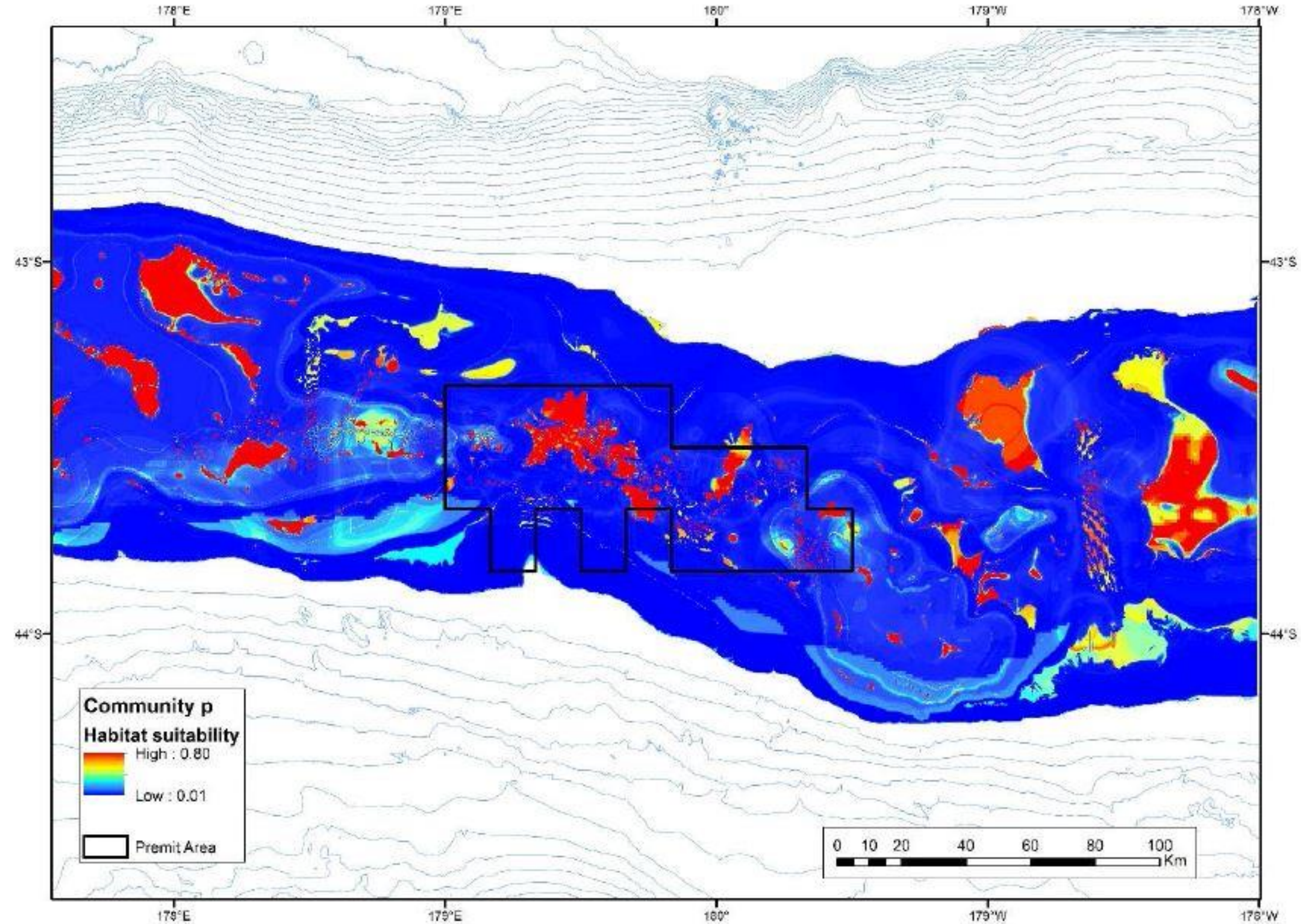

Figure 63: Predicted habitat suitability for epifaunal Community p (from Rowden et al. 2014a) (Appendix 16). Note the non-linear colour scheme.

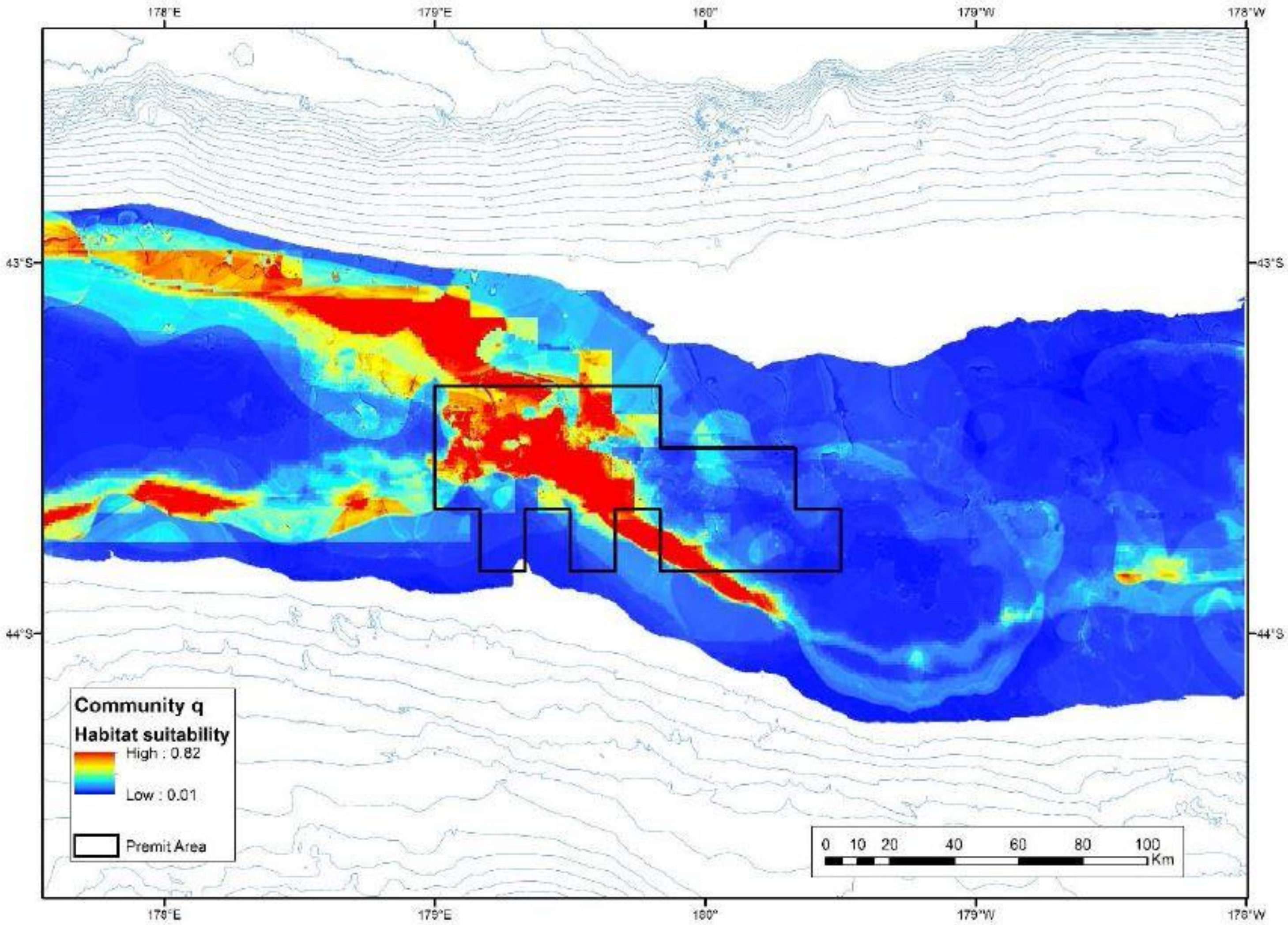

Figure 64: Predicted habitat suitability for epifaunal Community q (from Rowden et al. 2014a) (Appendix 16). Note the non-linear colour scheme.

6.3.3.3 Corals

Several species of corals have been identified as a conspicuous and important component of the benthic communities on the Chatham Rise. Consalvey et al. (2006) reviews the distribution of deep sea corals in New Zealand waters and Baird et al. (2012) examined the distribution of protected coral groups, including those protected by the Wildlife Act: all families of black coral (Order Antipatharia), all gorgonian families (part of Order Alcyonacea), all stony coral families (Order Scleractinia), and one family of hydrocorals (Order Anthoathecata). These data were obtained from research sampling (58 %) and from commercial fishing effort where observers had been present (42 %). The resulting dataset contained 7,731 records, of which 46 % were stony corals, 33 % were gorgonians, 11 % were hydrocorals, and 10 % were black corals. Coral records from the four orders were distributed throughout New Zealand's Fishery Management Areas, though differences by area and depth were evident at the family and genus level, where lower taxonomic detail was available.

Beaumont et al. (2013a) showed that Cnidaria (corals, anemones etc.) are present throughout most of the study area (refer to Appendix 13). Rowden et al. (2013, 2014a) (Appendices 15 and 16) described the presence and distribution of key epifaunal communities and taxa, including the stony coral *Goniocorella dumosa*, within and adjacent to MPL 52070.

Corals from protected groups that have been recorded from recent studies on the Chatham Rise are listed in Table 8, with comment on whether the species, genus or higher taxa identified are listed under the New Zealand treat classification system (Hitchmough et al. 2007).

Table 8: Coral species from protected coral groups that have been recorded from Chatham Rise habitats in recent studies 2012-2013 (from Rowden et al. 2013, 2014a).

Protected coral group	Identified corals	NZ threat classification (from Hitchmough et al. 2007)
Antipatharia (black corals)	*Leiopathes* sp.	Genus not listed
Gorgonacea (gorgonian corals)	Gorgonian (indent)	Unknown as not identified to species/genus level
Scleractinia (stony corals)	Caryophylliidae cup corals (stalked)	Unknown as not identified to species/genus level
	Desmophyllum/Caryophyllia sp.	Genera not listed
	Goniocorella dumosa	Not listed
	Stephanocyathus spp.	Genus not listed
	Flabellum spp.	Genus not listed
	Flabellum rubrum	Species not listed
Stylasteridae (hydrocorals)	*Calyptopora* spp.	Genus not listed
	Lepidotheca spp.	Genus not listed

The scleractinian or stony corals are the predominant protected coral group found on the Chatham Rise (Figure 65). The hydrocorals and stony corals are found in similar waters, throughout the depth range with peaks in 200 to 500 m and about 1,000 m, and the stony corals appeared to have a wider depth range in the deepest waters. The review by Tracey et al. (2011) showed that the key stony corals are found from shallow waters to depths of over 5,000 m. The depth distributions of gorgonians and black corals are similar, with most in 750 to 1,250 m, and a smaller peak in shallower waters.

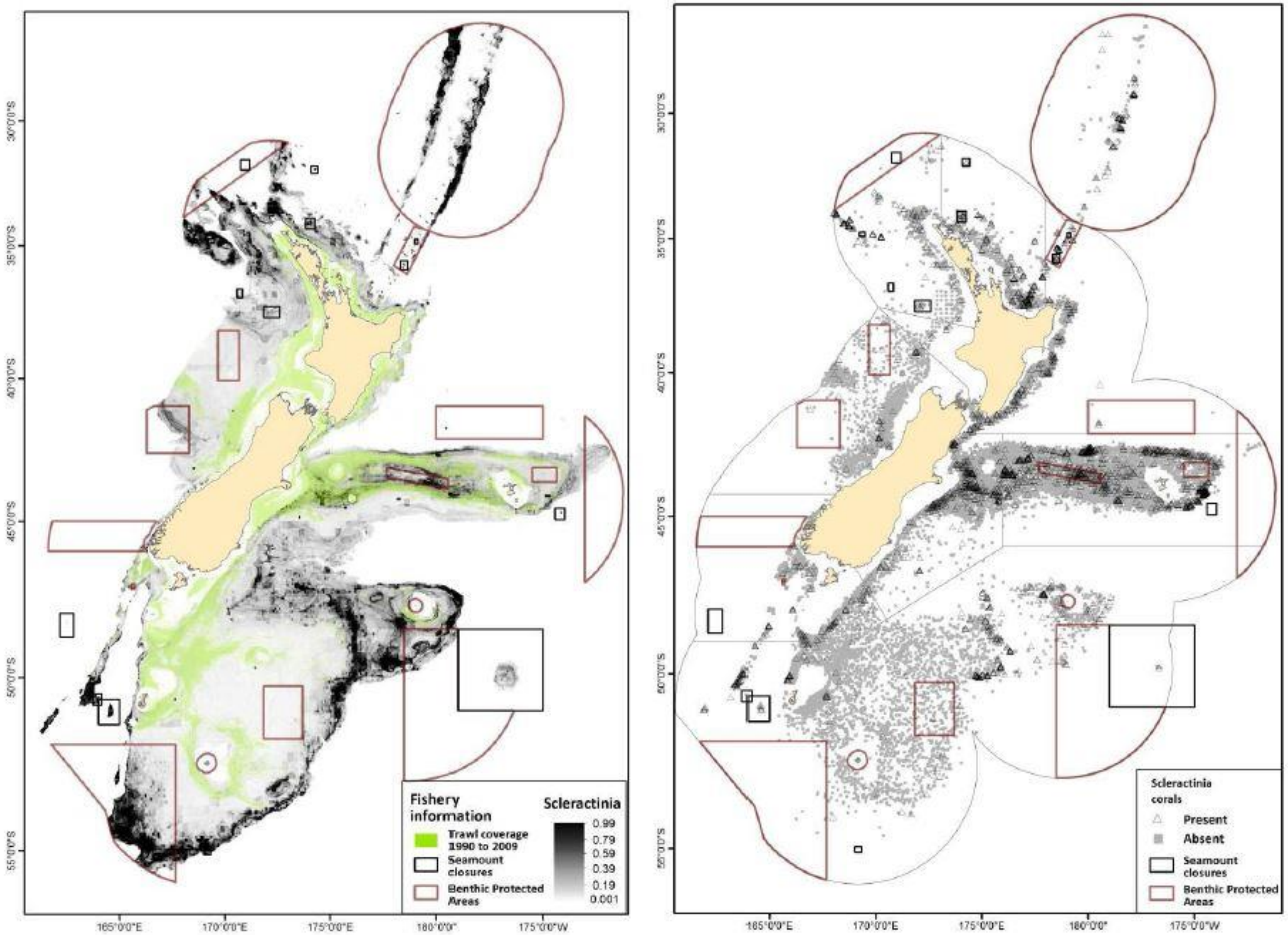

Figure 65: Predicted distribution (left) and coral presence/absence records (right) for stony corals (Order Scleractinia) (from Figure 3-8 in Baird et al. 2012). The EEZ BPA's are outlined.

Cold-water scleractinian corals have a cosmopolitan distribution, and there are 711 species worldwide (Roberts et al. 2009), of which 16.4 % are found within New Zealand's EEZ (Cairns 2007). The branching frame-building species make up 26 % of the scleractinian corals, with the remaining 74 % representing solitary species known as cup corals (Cairns 2007). Deep water stony corals, including habitat-forming species, are known to be widespread throughout the New Zealand region (Cairns 1995).

The dominant habitat-forming cold-water stony corals in the New Zealand region are *M. oculata*, *Solenosmilia variabilis*, *G. dumosa*, *Enallopsammia rostrata* and the endemic species *Oculina virgosa* (Cairns 1995, Consalvey et al. 2006, Tracey et al. 2007, Tracey et al. 2011). Tracey et al. (2011) identifies that these five species, along with *Lophelia*, are globally the most significant habitat-forming cold-water corals (Roberts et al. 2009), with three of these species, *M. oculata, S. variabilis*, and *E. rostrata*, being widely distributed and *G. dumosa* being the most common species recorded (40 %). These coral species are known to form biogenic habitat at seamounts, slope margins and on flat tops of slopes or rises in New Zealand waters, providing habitat for other corals as well as sponges, echinoderms, fish, bryozoans, crustaceans, molluscs and a wide range of other taxa (Consalvey et al. 2006, refer Squires 1965, Dawson 1984, Clark & O'Driscoll 2003 in Tracey et al 2011). Burgess (2002) reported that more than 60 % of the scleractinian coral samples examined in New Zealand were dead. This is not unusual as the structure of the coral is such that it remains in place following death but still provides habitat.

Some stony coral species produce colonies that can form biogenic structures that create habitat for other marine organisms. For instance, areas with *G. dumosa* can be referred to as 'coral thickets' when they are sufficiently dense (Rowden et al. 2014a). *Goniocorella dumosa* is the main taxa of the largest known deep water coral reef within the New Zealand EEZ. This reef is on the Campbell Plateau and covers 9.2 km^2 (Squires 1965, Baird et al. 2012). *S. variabilis* and *M. oculata* have a cosmopolitan distribution and reefs have only been seen at seamounts in the Tasman Sea and on the Chatham Rise (Koslow et al. 2001, Freiwald et al. 2004). *Enallopsammia rostrata* has been recorded to form reefs along the edges of some banks such as the Chatham Rise (Probert et al. 1997).

The diversity of cnidarians is greatest (as it is with most groups) at the Graveyard Seamount complex north of CRP's proposed marine consent area where sampling of hard substrate habitat has been most intense (Consalvey et al. 2006, Beaumont et al. 2013a). In this area large sessile species including scleractinian and stylasterid corals are thought to be a major faunistic component (Consalvey et al. 2006 and references therein). Areas just north of the proposed marine consent area include taxa such as deep sea anemones, bamboo coral (*Keratoisis* spp.), soft corals (Alcyonacea), cup corals (*Desmophyllum dianthus, Flabellum* spp.), stony corals (*Madrepora oculata, Goniocorella dumosa*) and a bottle brush coral and sea pens (Pennatulacea). The remainder of the Chatham Rise was considered by Beaumont et al. (2013a) to have relatively low cnidarian taxon richness.

Goniocorella dumosa was noted as being particularly common on the Chatham Rise, and is present within the proposed marine consent area (Rowden et al. 2013, 2014a – Appendices 15 and 16). *Goniocorella dumosa* is widely distributed but has only previously been observed at low densities or in isolated colonies (Freiwald et al. 2004, Rowden et al. 2014a). Tracey et al. (2011) described this species over a wide range of depths (88 to 1,488 m) and a variety of features, including from rises (34 %), seamounts (36 %) and slopes (24 %).

G. dumosa was observed on seabed video and photographs to be most abundant in the centre of MPL 50270 and present in lower abundance near its eastern and western edges (Figure 66). *Goniocorella dumosa* was absent from all sampling transects outside the area associated with MPL 50270, except for two transects located immediately to the west within the proposed western prospecting area.

Tracey et al. (2011) carried out predictive modelling of the distribution of the key stony coral species examined in their review. They showed that there is a high probability of occurrence of *G. dumosa* at relatively shallow depths on the continental slopes of both main islands, along all of the Chatham Rise, on the rises of the Campbell and Bounty plateaux and Bollons Seamount (Tracey et al. 2011).

Rowden et al. (2014a) further predicted that suitable habitat for *G. dumosa* is likely to occur in a large area to the northwest of the proposed marine consent area, as well as smaller patches in the central and eastern regions of MPL 50270 (Figure 67). Therefore, as for Communities *n* and *o* described in the preceding section, the greatest probability of encountering this coral community is outside of the proposed marine consent area, to the northwest. There is the moderate to high possibility of patchy habitat within the eastern part of MPL 50270, and some possibility that this community is found elsewhere in the marine consent area. This prediction is most strongly related to SST gradient with the most suitable habitat for this coral occurring where SST is highest. High SST is indicative of oceanographic fronts where surface productivity can be concentrated and where associated down-welling can enhance the flux of potential food material to the benthos (Rowden et al. 2014a).

Water depth and topographic variable such as rugosity, aspect and variation in slope also contributed to the habitat suitability model for *G. dumosa*, such that suitable habitat is likely to occur in relatively shallow (<380 m) water depths and where small-scale elevations in the seabed are likely to raise the organisms into faster water flows that contain food material (Rowden et al. 2014a). These corals require hard substrates for attachment which can be provided by relatively large phosphorite nodules, or other hard seabed material, although the presence of nodules was not specifically identified as an important variable in the habitat suitability model for *G. dumosa*.

Corals tend to be relatively slow growing compared to many other members of the Chatham Rise ecosystem. Studies of coral growth have shown that for species such as M. oculata (based on a size 45.5 cm), a linear growth rate was estimated of 15 mm/year and an age of 31 years. For Lophelia pertusa (based on size 80 cm) a linear growth rate was estimated of 8.5 mm/year (Sabatier et al. 2011). The growth rate of *Goniocorella dumosa* is not known, but if comparisons are made with studies in the North Atlantic, e.g., *Lophelia pertusa*, then a metre-high colony might be 200 to 360 years (refer Wilson 1979, Cairns & Stanley 1981 in Consalvey et al. 2006).

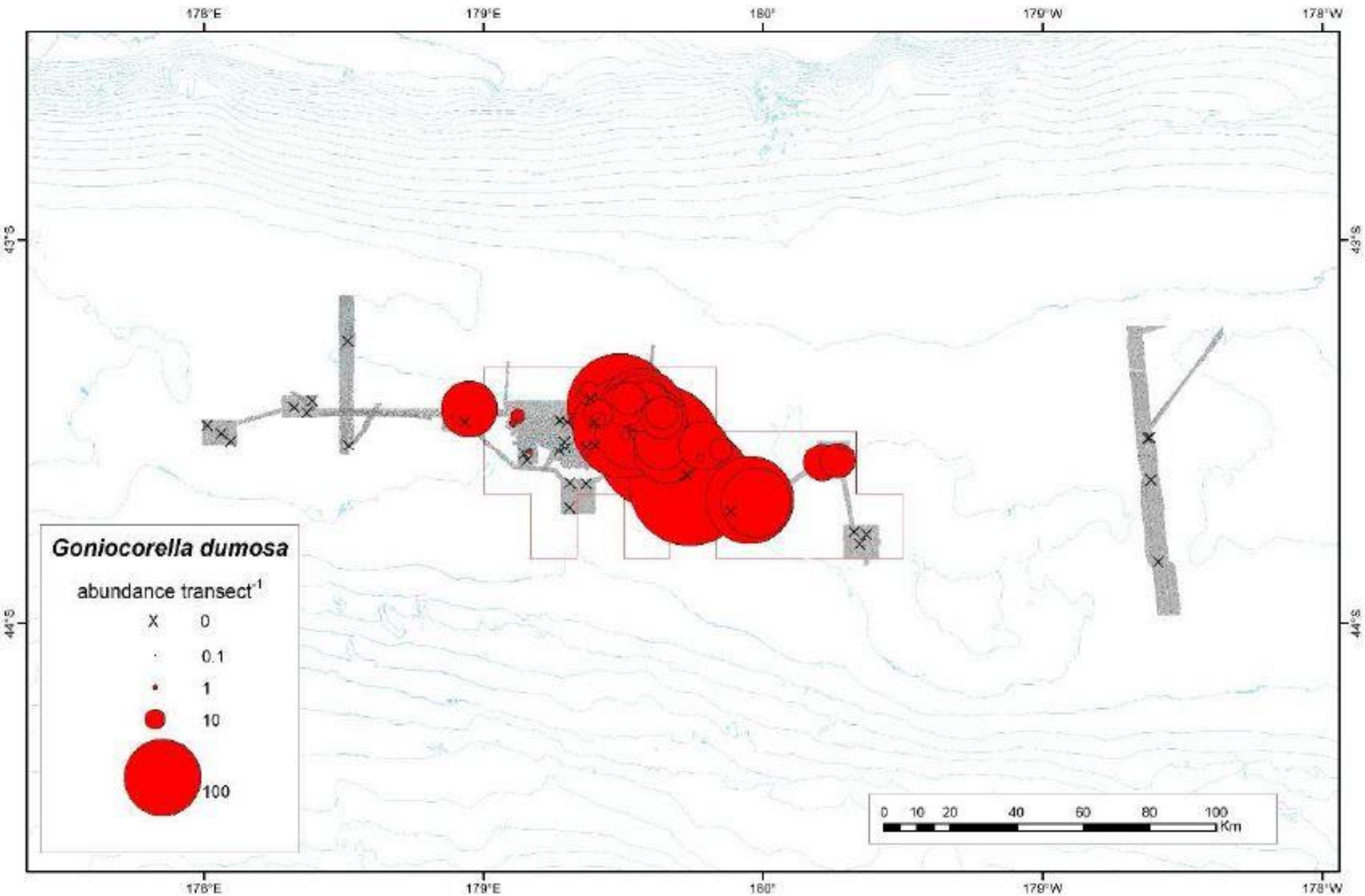

Figure 66: Distribution of the relative abundance of the stony coral Goniocorella dumosa in the study area for the 2012 and 2013 studies (from Rowden et al. 2014a) (Appendix 16).

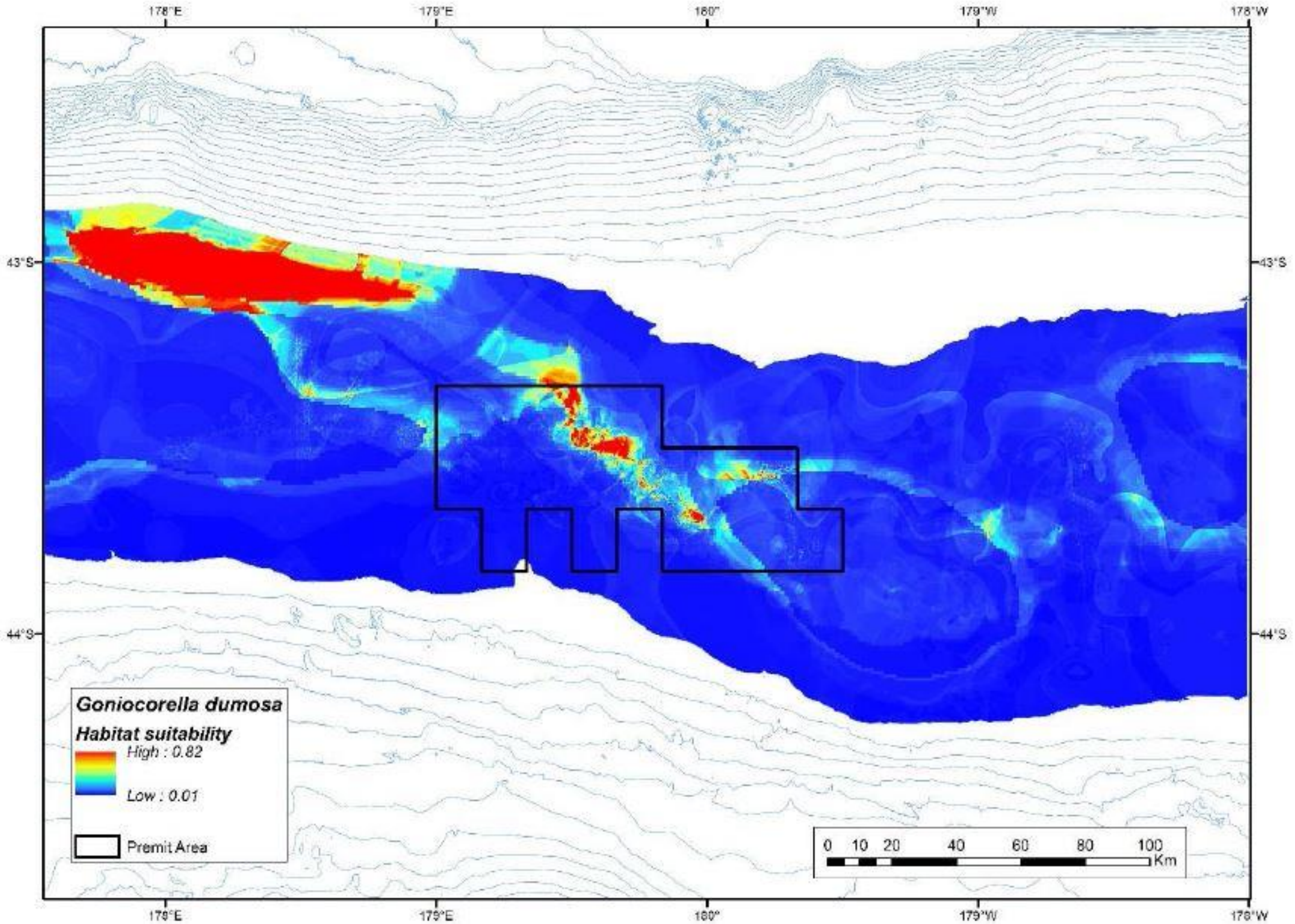

Figure 67: Predicted habitat suitability for the stony coral Goniocorella dumosa (from Rowden et al. 2014a) (Appendix 16). Note the non-linear colour scheme.

6.3.3.4 Infauna

Key species and community composition

A total of 307 infauna taxa were identified from samples taken from 73 box core samples collected in 2012 from MPL 50270 and were used in the final analyses of community structure (sample details are in Rowden et al. 2013 – Appendix 15). Arthropods and annelids were the most diverse phyla (87 and 80 taxa, respectively), followed by bryozoans (60), molluscs (36), echinoderms (27), and cnidarians (8). Annelids were the most abundant taxon (51 % of total abundance), followed by arthropods (26 %), echinoderms (7 %), bryozoans (6 %), molluscs (3 %), and cnidarians (2 %). Evaluation of the data separated the samples into five community groups. Most of the samples (88 %) were placed into three community groups (identified as Communities *d, g* and *h*). Key features include:

- The phoxocephalid amphipods were one of five species contributing to the within group similarity of all groups except Community *e*. The phoxocephalid amphipods feed on a range of small biota (copepods, annelids, nematodes, diatoms and detritus (Oliver et al. 1982).
- Polychaete worms (lumbrinerids and cirratulids) were the key fauna within Community *g*.
- Lysianassoid amphipods and capitellid polychaetes were high contributors to characterising Community *d*. Lysianassoid amphipods are considered to be a key group of very effective epibenthic scavengers in both deep and shallow waters (Moore 1994).
- *Kinbergonuphis* sp. (Onuphidae) and syllid polychaetes characterised Community *h*.
- A bryozoan (*Escharella spinosissimia*), and nephtydid and cirratulid polychaetes characterised Community *e*.
- Communities *e* and *i*, and *e* and *h* showed the most dissimilarity in community composition.

Modelling of infauna relationship with seabed characteristics

Modelling the relationship between physical factors and the main infaunal communities (Rowden et al. 2013 - Appendix 15), was considered 'useful' but the model for Community *d* was not considered robust. The following observations were made about the communities:

- Suitable habitat for Community *d* (dominated by two species of amphipod) is predicted to occur mainly in the western part of the study area (which covers an area generally associated with the mining permit area), although there are also smaller areas of suitable habitat in the east (Figure 68). Areas of suitable habitat are generally shallow, and occur over a narrow depth range (and with little variation in depth within this range). Habitat suitability for this community is strongly and positively related to nodule density and topographic measures of the seabed (plan curvature, variation in depth and slope, aspect (northwest) and rugosity)
- The habitat suitability model for Community *g* (characterised by a mix of polychaete and amphipod species) predicts that suitable habitat for this infaunal community is widespread throughout the study area, although there is more habitat in the east than in the west (Figure 69). Highly suitable habitat generally occurs in relatively small areas that align with the slope of seafloor depressions, troughs or iceberg furrows. Nodule density is typically low for this habitat.
- The most suitable habitat for Community *h* (characterised by an amphipod and a number of polychaete taxa) is predicted to occur in relatively small patches with a narrow depth range in the western part of the study area (Figure 70). The other variables that contribute to the distribution of this community are plan curvature (positive in and along slope direction), curvature of the seabed (when flat or slightly negative), and nodule density.

Figure 71 provides an integrated picture of the distribution of predicted habitats for Communities *g* and *h*.

6.3.4 Benthic species - endemism

6.3.4.1 Endemism in New Zealand's EEZ

Including known and undescribed taxa in museum collections, there are approximately 14,500 species of marine animals (sponges to vertebrates) in the entire EEZ (Gordon 2009, 2010, 2013), 45 % of which are nominally endemic (i.e., so far known only from New Zealand). However, it is likely, as more marine sampling is carried out in the wider Australasian region that some of these species will be found outside the EEZ. On the other hand, the distributional status of many undescribed species remains to be determined and many of these will no doubt be endemic, so the overall percentage may not change. Endemism is also likely to be underdetermined for many groups because relatively less taxonomic work has been carried out on organisms found beyond shelf depths.

6.3.4.2 Endemism among species found in MPL 50270

At least 351 benthic species were identified in the box-core samples from MPL 50270, distributed among 14 phyla. Of these, only 78 (22 %) were identified as named species, the rest were identified to genus only or to a higher taxonomic rank (family, order or class). The reason is a combination of the lack of taxonomic expertise in New Zealand across the full range of taxa and the time required to identify all of the species (particularly in diverse and taxonomically challenging groups like Crustacea). Identification is also hampered because large numbers of species in the EEZ have not yet been formally described and therefore no species names are available for them. As a consequence, estimates of endemism among the samples from MPL 50270 can be based only on the 78 named species, which is may not be widely representative.

Table 9 provides information on the level of endemism for the phyla found in the box-core samples from CRP's 2012 research. The numbers of named species is highest for Bryozoa (22 named species, 37 % of them endemic), Mollusca (19, 51 % endemic), Annelida (18, 20 % endemic) and Echinodermata (15, 45 %). These four phyla are therefore the most informative groups as all other phyla had only two or no named species.

Endemism among benthic species on the Chatham Rise would be based on a number of factors, including geology (presence of suitable habitat), biology (e.g., reproductive isolation, speciation rates, type of larva (if any) and duration of larval life, rates of dispersal of larvae and adults, and species duration in geological time), and hydrology (e.g., currents and water properties). However, integrated studies to determine the influence of these factors are rare or non-existent for most groups of organisms. Additionally, determining endemism is confounded by sampling density and the availability of taxonomists who can identify the huge diversity of marine life.

Nevertheless, with respect to the four groups, Bryozoa is a good proxy for many types of marine life. All bryozoan species beyond shallow coastal waters have short-lived (24 hr or less) non-planktonic larvae so it might be expected that the majority are not very widespread compared to organisms with planktonic larvae. Bryozoan endemism in the New Zealand EEZ is relatively high (61 % of all species), but even endemic species tend to be fairly widespread. Of the 22 named species in the CRP samples, 77 % are endemic to the EEZ but none are endemic to the Chatham Rise. From what is known about the remaining 38 undescribed species, few if any of them appear to be endemic to the Chatham Rise.

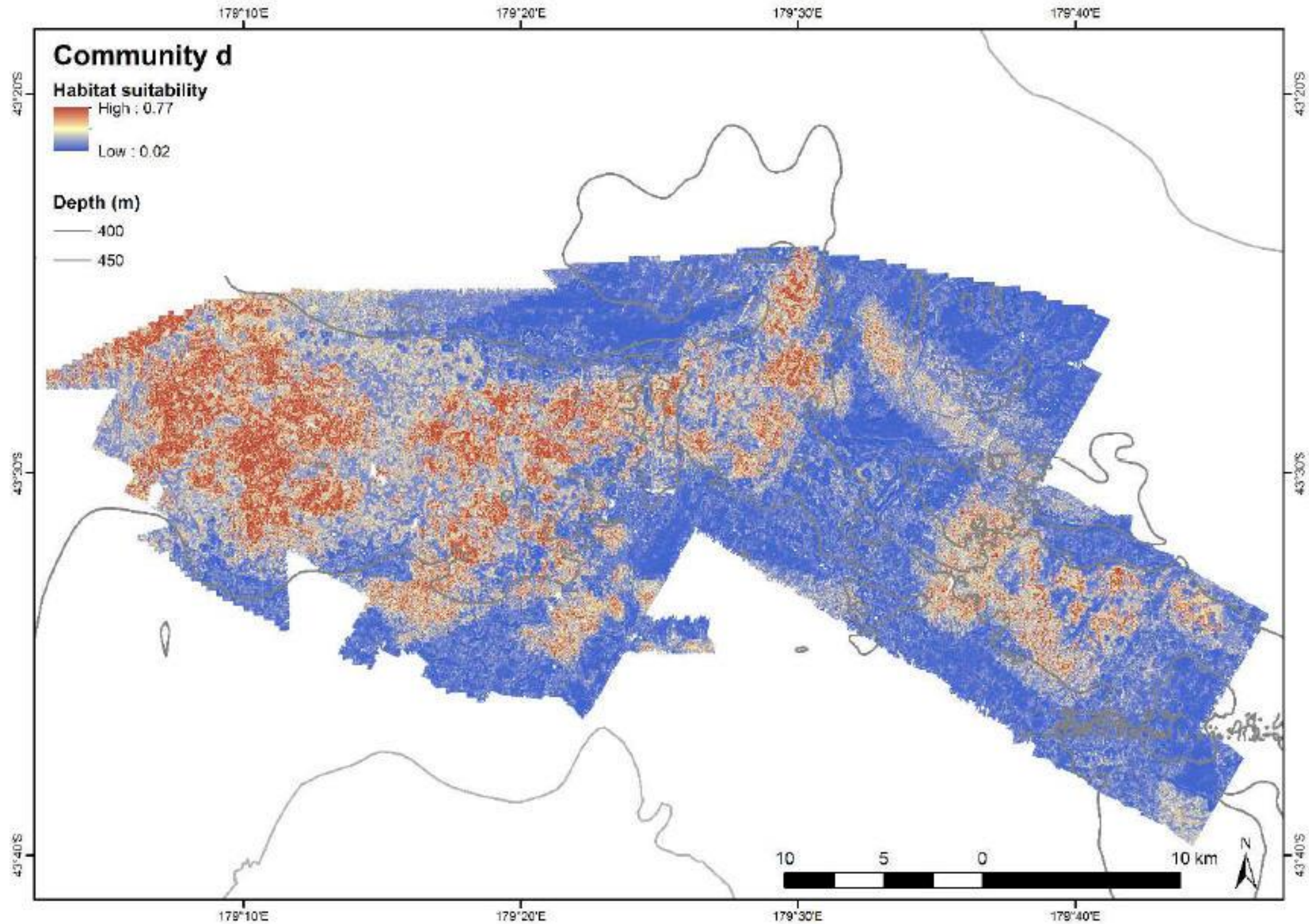

Figure 68: Predicted occurrence of infaunal Community d within the area covered by multi-beam swath bathymetry data (from Rowden et al. 2013). Note the non-linear colour scheme.

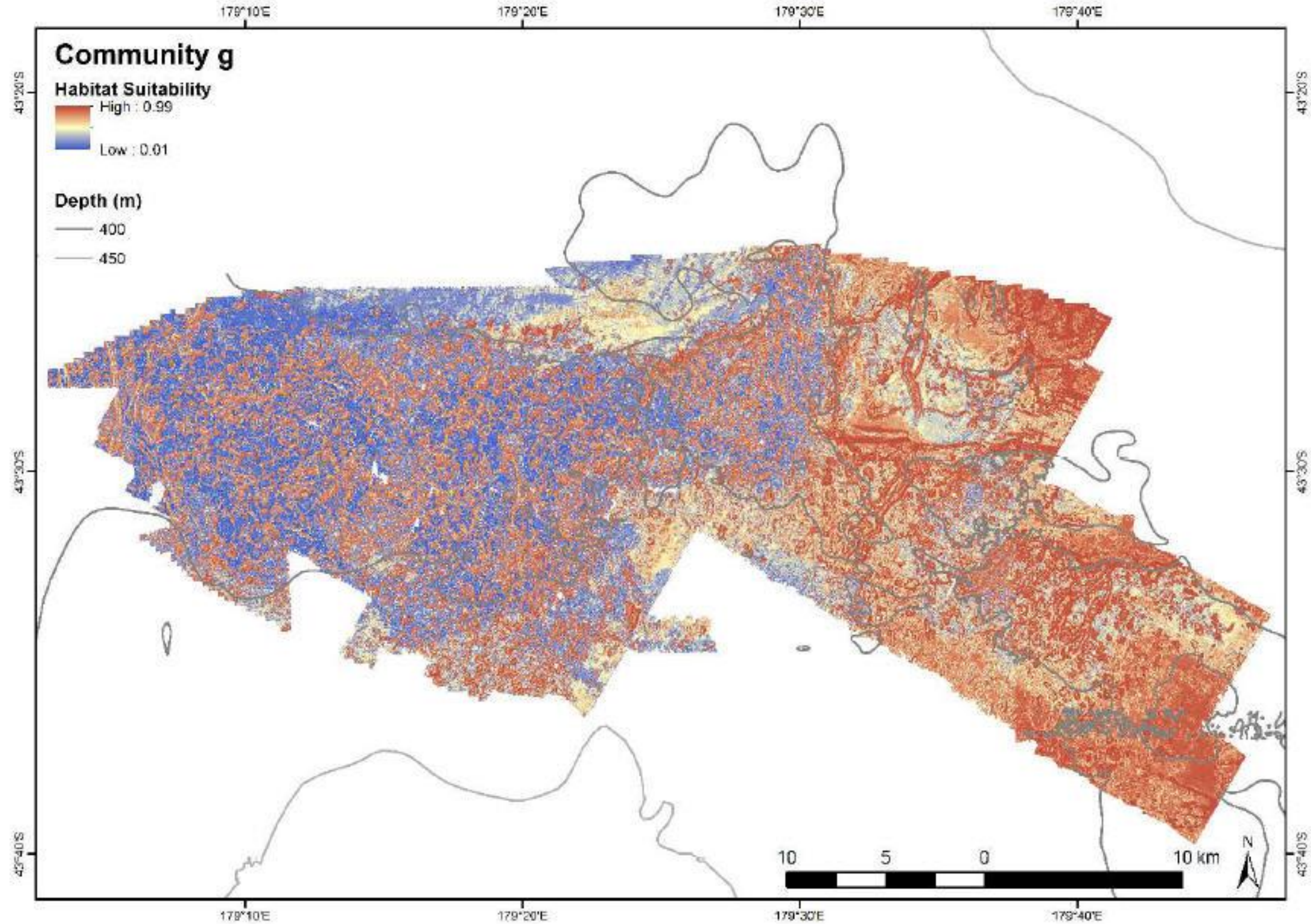

Figure 69: Predicted occurrence of infaunal Community g within the area covered by multi-beam swath bathymetry data (from Rowden et al. 2013). Note the non-linear colour scheme.

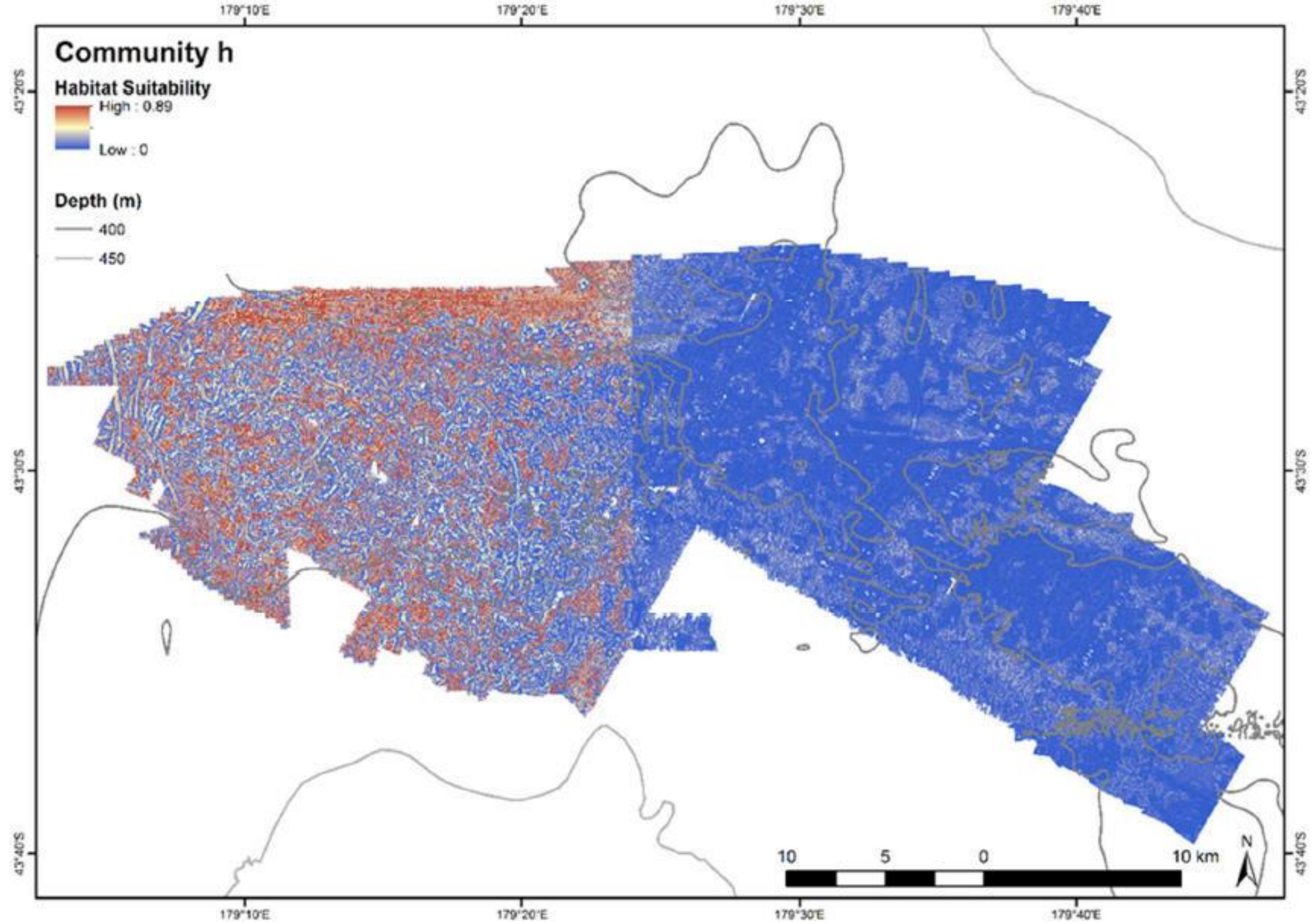

Figure 70: Predicted occurrence of infaunal Community h within the area covered by multi-beam swath bathymetry data (from Rowden et al. 2013). Note the non-linear colour scheme. .

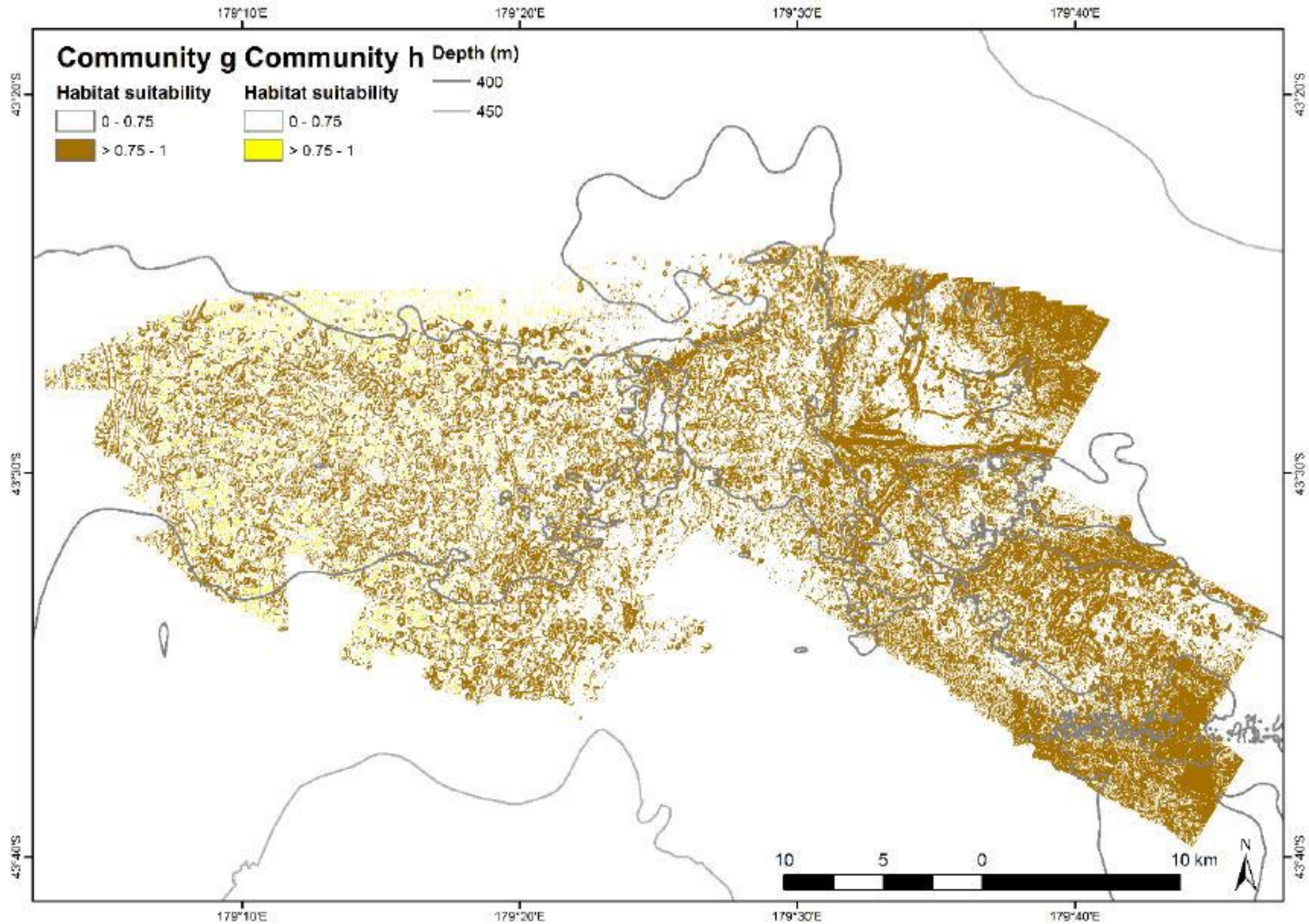

Figure 71: Predicted habitat suitability for infaunal Communities g and h in the area covered by multi-beam swath bathymetry data (from Rowden et al. 2013).

Table 9: Indicative endemism among taxa found in CRP box-core samples. The table gives the numbers of species per phylum found in the samples, the proportion of species named, the level of endemism for those named species, and the calculated likely endemism for each phylum in the samples based upon what is known for the phylum in the entire EEZ.

Phylum	Common name	Total species in CRP*	Named species in CRP samples	Undetermined species in CRP samples	% of species named in CRP samples	% of named CRP species that are endemic in EEZ	% likely endemism of all CRP species (based on all species of phylum in EEZ)†
Cercozoa	Gromiids	1	0	1	0	-	0
Porifera	Sponges	3	0	3	0	-	48
Cnidaria	Corals, anemones, hydroids etc.	13	2	11	15	0	21
Platyhelminthes	Flat worms	1	0	1	0	-	28
Mollusca	Clams, snails, octopus, etc.	37	19	18	51	89	81
Brachiopoda	Lamp shells	2	0	2	0	-	86
Bryozoa	Bryozoans, sea mats, lace corals	60	22	38	37	77	61
Annelida	Bristle worms	90	18	72	20	44	30
Sipuncula	Peanut worms	2	0	2	0	-	8
Nemertea	Ribbon worms	3	0	3	0	-	52
Arthropoda	Shrimps, crabs etc.	100	2	98	2	100	36
Nematoda	Round worms	2	0	2	0	-	26
Echinodermata	Sea stars, sea urchins, etc.	33	15	18	45	47	39
Tunicata	Sea squirts	4	0	4	0	-	65
Totals		351	78	273	-	-	-

Note that all percentages are rounded.

* Minimum number (some taxa indicated by "spp."; in this instance, two was taken to be the minimum number)

† Percentage based upon what is known for the entire phylum in the EEZ generally (underdetermined for several groups in which large numbers of species have not yet been described) (derived from Gordon et al. 2010, Table S1; Gordon 2013).

On the other hand, several bryozoan species and one genus are known only from the Graveyard Seamount complex (Gordon & Taylor 2010), but there are few sampled sites (one or two) and wider distributions are expected.

Phylum Mollusca in New Zealand has an even higher level of endemism (at least 81 % for the EEZ), which is remarkable given the relatively large numbers of species that have planktonic larvae. Within the Mollusca, cephalopods (squids and octopods) have the least endemicity (~23 %), followed by sea slugs (~50 %) but all other groups (mostly shellfish), including bivalves, have endemism levels of 70 to 90 % for the EEZ. Te Papa mollusc specialist Bruce Marshall (pers. comm.) notes that very few mollusc species (fewer than a dozen) seem to be endemic to the Chatham Rise. However, this conclusion is based on relatively few museum records and/or species, most from the Mernoo Bank or Chatham Islands.

Phylum Annelida is represented in the sea mostly by bristle worms (Polychaeta), the majority of which have planktonic larvae that are carried by currents. Accordingly, marine Annelida have relatively low endemicity in the EEZ (30 %). Phylum Echinodermata exhibits a range of larval types, mostly planktonic. Endemicity of the phylum is 39 % in the EEZ. NIWA specialists of these two phyla (G. Read and K. Neall, pers. comm.) suspect that the relatively few endemic species known from the Chatham Rise reflect limited sampling. Such is the case for some glass sponges (Reiswig & Kelly 2011) given that a few species are apparently restricted to the Rise but knowledge of their distribution is based on only one or two specimen localities. A few species of Amphipoda (Crustacea) presently have wide distributions only on the Chatham Rise (Lörz & Coleman 2013) but, as with isopod crustaceans, individual species are found both on northern, central and southern areas of the Rise, under different water masses, and it appears unlikely that any species would not also be found elsewhere in the EEZ (Anne-Nina Loerz and Stefanie Kaiser, pers. comm.).

None of the important habitat-forming stony corals (phylum Cnidaria — chiefly *Goniopora dumosa*) is endemic. All stony-coral species in the box-core samples are widely distributed in New Zealand and beyond. Their presence causes local elevation in the species diversity of mobile fauna and sessile epifauna.

Far fewer species were identified from seabed images than from box-core samples. Of the approximately 167 taxa recognised in images, only 46 were positively identified to species. Not surprisingly, the majority (23) were fish. The rest were sea stars and sea urchins (7), sponges (5), molluscs (4), bryozoans (2), corals (2), crustaceans (2) and a sea squirt (1). Seven of the fish species are endemic to the EEZ but not to the Chatham Rise.

Two putative Chatham Rise endemic species—the hydrocoral *Errina chathamensis* (Cnidaria: Stylasteridae) and lamp shell *Neothyris dawsoni* (Brachiopoda), are now known to be not endemic to the Rise (as discussed below). Neither was identified in the samples collected for this project. Although published literature indicates that both are found only on the Chatham Rise, NIWA station data show that this is not the case. Whereas the holotype specimen of *E. chathamensis* came from Veryan Bank (at the western end of Chatham Rise), the paratype came from off Cape Palliser, North Island. All other positively identified samples in the NIWA collection are, however, from the Chatham Rise. Most records of the brachiopod *N. dawsoni* are from Matheson Bank, very close to MPL 50270, but, based on recent identifications of NIWA's brachiopod collection by specialist Jeffrey Robinson (University of Otago) the species is also found off East Cape and on the Challenger Plateau east of Cape Egmont.

6.3.4.3 Summary

Based on present knowledge, the vast majority of macrobenthic species found on the Chatham Rise are not restricted to the Rise. Of those species that have only been found on the Rise, many have been found only at one or two locations, strongly suggesting that their rarity is an artefact based on limited sampling. Relatively few species are both widely distributed on the Chatham Rise and found nowhere else.

Assessment of the percentage of endemic species habitat that might be lost from the total habitat of the Rise as a result of mining activities has not been conducted. Following conservation principles in terrestrial environments this approach would be desirable but is highly problematic in the marine environment. In the first instance, notions of endemism are based on both very limited sampling and requisite specialist identification. Second, not enough is known about the distribution of all macrobenthic species on the Chatham Rise to make the desired assessment. Rather than base decisions on individual species (other than those that are major habitat-formers), it is preferable to compare habitats and assemblages. The phosphorite nodule habitat is considered unique in New Zealand's EEZ, but major habitat-forming species that are found in the proposed marine consent area are widespread in New Zealand.

6.3.5 Summary - Benthic Fauna

Overview

Overall, Rowden et al. (2013, 2014a) (Appendices 15 and 16) has provided a detailed examination of the benthic community structure within the proposed marine consent area, with a focus on the area within which mining is proposed. The evaluation presented in the previous section utilised the extensive physical information collected in 2007 to 2013 to predict the occurrence of the identified epifaunal and infaunal communities. As a result of this analysis, an understanding of the benthic ecology obtained from the extensive ROV video, still images and seabed sampling resulted in the interpretation of 13 epifaunal and five infaunal communities.

Comparison of the benthic communities identified by this study and communities described from previous sampling on the Chatham Rise indicates that some epifaunal communities within the proposed marine consent area have not been found elsewhere on the Rise, and may be unique to the area. Two epifaunal communities, both of which show a patchy distribution almost only observed within CRP's mining permit area, are dominated by the stony coral *Goniocoralla dumosa*. This coral relies upon hard substrate, such as that provided by relatively large nodules or other hard/rocky outcrops, for attachment. Similar corals, particularly when in high abundance, are known to provide habitat for a diverse community of other invertebrates and, potentially, larval or juvenile fish.

However, habitat suitability modelling predicts that all the identified epifaunal communities could be more widespread within the study area, including the communities dominated by *G. dumosa*. Habitat suitability models predict a relatively large area that contains suitable habitat for *G. dumosa* and associated communities in the northwestern part of the study area. These predictions are largely driven by high values for SST gradient, indicative of a front which extends southeast into the mining permit area.

The nature of the benthic communities on the Chatham Rise and within the study area varied both in terms of the types of habitat and in the way the organisms in the benthic community feed. Pinkerton (2013) (Appendix 22) identifies that benthic macrofauna take about half their food from benthic sources and half from the water column. However, groups such as the decapods (shrimps etc.) take their food from the water column (e.g., while they are undertaking diel migrations, also known as diurnal, up into the water column).

Trophic importance

In the TI1 and TI2 assessments in Pinkerton (2013) (Appendix 22), macrobenthos (ranks 10 and 13 respectively) and meiobenthos (ranks 14 and 8) ranked higher than all other benthic groups, as they contributed positive linkages to a number of other groups, including a variety of fish groups and guilds (the relative rankings for the TI2 are shown in Figure 120). The higher TI of meiobenthos is related to a strong positive dependence to holothurians. The high ranking of macrobenthos is related to the number of positive linkages to both a range of fish guilds and invertebrates.

6.4 Plankton

6.4.1 Plankton ecology

As described in Section 5, the STF along the Chatham Rise marks the transition between warm (14 to >18°C) and saline (>35.1 ppt) STW to the north and cool (<10 to 14°C) and relatively fresh (<34.6 ppt) SAW to the south (Sutton 2001). Therefore, there are three differing water masses in the vicinity of the Chatham Rise that influence primary production and plankton ecology as well as flow-on effects though the trophic food web of the Rise (Pinkerton 2013 – Appendix 22).

The waters of the Chatham Rise are associated with high levels of chlorophyll -*a* and therefore primary production (Hall et al. 1999, Beaumont et. al 2013b (Appendix 14)). In SAW in winter through spring and in STW waters in spring, the microbial food web is the dominant pathway for carbon and energy flow. In contrast, in STF waters in winter through spring and STW in winter, the phytoplankton population is dominated by large >20 mm phytoplankton, which suggests that the microbial food web is less important (Hall et al. 1999).

6.4.2 Phytoplankton

6.4.2.1 Introduction

Primary production on the Chatham Rise is driven by phytoplankton within the euphotic zone over the Rise and in adjacent waters that flow over the Rise. The Chatham Rise is recognised as an area of enhanced phytoplankton and primary production (Bradford-Grieve et al. 1997). Due to the scale of phytoplankton production, abundance and production are best measured using remote sensing (Pinkerton 2013 - Appendix 22). Figure 72 illustrates average long-term annual near surface chlorophyll-*a* concentrations over the Chatham Rise. More information on primary production is in Appendix 22.

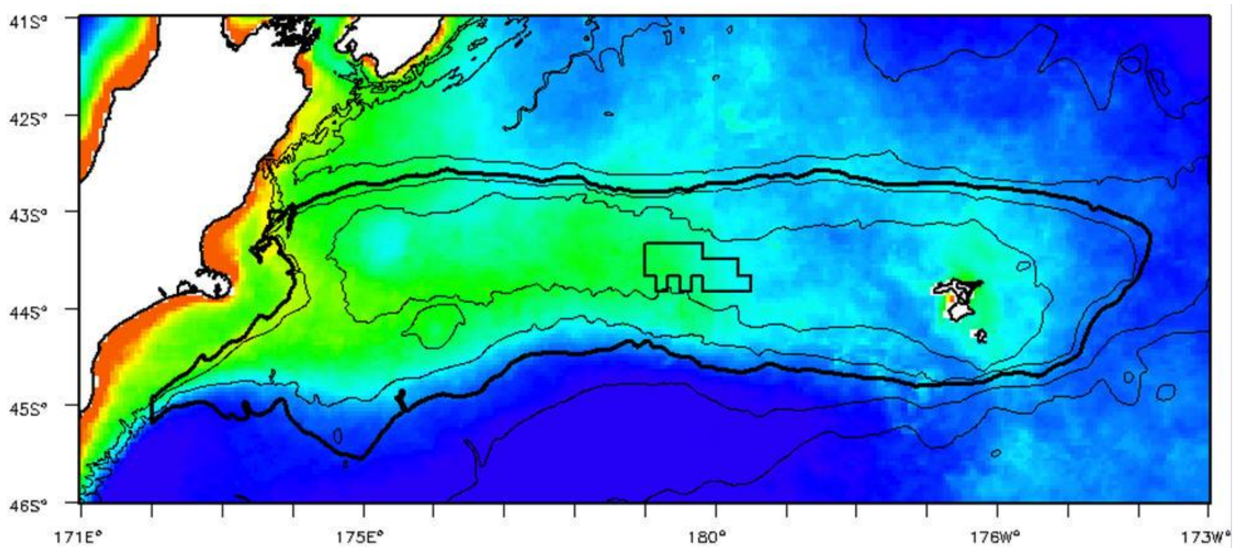

Figure 72: Long-term annual (2001-2012) average near surface chlorophyll-a concentrations. Chlorophyll-a concentrations range from 0.3-21.6 mgChl-a/m^3 over the colour range blue through red (from Pinkerton 2013).

Chang & Gall (1998) examined phytoplankton assemblages along a transect that included two locations on the Chatham Rise (STF), and several south (SAW) and north of the Rise (STW). The samples were collected in 1993 as part of the Joint Global Ocean Flux Study.

The most abundant diatom species recorded in both winter and spring in the STF were *Lauderia annulata* and *Nitzschia/Pseudo-nitzschia* spp. In the STW dinoflagellates and diatoms were found to dominant in winter and spring, respectively. However, to the south in both winter and spring, small-celled nanoflagellates were dominant in the high nutrient and low chlorophyll SAW. The generally shallower, nutrient rich waters over Chatham Rise in the STF provide a relatively stable water column, and are suggested to support a high abundance of diatoms. Low concentrations of dissolved reactive silicate (DRSi) and the build-up of diatoms observed in the STF in spring implied DRSi limitation (Chang & Gall 1998).

6.4.2.2 Trophic importance

The source of primary production on the Chatham Rise is the phytoplankton present in the euphotic zone. Phytoplankton fix carbon with the amount of primary production varying seasonally. Net productivity rates for the Chatham Rise are considered to be comparable to those measured in marine ecosystems around the world that support large scale fisheries (Pinkerton 2013). The elevated phytoplankton productivity in the Chatham Rise area supports a rich pelagic and benthic ecosystem which in turn supports the deep water fisheries (Beaumont et al. 2013b – Appendix 14).

As described in Section 6.10, phytoplankton are identified as the most significant trophic group in the Chatham Rise ecosystem when TI is assessed using a multiple step impact assessment process. This is not surprising in that phytoplankton have positive trophic impacts on many of the other components of the Chatham Rise ecosystem. The exclusively one way (positive) influence is due to their role at the base of the trophic system. More detail can be found in Appendix F in Pinkerton (2013) (Appendix 22).

6.4.3 Zooplankton

6.4.3.1 Introduction

Zooplankton are organisms of varying size that primarily drift with currents (some have locomotion that allows them to avoid predators). Some zooplankton moves vertically in the water column on a daily basis (known as diel migration). As with phytoplankton, zooplankton are grouped and referred to by their size. Microzooplankton (approximately 20 to 200 µm in size) include heterotrophic[22] flagellates and ciliates and other organisms such as the early life stages of crustacea. They play a pivotal role in the transfer of microbial biomass to higher trophic levels as they are the primary grazers of bacteria and picophytoplankton (Sherr & Sherr 1983, Sanders et al. 1992, James et al. 1996 in Hall et al. 1999). Mesozooplankton are larger (0.2 to 2 mm in size) and include crustacean such as copepods. There are larger macrozooplankton (2 to 20 mm) that include copepods, euphasids, chaetognaths and larval crustaceans and these are described in the following section on mesopelagic biota.

6.4.3.2 Biomass

Bradford-Grieve et al. (1998, 1999) suggest that microzooplankton (ciliates) and mesozooplankton biomass in the STW, SAW and STF of the Chatham Rise in spring and winter is correlated with net phytoplankton production. The total zooplankton biomass was found to be largest in spring in all water types. Biomass was found to be concentrated in the upper 100 m of the water column both during the day and night. Variations in biomass (locationally and within the water column) are caused by the patchy nature of zooplankton and diel migration of zooplankton.

[22] Heterotrophs use organic carbon for growth as opposed to autotrophs, such as plants and algae that use energy from sunlight.

Bradford-Grieve et al. (1998) showed that mesoplankton population biomass was greatest for the >1,000 µm fraction followed by the 500 to 1,000 µm, and 200 to 500 µm fractions. The unusually small fraction of biomass residing in the smallest fraction was considered to be due to predation by larger mesozooplankton.

6.4.3.3 Population composition

The composition of the microzooplankton population changes between seasons in the region of the STF (Hall et al. 1999). The proportion of the biomass contributed by heterotrophic nanoflagellates increases from winter to spring in all three water masses. The lower proportion of heterotrophic nanoflagellates in winter may be due to increased grazing pressure by ciliates, which may also be responsible for in the decrease in size of heterotrophic nanoflagellates observed during that season (Safi & Hall 1997 in Hall et al. 1999). In spring, the heterotrophic nanoflagellate population contributes a larger proportion of the microzooplankton, have a larger cell size and higher ratios of potential prey (Safi & Hall 1997 in Hall et al. 1999). The lower relative abundance of ciliates in spring may be a result of increased predation pressure by larger mesozooplankton (0.2 to 2.0 mm) populations found in all water masses in spring (Bradford-Grieve et al. 1997 in Hall et al. 1999).

6.4.3.4 Diet

During both winter and spring, the proportion of primary production grazed by microzooplankton (20 to 200 µm in size) is high in all water masses within the STF region (Hall et al. 1999). In winter, grazing can be greater than primary production. In spring, grazing is also greater than primary production in the STF and SAW, although growth of phytoplankton is greater than grazing in subtropical waters during this season. The impact of grazing by microzooplankton on picophytoplankton (plankton between 0.2 and 2 µm in size) ranges from 13 to 75 % of standing stock and 27 to 297 % of picophytoplankton production (Hall et al. 1999). Overall, the STF food web is classified as ‘multivorous’ in spring and ‘herbivorous’/‘multivorous’ in winter, even though grazing was dominated by microzooplankton.

Despite similar biomass of microzooplankton between the water masses of the STF region, the composition of phytoplankton in their diet varies between water masses (Hall et al. 1999). In STW and SAW during winter and spring, picophytoplankton contributed 38 to 49 % and 26 to 70 % of the microzooplankton diet, respectively. By comparison, in STF, phytoplankton over 20 µm in size (micro-plankton and larger) made up the majority of the microzooplankton diet as picophytoplankton contributed only 1 to 13 % of the total phytoplankton consumed. It is thought that the microzooplankton prey on small cell chains formed by diatoms *Lauderia annulata* and *Hemiaulus* sp. (Hall et al. 1999).

It is presumed that mesozooplankton feed on phytoplankton, microzooplankton, and other mesozooplankton (Bradford-Grieve et al. 1998, Zeldis et al. 2002).

6.4.3.5 Trophic importance

Microzooplankton (part of the microbial loop – refer Section 6.10) are potentially the most important food source for the >0.2 mm zooplankton in early winter and spring in Chatham Rise waters, and are therefore a key link between the microbial food web and the higher trophic levels (Hall et al. 1999).

As described in Section 6.10, mesozooplankton are considered to be a key group in the pelagic ecosystem on the Chatham Rise. The importance derives from their relatively large positive and negative effects on many trophic groups on the Chatham Rise (i.e., they are eaten by many groups and are important predators of groups such as ciliates and hetroflagellates which are their prey).

6.5 Mesopelagic Biota

6.5.1 Introduction

Mesopelagic biota (middle trophic-level organisms living in the water column) on the Chatham Rise comprise four main groups of biota: mesopelagic fishes (dominated by myctophids), cephalopods (mainly pelagic squids but also including benthic octopods), hard-bodied macrozooplankton (mainly krill) and gelatinous zooplankton (like salps and jellyfishes) (Pinkerton 2013 – Appendix 22). Commercial species of mesopelagic fish are discussed in Section 6.6.

6.5.2 Mesopelagic fish

The mesopelagic fish population on the Chatham Rise is dominated by myctophid lantern fish (including *Symbolophorus boops* and *Lampanyctodes hectoris*) and the sternoptychid *Maurolicus australis*. These fish are small, typically 5 cm in length. The group also includes juveniles of a range of fish species that are considered too large to be macrozooplankton and too small to be within any fish group. This group of organisms forms an important part of the diet of the commercial fish species caught on and around the Chatham Rise (Horn & Dunn 2010, Connell et al. 2010).

Mesopelagic fish feed on meso- and macrozooplankton, including copepods and euphasids and probably on other organisms such as soft-bodied zooplankton (refer below), juvenile fish and fish eggs. They may also feed on some macrobenthic species (Pinkerton 2013 - Appendix 22). Schools and layers of mesopelagic fish typically occur at 100 to 500 m depth during the day, and migrate to the upper 200 m at night (O'Driscoll et al. 2009).

Acoustic data collected from the water column during trawl surveys have been used to determine the relative abundance of mesopelagic fish from year to year and their spatial and depth distribution (McClatchie & Dunford 2003, McClatchie et al. 2005, O'Driscoll et al. 2009, 2011). McClatchie & Dunford (2003) estimated a biomass of 665,000 t of mesopelagic fish on the Chatham Rise based on acoustic data collected during the 2000/01 trawl surveys (refer to caveats in their discussion). McClatchie et al. (2005) then examined the spatial distribution of mesopelagic backscatter from Chatham Rise surveys in 2001/03, and inferred that hoki abundance and condition were correlated with the abundance of their mesopelagic prey.

O'Driscoll et al. (2011) found no clear trend in mesopelagic fish biomass on the Chatham Rise from 2001 to 2009. Abundance of mesopelagic fish was consistently higher on the western Chatham Rise (west of 177°E) than in the east (Figure 73). Spatial patterns in mesopelagic fish abundance closely matched the distribution of hoki, but temporal changes in mesopelagic fish abundance were not strongly correlated with hoki biomass (O'Driscoll et al. 2011). O'Driscoll et al. (2011) hypothesised that prey availability influences hoki distribution, but that hoki abundance is driven by other factors such as recruitment variability and fishing.

In 2013, Stevens et al. (2014) found most acoustic backscatter was between 200 and 600 m depth during the day, and migrated to the upper 200 m at night (Figure 74). The vertically migrating component of acoustic backscatter was assumed to be dominated by mesopelagic fish. Daytime backscatter in 2013 was similar to that observed in 2012. The overall mesopelagic estimate for the Chatham Rise decreased by 18 % from 2012 and the 2013 estimate was the second lowest of the time series (the lowest was in 2009). The 2013 mesopelagic index increased on the northwest Chatham Rise, but decreased in the other three sub-areas.

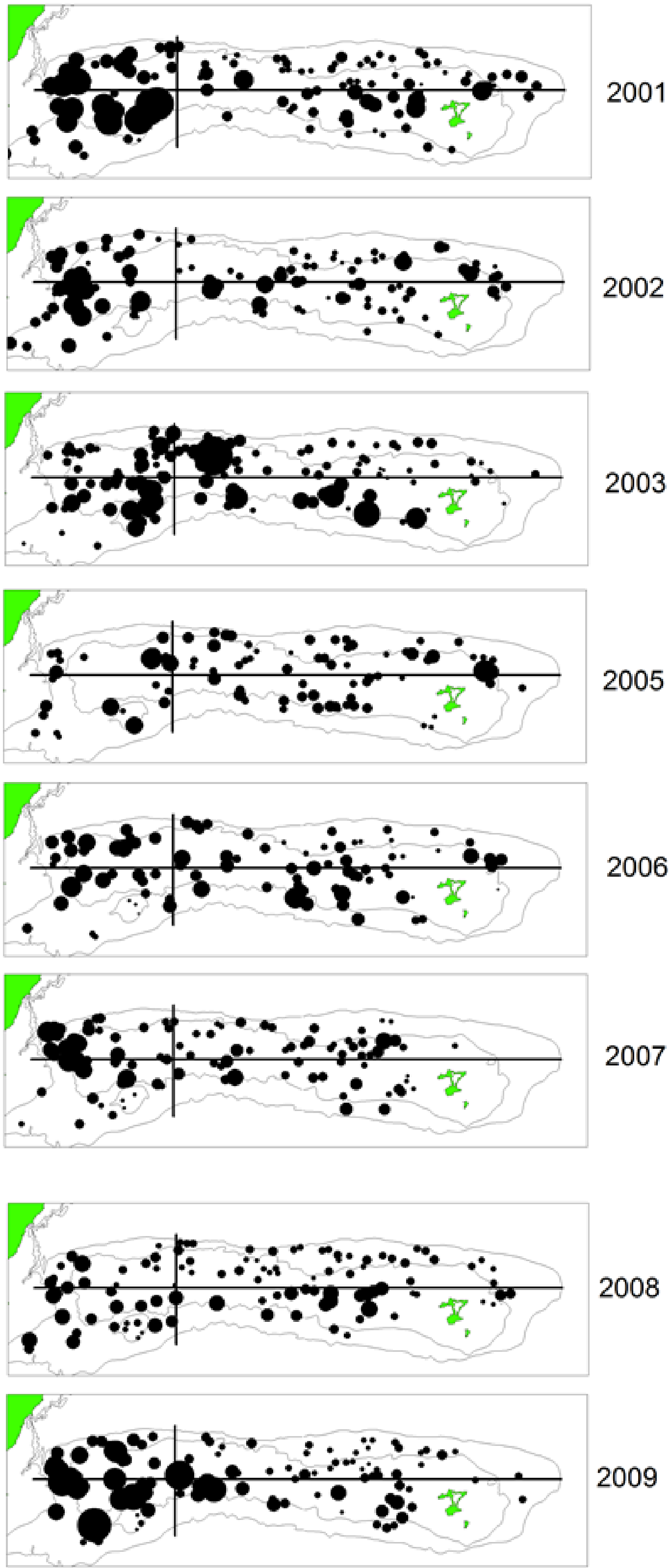

Figure 73: Spatial distribution of mesopelagic fish estimated from acoustic backscatter data on the Chatham Rise from 2001 to 2009 (from O'Driscoll et al. 2011). Circle area is proportional to the acoustic backscatter (maximum symbol size = 250 m^2/km^2). Lines separate four acoustic strata.

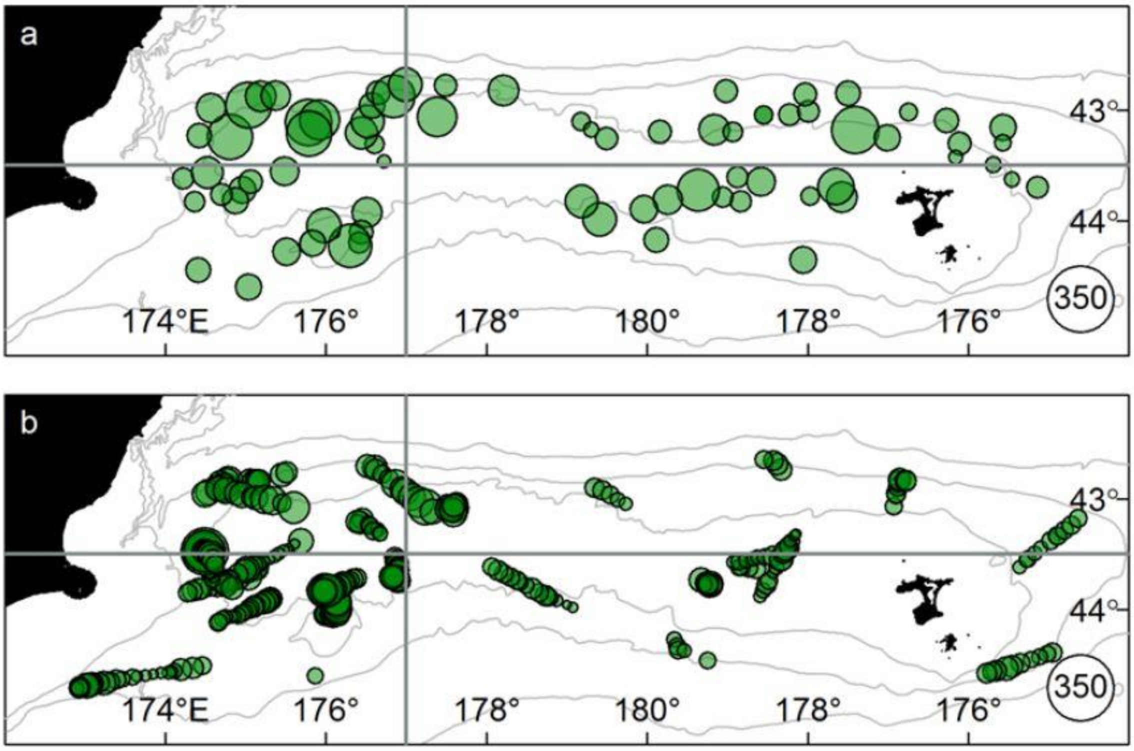

Figure 74: Distribution of total acoustic backscatter (green circles) observed on the Chatham Rise during daytime (a) tows and night-time (b) steams in January 2013 (from Stevens et al. 2014). Circle area is proportional to the acoustic backscatter strength (white circle on bottom right represents maximum symbol size in m^2/km). Grey lines separate the four acoustic strata.

6.5.3 Cephalopods

Cephalopods (octopus and squid) have been recorded throughout most of the Chatham Rise (Beaumont et al. 2013b – Appendix 14). Cephalopods are a key food source for a range of key fish species, marine mammals and seabirds.

The most commonly captured cephalopod by commercial and research bottom trawls on the Chatham Rise is the arrow squid (*Nototodarus sloanii*). Arrow squid are thought to live for about one year, with rapid length growth of more than 3 cm per month (Gibson 1995, Annala et al. 2003a in Pinkerton 2013 – Appendix 22). Arrow squid feed on other squid, small fish and zooplankton including large copepods, mysids, euphasids and decapod shrimps (refer references in Pinkerton 2013 – Appendix 22). Dunn (2009a) determined that mesopelagic fish dominated the diet of arrow squid on the Chatham Rise.

A number of other squid species are present on the Chatham Rise (Livingston et al. 2003), including warty squid (*Onykia ingens, O. robsoni*), red squid (*Ommastrephes bartrami*) and giant squid (*Architeuthis*). Warty and red squid live deeper in the water column and are caught in smaller quantities than arrow squid (Anderson et al. 1998). Squid are thought to be difficult to catch in trawls and the majority of commercial trawling operations on the Chatham Rise are bottom trawls. Many pelagic squid species would be poorly sampled but are likely to be common. These include species such as the cranchiid *Teuthowenia pellucida* and the violet squids (*Histioteuthis* species, mainly *H. atlantica* and *H. miranda*). Based on their prevalence in giant stargazer stomachs, the bobtail squid *Sepioloidea* spp. is also likely to be common. For interest it is noted that giant squid are found in water depths of 300 to 600 m to the south and east of New Zealand (Förch 1998 in Pinkerton 2013 – Appendix 22). The highest taxonomic richness of cephalopods in the Chatham Rise area has been recorded on the Graveyard Seamount complex, and high richness has also been recorded around the 1,000 m depth contours. Low levels of cephalopod taxonomic richness have been recorded in MPL 50270.

The distribution of squid appears to follow distribution patterns of benthic and demersal fish (Beaumont et al. 2013b – Appendix 14). The diet of squid is thought to consist of squid, mesopelagic fish, macrozooplankton (especially mysids, euphausiids and decapod shrimps) and a small proportion of adult and juvenile fish (Pinkerton 2013 and references therein – Appendix 22).

The distribution of octopus on the Chatham Rise is focussed on the central area between the 250 and 500 m depth contours (Beaumont et al. 2013b – Appendix 14). The greatest catch rates have been recorded on the edge of MPL 50270, within the BPA and in patches on the east and west of the southern half of the Chatham Rise. The most commonly captured 'shallower water' species by Chatham Rise trawl surveys is the dwarf Octopus (*Octopus mernoo*). The deep water octopus (*Granelodone* spp.) dominates the records of octopus in depths greater than 500 m. The distribution of other octopus species (for example *Enteroctopus zealandicus*) appears to be similar to that of the sponges on the Chatham Rise (Beaumont et al. 2013b).

6.5.4 Hard bodied macro-zooplankton

Euphausiids, decapods and amphipods make up most of the hard bodied macro-zooplankton found in waters over the Chatham Rise (Figure 75). Pinkerton 2013 (Appendix 22) provides further information on species present. In 2011 to 2012 an acoustic and trawling survey on the Chatham Rise examined the mesopelagic zone (refer to Gauthier et al. 2013). The study provided information on krill (euphausiids) density and biomass on the Rise. Krill are assumed to make up most of the macrozooplankton biomass on the Chatham Rise (Pinkerton 2013). Macrozooplankton such as euphausiids consume phytoplankton, microzooplankton and mesozooplankton such as copepods.

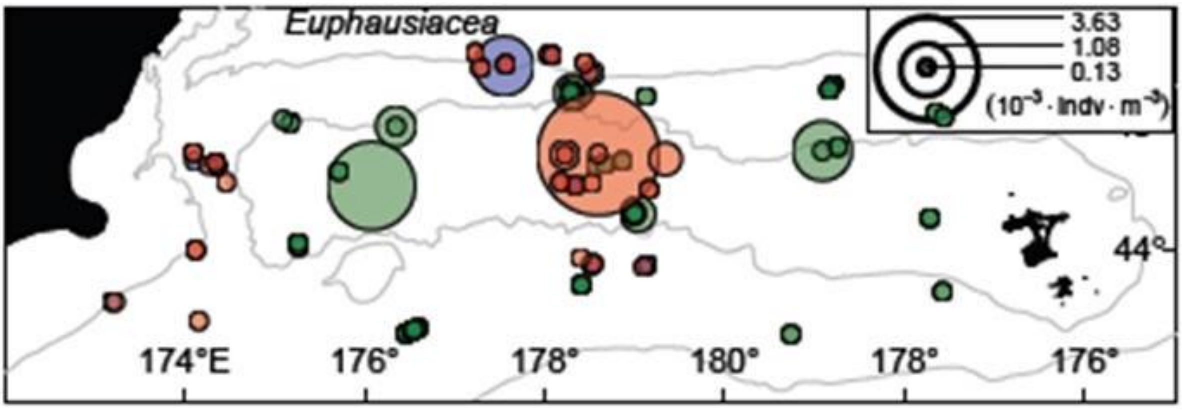

Figure 75: Spatial distribution of catch rates (individuals per unit volume) of euphausiids on the Chatham Rise (from Gauthier et al. 2013, refer Pinkerton 2013). Colours correspond to different NIWA Tangaroa voyages. Depth contours are 500 and 2,000 m.

6.5.5 Soft bodied zooplankton

Soft bodied or gelatinous macrozoolankton include jellyfish, salps, siphonophores and chaetognaths (Pinkerton 2013 – Appendix 22). The catch rate distribution of soft bodied zooplankton (in this case salps) is shown in Figure 76).

Gelatinous plankton are opportunistic species and can often increase in population size under favourable conditions. This can consequently have impacts on available food for other species as they feed on plankton of a variety of sizes, and also bacteria and detritus. This group of plankton provides food for seabirds at the surface as well as for fish in the lower water column.

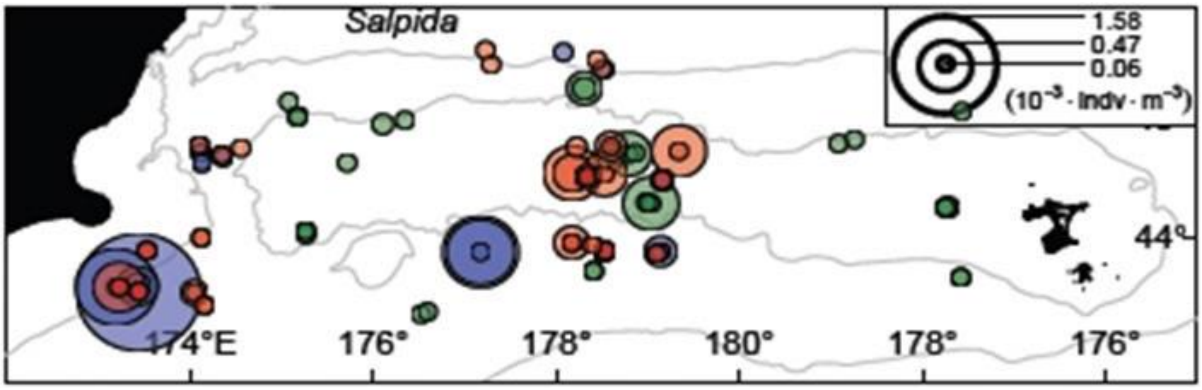

Figure 76: Spatial distribution of catch rates (individuals per unit volume) of salps on the Chatham Rise (from Gauthier et al. 2013, refer Pinkerton 2013). Colours correspond to different NIWA Tangaroa voyages. Depth contours are 500 and 2,000 m.

6.5.6 Trophic importance

Mesopelagic biota fills a range of trophic positions within the Chatham Rise ecosystem, as modelled by Pinkerton 2013 (Appendix 22). Key observations regarding their trophic importance include:

- The TI of cephalopods in Pinkerton's (2013) trophic model is ranked at 4 of 28 groups, meaning that squid are more important in maintaining the balance within the model than meiobenthos, some demersal fish (8 species groups), birds, cetaceans and pinnipeds. As described by Pinkerton (2013), squid are important as a major food source for a wide variety of predators, including fish, marine mammals and seabirds.
- Mesopelagic fish ranked 7 in both the TI1 and TI2 models. In the TI2 model, mesopelagic fish have positive effects on a number of fish groups (e.g., hoki) and high end predator groups (e.g., birds, toothed whales, pinnipeds etc.). This group also has negative impacts on groups such as hard bodied macrozooplankton such as krill.
- The soft-bodied macrozooplankton ranked 8 in the TI1 model and 10 in the TI2 model. This group has positive effects on two key fish groups – the oreos and warehou.
- The hard-bodied macrozooplankton (krill) ranked 12 in the TI1 and TI2 models. The two key groups that krill have positive impacts on are birds and baleen whales.

6.6 Fish

6.6.1 Introduction

The importance of the fisheries in the Chatham Rise region is reflected in the considerable body of environmental and fisheries knowledge that exists for the area (Beaumont et al. 2013b – Appendix 14). The detail of knowledge associated with fisheries on the Chatham Rise includes assessments of fisheries catch and by-catch, marine community structures, trawl areas and the effects of trawling on the substrate and benthic fauna of seamounts, biodiversity, and analysis of sediment types, bathymetry, oceanography and hydrology (Beaumont et al. 2013b and references therein).

This section describes the fish species on the Chatham Rise, including New Zealand's commercial fisheries. The nature of the commercial fishery is discussed in Section 6.7.

Commercial fishing activity in the marine consent area is primarily in the east within PP 55967, and is associated with long-lining for ling. Approximately half of the marine consent area lies within the eastern part of the Mid Chatham Rise BPA and is closed to bottom trawling (Figure 6 in Section 2.4.3). The Mid Chatham Rise BPA is one of 17 BPAs established with the co-operation of the deep water fishing sector (refer to Section 8.6.6.4 for further information).

The main commercial fisheries of the Chatham Rise are hoki (*Macruronus novaezelandiae*), hake (*Merluccius australis*), ling (*Genypterus blacodes*), silver warehou (*Seriolella panctata*) and scampi (*Metanephrops challengeri*), along with orange roughy (*Hoplostethus atlanticus*) and oreos (*Pseudocyttus maculatus, Allocyttus niger,*) in deeper waters. These fisheries, as for most New Zealand fisheries, are managed by a Quota Management System (QMS).

Fish caught as by-catch on the Chatham Rise include other QMS species such as giant stargazer (*Kathetostama giganteum*), spiny dogfish (*Squalus acanthias*), jack mackerel (*Trachurus* spp), barracouta (*Thyrsites atun*), pale ghost shark (*Hydrolagus bemisi*), and lookdown dory (*Cyttus traversi*), as well as non-QMS species such as javelinfish (*Lepidorhynchus denticulatus*), other rattails (more than 20 species including Bollon's (*Caelorinchus bollonsi*), Oliver's (*C. oliverianus*), oblique banded (*C. aspercephalus*) and banded (*C. fasciatu*s) rattails), deep water sharks (more than 10 species including shovelnose spiny dogfish (*Deania calcea*)), slickheads (six species including *Alepocephalus australis, A. antipodianus),* deepsea flathead (*Hoplichthys haswelli*), chimaeras (e.g., *Chimaera* spp., *Harriotta raleighana*), spineback (*Notocanthus sexspinis*), and basketwork eel (*Diastobranchus capensis*).

This section presents information on:

- The range of fish species that have been caught on the Chatham Rise.
- The fish assemblages (communities) on the Chatham Rise.
- Specific information on the ecology of key fish species on the Chatham Rise.

6.6.2 Fish species on the Chatham Rise

More than 200 species of fish have been identified on the Chatham Rise (Pinkerton 2013 – Appendix 22). Information on the fish species present comes from the research trawls undertaken on the Rise encompassing the shallowest areas on the various banks (refer to Section 5.2) to the northern and southern flanks of the Chatham Rise which are 1,000 m and deeper.

Stevens et al. (2014) reported the results of a trawl survey to estimate the relative biomass of hoki and other middle depth species on the Chatham Rise. The survey which was carried out in January 2013, comprised 91 biomass tows at 200 to 800 m deep and 32 biomass tows at 800 to 1,300 m deep. The total catch (including both depth strata) was 135.2 t, of which 38.0 % was hoki, 2.7 % was ling and 0.8 % was hake. It follows that, hoki were estimated to have the highest relative biomass (124,112 t) with much of this biomass including 1+ year old hoki (50,943 t). Ling had the second highest relative biomass (8,714 t) and the time series data showed no overall trend in their population on the Chatham Rise. Hake had the next greatest relative biomass (1,793 t), but this estimate was low compared to those from the early 1990s. The survey to a depth of 1,300 m identified 166 teleosts (bony fishes), 34 elasmobranchs (sharks, rays and skates) and two agnathans (jawless fishes, i.e., hagfishes).

Table 10 summarises the key fish species identified in the 200 to 800 m trawls which are the water depths relevant to CRP's proposed marine consent area and surrounds. The list does not include some of the species found in only one tow of all those undertaken in 2013, which were predominantly rattail species. Table 10 also identifies the biomass estimates for key QMS and non-QMS species as reported by Stevens et al. (2014). Golder (2014b) (Appendix 17) presents the probability of capture for 121 fish species, to provide some context to the distribution and likelihood of encountering the fish species described in the table. The output maps were produced using research trawl data from 1997 to 2005 that has been modelled and matched to environmental data to provide a proxy for fisheries habitat preference and distribution. As described in Golder (2014b), the broader Chatham Rise supports a range of shallow inshore species (e.g., snapper and spotty etc.) that are not found in the deeper water on the crest of the Rise. These species (identified in Appendix 17) are not included in Table 10.

Within the 200 to 800 m depth sampled by Stevens et al. (2014), hoki was the most abundant species caught. The next most abundant commercially caught species were alfonsino, dark ghost shark, black oreo, ling, sea perch, lookdown dory, silver warehou, spiny dogfish, pale ghost shark, spiky oreo, giant stargazer, and white warehou. The majority of the hoki, hake and ling catch was collected from these water depths, with less than 5 % of the total catch for these species coming from deeper water (800-1,300 m). Of the other (non-commercial) fisheries in the 200 to 800 water depths, the most abundant were javelinfish, big-eye rattail, shovelnose dogfish, oblique banded rattail, Oliver's rattail, banded bellowsfish, Baxter's dogfish, and longnose spookfish.

Stevens et al. (2014) and Golder (2014b) (Appendix 17) provide information as to the distribution of fish species in relation to CRP's marine consent area. The catchability summary in Golder (2014b) indicates:

- Some 27 fish species are only found in in-shore waters including the area immediately around the Chatham Islands. These species include snapper, spotty, elephant fish, kingfish, and kahawai.
- Twenty-nine fish species were identified in deeper waters on the slopes of the Rise rather than the crest and therefore the catchability evaluation did not identify them as occurrence within the marine consent area. These species include smooth oreo which were mainly caught on the northern slopes at depths of 1,000 to 1,300 m. Orange roughy is widespread to the north and east of the Rise at water depths of 800 to 1,300 m, with the largest catch of the 2013 survey taken to the northeast of the Rise. These species also included a number of dogfish and rattail species.
- Six species (including black oreo, spotted gurnard, and deepsea skate) were identified as being catchable on the crest of the Chatham Rise but with a low probability of being present within the marine consent area. Black oreo, predominantly juveniles, were almost entirely caught to the southwest at depths of 600 to 800 m.
- Thirty-seven fish species were identified as occurring with the marine consent area with a catchability of typically <50 %. These include spiky oreo which are more widespread and most abundant on the northeastern Rise at depths of 500 to 800 m.
- Twenty-two fish species were identified as occurring within the marine consent area with a catchability of >50 %. Of these:
    - Lookdown dory, sea perch and spiny dogfish are widely distributed throughout the area at 200 to 600 m depths, with the largest catch rates taken at the eastern end of the Chatham Rise.
    - Silver warehou and white warehou are also found at depths of 200 to 600 m and are patchily distributed with the largest catches in the west.
    - Giant stargazers are also mainly caught in shallower depth strata, with the largest catch taken around Mernoo Bank.
    - Dark ghost shark are mainly caught at 200 to 400 m depths, and are particularly abundant on Veryan Bank, while pale ghost shark are mostly caught in deeper water at 400 to 800 m depth, with higher catch rates to the west.

Table 10: Key fish species on the Chatham Rise (200-800 m depth).

Fish stock code	Common name	Species	Biomass (t) 200-800 m	Catchability figure (App. 17)[+]	References
BAR*	barracouta	*Thyrsites atun*	980	Figure 3	MPI 2013a, Stevens et al. 2014
BBE	banded bellowsfish	*Centriscops humerosus*	1,294**	Figure 4	Stevens et al. 2014
BEE	basketwork eel	*Diastobranchus capensis*		Figure 6	Stevens et al. 2014
BJA	black javelinfish	*Mesobius antipodum*		Figure 7	Stevens et al. 2014
BNS	bluenose	*Hyperoglyphe antarctica*	80	Figure 8	MPI 2013a, Stevens et al. 2014
BOE	black oreo	*Allocyttus niger*	10,779	Figure 9	MPI 2013b, Black & Wood 2014, Stevens et al. 2014
BGZ	banded stargazer		16		
BSH	seal shark	*Dalatias licha*		Figure 11	Stevens et al. 2014
BSL	black slickhead	*Xenodermichthys spp.*		Figure 12	Stevens et al. 2014
BYX* or BYS	alfonsino	*Beryx splendens, B. decadactylus*	44,779	Figure 13	MPI 2013a, Stevens et al. 2014
CAR	carpet shark	*Cephaloscyllium isabellum*		Figure 14	Stevens et al. 2014
CAS	oblique banded rattail	*Caelorinchus aspercephalus*	2,110**	Figure 15	Stevens et al. 2014
CBA	humpback rattail (slender rattail)	*Coryphaenoides dossenus*		Figure 16	Stevens et al. 2014
CBO	Bollon's rattail	*Caelorinchus bollonsi*	13,447**	Figure 18	Stevens et al. 2014
CDO	capro dory	*Capromimus abbreviatus*		Figure 19	Stevens et al. 2014
CFA	banded rattail	*Caelorinchus fasciatus*		Figure 20	Stevens et al. 2014
CHA	viper fish	*Chauliodus sloani*		Figure 21	Stevens et al. 2014
CHP	brown chimaera	*Chimaera sp. C*		Figure 22	Stevens et al. 2014
CIN	notable rattail	*Caelorinchus innotabilis*		Figure 23	Stevens et al. 2014
CKA	kaiyomaru rattail	*Caelorinchus kaiyomaru*		Figure 24	Stevens et al. 2014
CMA	mahia rattail	*Caelorinchus matamua*		Figure 25	Stevens et al. 2014
COL	Oliver's rattail	*Caelorinchus oliverianus*	1,618**	Figure 26	Stevens et al. 2014
CSE	serrulate rattail	*Coryphaenoides serrulatus*		Figure 27	Stevens et al. 2014
CSQ	leafscale gulper shark	*Centrophorus squamosus*		Figure 28	Stevens et al. 2014
CSU	four-rayed rattail	*Coryphaenoides subserrulatus*		Figure 29	Stevens et al. 2014

Fish stock code	Common name	Species	Biomass (t) 200-800 m	Catchability figure (App. 17)+	References
CYO	smooth skin (Owstons) dogfish	*Centroscymnus owstoni*		Figure 31	Stevens et al. 2014
CYP	longnosed velvet dogfish	*Centroscymnus crepidater*		Figure 32	Stevens et al. 2014
ELE	elephantfish	*Callorhinchus milii*		Figure 34	MPI 2013a
EMA	blue mackerel	*Scomber australasicus*		Figure 35	MPI 2013a
EPT	deepsea (black) cardinalfish	*Epigonus telescopus*	75	Figure 36	MPI 2013a, Stevens et al. 2014
ETB	Baxter's dogfish	*Etmopterus baxteri*	1,011**	Figure 38	Stevens et al. 2014
ETL	lucifer dogfish	*Etmopterus lucifer*		Figure 39	Stevens et al. 2014
FHD	deepsea flathead	*Hoplichthys haswelli*		Figure 40	Stevens et al. 2014
FRO	frostfish	*Lepidopus caudatus*	72	Figure 41	MPI 2013a, Stevens et al. 2014
GSH	dark ghost shark	*Hydrolagus novaezealandiae*	11,723		MPI 2013a, Stevens et al. 2014
GSP	pale ghost shark	*Hydrolagus bemisi*	4,270	Figure 43	MPI 2013a, Stevens et al. 2014
HAK	hake	*Merluccius australis*	1,793	Figure 45	MPI 2013a, Black & Wood 2014, Stevens et al. 2014
HAP	hapuku	*Polyprion oxygeneios*	225	Figure 46	MPI 2013a, Stevens et al. 2014
HCO	hairy conger	*Bassanago hirsutus*		Figure 47	Stevens et al. 2014
HJO	Johnson's cod	*Halargyreus johnsonii*		Figure 48	Stevens et al. 2014
HOK	hoki	*Macruronus novaezelandiae*	124,112	Figure 49	MPI 2013a, O'Driscoll & Ballara 2014, Black & Wood 2014, Stevens et al. 2014
HPB & BAS	groper (hapuku and bass)	*Polyprion oxygeneios, Polyprion americanus*	42	Figure 13	MPI 2013, Stevens et al. 2014
HPE	common halosaur	*Halosaurus pectoralis*			Stevens et al. 2014
HYB	black ghost shark	*Hydrolagus sp. A*		Figure 51	Stevens et al. 2014
JAV	javelin fish	*Lepidorhynchus denticulatus*	15,418**	Figure 52	Stevens et al. 2014
JMD or JMA	horse mackerel (jack mackerel)	*Trachurus declivis*	5	Figure 55	MPI 2013a, Black & Wood 2014, Stevens et al. 2014
JMM or JMA	murphys mackerel (jack or slender mackerel)	*Trachurus murphyi*	29	Figure 56	MPI 2013a, Black & Wood 2014, Stevens et al. 2014
JMN or JMA	golden mackerel (jack mackerel)	*Trachurus novaezelandiae*		Figure 57	MPI 2013a, Black & Wood 2014

Fish stock code	Common name	Species	Biomass (t) 200-800 m	Catchability figure (App. 17)[+]	References
LCH	longnose spookfish (longnose chimaera)	*Harriotta raleighana*	832**	Figure 60	Stevens et al. 2014
LDO	lookdown dory	*Cyttus traversi*	7,141	Figure 61	MPI 2013b, Stevens et al. 2014
LIN	ling	*Genypterus blacodes*	8,714	Figure 63	MPI 2013b, Black & Wood 2014, Stevens et al. 2014
LSO	lemon sole	*Pelotretis flavilatus*	75	Figure 64	Stevens et al. 2014
MCA	ridge scaled rattail	*Macrourus carinatus*		Figure 65	Stevens et al. 2014
NNA	squashed face rattail	*Nezumia namatahi*		Figure 67	Stevens et al. 2014
NSD	northern spiny dogfish	*Squalus sp. cf mitsukurii or S. griffini*		Figure 68	Stevens et al. 2014
OPE	orange perch	*Lepidoperca aurantia*		Figure 69	Stevens et al. 2014
ORH	orange roughy	*Hoplostethus atlanticus*	3	Figure 70	MPI 2013b, Black & Wood 2014, Stevens et al. 2014
PDG	prickly dogfish	*Oxynotus bruniensis*		Figure 72	Stevens et al. 2014
PHO	lighthouse fish	*Photichthys argenteus*		Figure 73	Stevens et al. 2014
PLS	Plunket's shark	*Proscymnodon plunketi*		Figure 74	Stevens et a. 2014
PSK	longnose deepsea skate	*Bathyraja shuntovi*		Figure 77	Stevens et al. 2014
PSY	blob fish	*Psychrolutes microporos*		Figure 78	Stevens et al. 2014
RBM	Ray’s bream	*Brama brama & B. australis*	3	Figure 79	Stevens et al. 2014
RBT	redbait	*Emmelichthys nitidus*		Figure 80	MPI 2013b
RCO	red cod	*Pseudophycis bachus*	406	Figure 82	MPI 2013b, Stevens et al. 2014
RIB	ribaldo	*Mora moro*	428	Figure 83	MPI 2013c, Stevens et al. 2014
RSK	rough skate	*Zearaja nasuta*	38		MPI 2013c, Stevens et al. 2014
RUD	rudderfish	*Centrolophus niger*		Figure 85	Stevens et al. 2014
SBI	bigscaled brown slickhead	*Alepocephalus sp.*		Figure 86	Stevens et al. 2014
SBW	southern blue whiting	*Micromesistius australis*		Figure 87	MPI 2013c, Black & Wood 2014
SCG	scaly gurnard	*Lepidotrigla brachyoptera*		Figure 88	Stevens et al. 2014
SCH	school shark	*Galeorhinus galeus*	531	Figure 89	MPI 2013c, Stevens et al. 2014
SCO	swollenhead conger	*Bassanago bulbiceps*		Figure 90	Stevens et al. 2014
SDE	seadevil	*Cryptopsaras couesi*			Stevens et al. 2014
SDO	silver dory	*Cyttus novaezealandiae*		Figure 91	Stevens et al. 2014

Fish stock code	Common name	Species	Biomass (t) 200-800 m	Catchability figure (App. 17)[+]	References
SMC	small-headed cod	*Lepidion microcephalus*		Figure 94	Stevens et al. 2014
SND	shovelnose dogfish	*Deania calcea*	8,100*	Figure 96	Stevens et al. 2014
SOR	spiky oreo	*Neocyttus rhomboidalis*	4,045	Figure 97	Stevens et al. 2014
SPD	spiny dogfish	*Squalus acanthias*	6,864	Figure 98	MPI 2013c, Stevens et al. 2014
SPE	sea perch	*Helicolenus percoides*	7,785	Figure 99	MPI 2013c, Stevens et al. 2014
SQU or NOS	arrow squid (NZ southern – N. sloanii)	*Nototodarus gouldi, N. sloanii*	308		MPI 2013a, Stevens et al. 2014
SRH	silver roughy	*Hoplostethus mediterraneus*		Figure 102	Stevens et al. 2014
SSI	silverside	*Argentina elongata*		Figure 104	Stevens et al. 2014
SSK	smooth skate	*Dipturus innominatus*	1,494		MPI 2013c, Stevens et al. 2014
SSM	smallscaled brown slickhead	*Alepocephalus australis*		Figure 105	Stevens et al. 2014
SSO	smooth oreo	*Pseudocyttus maculatus*	1,532	Figure 106	MPI 2013b, Black & Wood 2014, Stevens et al. 2014
STA or GIZ	giant stargazer	*Kathetostoma giganteum*	2,108		MPI 2013c, Stevens et al. 2014
SWA	silver warehou	*Seriolella punctata*	6,945	Figure 108	MPI 2013c, Stevens et al. 2014
TAR or NMP	tarakihi	*Nemadactylus macropterus*		Figure 109	MPI 2013c, Stevens et al. 2014
TOP	pale toadfish	*Ambophthalmos angustus*		Figure 110	Stevens et al. 2014
TRS	cape scorpionfish	*Trachyscorpia capensis*		Figure 112	Stevens et al. 2014
TUB	Tubbia tasmanica	*Tubbia tasmanica*		Figure 113	Stevens et al. 2014
VCO	violet cod	*Antimora rostrata*		Figure 114	Stevens et al. 2014
VNI	blackspot rattail	*Ventrifossa nigromaculata*		Figure 115	Stevens et al. 2014
WAR	blue (or common) warehou	*Seriolella brama*		Figure 116	MPI 2013a
WIT	witch	*Arnoglossus scapha*		Figure 118	Stevens et al. 2014
WOE	warty oreo	*Allocyttus verrucosus*		Figure 119	Stevens et al. 2014
WWA	white warehou	*Seriolella caerulea*	2,030	Figure 121	MPI 2013c, Stevens et al. 2014

Note: [+] denotes species for which maps of probability of capture are presented in Golder (2014b) (Appendix 17). Biomass data from Stevens et al. (2014). All species except those notes are QMS species. * Commercial non-QMS species (where biomass >30 t). ** Non-commercial species (where core biomass >800 t).

The location of juvenile distribution for key fish species are summarised in Table 11 and the spawning, pupping or egg-laying distributions in Table 12. According to O'Driscoll et al. (2003) a variety of fish species spawn on the slopes or on the crest of the Chatham Rise, including CRP's proposed marine consent area . More information is provided in relation to the spawning of key species in the following sections.

More detailed information on the key fish species, especially those having key biomass or commercial importance, is in Sections 6.6.4 to 6.6.17. For each species, information is provided on distribution and feeding, and reference is made to maps in Appendix 17 that illustrate the probability of capture (i.e., probability of being present) of individual species. That is where the species is predicted to occur on the Chatham Rise, not where the species is commercially caught. The latter is described in Section 6.7.4.

6.6.3 Fish assemblages on the Chatham Rise

Different deep water fish assemblages occur on the north and south Chatham Rise due to the different water masses on either side of the STF (Bull et al. 2001, Beaumont et al. 2013b (Appendix 14)). Leathwick et al. (2006) developed a demersal fish community map for New Zealand's EEZ, which includes descriptions of the demersal fish assemblages (group classification) in the vicinity of the Chatham Rise (Figure 77).

There are six group classifications described for the Chatham Rise area, defined on the basis of similarity in fish composition (Leathwick & Julian 2006): two shallow upper slope groups (Chatham Rise 1 and Chatham Rise 2), two mid-water upper slope groups (Chatham Rise 3 and Campbell Plateau 3) and two mid slope groups (Southern Mid Slope and Deep Mid Slope). Table 13 identifies the key fish found in each of these fish assemblages (Leathwick & Julian 2006).

The marine consent area is within the region occupied by fish assemblages Chatham Rise 1 (down to approximately 250 m depth), Chatham Rise 2 (an average depth of about 370 m) and Chatham Rise 3 (to about 550 m). These demersal fish assemblages include several predominant species and groups (some of which are key commercial fisheries) such as hoki, spiny dogfish, silver warehou and ling (Leathwick & Julian 2006).

Pinkerton (2013) (Appendix 22) further grouped fish found on the Chatham Rise into 11 groups, based on key species (or groups of species) and five trophic guilds. The five feeding groups were demersal invertebrate foragers, demersal predators, benthopelagic invertebrate foragers, benthopelagic predators, and pelagic foragers. The nine Chatham Rise trophic guilds from Dunn et al., (submitted) are identified in Table 14.

The most abundant and/or most commonly encountered fish species in the main assemblages on the Chatham Rise are described in the following sections. Their trophic importance, as part of the Chatham Rise trophic web, is also highlighted (based on Pinkerton 2013) (Appendix 22).

Table 11: Summary of juvenile distributions from the South Island (NEC, east coast north of Banks Peninsula; SEC, east coast south of Banks Peninsula; Sth, Southland; SP, Southern Plateau; NCR, north Chatham Rise; SCR, south Chatham Rise(from O'Driscoll et al. 2003).

	NEC	SEC	Sth	SP	NCR	SCR
Deep water species						
Allocyttus niger	+	[Low]	[High]	[Medium]	[Low]	[High]
Argentina elongata		[Low]	+		[Medium]	[Medium]
Beryx splendens	+				[High]	
Brama brama		[Low]	[Medium]	[Low]	[Medium]	[Medium]
Centroscymnus crepidater	?	?	?	?	[Medium]	[Low]
Centroscymnus owstoni	?	?	?	?	+	+
Cyttus traverse	+	[Low]	[Low]	[Low]	[High]	[High]
Deania calcea	?		[Low]	?	[High]	[Medium]
Dipturus innominatus	[Medium]	[Medium]	[Low]	[Low]	[Medium]	[Medium]
Dipturus nasutus	[High]	[High]	[Low]	[Low]		+
Emmelichthys nitidus	?	[High]	[Medium]		[Low]	[Low]
Epigonus telescopus	+		[High]		[Medium]	
Etmoperus baxteri	?	?	?	+	[High]	[Low]
Genypterus blacodes	[Low]	[High]	[Medium]	[Medium]	[Medium]	[High]
Hoplostethus atlanticus	[Low]	[Low]	[Low]	[Low]	[High]	[Medium]
Hydrolagus novaezealandiae	[Medium]	[High]	[Low]	[Low]	[Low]	[Medium]
Hydrolagus sp. B2	[Low]	[Low]	[Low]	[Medium]	[Medium]	[High]
Hyperglyphe antartica		+	[Low]		[High]	[Low]
Lepidoperca aurantia	?	?	[Medium]		[Low]	[Low]
Lepidoperca caudatus	?	?	?		[Low]	
Macruronus novaezelandiae	[Medium]	[High]	[High]	[Medium]	[High]	[High]
Merluccius australis		[Low]	[High]	[Low]		[Low]
Micromesistius australis		[Low]	[Low]	[High]	[Low]	[Low]
Mora moro	+		[Low]	[Low]	[Medium]	[Low]
Neocyttus rhomboidalis	?		[Low]	+	[High]	[High]
Plagiogeneion rubiginosum					[Low]	
Pseudocyttus maculatus	[Low]	[High]	[Medium]	[Medium]	[Medium]	[High]
Seriolella caerulea	[Low]	[Medium]	[Low]	[Low]	[Low]	[High]
Seriolella punctate	[Medium]	[High]	[Medium]	[Low]	[High]	[High]
Squalus mitsukurii	?	?			[Low]	
Trachyrinchus longirostris	?	?	?	?	[Medium]	+
Zenopsis nebulosus	?	?			?	
Pelagic species						
Engraulis australis	?	?				
Lampris guttatus		?	+			
Sardinops neopilchardus	?					
S.antipodum, S. Muelleri	+	+				

+ indicates presence (from literature or trawl data) where abundance not determined because of insufficient records. ? indicates possible occurrence where no fish measured.

Survey abundance:

Low (yellow) Medium (light blue) High (dark blue)

Table 12: Summary of spawning, pupping or egg-laying distributions from the South Island (NEC , east coast north of Banks Peninsula; SEC, east coast south of Banks Peninsula; Sth, Southland; SP, Southern Plateau; NCR, north Chatham Rise; SCR, south Chatham Rise (from O'Driscoll et al. 2003).

	NEC	SEC	Sth	SP	NCR	SCR
Deep water species						
Allocyttus niger						
Argentina elongata	ND	ND	ND	ND	ND	ND
Beryx splendens						
Brama brama						
Centroscymnus crepidater	ND	ND	ND	ND	ND	ND
Centroscymnus owstoni	ND	ND	ND	ND	ND	ND
Cyttus traverse						
Deania calcea	ND	ND	ND	ND	ND	ND
Dipturus innominatus						
Dipturus nasutus						
Emmelichthys nitidus						
Epigonus telescopus						
Etmoperus baxteri	ND	ND	ND	ND	ND	ND
Genypterus blacodes						
Hoplostethus atlanticus						
Hydrolagus novaezealandiae	ND	ND	ND	ND	ND	ND
Hydrolagus sp. B2	ND	ND	ND	ND	ND	ND
Hyperglyphe antartica						
Lepidoperca aurantia	+	ND	ND	ND	ND	ND
Lepidoperca caudatus		+				
Macruronus novaezelandiae						
Merluccius australis						
Micromesistius australis						
Mora moro						
Neocyttus rhomboidalis						
Plagiogeneion rubiginosum						
Pseudocyttus maculatus						
Seriolella caerulea	+	+				
Seriolella punctate						
Squalus mitsukurii	ND	ND	ND	ND	ND	ND
Trachyrinchus longirostris	ND	ND	ND	ND	ND	ND
Zenopsis nebulosus	ND	ND	ND	ND	ND	ND
Pelagic species						
Engraulis australis	ND	ND	ND	ND	ND	ND
Lampris guttatus	ND	ND	ND	ND	ND	ND
Sardinops neopilchardus	ND	+	ND	ND	ND	ND
S.antipodum, S. Muelleri	+	+	ND	ND	ND	ND

+ indicates presence from literature, ND = no data.

Ripe/Running Ripe:

Rare **Occasional** **Common**

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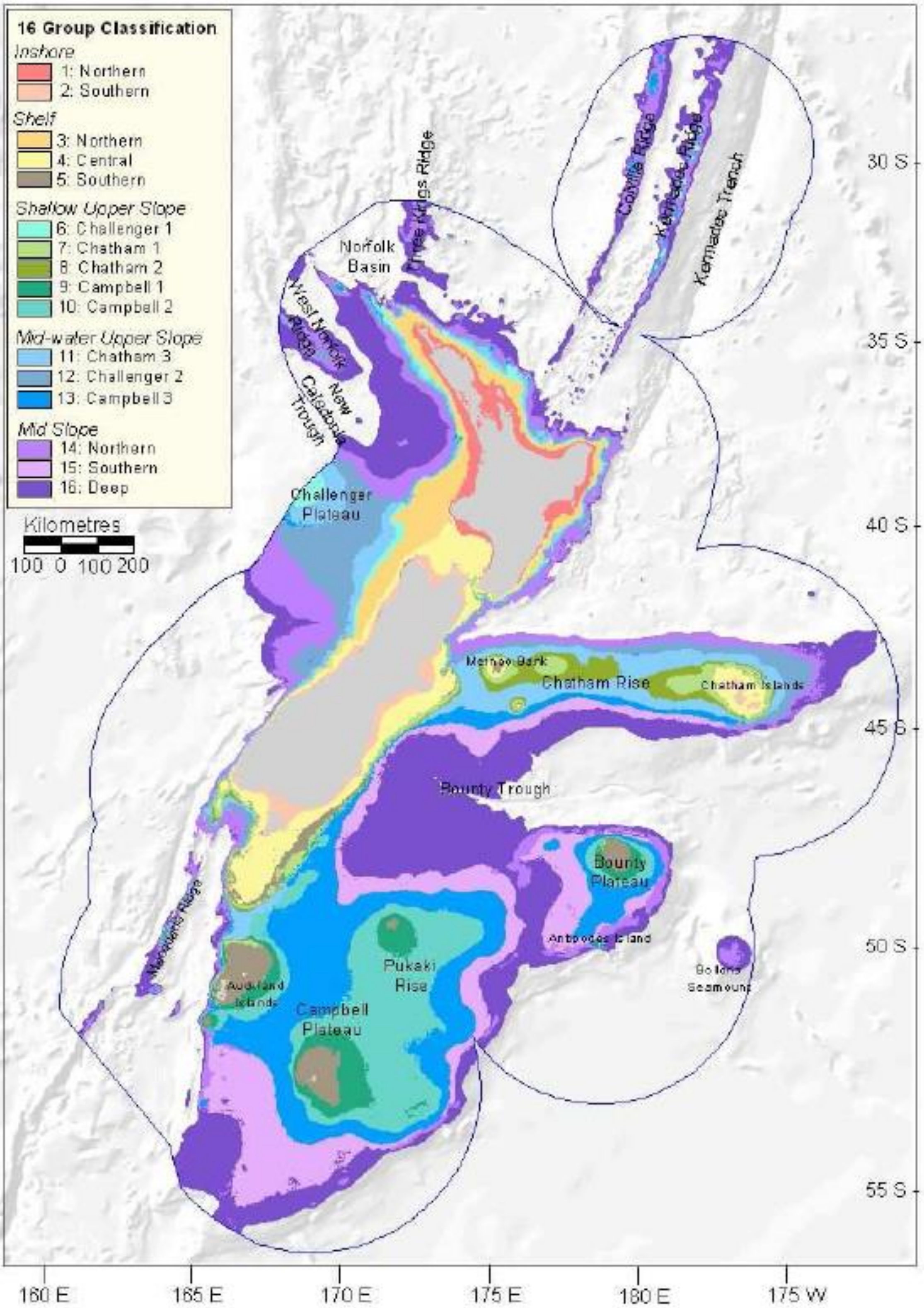


Figure 77: Geographic distribution of 16 demersal fish assemblages within the EEZ (from Leathwick & Julian 2006)

Table 13: Demersal fish assemblages in the Chatham Rise region, after Leathwick et al. (2006).

Assemblage	Distribution and environmental conditions	Key species	Other fish in assemblage*
Chatham Rise 1	• Mostly on Chatham Rise • Restricted east & south of South Is. • Scattered occurrences south to latitude 51°S • At depths of ~250 m • Strong tidal currents	• Spiny dogfish & silver warehou most frequent, caught in high volumes • Hoki occasionally caught in large amounts • Red cod, barracouta & silver dory less frequently caught • Hapuku, javelinfish, ling, sea perch, witch & silverside are also important species in this assemblage	Bellowsfish (2), blue cod, bluenose, dogfish & sharks (8), alfonsino, rattails (4), dory (3), cucumber fish, deepsea flathead, frostfish, gurnard (3), hake, conger (2), mackerel (3), longnose spookfish, lemon sole, orange perch, silver roughy, Ray's bream, redbait, ribaldo, rudderfish, spineback, gemfish, rig, tarakihi, pale toadfish, warehou (2)
Chatham Rise 2	• Adjacent to Chatham Rise 1 • At depths ~370 m across Rise • Along shelf edge east & south of South Is.	• Relatively species rich; Hoki, spiny dogfish, javelinfish & ling most widespread • Catch rates highest for hoki & spiny dogfish • Sea perch, lookdown dory, silverside & white warehou moderately widespread • Banded bellowsfish, pale ghost shark, alfonsino, silver dory, deepsea flathead, hake, red cod, ling, lemon sole, witch & silver warehou are also important species in this assemblage	Barracouta, crested bellowsfish, bluenose, dogfish & sharks (9), rattails (4), dory (2), cucumber fish, deepsea cardinal fish, frostfish, gurnard (2), hapuku, conger (2), mackerel (2). longnose spookfish, orange perch, silver roughy, Ray's bream, redbait, ribaldo, rudderfish, spineback, southern blue whiting, gemfish, spikey oreo, rig, tarakihi, pale toadfish
Chatham Rise 3	• Wide latitudinal range (33-51°s) • Most extensive on Chatham Rise • At depths ~550 m • Around much of north & south is. • Around Auckland Is. Further south	• Javelinfish, hoki & ling most widespread • Catch rates highest for hoki & ling • Shovelnose & spiny dogfish occasionally caught in large numbers • Lookdown dory, sea perch, pale ghost shark & bollon's rattail moderately widespread • Ribaldo, hake, lucifer dogfish & capro dory occur frequently but small catches	Banded bellowsfish, basketwork eel, bluenose, dogfish & sharks (10), alfonsino, rattails (12), dory (2), cucumber fish, deepsea flathead, frostfish, spotted gurnard, conger (2), cod (3), common halosaur, Murphy's mackerel, spookfish (2), lemon sole, roughy (2), lighthouse fish, longnose deepsea skate, Ray's bream, redbait, rudderfish, slickhead (2), southern blue whiting, gemfish, oreo (4), orange perch, slender smooth-hound, silverside, pale toadfish, trevally, warehou (2), witch

Assemblage	Distribution and environmental conditions	Key species	Other fish in assemblage*
Campbell Plateau 3	• South to about latitude 54°S • Along southern Chatham Rise • At depths ~720 m on upper slope • Extensive over Campbell & Bounty Plateau • East & south east of South Is.	• Relatively species poor • Javelinfish, hoki & pale ghost shark most widespread • Catch rates highest for javelinfish & hoki • Banded rattail, ribaldo, ling & spineback moderately widespread • Black oreo & small-scaled brown slickhead occasionally caught in large quantities	Banded bellowsfish, basketwork eel, bluenose, dogfish & sharks (10), alfonsino, rattails (13), lookdown dory, viper fish, deep sea cardinal fish. deepsea flathead, hake, conger (2), cod (3), common haloaur, black javelinfish, spookfish (2), roughy (2), lighthouse fish, longnose deepsea skate, blob fish, Ray's bream, rudderfish, slickhead (2), southern blue whiting, oreo (2), sea perch, silverside, pale toadfish, trevally, Tubbia tasmanica, warehou (2)
Southern mid slope	• Extending south to latitude 55°S • Southern Chatham Rise • At depths of ~1,020 m • East & south of South Is. • Extensive around Campbell & County Plateaux	• Basketwork eels most widespread • Kaiyomaru rattails, smooth oreo, Baxter's dogfish, small-scaled brown slickhead & violet cod moderately widespread • Catch rates highest for smooth oreo • Black oreo & orange roughy occasionally caught in large amounts • Ridge scaled rattails, Johnson's cod & four-rayed rattails occur frequently but in small amounts	Sharks (5), rattails (10), viper fish, brown chimera, dogfish & sharks (5), deepsea cardinal fish, hake, conger (2), small-headed cod, hoki, javelinfish (2), spookfish (2), ling, lighthouse fish, longnose deepsea skate, blob fish, Ray's bream, ribaldo, rudderfish, slickheads (2), spinehead, southern blue whiting, oreo (2), silverside, pale toadfish, trevally, *Tubbia tasmanica*
Deep mid slope	• Most extensive group throughout NZ • In deepest fishable waters at average 1,540 m • Concentrated around upper North Is. & South Is. in east & south	• Relatively depauperate fish fauna • Violet cod &basketwork eel most widespread • Smooth oreo occasionally caught in large quantities • Small-scaled & big-scaled brown slickhead, ridge scaled rattail, Johnson's cod & longnose deepsea skate moderately widespread • Lighthouse fish, spineback and Baxter's dogfish caught frequently in small volumes	Banded bellowsfish, bluenose, dogfish & sharks (10), alfonsino, rattails (12), viper fish, brown chimera, deepsea cardinal fish. hake, conger (2), small-headed cod, hoki, javelinfish (2), spookfish (2), ling, roughy (2), blob fish, Ray's bream, ribaldo, rudderfish, black slickhead, southern blue whiting, oreo (3), silverside, ale toadfish, trevally, *Tubbia tasmanica*

Notes: * numbers in brackets indicate the number of species for each type of fish present in the assemblage; see Leathwick et al. (2006) for details of individual species.

Table 14: Fish guilds on the Chatham Rise (from Pinkerton 2013, Dunn et al. submitted).

Guild(s)	Guild name	Species	Description
1	Salp specialists	White warehou, Silver warehou	Feeding almost exclusively on salps (97 % by weight), with jellyfish and amphipods the next most important dietary items
2	Benthopelagic foragers (crustaceans)	Banded bellowsfish, Oliver's rattail Javelinfish (small)	Feeding on wide range of crustaceans, but mainly copepods, shrimps and amphipods
3	Benthopelagic foragers (krill)	Orange perch	Fed almost exclusively on euphausiids
4	Pelagic foragers	Hoki (small-medium), Alfonsino, Ray's bream, Javelinfish (med, large)	Fish and shrimps dominated the diet in this group. The numbers of prey categories consumed by members of this guild were generally low
5	Benthopelagic foragers (fish & squid)	Hoki (large), Hake (small), Shovelnose dogfish	Small fish (both demersal rattails and small pelagic species), with significant cephalopod component
6	Benthic foragers (fish & small invertebrates)	Dark & pale ghost sharks, Long-nosed chimaeras, Oblique banded rattail, Bollons' rattail	Some diets strongly dominated by crabs, but with a significant echinoid component; others more generalised benthic invertebrate diet comprising worms, crabs, galatheids, and shelled molluscs. This guild also ate salps
7	Benthic foragers (rattails & shrimps)	Lookdown dory	Feeding almost exclusively on rattails and shrimps
8	Benthic foragers (fish & large crustaceans)	Smooth skates, Ling, Red cod, Sea perch	Benthic foraging for fish and crustaceans, including fishing discards. Feeding on relatively broad range of demersal fishes. Crustaceans generally medium-large (scampi, galatheids, crabs, large shrimps)
9	Benthopelagic foragers (squid)	Giant stargazer, Southern spiny dogfish, Barracouta, Hake (large)	Feeding mainly on cephalopods and benthopelagic fishes, but also commercial fishing discards

6.6.4 Hoki (*Macruronus novaezelandiae*)

6.6.4.1 Lifecycle and distribution

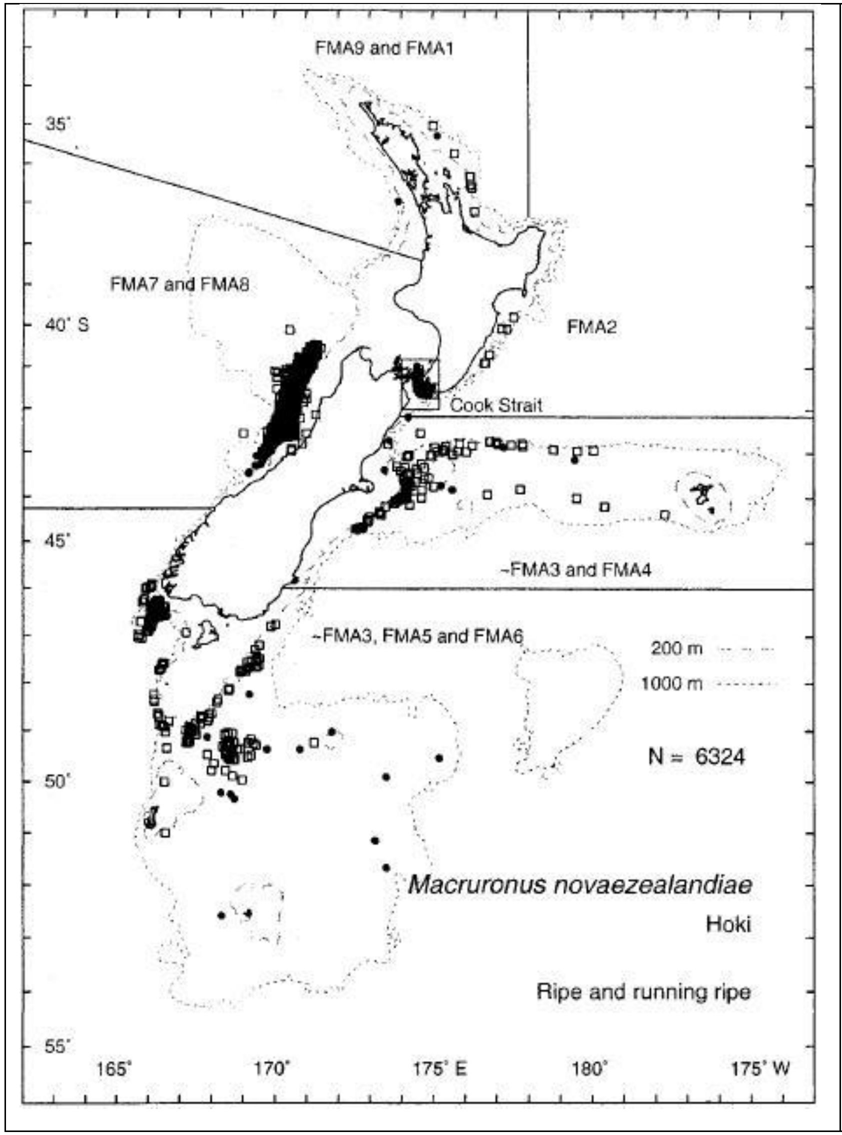
Hoki are widely distributed throughout New Zealand's EEZ in depths of 200 to 1,000 m (Anderson et al. 1998; MPI 2013c). O'Driscoll & Ballara (2014) (Appendix 18) describe the hoki fishery and key aspects of hoki distribution and life history. There are two main stocks of hoki, a western stock spawning off the west coast of the South Island and residing in SAW around the Campbell Plateau, and an eastern stock spawning in Cook Strait and residing on the Chatham Rise. These stocks have different body forms (i.e., different morphometrics) and growth rates, although they do not appear to be genetically distinct (Livingston et al. 2002 and references therein). MPI (2013e) contains the most recent fisheries management assessment for hoki and a summary of historical fishing information.

Hoki spawn from June to September. The main hoki spawning grounds are centred on the Hokitika Canyon off the West Coast of the South Island and in Cook Strait Canyon. Other 'satellite' spawning areas also exist off Puysegur, and in Pegasus Canyon near the western end of the Chatham Rise (Figure 78). The planktonic eggs and larvae move inshore by advection or upwelling and are widely dispersed north and south with the result that 0+ and one year old hoki can be found in most coastal areas of the South Island and parts of the North Island (Figure 79). Juvenile hoki (one year old or less) are found in schools in mid-water depths (pelagic). By two years old hoki start to adopt a more bottom-orientated (demersal) life-style. The Chatham Rise is the main nursery area for juvenile hoki aged two to four years from both stocks (Livingston et al. 2002). Two year old hoki are mainly found at depths of 200 to 400 m on the western Chatham Rise, but disperse and move deeper as they grow (Figure 80) Mean length (i.e., size) of hoki increases with depth from 350 m to 800 m (Livingston et al. 2002).

When hoki reach maturity, a proportion of the population moves away from the Chatham Rise nursery ground and recruits to the Campbell Plateau in the sub-Antarctic where they join the western stock (Livingston et al. 2002 and references therein). Some year classes appear to leave the Chatham Rise as early as two years old, but most depart at 4 to 8 years old. Overall, 80 to 100 % of fish aged one to two years are located on the Chatham Rise, but this drops to about 60 % of fish aged three to seven years (Livingston et al. 2002). After this movement, hoki remain on their respective home grounds for the rest of their lives, apart from excursions to their spawning grounds.

Stevens et al. (2013, 2014) report that highest catch rates of hoki in the 2012 Chatham Rise trawl survey occurred in water depths of 400 to 600 m. Stevens et al. (2014) reported that estimated relative biomass of hoki in depths of 200 to 800 m was 42 % higher than reported for January 2012 (Stevens et al. 2013). This was largely driven by a high biomass estimate for 1+ hoki. The relative biomass of 3+ year old hoki was also 29 % higher than reported in 2012, but the biomass of 2+ year old hoki was the lowest in the time series. The highest catch rate of hoki in 2013 occurred in the southwest Chatham Rise area, close to Mernoo Bank. The 2012 and 2013 surveys (Stevens 2013, 2014) found that 1+ year old hoki were found mainly around the Mernoo, Veryan and Reserve Banks while 2+ year old hoki were found throughout much of the Rise, often in water 200 to 600 m deep. The distribution of 3+ year old fish was similar to 2+ year old but extended into deeper water. Acoustic studies have shown that hoki on the Chatham Rise generally occur on the bottom, in schools 40 to 100 m high, and that hoki schools rise off the bottom before sunset (Bull 2000).

There is a high probability of capture (over 90 % probability) of hoki in most of the marine consent area, particularly in the western half of the area. There is lower likelihood of capture (60 % or less probability) in the eastern quarter of the marine consent area, close to the Chatham Islands (Golder 2014b) (Appendix 17).



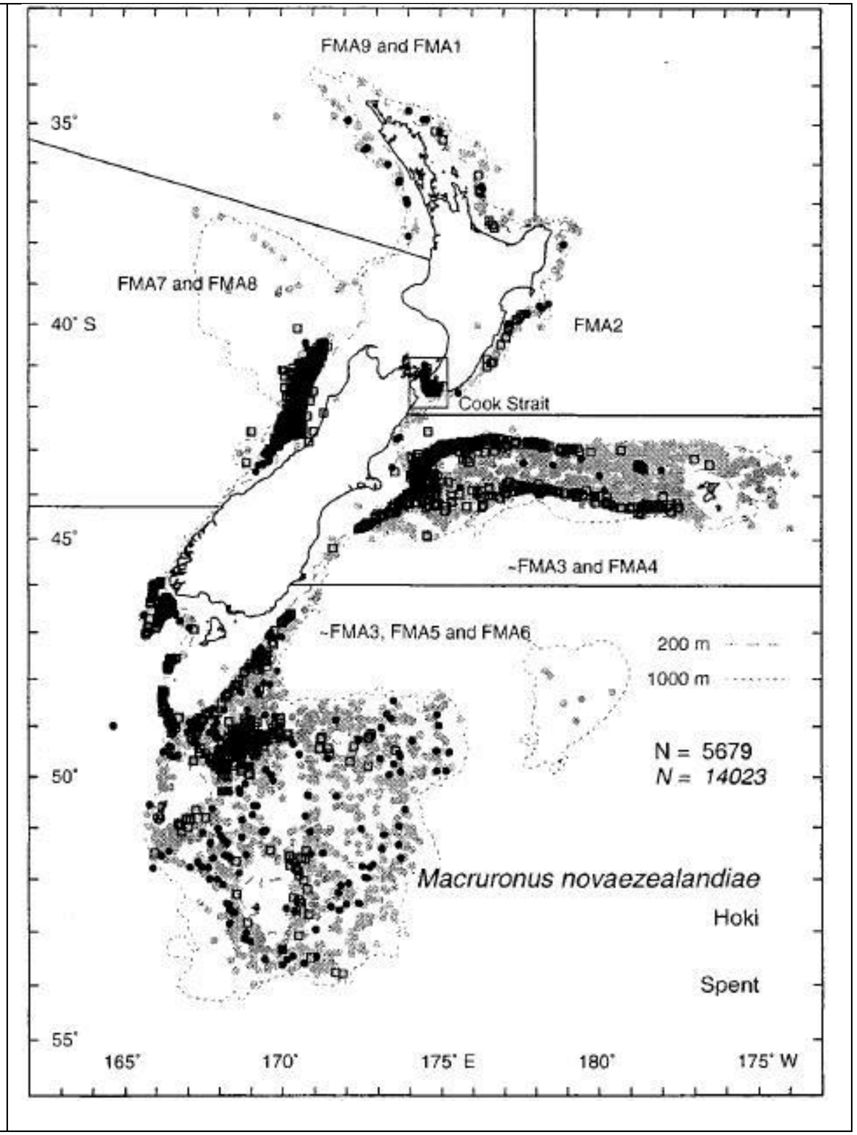


Figure 78: Spawning information for hoki within the EEZ (from O'Driscoll et al. 2003).

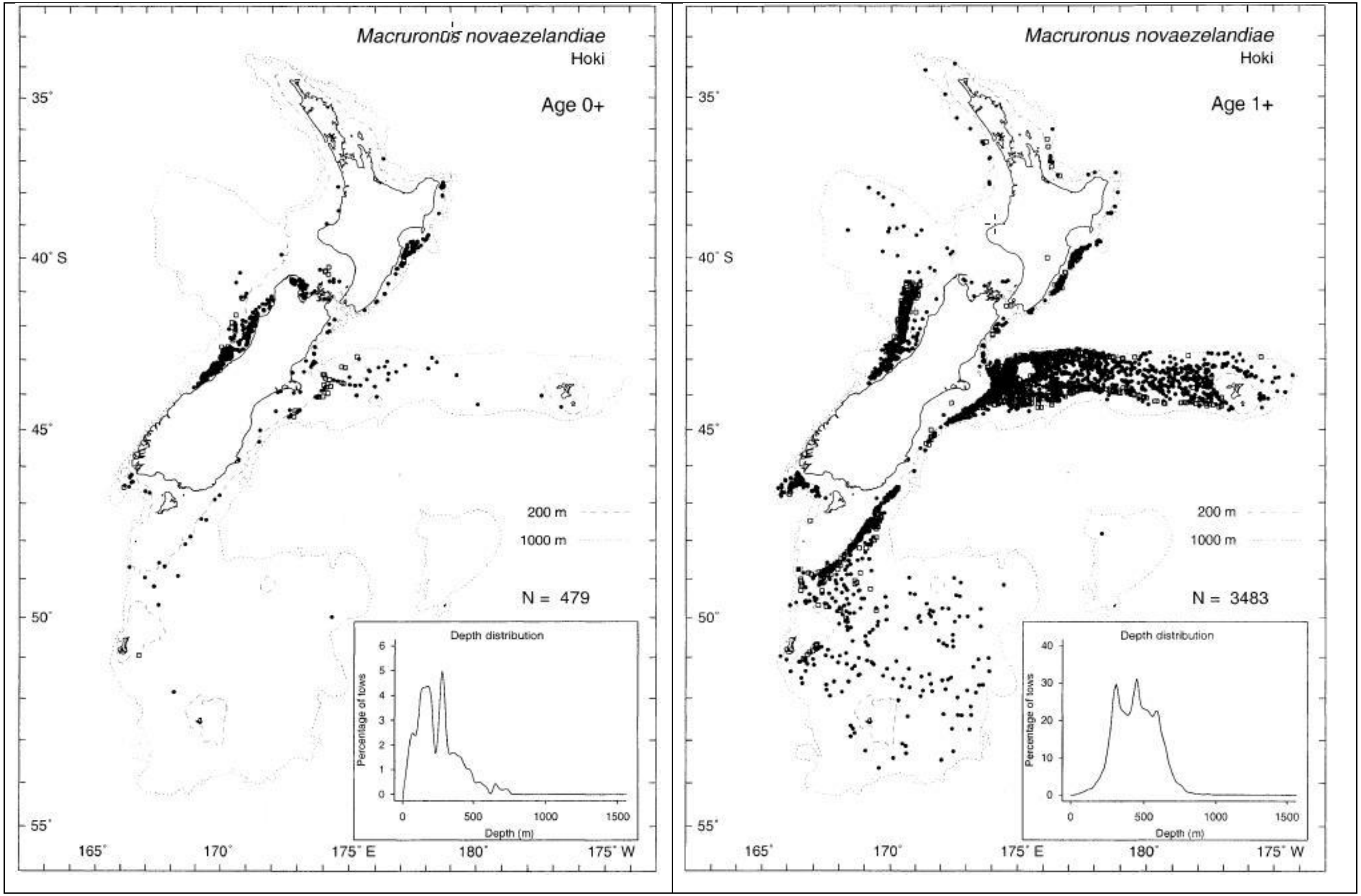
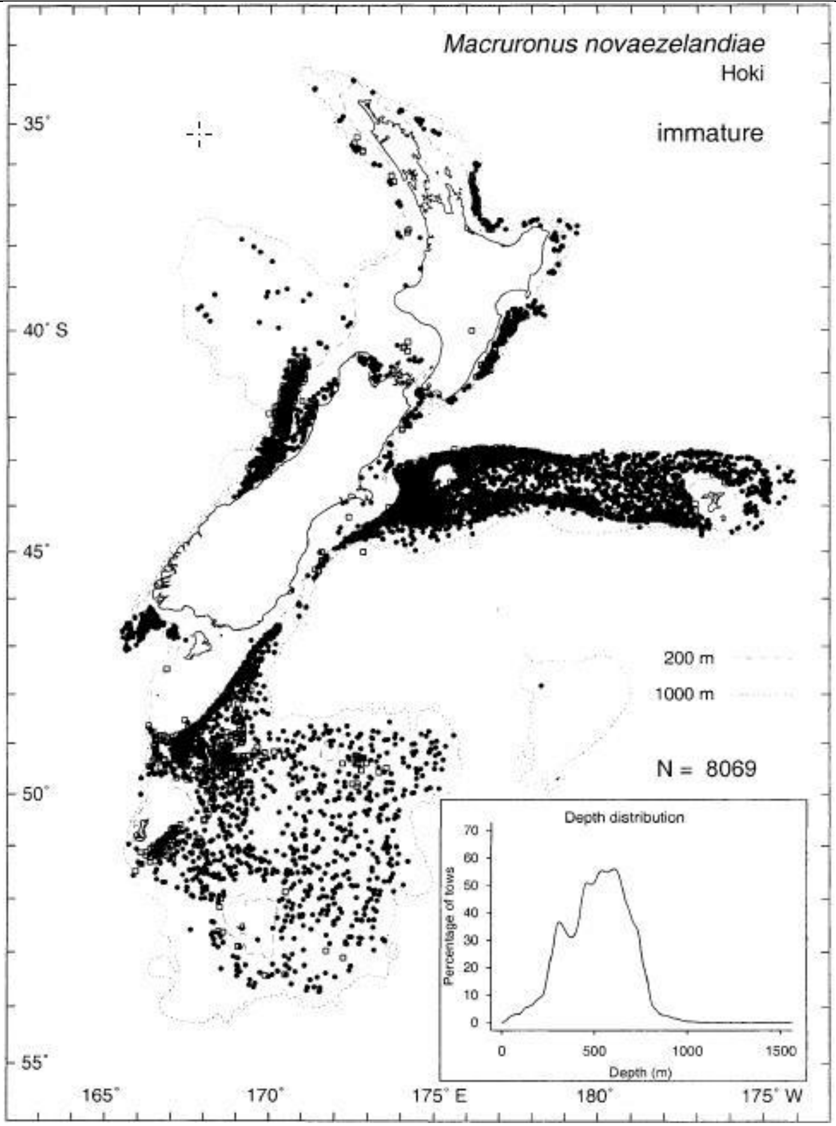


Figure 79: Distribution data for hoki juvenile (0+ and 1+) fish within the EEZ (from O'Driscoll et al. 2003).



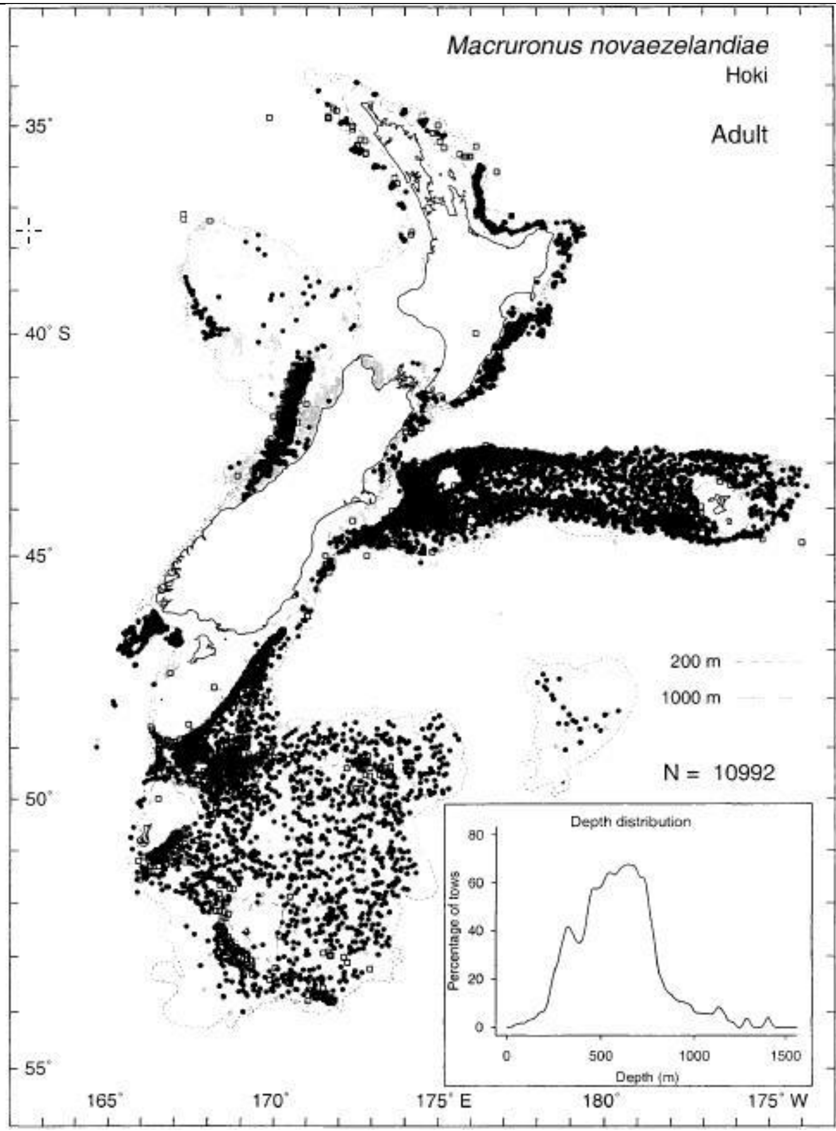


Figure 80: Distribution data for hoki immature and adult fish within the EEZ (from O'Driscoll et al. 2003).

6.6.4.2 Diet

Juvenile and adult hoki typically feed on mesopelagic fishes, krill and squid, with lantern fishes reported to be the most important component of the diet of adults (Clark 1985, Horn & Dunn 2010, Connell et al. 2010, Stevens et al. 2011).

There appears to be a general transition in diet as fish get older and increase in size (Connell et al. 2010, Horn & Dunn 2010). Euphausiids and sternoptychid fishes were important for smaller hoki (26–55 cm), myctophid fishes and natant decapod crustaceans for larger hoki, and rattails for the largest hoki (greater than 84 cm) (Connell et al. 2010).

There appears to be little seasonal variation in hoki diet (Stevens et al. 2011), but Horn & Dunn (2010) have noted that the proportion of fish in the diet of hoki increased from 1989 to 2009. Hoki diet varies across the Chatham Rise (Connell et al. 2010). Natant decapods (mainly pasiphaeids) were more important in the diet of hoki on the western Rise to the north of the STF. Sternoptychid fishes and euphausiids were important in the STF convergence area, and myctophids were most important in the centre of Chatham Rise.

6.6.4.3 Trophic importance

The trophic importance analysis suggests that hoki play a key role in the Chatham Islands ecosystem (3rd or 4th most important group). The trophic impact matrix indicates that hoki can be influenced by changes in the biomass of groups such as javelinfish, rattails and ghost sharks and small demersal fish on the Chatham Rise (Pinkerton 2013).

6.6.5 Hake (*Merluccius australis*)

6.6.5.1 Lifecycle and distribution

Hake have been recorded mainly in 250 to 1,200 m depths around the South Island, some parts of the North Island, on the Challenger Plateau and Chatham Rise, and in the Sub-Antarctic (Anderson et al. 1998, Hurst et al. 2000). Research trawl catch rates (deeper than 200 m) on the Chatham Rise were highest in the northwest around Mernoo Bank (Hurst et al. 2000). Stevens et al. (2014) describes recent research trawl data for hake on the Chatham Rise at two water depths, 200 to 800 m and 800 to 1,300 m depths.

There are thought to be at least three distinct hake spawning grounds within the EEZ (Hurst et al. 2000, Colman 1998). The main centre of spawning activity appears to be the west coast of the South Island north of the Hokitika Canyon in 600 to 700 m deep water. Spawning takes place off the west coast of the South Island from June onwards, peaking in September. Spawning to the northwest (approximately 130 km) of the Chatham Islands takes place in September and October, as it does at the Auckland and Snares Islands (Colman 1998a, Hurst et al. 2000). Hake have been observed to aggregate before spawning off the west coast of the South Island and also on the Chatham Rise (Patchell 1981, 1987, Hurst et al. 2000). Figure 81 shows that spawning hake are found on both the north and south slopes of much of the Chatham Rise. Fishing on aggregated schools of spawning hake occurred during October to November 2008 and 2010 on the western Chatham Rise and the trawl survey took high catches of young, mature fish in this area in January 2009. On the Chatham Rise, younger hake tend to be concentrated in the west, with the population dominated by fish aged two to ten years, while middle-aged and older hake (i.e., five to 15 years old) tend to dominate catches in the eastern Rise (Horn & Sutton 2014).

The distribution of juveniles is similar to that of spawning adults, including off the west coast of the South Island, the Chatham Rise, and the Campbell Plateau (Colman 1988a, Hurst et al. 2000) (Figure 82 and Figure 83).

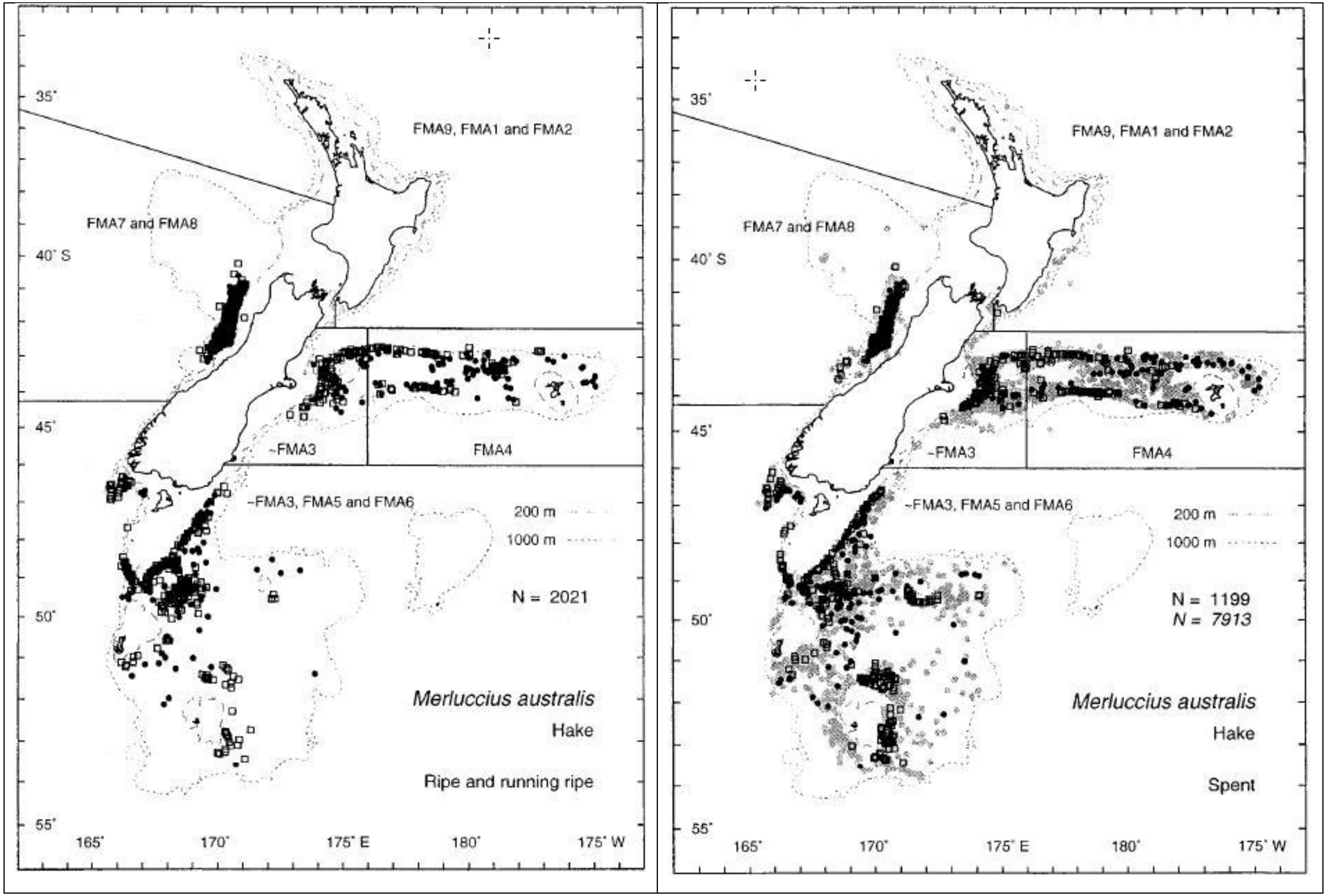


Figure 81: Spawning information for hake within the EEZ (from O'Driscoll et al. 2003).

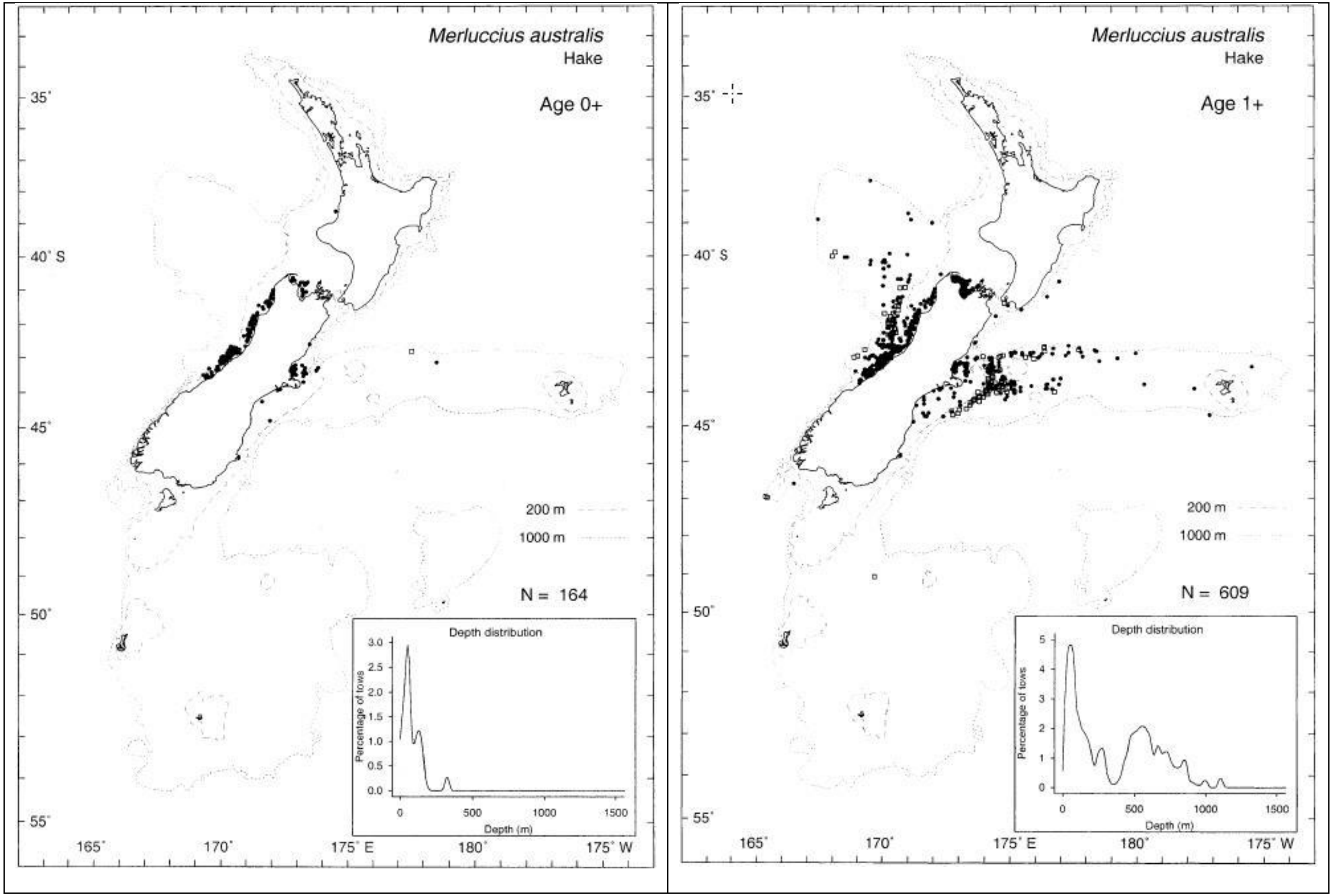


Figure 82: Distribution data for hake juvenile (0+ and 1+) and adult fish within the EEZ (from O'Driscoll et al. 2003).

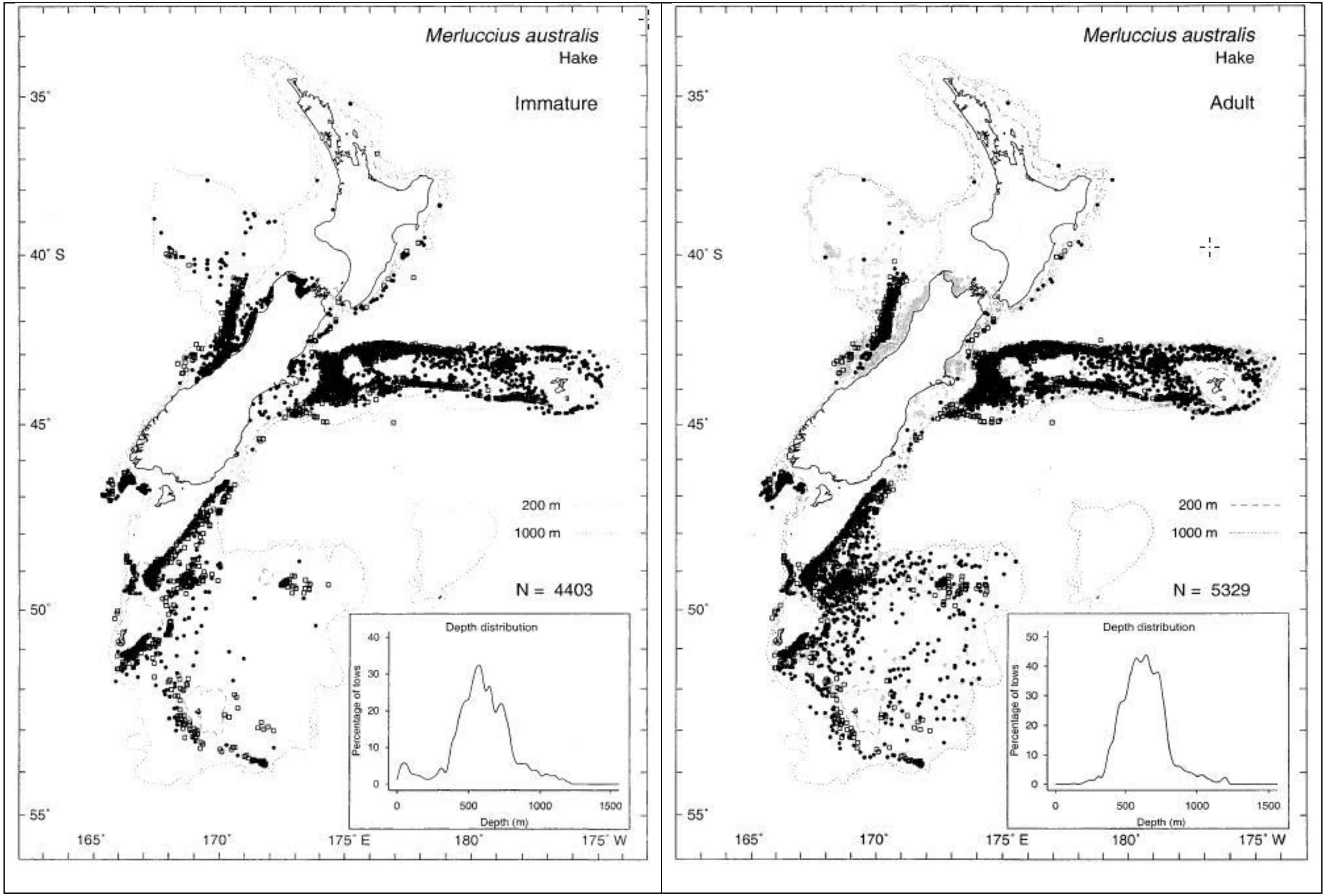


Figure 83: Distribution data for hake immature and adult fish within the EEZ (from O'Driscoll et al. 2003).

Immature fish (25-40 cm long) are widespread in water shallower than 100 m around the South Island (Patchell 1981) and there are hake nursery grounds at several locations throughout their distribution, but no nursery has been noted at or near the Chatham Rise (Hurst et al. 2000). Female hake mature at 50 to 60 cm when they are five to six years old, but size at maturity varies with area, and west coast South Island fish appear to reach maturity at a smaller size than those of the Chatham Rise and the Campbell Plateau (Patchell 1981, Hurst et al. 2000). Males reach maturity about a year before females (Colman 1998a, Hurst et al. 2000).

The 2013 relative biomass of hake in 200 to 800 m water depths is low compared to historical records. The highest catch rates have occurred on the southwest Chatham Rise, where relatively high catches of hake have been made to the northwest of Mernoo Bank in 2009 and 2010. High catch rates also occur on the northeast Rise (Stevens et al. 2014).

The probability of capture for hake in the marine consent area is greatest in the middle of MPL 50270 (approximately 60 % probability or greater) but is general lower than 50 % probability of capture throughout the remaining marine consent area. The probability of capture is particularly low in the eastern part of the area, close to the Chatham Islands (Golder 2014b) (Appendix 17).

6.6.5.2 Diet

Dunn et al. (2010) reported that teleost fish, principally javelinfish (*Lepidorhynchus denticulatus*), made up 44 % of the prey weight. Hoki were also taken by hake and accounted for around 37 % of the prey weight (recorded in 51 % of hake stomachs) (Dunn et al. 2010a, Horn & Dunn 2010, Stevens et al. 2011). Prawns have been reported from 11 % of hake stomachs taken by research trawls, and squid occurred in 6 % of hake stomachs (Horn & Dunn 2010).

Crustaceans decrease in dietary importance with increasing hake size, while teleosts and cephalopods correspondingly increase in importance in the diet of larger hake (Stevens et al. 2011). The composition of the fish species in the hake diet also changes with the size (length) of the fish and primarily involves changes in the proportions of hoki, javelinfish, Oliver's rattail and myctophid prey (Horn & Dunn 2010). The diet of smaller hake is dominated by small rattail species and javelinfish, while medium-sized hake have a diet transitioning between javelinfish and hoki, with reducing volumes of the smaller rattails. Large hake have a diet dominated by hoki, with some javelinfish.

Most macrourids are demersal or benthic feeders, but the most important macrourid prey for ling and hake, *Coelorinchus oliverianus* and *L. denticulatus*, feed predominantly on mesopelagic prey (Stevens & Dunn 2010).

6.6.5.3 Trophic importance

In the assessment of TI by Pinkerton (2013), hake were included in a feeding guild that includes several other benthopelagic predators (spiny dogfish, giant stargazer, barracouta, shovelnose spiny dogfish) (Appendix 22). The hake guild represents one of a number of key demersal fish guilds that comprise the diverse demersal fish present on and adjacent to the Chatham Rise. This guild is ranked 9th for direct (TI1) and 14th for multi-step (TI2) assessment of trophic importance. The guild has negative potential impacts on a range of other fish guilds and groups (Pinkerton 2013).

6.6.6 Ling (*Genypterus blacodes*)

6.6.6.1 Lifecycle and distribution

Ling are widely distributed through the middle depths from 200 to 800 m of the New Zealand EEZ, particularly south of latitude 40° S (Annala et al. 1999, Hurst et al. 2000, Dunn et al. 2010a, MPI 2013d). These fish are one of the largest teleosts commonly found in deep water fish assemblages around New Zealand, where they are only surpassed in size by a few species of sharks and skates (Dunn et al. 2010b). Baird (2014) (Appendix 19) provides a summary of the ling fishery within and adjacent to the marine consent area. Stevens et al. (2014) describes recent research trawl data on the distribution and biomass of ling on the Chatham Rise over two water depths, 200 to 800 m and 800 to 1,300 m.

Spawning is known to occur off the west and east coasts of the South Island, the Chatham Rise (including within CRP's proposed eastern prospecting permit area), Puysegur Bank, Campbell Plateau and in Cook Strait (Patchell & McKoy 1985, Colman 1988b, Horn 1993a, Horn & Ballara 1999, Hurst et al. 2000) (Figure 84). Data on spawning condition suggest that spawning occurs in spring and early summer (Graham 1939, Annala et al. 1999, Hurst et al. 2000). A few ling larvae have been recorded from inner shelf waters in December (Parsons 1999, Hurst et al. 2000).

Little is known about the distribution of juveniles until they are about 40 cm long when they begin to appear in trawl samples over most of the adult range (Annala et. al. 1999, Hurst et al. 2000). There are some records of 0+ juveniles in shallow inshore areas but most occur from 200 to 500 m depth, primarily in the Bay of Plenty and central east coasts of the North and South Islands (Hurst et al. 2000). A few juveniles have been recorded from the west coast of the South Island, Chatham Rise, Southland and the Auckland Islands (Hurst et al. 2000). Two year old ling (mean length 34.9 cm) have been reported on the Chatham Rise and Southern Plateau (Horn 1993b, Hurst et al. 2000). Most ling reach maturity at about six or seven years old (Annala et al. 1999, Hurst et al. 2000). Adults have a similar distribution to the juveniles but tend to be less common in inshore shelf areas, except for Southland where they are more commonly caught than juveniles (Hurst et al. 2000) (Figure 85 and Figure 86).

Research trawl data from 2013 shows that catches of ling are evenly distributed throughout most of the Rise with highest catch rates mainly in the north in water depths of 400 to 600 m. However, in 2013 the largest catch was on the Reserve Bank at depths of 370 to 390 m (Stevens et al. 2014). The distribution patterns have been stable over several years (Stevens et al. 2014).

The probability of capture for ling in the marine consent areas is estimated to be high (over 90 % probability) for most of the area, with a lower probability of approximately 60 % or less in the eastern part of the marine consent area near the Chatham Islands (Golder 2014b) (Appendix 17).

6.6.6.2 Diet

Ling appear to be opportunistic feeders and their diet is diverse, but is characterised by benthic crustaceans and demersal fishes (Mitchell 1984, Dunn et al. 2010a, Horn & Dunn 2010, Stevens et al. 2011). Galatheids (mainly *Munida gracilis*) occurred in 50 % of stomachs, though as they are relatively small they contributed only 7 % of prey weight. By comparison, scampi (*Metanephrops challengeri)*, a relatively large crustacean, occurred in only 9 % of the samples but contributed a similar weight to galatheids. Fish prey in the diet included benthic species, such as eels and flatfish, demersal species such as hoki, and mesopelagic species such as myctophids. The most important fish prey were demersal macrourids, found in 17 % of stomachs and contributing 16 % of prey weight. In examination of samples from the Chatham Rise area, Dunn el al. (2010a) reported that 30 % of the weight of stomach contents was from discarded fish remains, predominantly severed heads and/or tails of the pelagic jack mackerel (*Trachurus* spp).

Prey composition varied with depth, which appears to relate to prey availability (Dunn et al. 2010a). By prey weight, squat lobsters (Galatheidae), caridean shrimp (Pandalidae) and decapod crabs (from the family Goneplacidae) were most important in the ling diet at depths of 255 to 381 m (Dunn et al. 2010a). Squat lobsters and scampi were most important at depths of 382 to 428 m, along with rattails (Marouridae), mysid shrimps (Mysidae) at depths of 429 to 791 m. Fish offal was most common in stomachs of ling caught at depths of 429 to 514 m.

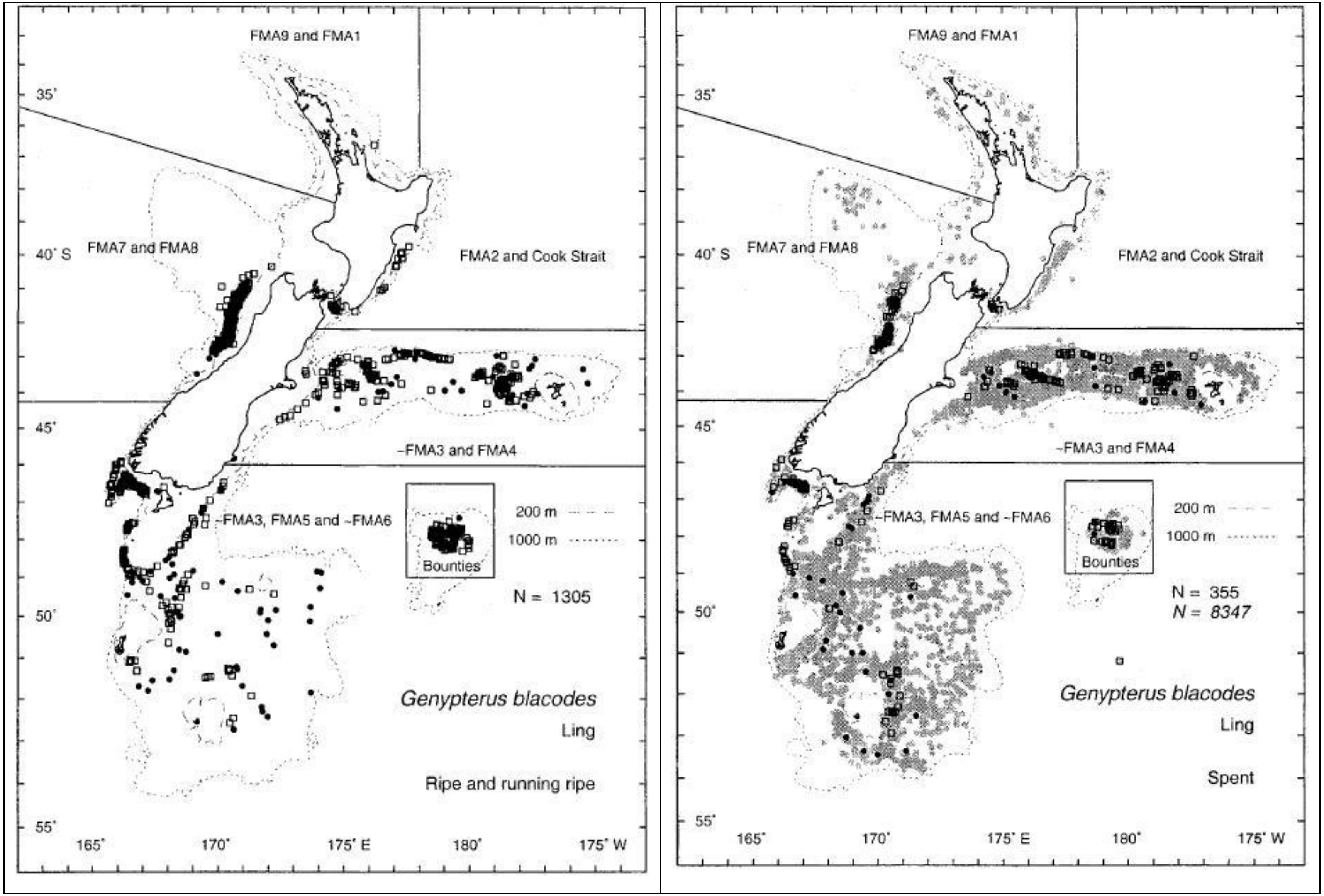


Figure 84: Spawning information for ling within the EEZ (from O'Driscoll et al. 2003).

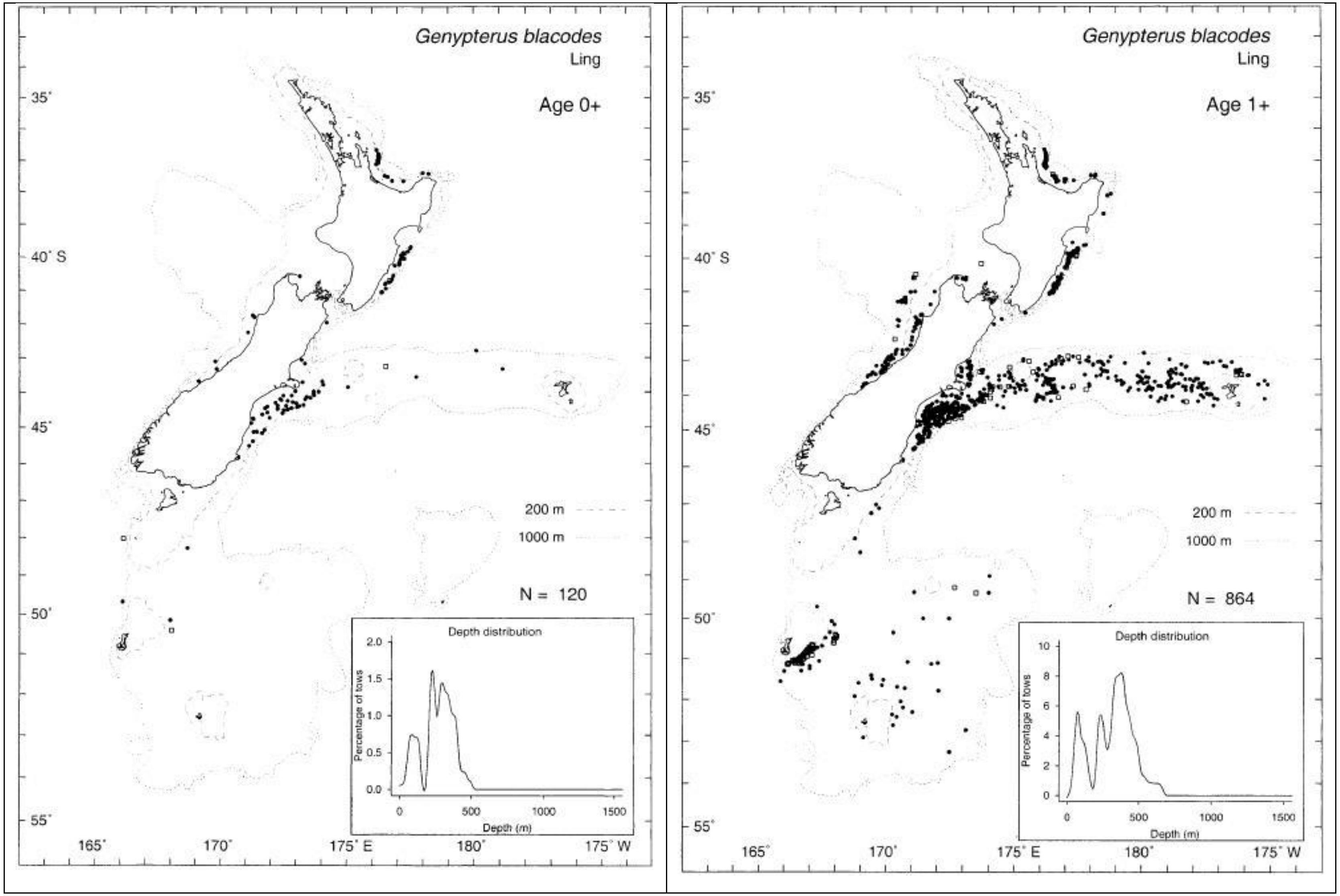
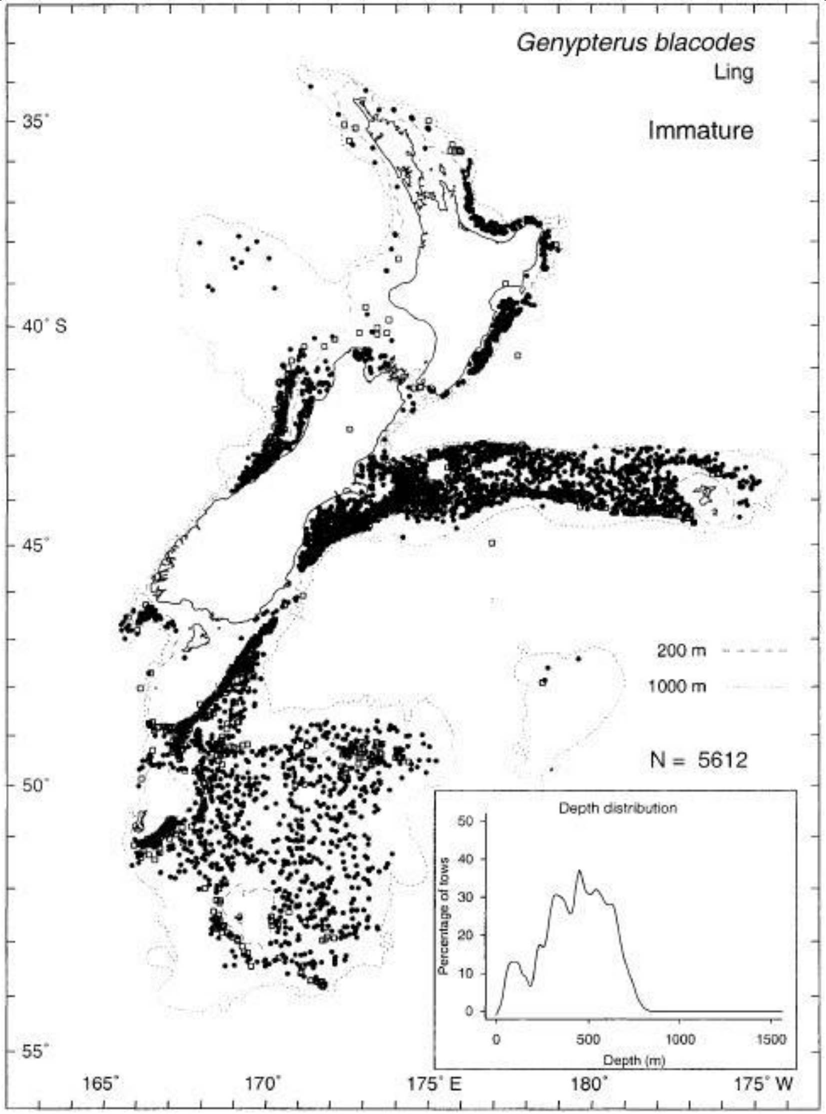


Figure 85: Distribution data for ling juvenile (0+ and 1+) ling within the EEZ (from O'Driscoll et al. 2003).



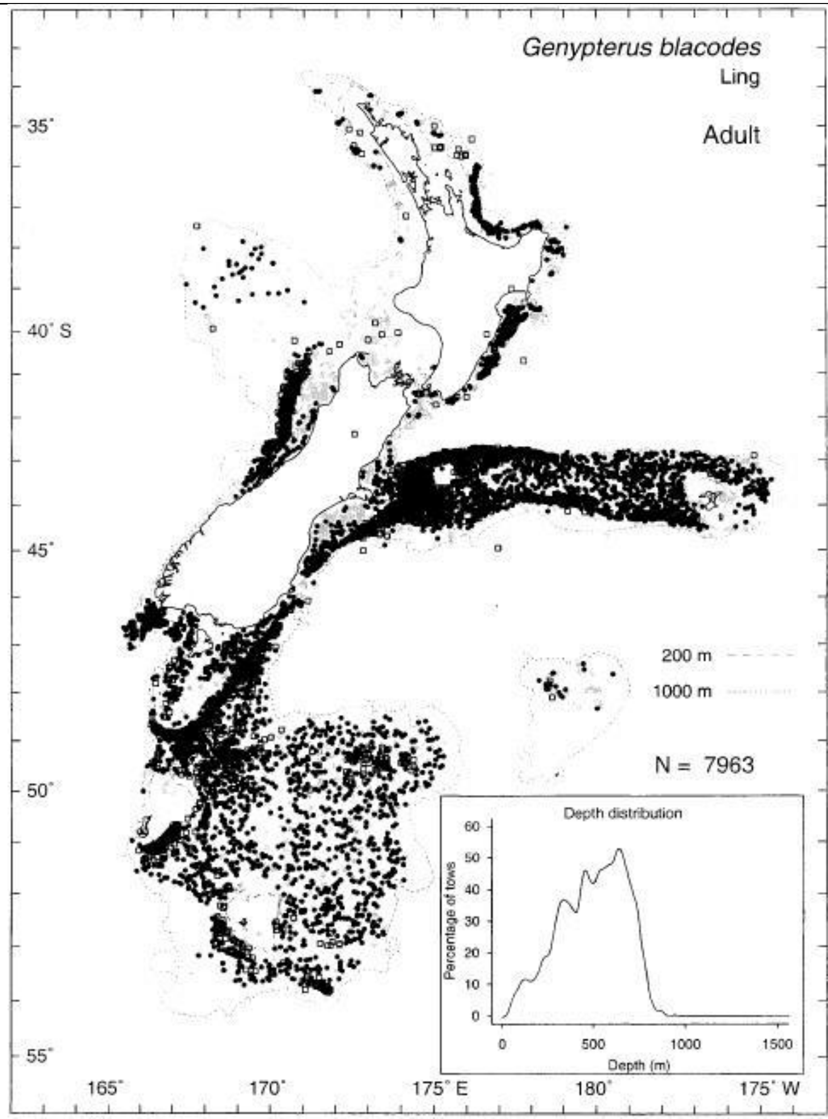


Figure 86: Distribution data for ling immature and adult ling within the EEZ (from O'Driscoll et al. 2003).

6.6.6.3 Trophic importance

Ling are ranked 15th for direct TI and 16th for multi-step TI in the Chatham Rise trophic model (Pinkerton 2013 - Appendix 22). The ling guild are benthopelagic predators and broad feeders and as such, interact with a range of trophic groups within the model. Therefore their biomass can potentially be influenced by changes in the biomass of a number of groups. Their behaviour in consuming fishing discards suggests that they are opportunistic in feeding behaviour.

6.6.7 Silver warehou (*Seriolella punctata*)

6.6.7.1 Lifecycle and distribution

Silver warehou have been caught in research and commercial trawls across the Chatham Rise and around New Zealand (Hurst et al. 2000). Silver warehou occurs mainly in 100 to 600 m depths (Anderson et al. 1998, Hurst et al. 2000) and have been reported as patchily distributed at depths of 200 to 600 m. The largest catches of silver warehou occur in the western part of the Rise (Stevens et al. 2014).

Spawning silver warehou have been recorded from the west coast of the South Island in winter, Mernoo Bank in winter and spring, and at the Chatham Islands in spring and summer, and there is some evidence of possible spawning on the Stewart/Snares shelf in early spring (Livingston 1988, Hurst et al. 2000). Figure 87 shows ripe silver warehou at the eastern end of the Chatham Rise.

Hurst et al. (2000) summarise that juvenile silver warehou have been reported to occur throughout the year in South Island shelf areas (in particular on the Pegasus Bay shelf and Canterbury Bight) where they inhabit water less than 200 m depth. Juvenile silver warehou have been recorded on Tangaroa middle depth trawl surveys on the Chatham Rise and in tows around the Chatham Islands (Hurst et al. 2000). Juveniles occurred in the shallower depths sampled across the Chatham Rise (i.e., mainly 200-400 m).

The juveniles remain apart from sexually mature fish (Annala et. al. 1999, Garilov 1979, Hurst et al. 2000). Very young fish 12 to 14 cm long feed on plankton, and juveniles of 14 to 15.5 cm feed on amphipods and chaetognath worms in coastal waters (Garilov & Markina 1979, Hurst et al. 2000). When fish are 2.4 to 31 cm long they move into the deeper parts of the shelf. Silver warehou become sexually mature at four to six years, at about 47 cm long (Horn & Sutton 1995, 1996, Hurst et al. 2000).

The highest probability of capture for silver warehou is in the eastern quarter of the marine consent area with an approximate likelihood of 60 to 90 %. There is moderate probability of capture (70 % or less) within MPL 50270 and the southern part of PP 55971. However, there are areas of lower probability (less than 40 %) in patches throughout the marine consent area (Golder 2014b) (Appendix 17).

6.6.7.2 Diet

Salps are the main prey (97 %) and the only other prey groups to exceed 1 % occurrence in gut content analyses are polychaetes (1.4 %) and crustaceans (3 %), mainly euphausiids. A total of at least 10 main invertebrate groups in six phyla and one teleost species were identified in the diet by Stevens et al. (2011). Gavrilov & Markina (1979) also found small silver warehou (12-18 cm) have additional important prey groups including amphipods (75 %), chaetognaths (60 %), euphausiids (38 %) and copepods (23 %).

6.6.7.3 Trophic importance

All warehou (silver and white warehou) are ranked 23rd for direct TI and 21st for multi-step TI (TI2) in the Chatham Rise trophic model. Their biomass can be influenced by groups such as the gelatinous zooplankton (Pinkerton 2013 – Appendix 22).

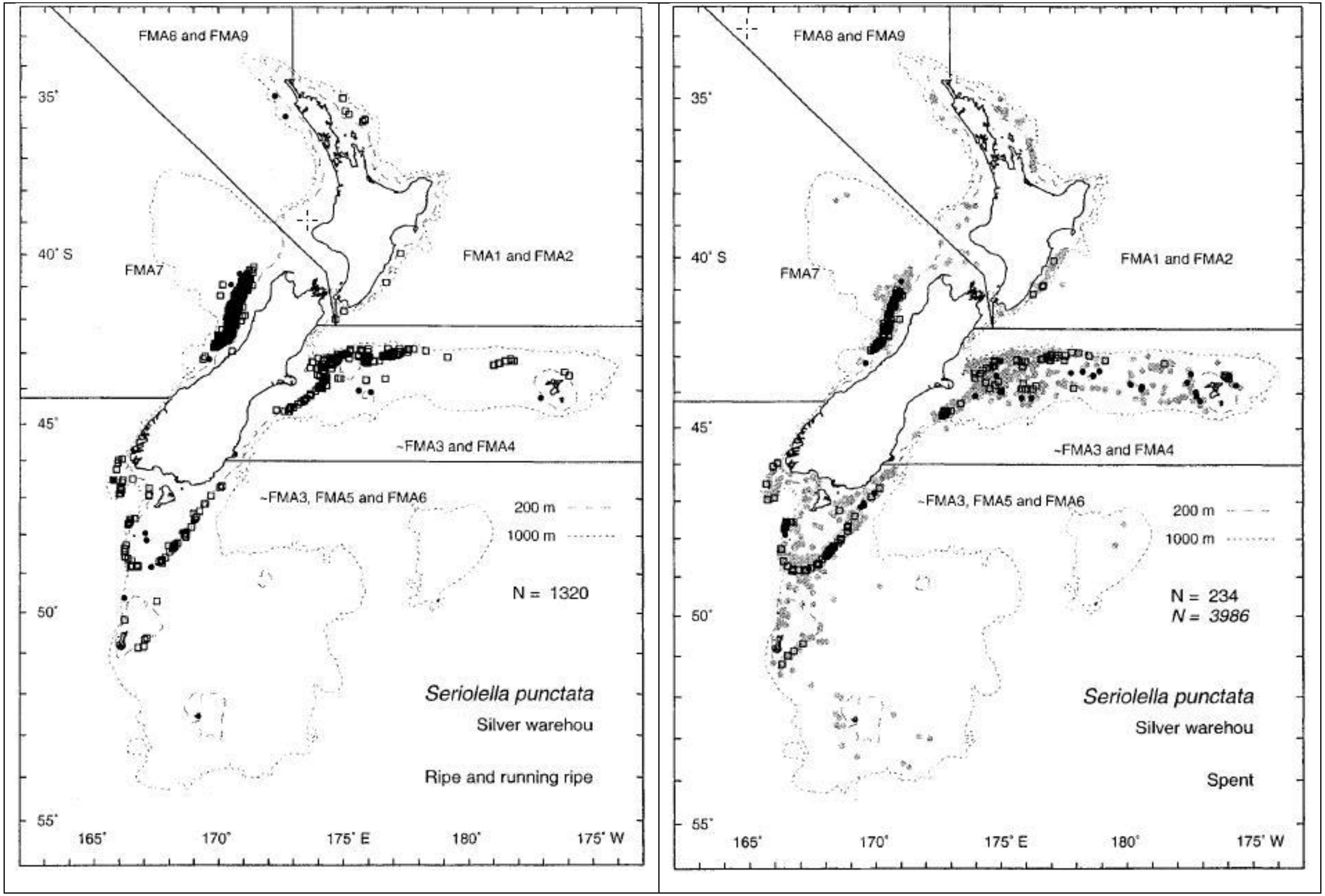


Figure 87: Spawning information for silver warehou within the EEZ (from O'Driscoll et al. 2003).

6.6.8 Orange roughy (*Hoplostethus atlanticus*)

6.6.8.1 Lifecycle and distribution

Orange roughy are one of the most recognised deep water fish in New Zealand. Orange roughy are found at depths of 700 to 1,500 m around New Zealand. Early juvenile orange roughy probably inhabit shallower waters than adults (e.g., depths of 700 to 800 m) and therefore may have a mesopelagic niche (Dunn et al. 2009a). Dunn et al. (2009b) identify that the orange roughy fishery around New Zealand is composed of different stocks separated by biogeographic factors such as the STF. Stevens et al. (2014) describes the most recent research trawl information for orange roughy on the Chatham Rise.

The largest fisheries around New Zealand are on the northern and eastern flanks of the Chatham Rise, the largest spawning aggregations in an area referred to as the Spawning Box, and associated with the Graveyard Seamount Complex. The Spawning Box refer to the spawning area just to the northeast of the Chatham islands (refer dark patch in the upper figure within Figure 88) and extending around the shelf slope to the west and southwest to the south of Northeast Hills, with two occurrences at the northern edge of the Andes Seamount (Figure 88). Orange roughy form spawning aggregations and undergo reproductive changes over very short periods of time. Tracey et al. (2001) reported that female gonad stages progressed from mainly maturing on 10 July, to running ripe and spent on 16 July, through to mainly spent by 22 July. Males had a similar progression.

Dunn et al. (2009b) report that fish <5 cm long were relatively infrequent and were found near the known spawning grounds of Challenger Plateau, Cook Canyon, and east of the Spawning Box. Orange roughy of 5 to 9 cm were more frequent in catches, and their distribution was largely an expansion from the areas occupied by <5 cm fish (Figure 88). The spatial distribution of subsequent length classes generally showed continuing spatial expansion as shown in Figure 88, with adult orange roughy being distributed around the flanks of the Rise.

In 2013 research trawl data from the Chatham Rise, orange roughy represented 24 % of the total biomass caught in the water depths of 800 to 1,300 m. These data show that orange roughy were widespread on the northern and eastern parts of the Rise with the largest catch taken on the northeast of the Rise. (Stevens et al. 2014)

Based on research trawl data from 1997 to 2005, modelled with environmental parameters as described in Golder (2014b) (Appendix 17), there is 0 % probability of capture of orange roughy in the marine consent area.

6.6.8.2 Diet

Stevens et al. (2011) reports that the dominant prey groups of orange roughy are crustaceans, teleosts and cephalopods. The relative proportion of the prey groups changed with fish size in that smaller fish (up to 20 cm) are more crustaceans whilst larger fish (31 cm and above) ate more teleosts and cephalopods.

Crustaceans were the most important prey, comprising 58 % of stomach contents overall, dominated by natant decapods (33 %), followed by euphausiids (5 %), amphipods (4 %) and mysids (2 %). Molluscs (10 %), particularly squid (9 %), were also important. A total of at least 21 main invertebrate groups in seven phyla were identified as orange roughly prey.

Teleosts comprise 41 % of the diet overall and include at least 35 mesopelagic and 48 other species. The most commonly identified groups were myctophids (2 %) and macrourids (nearly 1 %, including individual species).

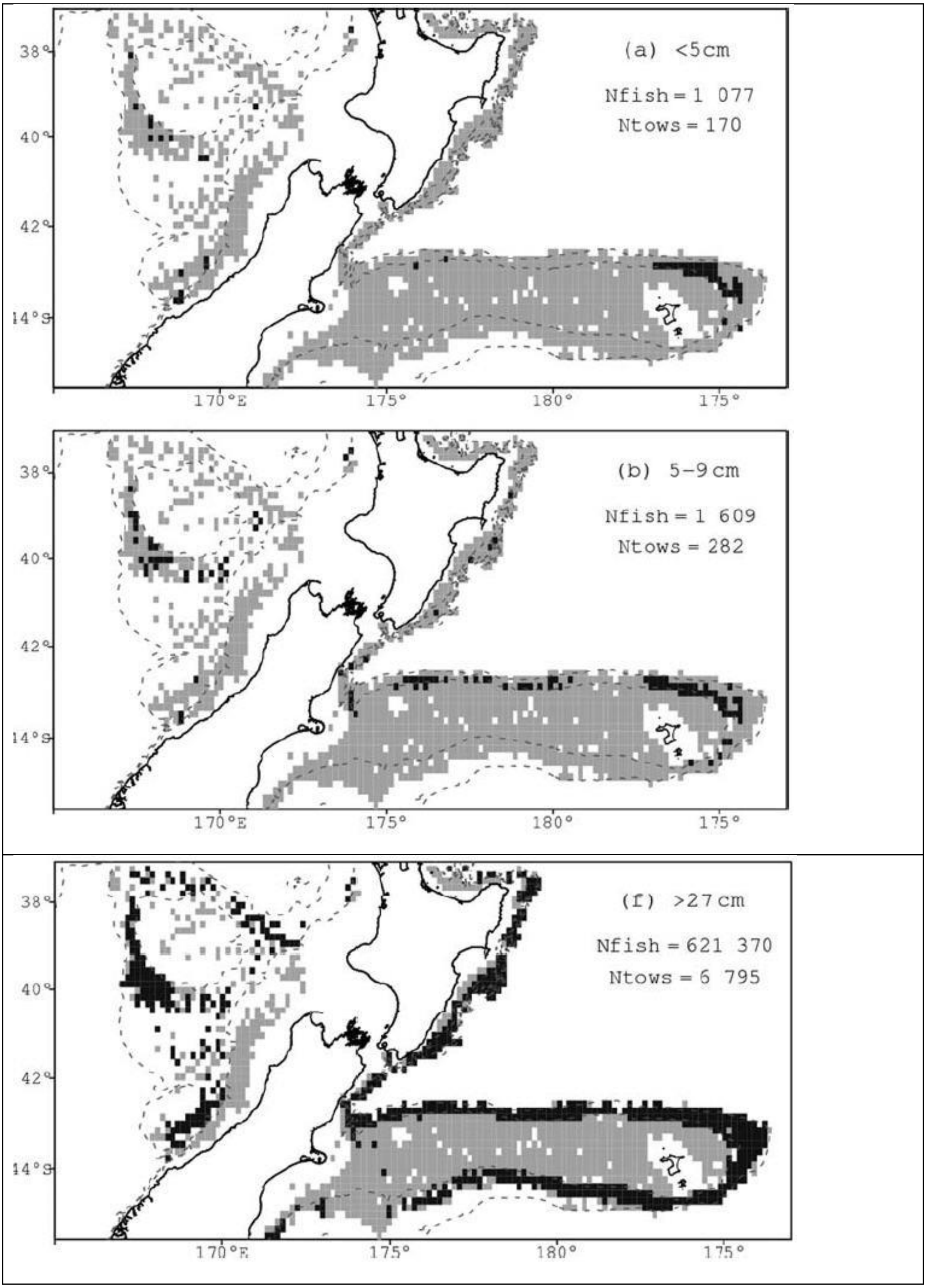


Figure 88: Occurrence of orange roughy in bottom trawls by length class (three of six size classes of data reported by Dunne et al. 2009 are shown). Grey-shaded areas were sampled, and black-shaded areas show where orange roughy were caught. The broken lines indicate the 750- and 1500-m isobaths.

6.6.8.3 Trophic importance

The trophic modelling work by Pinkerton (2013) (Appendix 22) ranked orange roughy at 18 to 19 in the sequence of 32 ecological groups based on either single or multi-step assessment. Their diet is varied and as such they interact with a range of mesopelagic and other fish and organisms (Pinkerton 2013 – Appendix 22).

6.6.9 Black oreo (*Allocyttus niger*), smooth oreo (*Pseudocyttus maculatus*) and spiky oreo (*Neocyttus rhomboidalis*)

6.6.9.1 Lifecycle and distribution

Smooth oreo (*Pseudocyttus maculatus*) are caught in depths over about 500 m mainly on the Chatham Rise, the southeast coast of the North Island, southern New Zealand and the west coast of the South Island.

Black oreo (*Allocyttus niger*) are also caught in depths greater than 500 m mainly on the Chatham Rise, but extending northward along the southeast coast of the North Island and southward to the northern edge of the Pukaki Rise.

Stevens et al. (2014) presents recent research trawl information for black, smooth and spiky oreo on the Chatham Rise. A greater proportion of black and spiky oreos were captured in the 200 to 800 m water depths than smooth oreos, and conversely, a greater proportion of smooth oreos were captured at water depths of 800 to 1,300 m in 2013. Black oreos, predominantly juveniles, were almost entirely caught on the southwestern part of the Rise at depths of 600 of 800 m while smooth oreos were mainly caught on the northern part of the Rise at depths of 1,000 to 1,300 m. Spiky oreos were more widespread than the other species and were most abundant on the northeastern part of the Rise at water depths of 500 to 800 m.

Figure 89 and Figure 90 shows that ripe and spent smooth and black oreo have been found predominantly on the southern slopes of the Chatham Rise.

Based on research trawl data from 1997 to 2005 modelled with environmental parameters as described in Golder (2014b) (Appendix 17), there is 0 % probability of capture of smooth or black oreos in the marine consent area. There is also 0 % probability of capturing spiky oreo throughout the majority of the marine consent area, although there is low probability (approximately 2-5 % and at least less than 10 %) of capture in the middle of MPL 50270.

6.6.9.2 Diet

Feeding habits of smooth oreo are known from studies on the Chatham Rise. Stevens et al. (2011) identified that salps comprised 80 % of the diet overall. Molluscs were the next most important (9 %), comprising mainly squid (8 %) but including octopods. Teleosts comprised 5 % overall, with mesopelagics the most important group identified. Coelenterates comprised 4 % and crustaceans 3 %, mainly amphipods and natant decapods. In total, at least 11 main invertebrate prey groups in six phyla and seven teleost species were recorded (Stevens et al. 2011). Stevens et al. (2011) considered their results were similar to those of Clark et al. (1989) who recorded mainly salps (82 %) as the most important item in the diet of smooth oreo from the southwest Chatham Rise. Clark et al. (1989) also recorded amphipods as important (38 %) and crustaceans as relatively unimportant (3 %).

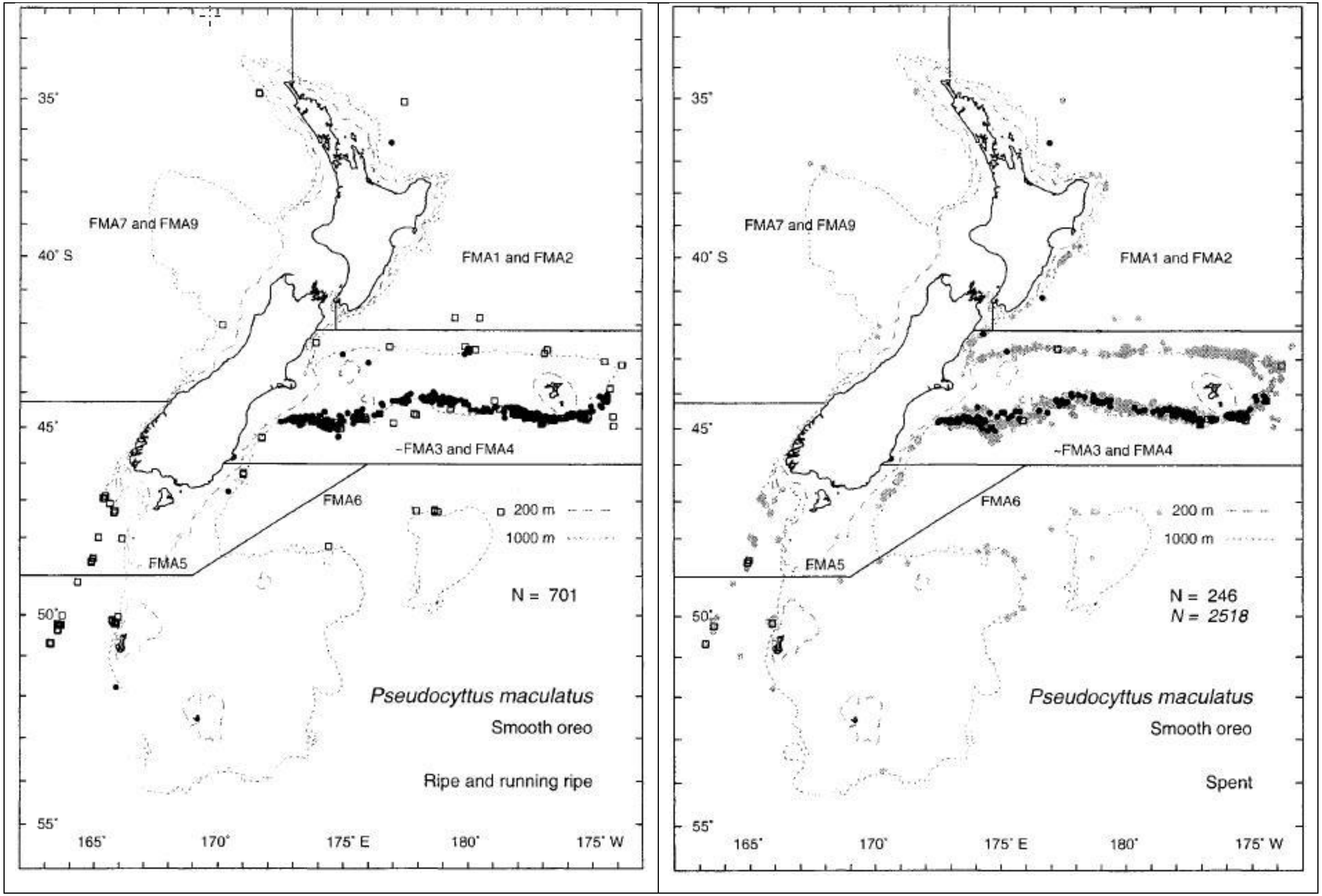


Figure 89: Distribution of ripe and spent smooth oreos within the EEZ (from O'Driscoll et al. 2003).

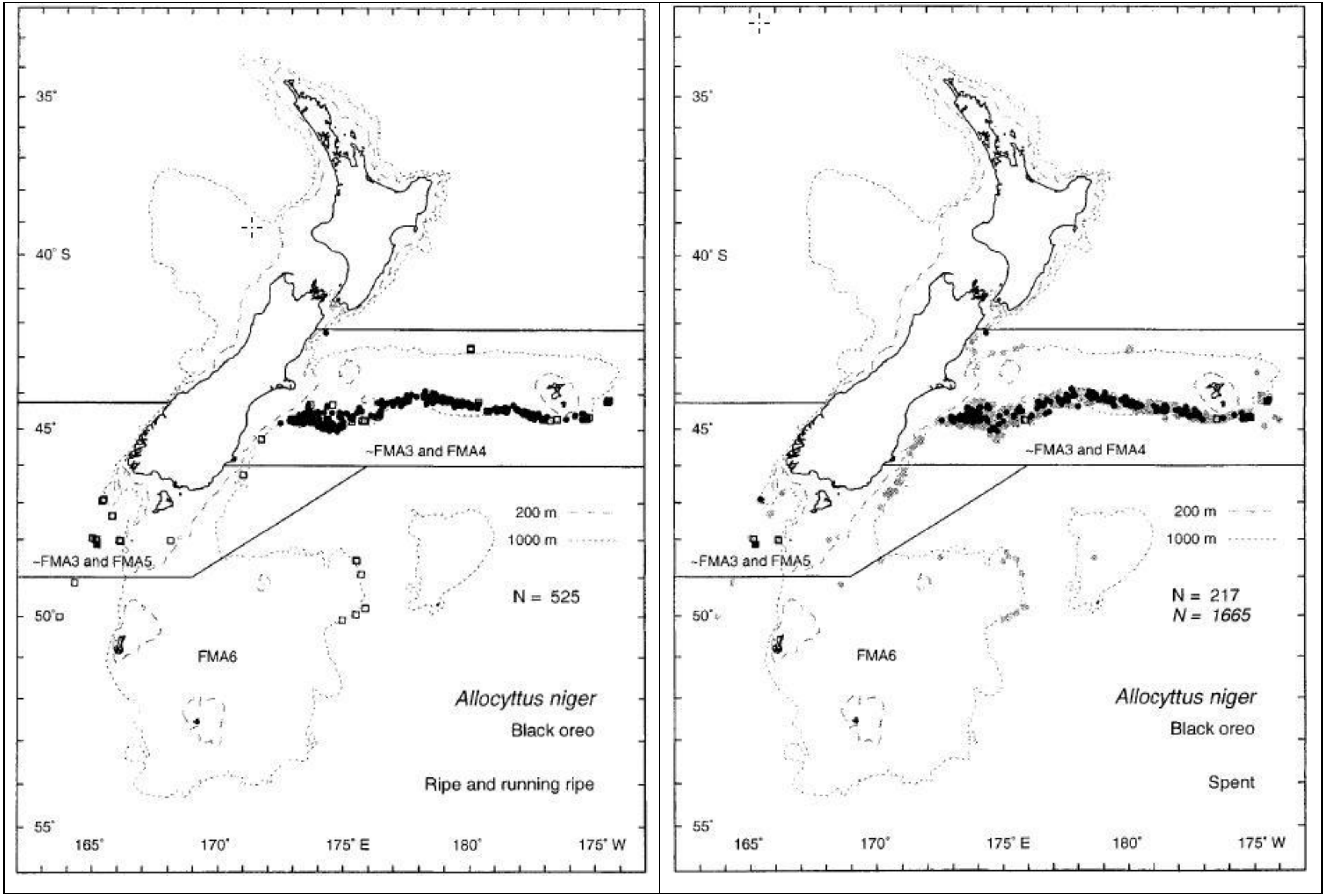


Figure 90: Distribution of ripe and spent black oreos within the EEZ (from O'Driscoll et al. 2003).

Stevens et al. (2011) summarised that black oreo feed mainly on teleosts (48 %), crustaceans (36 %) salps (24 %) and cephalopods (mainly squid, 6 %). Mesopelagic fish (5 %), mainly myctophids, were the most commonly identified teleost. Non-mesopelagic fish made up less than 1 % of the identified prey items. Crustaceans were mainly natant decapods (22 %). In total, at least 12 main invertebrate groups in four phyla and eight teleost species were recorded (Stevens et al. 2011). The authors noted that black oreo feeding habits differed between areas with salps and crustacean appearing more important on the Chatham Rise and teleosts less important. Stevens et al. (2011) noted that their findings differed to those of Clark et al. (1989) who found that salps (68 %), amphipods (72 %) and natant decapods (42 %) were the most important items in the diet of black oreo from the south-west Chatham Rise.

6.6.9.3 Trophic importance

Oreo are identified by Pinkerton 2013 (Appendix 22) as a moderately important fish group in the Chatham Rise ecosystem. The trophic modelling work undertaken by Pinkerton (2013) ranked the oreo group of fish at 15 and 16 in the sequence of 32 ecological groups based on either single or multi-step assessment. Their diet is varied and as such they interact with a range of mesopelagic and other fish and organisms (in particular with salps and crustaceans) (Pinkerton 2013 – Appendix 22).

6.6.10 White warehou (*Seriolella caerulea*)

Sexual maturity in the white warehou occurs at an age of about 3 or 4 years, at a length of approximately 38 to 47 cm. Sex ratios appear to show a slight bias towards males but there is insufficient data to determine whether this changes with season (MPI 2013e).

The existence of three possible spawning areas for white warehou, including Mernoo Bank, Puysegur Bank and the west coast of the South Island, suggests the possibility of three separate stocks.

Feeding records from the MFish research database show salps as the predominant prey item observed in white warehou stomachs, although fish, euphausiids and the tunicate Pyrosoma have also been recorded (MPI 2013e).

The probability of capture for white warehou in the marine consent area is 70 % or more throughout much of the area. The lowest probability of capture (less than 20 %) occurs in the eastern quarter of the marine consent area, near the Chatham Islands. The highest probability of capture (possibly more than 80 %) occurs within the mining permit area.

6.6.11 Giant stargazer (*Kathetostoma giganteum*)

Giant stargazer is a moderate-sized benthic teleost distributed widely in New Zealand waters where it supports a moderate-value, commercial trawl fishery (MPI 2013e).

Giant stargazer is found on muddy and sandy substrates to depths of 500 m, but is most common between 50 to 300 m on the Continental Shelf around the South Island. The stargazer fish stock occupies the Chatham Rise between 176°E and 175°W with the eastern end including the 200 m shelf around the Chatham Islands, and its western end bisects the 200 to 400 m Mernoo Bank fishing ground where several middle depth fish species are targeted.

The length-frequency distributions from the stargazer populations in Southland and the Chatham Rise are almost identical (Paul et al. 1999), therefore information from the Southland population could reasonably be assumed for the Chatham Rise population. Giant stargazer reach sexual maturity at an age of between five to seven years (MPI 2013e). Age and growth studies suggest that some individuals reach a maximum age of at least 25 years. Stargazers have an annual reproductive cycle with a winter spawning season, which probably occurs in mid and outer Continental Shelf waters all around New Zealand.

6.6.12 Dark ghost shark (*Hydrolagus novaezelandiae*)

Dark ghost sharks occur through much of the New Zealand EEZ in depths from 30 to 850 m. They are most abundant in waters 150 to 500 m deep on the west coast of the South Island and the Chatham Rise, and in water depths of 150 to 700 m on the Stewart-Snares shelf and Southland/sub-Antarctic. Smaller sharks (< 40 cm length) are more abundant in waters shallower than 200 m, particularly in the Canterbury Bight (MPI 2013e).

Stomach contents indicate that this species is predominantly a benthic feeder.

No published information is available on the age or growth rate of any Hydrolagus species, but as for most other elasmobranchs, ghost shark fecundity is likely to be low.

6.6.13 Alfonsino (*Beryx splendens, B. decadactylus*)

As described in MPI (2013e), both species of alfonsino occur throughout the world's oceans in depths from 25 to 1,200 m. These species are primarily associated with undersea structures such as the seamounts that occur off the lower east coast of the North Island and on the Chatham Rise, in depths from 300 to 600 m.

Alfonsino have a maximum recorded age of 17 years and females grow faster than males. Pre-spawning alfonsino has been recorded in New Zealand waters but spawning grounds are unknown. Summer-autumn spawning activity has been noted in the North and South Atlantic and North Pacific Oceans. Juvenile fish have been recorded in the pelagic and epipelagic zones in the North Pacific and Indian Oceans. Alfonsino less than 20 cm length are seldom recorded in New Zealand waters. It is likely that the New Zealand stocks utilise similar pelagic water systems for reproduction and juvenile development. Size at sexual maturity is probably about 30 cm length which occurs four to five years of age.

No information is available as to whether alfonsino is a single stock in New Zealand waters. Overseas data on alfonsino stock distributions suggest that New Zealand fish could form part of a widely distributed South Pacific stock. Current data on alfonsino movements are inconclusive and it is not known whether the fish on the east coast of the North Island spend some part of their life cycle in other New Zealand waters, or whether the east coast-Chatham Rise region is just one of several pre-reproductive regions. It is possible that the domestic trawl fishery may be exploiting part of the wider South Pacific stock.

The highest probability of capture for alfonsino (approximately 60-80 %) in the marine consent area is near the boundary between PP 55967 and MPL 50270 (Golder 2014b) (Appendix 17). In other parts of the marine consent area there is generally a lower probability, 30 % or less, for the capture of this species.

6.6.14 Sea perch (*Helicolenus percoides*)

Sea perch are widely distributed around most of New Zealand (MPI 2013e). Sea perch inhabit waters ranging from the shoreline to 1,200 m deep and are most common in water depths between 150 and 500 m. There is limited information on sea perch biology because of confusion between *H. percoides* and another species (*H. barathri*).

Trawl surveys from about 1990 show sea perch size to vary with depth and locality without an obvious pattern, possibly representing population differences as well as life history characteristics.

Sea perch are viviparous, extruding small larvae in floating jelly-masses during an extended spawning season. Sex ratios observed in trawl survey samples show slightly more males. Sea perch are opportunistic feeders and prey on a variety of animals on or close to the seabed.

There is high probability of capture for sea perch in the marine consent area with at least 80 % probability in the western half of the area and at least 50 % in the eastern half (Golder 2014b)

(Appendix 17). There are small patches of lower probability (50 % or less) in the eastern quarter of the marine consent area near the Chatham Islands.

6.6.15 Squaliforme sharks

6.6.15.1 Distribution

Squaliforme sharks are a common but potentially vulnerable by-catch in many deep water fisheries. Eleven species of squaliforme shark are commonly caught at depths of 200 to 1,200 m on the Chatham Rise (Dunn et al. 2013). The shovelnose dogfish, *Deania calcea*, and the spiny dogfish, *Squalus acanthias*, are the most commonly caught shark species during research bottom trawl surveys on Chatham Rise

Of the squaliforme shark species commonly caught by deep water (400 m) research bottom trawls on Chatham Rise, *Proscymnodon plunketi* and *Dalatias licha* are listed by the International Union for Conservation of Nature (IUCN) as 'near threatened', and *Squalus acanthias* and *Centrophorus squamosus* are listed as 'vulnerable'. The other seven commonly caught species, *Centroscymnus owstoni*, *Centroselachus crepidater*, *Deania calcea*, *Etmopterus baxteri, Etmopterus lucifer, Oxynotus bruniensis* and *Squalus griffini*, are listed as 'least concern' or 'data deficient'.

Although there is international concern over the vulnerability of sharks to commercial exploitation, research surveys on the Chatham Rise indicate that shark populations have not declined substantially over the last 20 years (O'Driscoll et al. 2011, Dunn et al. 2013).

There is very low (5 % or less) and 0 % probability of capture for shovelnose dogfish in the eastern half of the marine consent area, with a moderate to low probability of capture (less than 50 %) for this species in the western half of the area (Golder 2014b) (Appendix 17). Conversely, there is very high likelihood (80 % probability or higher) of capturing spiny dogfish throughout the marine consent area (Golder 2014b). Maps showing the probability of capture for other dogfish species are included in Golder (2014b), including Owston's dogfish, longnose velvet dogfish, Baxter's dogfish, Lucifer dogfish and prickly dogfish.

6.6.15.2 Diet

Dunn et al. (2010b) and Dunn et al. (2013) provide a description of the diets of a range of shark species (*D. licha*, *D. calcea, C. squamosus, C. owstoni, C. crepidater, Proscymnodon plunketi, and Galeorhinus galeus* and *S. acanthias)* on Chatham Rise. The authors also reviewed and classified the trophic role of *D. calcea*, *S. acanthias* and nine other squaliforme sharks commonly caught on Chatham Rise.

The diet of *D. calcea* was characterised by mesopelagic fishes. *S. acanthias* was characterised by benthic to pelagic fishes, but it was more adaptive and included likely scavenging. The eleven species had a variety of diets and depth and location preferences, consistent with niche separation to reduce interspecific competition.

The prey of *D. licha, C. squamosus*, and *P. plunketi* were predominantly benthic or demersal fishes and cephalopods. The prey of *C. owstoni* and *C. crepidater* were predominantly mesopelagic fishes and squids. *G. galeus* foraged throughout the water column. Scavenging of discards from commercial fishing vessels was likely in *C. squamosus, P. plunketi*, and *G. galeus*. The diet of all species except *C. crepidater* was dominated by the commercially important benthopelagic species hoki *Macruronus novaezelandiae* (Dunn et al. 2010b).

Dunn et al. (2013) grouped the prey of some shark species as: mesopelagic fishes and invertebrates (*Centroselachus crepidater*, *D. calcea*, and *Etmopterus lucifer*); mesopelagic and benthopelagic fishes and invertebrates (*Centroscymnus owstoni, Etmopterus baxteri*); demersal and benthic fishes (*Centrophorus squamosus, Dalatias licha, Proscymnodon plunketi*); and a generalist diet of fishes and invertebrates (*S. acanthias*). The diet of *Oxynotus bruniensis* and *Squalus griffini* are unknown.

6.6.16 Rattails

Stevens et al. (2014) provides recent research trawl survey data for fish species on the Chatham Rise, including rattails, over water depths of 200 to 800 m and 800 to 1,300 m. Data pertaining to rattails is summarised here to provide an indication of the most common rattail species likely to be encountered on the Rise.

Rattails, specifically big-eye rattail, oblique banded rattail, and Oliver's rattail, were among the most abundant non-QMS (i.e., non-commercial) fish species in water depths of 200 to 800 m. Bollon's rattail had the greatest weight of catch of all rattail species captured during the 2013 survey (5,731 kg) followed by oblique banded rattails (1,284 kg) and Oliver's rattail (640 kg).

The probability of capture for several rattail species is in Golder (2014b) (Appendix 17). In the marine consent area, there is low to moderate likelihood of capture for Oliver's, banded and oblique banded rattails, moderate probability for Bollon's rattail (only in MPL 50270 and 0 % probability elsewhere) and 0 % probability of capture for notable, Kaiyomaru, Mahia, serrulate, four-rayed, filamentous, ridge-scaled, squash faced and humpback rattails.

6.6.17 Scampi (*Metanephrops challengeri*)

Scampi are present around much of the New Zealand's Continental Shelf typically at depths between 200 and 500 m. The fishery is a relatively recent one that developed in the 1980s. The western end of the Chatham Rise is one of the main scampi fishery areas (Tuck 2013). MPI (2013e) provides a fisheries management assessment for scampi.

Scampi build and live in burrows in cohesive seabed sediment. Scampi appear to have diurnal and seasonal behavioural patterns of emergence and occupancy. Scampi moult several times a year and may live for up to 15 years. Scampi moulting and spawning activity occurs in spring through early summer. Female scampi produce small numbers of large eggs and larvae hatch at a late (advanced) stage resulting in a short larval stage (days) before moulting to the adult form (Figure 91 and Figure 92). Examination of ovary maturity on recent trawl surveys suggests that 50 % of females are mature at 30 to 38 mm orbital carapace length. Relatively little is known of the growth rate of any *Metanephrops* species in the wild. The maximum age of scampi is not known although analysis of tag return data and aquarium trials suggest that this species may be quite long lived. Further, the stock structure of scampi in New Zealand waters is not well known.

The images examined as a part of the 2012 Dorado Discovery survey were examined for a range of 'life signs' including burrows (refer to Rowden et al. 2013 – Appendix 15). Only three observations of scampi outside of (or visible in) their burrows, and 47 scampi burrows were recorded from the images that were analysed during the survey (n = 3,281). Where scampi and/or their burrows were observed in seabed images counts ranged from 1 to 10 per image. Figure 93 shows that scampi and/or their burrows were rarely observed in images taken along the ROV transects in all of the survey areas. The overall mean density of scampi was 0.0002 individuals per m^2, and for scampi burrows it was $0.0036/m^2$. These densities are much lower than those observed in the 2010 scampi stock assessment of the SCI 3 fishery area, $0.0172/m^2$ and $0.0653/m^2$, for visible scampi and major burrow openings, respectively (Tuck et al. 2011, Tuck 2013). Scampi and burrow densities in the study area are also much lower than for previous years in SCI 3 and compared to other scampi fishery areas (Tuck et al. 2011). Scampi are a significant prey for benthic fish species such as ling.

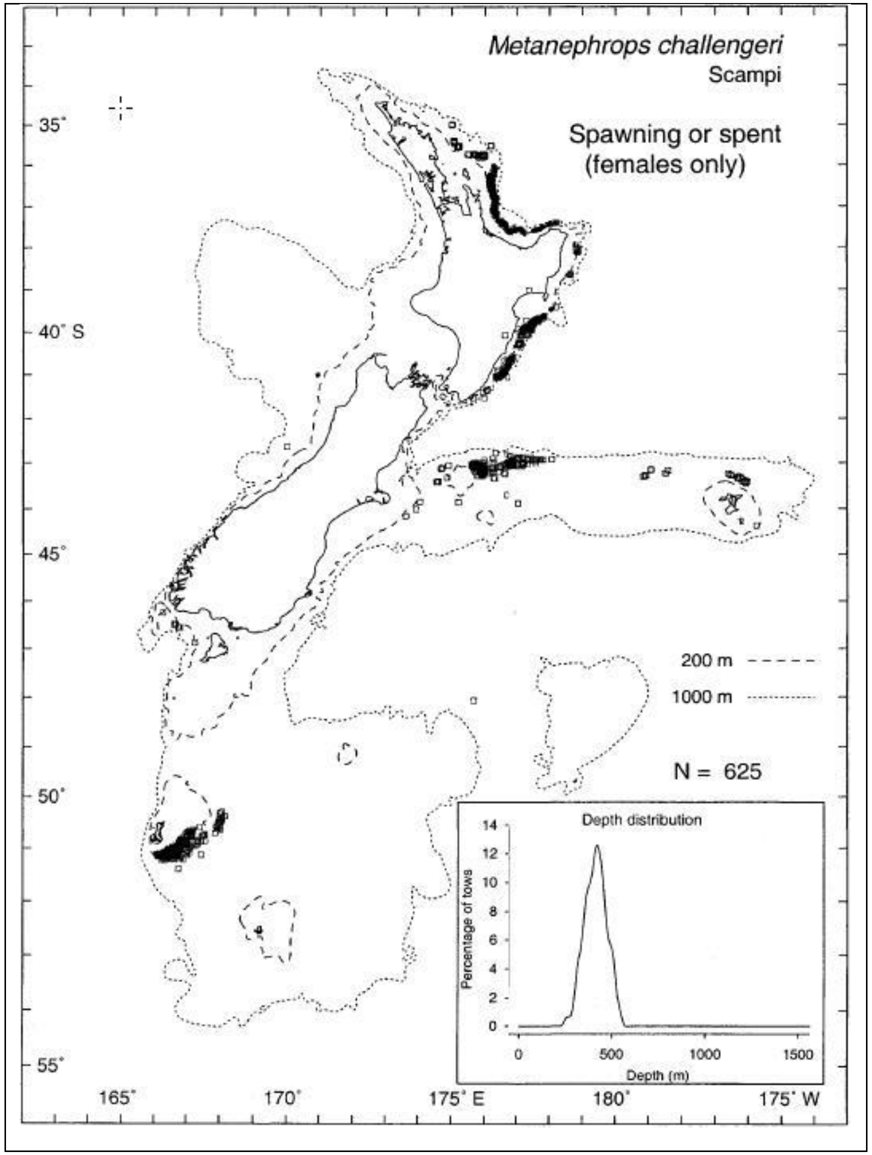


Figure 91: Distribution data for spawning scampi within the EEZ (from O'Driscoll et al. 2003).

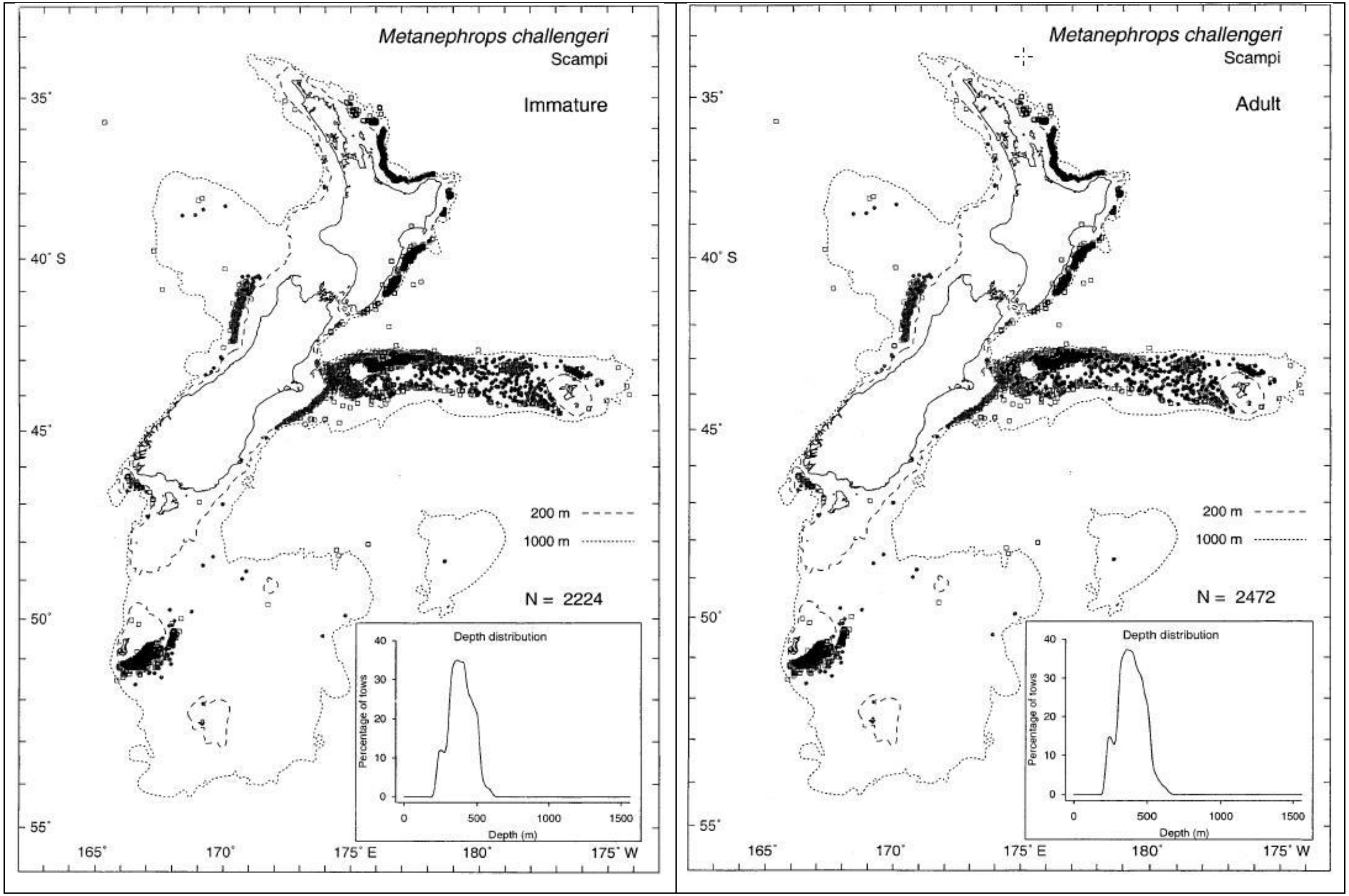


Figure 92: Distribution data for immature and adult scampi within the EEZ (from O'Driscoll et al. 2003).

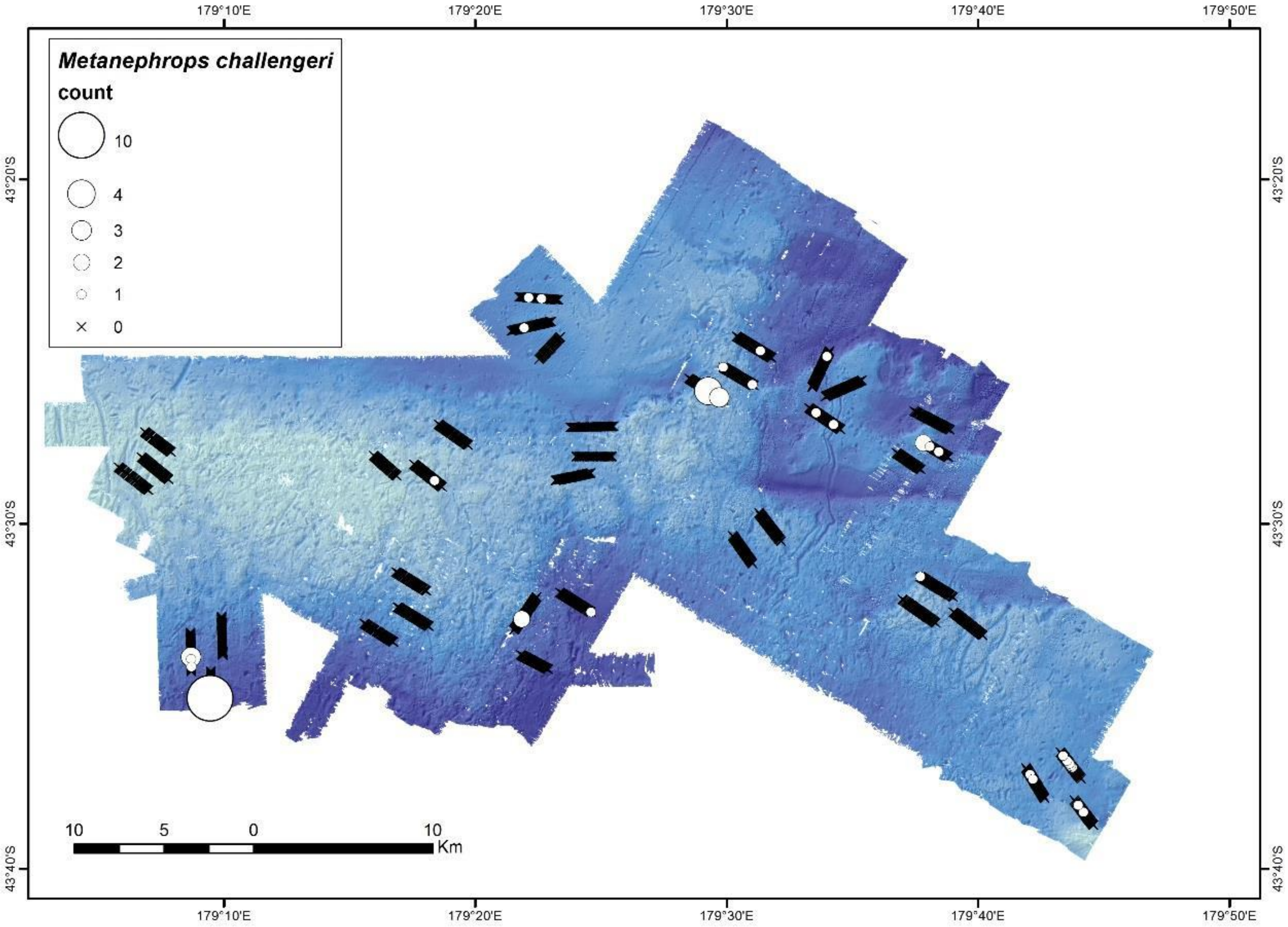


Figure 93: Numbers of scampi and/or scampi burrows observed in seabed images (each analysed photo image area 4 m^2) (from Rowden et al. 2013).

6.7 Commercial Fisheries and Fishing

6.7.1 Introduction

The Chatham Rise is an important fisheries area within New Zealand's EEZ, particularly in water depths down to 1,500 m. As described earlier, the elevated phytoplankton productivity in the Chatham Rise area supports a rich benthic and pelagic ecosystem which in turn supports valuable deep water fisheries. A wide range of commercial and other species occur on the Chatham Rise (Bull et al. 2001), but most fishing effort has been directed at hoki, hake, ling, silver warehou, and scampi in depths of 200 to 800 m, and orange roughy and oreos in depths of 800 to 1,300 m. The main commercial fisheries of the Chatham Rise are hoki (57 %), orange roughy and oreos (Pinkerton 2013 – Appendix 22). There are also important local inshore fisheries (commercial and recreational) around the Chatham Islands for paua, rock lobster, blue cod, and hapuku.

The differences in the benthic communities on the northern and southern flanks of the Chatham Rise (described in Section 6.3) reflect the different water bodies associated with these areas and are considered to contribute to differences in the distributions of some deep water fish species between them (Bull et al. 2001 in Beaumont et al. 2013b).

6.7.2 Fishing methods

Most of the deep water fishing on the Chatham Rise uses bottom trawls (Baird et al. 2011, Beaumont et al. 2013b). Other deep water fishing methods used in this region include mid-water trawls and bottom long-lines.

Analysis of the area of the seabed covered by trawls shows that commercial vessels carry out relatively few trawls in the central area of the Chatham Rise (Baird et al. 2006, Baird et al. 2011, Beaumont et al. 2013b (Appendix 14).

There has been very little bottom trawling in the proposed marine consent area between 1989 and 2008 (Figure 94). A few trawls targeted hoki in the southern part of MPL 50270 in water depths shallower than 500 m (Beaumont et al. 2013b). The fishing reported within MPL 50270 peaked in 2002/03, the year before a series of reductions in the Total Allowable Catch for hoki were implemented (Ministry of Fisheries 2009, Beaumont et al. 2013b). In the last few years, trawl effort across MPL 50270 has been minor and located entirely in the southwestern corner (Beaumont et al. 2013b). No trawls have been reported from the proposed mining area where it overlaps with the mid Chatham Benthic Protection Area (BPA) subsequent to the BPA Regulations coming into force in November 2007 (Beaumont et al. 2013b).

The other main fishing method used on the Chatham Rise is bottom long-line, though to a far lesser extent than trawling. Bottom long-lines rest on the seabed, usually at depths of between 300 to 500 m, and primarily target ling (Beaumont et al. 2013b).

An area north of the proposed marine consent area and another in the east of the marine consent area are an important for bottom long-lining and the ling fishery (Figure 95). From information provided by MPI, from 2002/03 to 2012/13, 3,276 long-lines (over 20 million hooks) were set in the eastern part of the marine consent area (PP 55967). This compares to 75 long-lines set in MPL 50270 and 21 long-lines the western prospecting permit area (PP 55971) over the same period of time. The annual catch of ling from 2002 to 2012 from sets that originated in MPL 50270 ranged from 1,145 to 16,474 kg.

Mid-water trawling is less extensive than bottom trawling. Examination of the effort in statistical areas 402-404 and 408-410 for the last five years (2007/09 to 2011/12) showed there were 539 instances of fishers using the code "MW" (mid-water trawl) to describe fishing effort. Of these, 530 were in statistical area 404 and most targeted alfonsino. This compares with 9,831 "BT" records (bottom trawl) from the same six statistical areas over the same time period. Most of the mid-water trawls were close to the bottom.

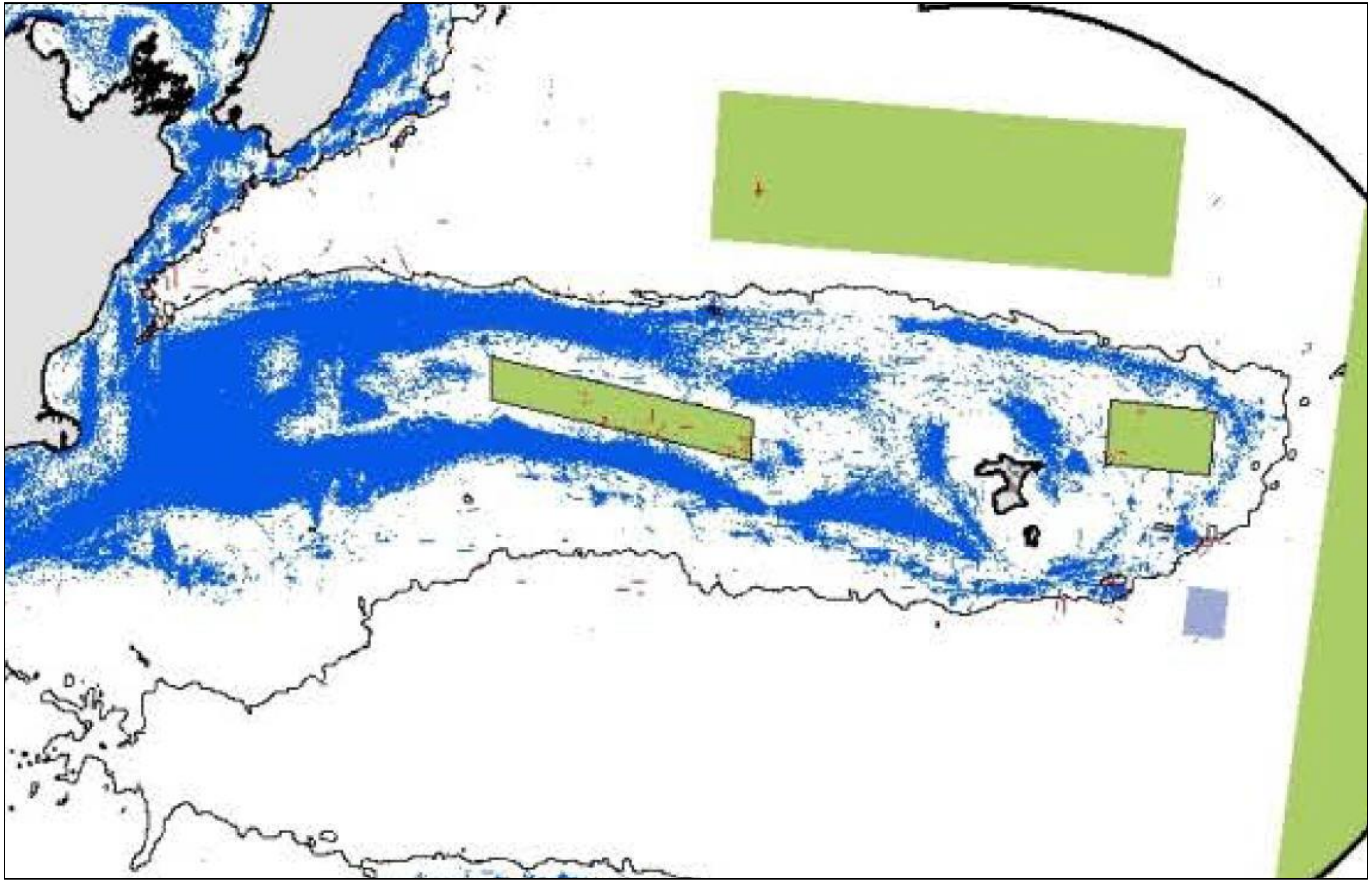


Figure 94: Commercial trawl footprint for all species for period 1989/90 to 2009/2010 (blue area: from Black et al. 2013) (BPA closures are shown in green).

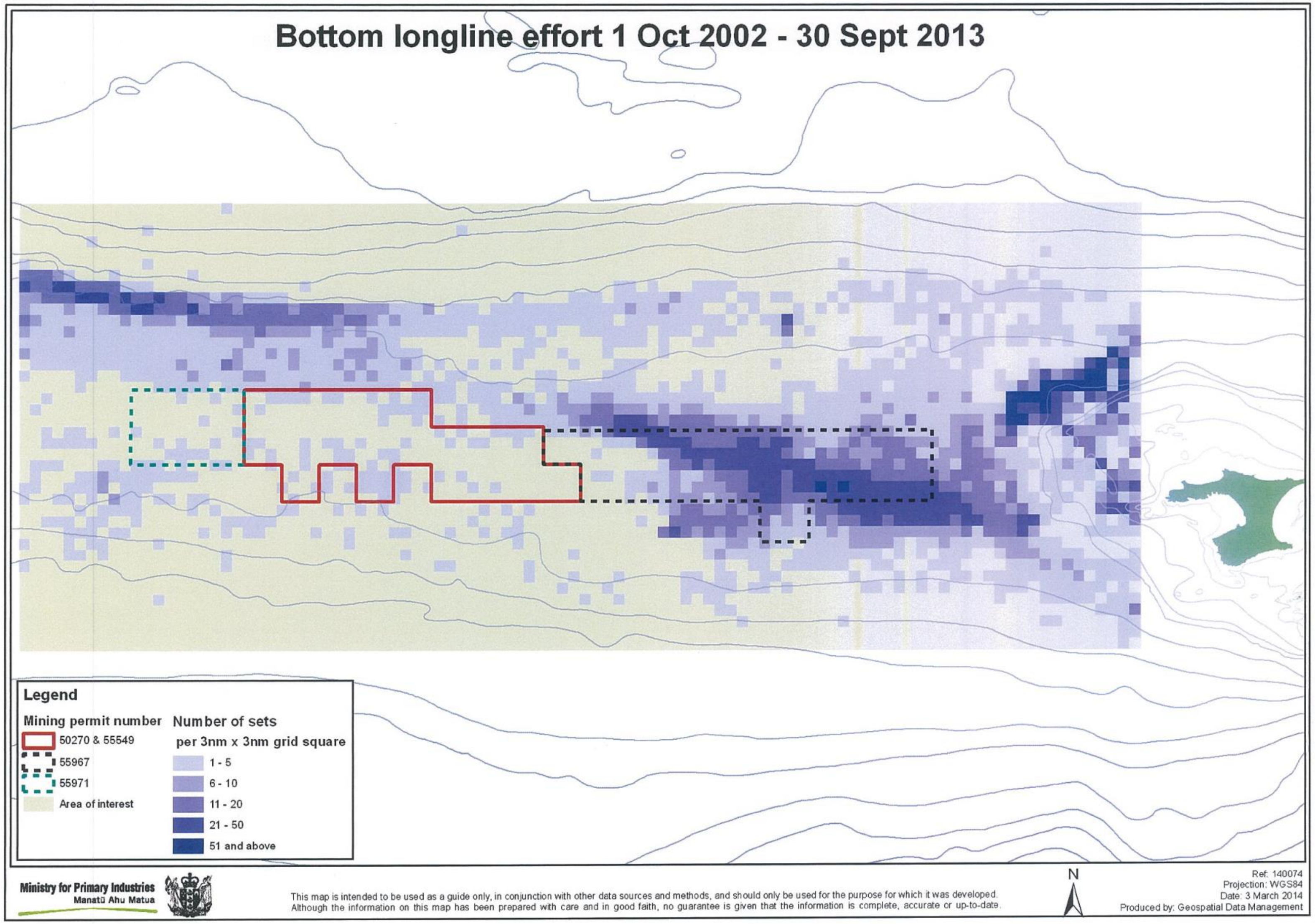


Figure 95: Bottom long-line fishing effort on the central Chatham Rise from 2002/03 to 2012/13, data provided by MPI.

6.7.3 Chatham Islands fisheries

The habitation of the Chatham Islands has been influenced by fisheries since the early 1800s, when large numbers of fur seals and whales were hunted. Fishing still forms the basis of the Chatham Islands' economy and the catch is dominated by high value species, including paua, rock lobster, blue cod, and hapuku (MPI 2013d).

Paua (*Haliotis iris*) is probably the most important species caught and it has a total allowable commercial catch (TACC) of 326 t. All three species of paua (*H. iris, H. australis, H.virginea*) are found at the Chatham Islands, but the blackfoot paua (*H. iris*) is the most abundant and forms the basis of the fishery.

In the 1960s, the rock lobster (*Jasus edwardsii*) fishery at the Chatham Islands expanded rapidly, with the catch peaking at 6,000 t in 1968, then declining to about 500 t by 1974 (Schiel 2003). The current TACC for rock lobster at the Chatham Islands is 360 t. There has not been a rock lobster stock assessment undertaken for the Chatham Islands stock since 1996 and although the stock is uncertain the annual catch has been within 10 t of the TACC since the 2004-05 fishing year, suggesting that the stock is stable (MPI 2012b).

The TACC for blue cod (*Parapercis colias*) at the Chatham Islands is 759 t and reported landings are generally close to this. The TACC for hapuku is currently 223 t, although the annual catch is often much lower (MPI 2012b). Other commercial inshore species include blue moki, tarakihi, trumpeter, butterfish, dredge oysters, kina, and paddle crabs (Schiel 2008). There is currently no active aquaculture in this region, but there is growing interest in developing an aquaculture industry on the Islands.

There are also important non-commercial fisheries on the Chatham Islands (Davey et al. 2011). There are two major non-commercial sectors: the local fishery which consists of local residents who fish for subsistence and/or recreation, and the tourist fishery. Local residents fish throughout the year, slightly more often in summer. The major local fishing methods are snorkelling and baited line. The tourist sector includes three sub-fisheries: charter vessels, New Zealand mainland vessels, and, shore-based tourist ventures. Most tourist fishers are from mainland New Zealand and the most popular fishing method is baited line. The key non-commercial species for the non-commercial Chatham Island fishery are blue cod, hapuku, rock lobster and paua. The most commonly harvested species are blue cod (estimated landed weight of 14,881 kg in 2008/09) and hapuku (estimated landings 9,334 kg), with the tourist sector accounting for about half of the catch of these species (Davey et al. 2011). Rock lobster and paua were mostly harvested by local residents (with estimated harvest weights of 2,811 and 3,678 kg, respectively, in 2008–09) (Davey et al. 2011).

6.7.4 Key fisheries on the Chatham Rise

6.7.4.1 Introduction

Detailed information on the commercial fisheries stocks of New Zealand is provided on the NZ Fisheries InfoSite (administered by MPI). Relevant information from this site on the main fisheries on the Chatham Rise is summarised below to provide context for the fisheries within the broader Chatham Rise region. Assessment of 2011/12 commercial fisheries data indicated that hoki was the most abundant species caught, and the next most abundant species were alfonsino, dark ghost shark, black oreo, ling, sea perch, lookdown dory, silver warehou, spiny dogfish, pale ghost shark, spiky oreo, giant stargazer, and white warehou (Stevens et al. 2014). MPI (2013e) contains further information in relation to current fisheries assessments in New Zealand.

In this section, information is presented for a range of key commercial fish species to illustrate where they are caught based on research trawl catch records. Figures presented in this section indicate the likelihood that commercial fishing activity will catch that species in the marine consent area.

Of the key fisheries, hoki, hake, ling, silver and white warehou, dark ghost shark, sea perch and spiny dogfish have been commercially caught within the marine consent area, some of these species as by-catch of other targeted fisheries. Higher catch rates for most of these species are found elsewhere on the Chatham Rise. Of the other Chatham Rise fisheries, giant stargazers, pale ghost shark, alfonsino, and scampi are less commonly caught in marine consent area, as higher catch rates occur in other locations on the Rise. Oreos and orange roughy are unlikely to be found within the marine consent area.

6.7.4.2 Hoki

It is likely that hoki fishing could occur in the marine consent area, although other areas of high hoki abundance also occur further west nearer to the mainland (Figure 96).

There is a substantial hoki fishery on the Chatham Rise which generally has constant catch levels except during the period July to September when catches are lower because fishing vessels move to the spawning grounds near the Campbell Plateau and in Cook Strait. Outside the spawning season (July-September), most of the catch is taken from October to June on the Chatham Rise and in the sub-Antarctic (Ballara & O'Driscoll 2014, O'Driscoll & Ballara 2014 (Appendix 18)). The hoki trawl fishery has interactions with a variety of protected species, most notably seabirds and with the benthic habitat in the predominantly bottom trawl fishery on the Chatham Rise. The hoki fishery received Marine Stewardship Council Certification as a sustainable fishery in 2001 and was recertified as a sustainably managed fishery in 2007.

The hoki fishery is one of the most commercially valuable fisheries in New Zealand (MPI 2013c). The total market value of hoki quota was estimated to be $730 million in 2008. Stevens et al. (2014) provides information on research trawl catch rates in all years between 1992 and 2013 (Figure 96). Ballara & O'Driscoll (2014) further summarise the catch by area and presents the length and age structure of hoki caught commercially during the 2011/12 fishing year. The total reported hoki catch in 2011/12 was 130,000 t with catches showing an increase in all areas compared to recent fishing years (MPI 2013e). Of the non-spawning areas, the Chatham Rise was the second largest fishery, with 39,000 t taken, and contributed about 30 % of the total catch in 2011/12 (MPI 2013e). On the Chatham Rise, most of the catch was taken by bottom trawling.

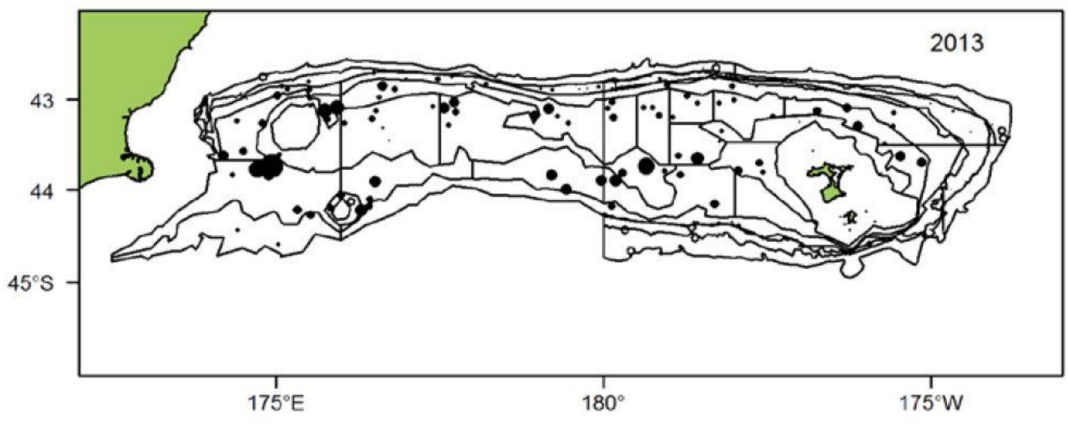


Figure 96: Catch rate and distribution of hoki (>3 years) in 2013. Filled circles are proportional to catch rates and open circles are zero catch (from Stevens et al. 2014).

Length frequencies and catch-at-age results from the commercial fishery show that most of the catch in 2011/12 was fish aged three to seven years. Stevens et al. (2014) also provided an estimate of hoki biomass and other middle depth species on the Chatham Rise from a trawl survey carried out in January 2013. The relative biomass index for all hoki from the 2013 Chatham Rise trawl survey increased by 42 % relative to the January 2012 survey, with an increase of 29 % in estimated biomass of recruited hoki (aged three years and older).

6.7.4.3 Hake

There is a moderate to high likelihood of commercial catch for hake in the marine consent area, although higher catch rates occur in the western and northeastern part of the Rise (Figure 97).

The largest fishery has been off the west coast of the South Island (HAK 7) with the highest catch recorded in 1977, immediately before the establishment of the EEZ. The west coast South Island hake fishery has generally consisted of by-catch in the much larger hoki fishery, but it has undergone a number of changes during the last decade. These include changes to the total allowable commercial catches of both hake and hoki, as well as changes in fishing practices such as gear type, tow duration, and strategies to limit hake by-catch. In some years there has been a hake target fishery in September after the peak of the hoki fishery is over.

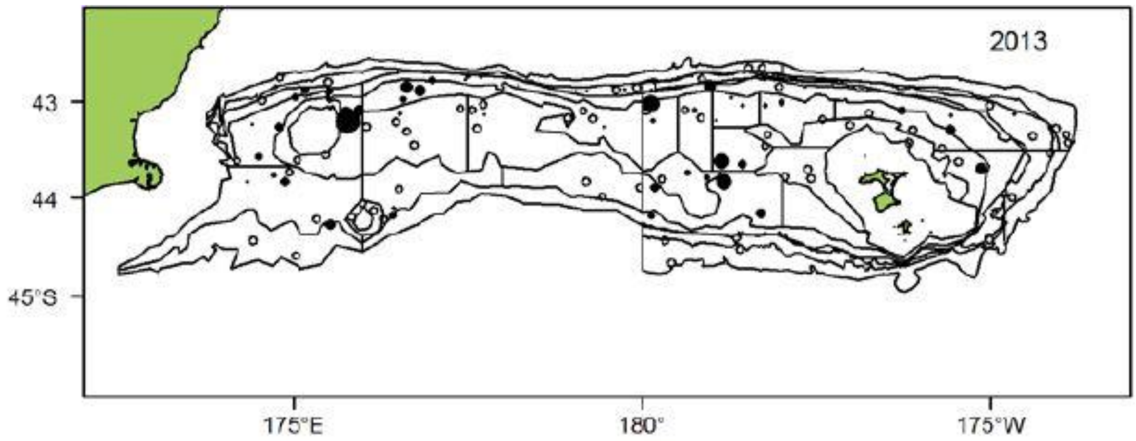


Figure 97: Catch rate and distribution of hake in 2013. Filled circle area is proportional to catch rate (kg/km^2). Open circles are zero catch. Maximum catch rate in series is 620 kg/km^2 (from Stevens et al. 2014).

On the Chatham Rise and in the sub-Antarctic, hake have been caught mainly as by-catch by trawlers targeting hoki. However, significant targeting for hake has also occurred in both areas, particularly in HAK 4, which includes the Rise, and around the Norwegian Hole between the Snares and Auckland Islands in the sub-Antarctic. Landings from HAK 4 have declined since 1998/99 to a low of 161 t in 2011/12.

6.7.4.4 Ling

Ling may be targeted for commercial fishing in the marine consent area, although catch rates of ling are currently evenly distributed throughout most of the trawl survey area over the wider Chatham Rise(Figure 98).

Since 1980 ling have been caught by a variety of fishing methods including those employed by large trawlers and small domestic long-liners (MPI 2013d, Dunn et al. 2013). In the early 1990s the domestic fleet was increased by the addition of several larger long-liners fitted with autoline equipment which caused a large increase in the catches of ling off the east and south of the South Island. However, since about 2000 there has been a decline in catches taken by long-line vessels in most areas, offset, to some extent, by increased trawl landings. The Chatham area was the most productive area for the ling fishery, but its recent landings (2010/11) were only about a third of those taken at its peak in the mid-1990s (Dunn et al. 2013).

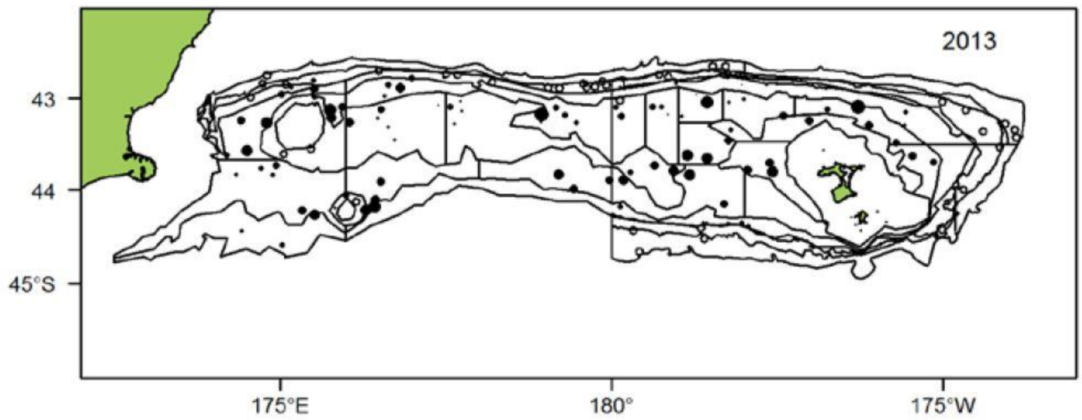


Figure 98: Catch rate and distribution of ling in 2013. Filled circles are proportional to catch rates and open circles are zero catch (from Stevens et al. 2014).

Ling is a relatively high value fishery with export revenues in 2007 totalling approximately $54 million (MPI 2013d). Baird (2014) (Appendix 19) provides a summary of the ling fishery activity on the Chatham Rise.

Research has indicated that there are at least five major biological stocks of ling in New Zealand waters (Horn 2005), including the Chatham Rise, the sub-Antarctic (including the Stewart-Snares shelf and Puysegur Bank), the Bounty Plateau, the west coast of the South Island, and Cook Strait (Dunn et al. 2013).

The most current commercial catch and effort data and stock assessments are provided in Dunn et al. (2013). The overall 2010/11 ling catch from the EEZ was slightly lower than the previous year, and markedly lower than catches from 1991/92 to 2007/08. The distribution and size of both the trawl fishery landings and long-line fishery catch distribution changed little in 2010/11, with slight decreases in catch in the Chatham region, but with variable increases and decreases in other regions.

Horn & Sutton (2014) described the catch-at-age distributions for ling from length data collected by observers between October 2011 and May 2012. The ling long-line fisheries catch few fish younger than seven years, and much of the catch is older than 12 years. Sex ratios of the long-line catch are equal in the Chatham Rise and Cook Strait fishery, although there tends to be biased towards females in the other fisheries (Horn & Sutton 2014). Recruitment to the trawl fisheries is generally about two years earlier than to the long-line fisheries (i.e., at about 5 years), and most of the catch is 13 years or younger.

Based on data from a January 2013 research trawl survey (Stevens et al. 2014), the relative biomass of ling was most recently estimated at 8,714 t, 7.6 % higher than for January 2012, although the time series for ling biomass shows no overall trend.

The highest catch rates were mainly on the north Chatham Rise in 400 to 600 m, although the largest catch rate was on the Reserve Bank in 370 to 390 m. Ling distribution was consistent, and catch rates relatively stable, over the time series (Steven et al. 2014).

Further, Horn et al. (2013) describe model estimates of the state of the ling stock in the Chatham region, indicating that current biomass is at least 40 % of the original level, and that it is likely to remain unchanged in the short term. Catches at the recent level are likely to be sustainable in the long term (assuming no exceptional decline in future recruitments), but catches at the total allowable commercial catch are likely to cause a decline.

6.7.4.5 *Silver warehou*

The distribution and catch rate information in Figure 99 shows that there is some likelihood of commercial catch for silver warehou in the marine consent area, although higher catch rates are located on the western part of the Chatham Rise.

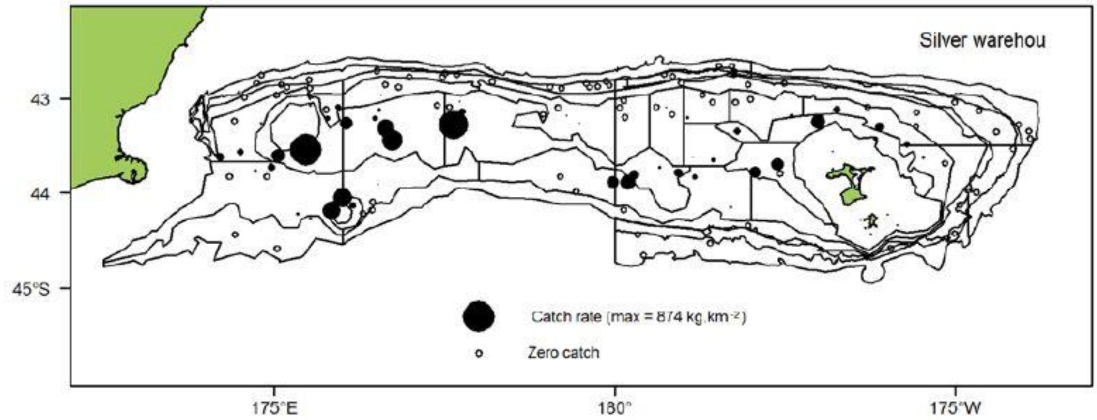


Figure 99: Catch rate and distribution of silver warehou in 2013. Filled circles are proportional to catch rates and open circles are zero catch (from Stevens et al. 2014).

Silver warehou are common around the South Island and on the Chatham Rise in depths of 200 to 800 m. The majority of the commercial catch is taken from the Chatham Rise, Canterbury Bight, southeast of Stewart Island and the west coast of the South Island. Historical and recent fisheries information is presented in MPI (2013e).

Prior to the establishment of the EEZ in 1978, white, silver and blue (or common) warehou landings were combined as 'warehous'. In recent years, most of the silver warehou catch has been taken as a by-catch of the hoki, squid, barracouta and jack mackerel trawl fisheries. Some target fishing for silver warehou still occurs, predominantly on the Mernoo Bank and along the Stewart-Snares shelf. Reported landings in 2011/12 in SWA 4 (which covers the Chatham Rise and most of the offshore region of the EEZ from the northeastern coast of the South Island around to north of Fiordland on the west coast) were 2,783 t which is 39 % of the total landings for that period. The highest catch was from SWA 3 along the inshore region of the eastern South Island, with 3,318 t (47 % of total landings) landed in 2011/12.

6.7.4.6 *Orange roughy*

There is a low likelihood of commercial catch for orange roughy in the marine consent area as higher catch rates occur on the northern and eastern flanks of the Rise (Figure 100). The main orange roughy stock in the vicinity of the Chatham Rise and southern New Zealand falls within the Chatham Rise and Puysegur fisheries management area (ORH 3B). This species is found in waters deeper than 750 m throughout the management area.

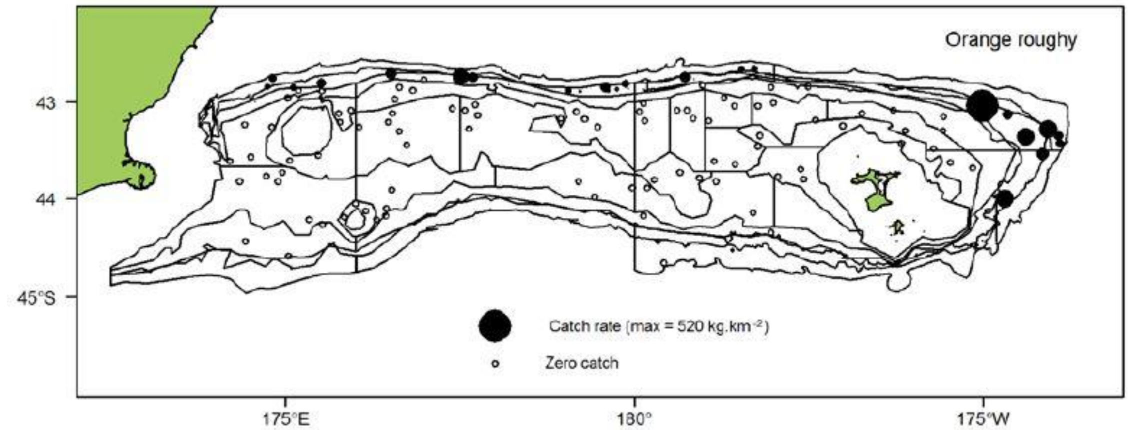


Figure 100: Catch rate and distribution of orange roughy in 2013. Filled circles are proportional to catch rates and open circles are zero catch (from Stevens et al. 2014).

The management area for orange roughy has been historically subdivided into the following stocks: northwest Chatham Rise, east Chatham Rise, south Chatham Rise, Puysegur and other minor stocks (MPI 2013e). Two main stocks are genetically recognised within ORH 3B (Chatham Rise and Puysegur) and these are considered to be distinct from stocks in adjacent areas (Cook Canyon and Ritchie Bank). However, it is likely that concentrations of spawning fish on the Arrow Plateau (near the Auckland Islands) and west of the Antipodes Islands also form separate stocks because of their geographical separation and discontinuities in the distribution of orange roughy. Furthermore, there is evidence that a separate stock exists on the northwest part of the Chatham Rise as it contains a substantive spawning ground on the Graveyard seamount complex, and also nursery grounds around, and primarily to the west of, the Graveyard seamount complex. Therefore, based on stock analyses, the Chatham Rise has been subdivided into two areas: the Northwest, and the East and South Rise combined. The centre of the Northwest stock is the Graveyard seamount complex while the centre of the East and South Rise stock is the Spawning Box during spawning, and the southeast corner of the Rise during non-spawning.

There have been major changes in the distribution of catch and effort over the history of this fishery. Historically, the main fishery has been concentrated on the Chatham Rise and, until 1982, most of the catch was taken from areas of relatively flat bottom on the northern slopes of the Rise (in the Spawning Box), between mid-June and mid-August, when the fish formed large aggregations for spawning. Annual reported catches were mostly just over 30,000 t in the 1980s but have been progressively decreasing since 1989/90 because of a series of total allowable commercial catch reductions. For comparison, the reported catch for 2011/12 was 2,765 t.

From 1983 to 1989 about one third of the catch was taken from the southern and eastern parts of Chatham Rise, where fishing grounds developed on and around knolls and hill features. Much of the catch from these areas was taken outside the spawning season as the fishery extended to most months of the year. In the early 1990s, effort within the Chatham Rise shifted further from the Spawning Box to the eastern and northwestern parts of the Rise. Since 1992/93, the distribution of the catch within ORH 3B has been affected by a series of catch limit agreements between the fishing industry and the government. Within the Chatham Rise, catches have generally been about the same as these agreed catch limits. In 2011/12, the greatest catches of orange roughy were from outside and inside the Spawning Box (750 t and 660 t respectively) and the Andes (450 t).

6.7.4.7 *Oreos*

Based on the distribution and catch rate information presented in Figure 101, it is unlikely that commercial fishing of oreos would occur within the marine consent area.

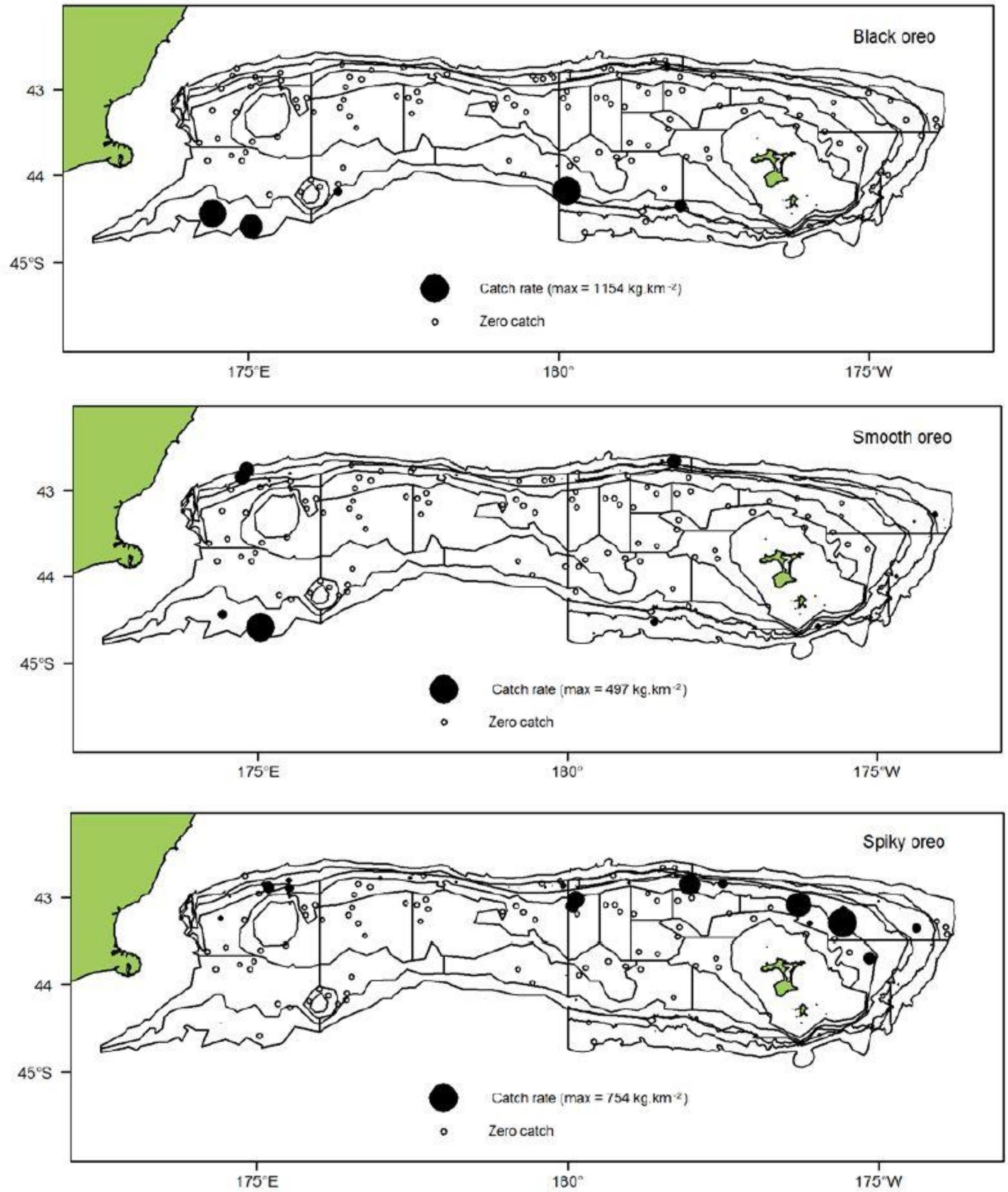


Figure 101: Catch rate and distribution of oreos in 2013. Filled circles are proportional to catch rates and open circles are zero catch (from Stevens et al. 2014).

Commercial fisheries occur for black oreo and smooth oreo although oreos are managed as a species group, which includes spiky oreo as well.

Smooth and black oreo dominate relative abundance estimates from trawl surveys of demersal fish species at 650 to 1,200 m on the south and southwest slope of the Chatham Rise. They are probably also dominant at those depths on the southeast slope of the South Island and other southern New Zealand slope areas including Bounty Plateau, and Pukaki Rise. At depths of about 700 to 1,200 m they are replaced on the east and northern slope of Chatham Rise by orange roughy.

The Chatham Rise (OEO 3A and OEO 4) is the main fishing area, but other fisheries occur off Southland on the east coast of the South Island, and on the Pukaki Rise, Macquarie Ridge and Bounty Plateau. Both species of oreo are sometimes taken as by-catch in orange roughy target fisheries and in smaller numbers in hoki target fisheries.

In 2011/12, oreo landings in OEO 3A were 3,324 t and 6,858 t in OEO 4, representing 25 % and 52 % of the total catch respectively. In OEO 3A, black oreo catches have decreased with total allowable commercial catch limits since the early 1990s and have remained low but relatively constant over the last ten years.

In OEO 4, oreo catch data has shown marked changes in fishing patterns over time with large catches first starting in the west and then progressing eastwards as new areas are fished. The target species and the type of fishing also changed over time with smooth oreo being the target species in the west on flat, drop-off, and seamounts from the late 1970s, with a gradual change to target fishing for orange roughy on seamounts in the east from the late 1980s. Since the late 1990s, there has been an increase in targeted fishing for smooth oreo in the east, with more fish being caught as a target species than as by-catch.

6.7.4.8 White warehou

There is a small likelihood of commercial catch for white warehou near the marine consent area, although higher catch rates occur in the western part of the Rise (Figure 102).

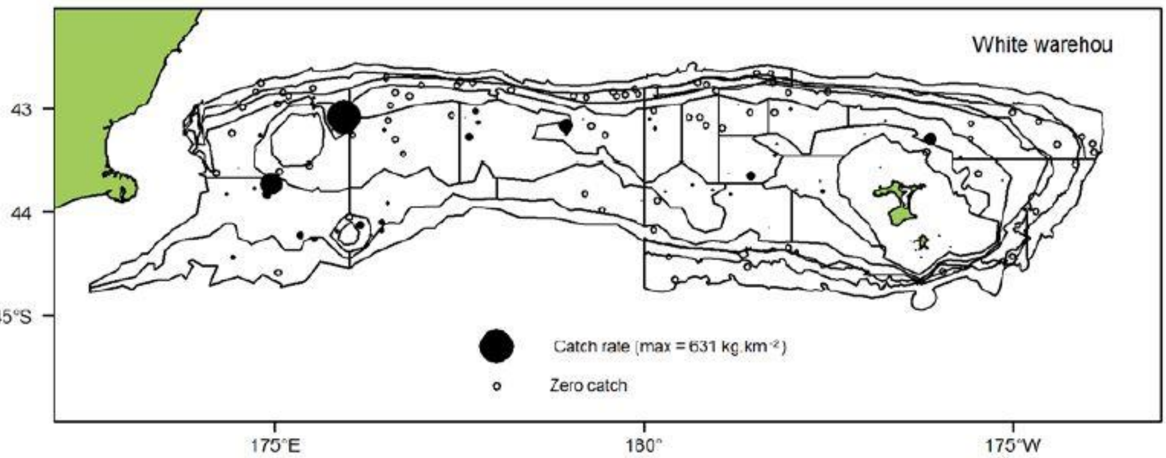


Figure 102: Catch rate and distribution of white warehou in 2013. Filled circles are proportional to catch rates and open circles are zero catch (from Stevens et al. 2014).

Prior to the establishment of the EEZ in 1978, white warehou commercial catches were combined with silver and blue (or common) warehou as ‘warehous’. White warehou are now predominantly taken as by-catch from target trawl fisheries on hoki and silver warehou, and to a lesser extent, hake, ling and scampi. White warehou are mostly caught in 150 to 800 m depths by the relatively large fishing vessels. Annual catches of white warehou have been variable and the main areas of fishing are around Southland and the Chatham Rise, with some extension into the sub-Antarctic area since 1990/91.

Target fishing for this species is also reported from around Mernoo Bank, the Stewart-Snares shelf, Puysegur Bank and on the west coast of the South Island, but typically (and historically) accounts for a small (<10 %) proportion of the annual catch. In 2011/12, white warehou landings were 112 t (8 % of the total landings) for WWA 4 around the Rise and 204 t (15 % of total landings) for WWA 3 further inshore along the east coast of the South Island.

6.7.4.9 Giant stargazer

Based on the distribution and catch rate information, there is some likelihood of commercial catch for giant stargazer in the marine consent area, although higher catch rates occur in the western part of the Rise (Figure 103).

Giant stargazer is found throughout the New Zealand EEZ. The species is most plentiful around the South Island and at the Mernoo Bank on the Chatham Rise.

The giant stargazer was incorporated into the QMS in late 1997 and is managed as eight separate fish stocks with the most recent fisheries information reported by MPI (2013e). MPI (2013e) noted that fishing in STA 4 (the fisheries management area over the Rise) occurs in two geographically distinct locations, one around the Chatham Islands and the other to the west, adjacent to the east coast of the South Island (STA 3).

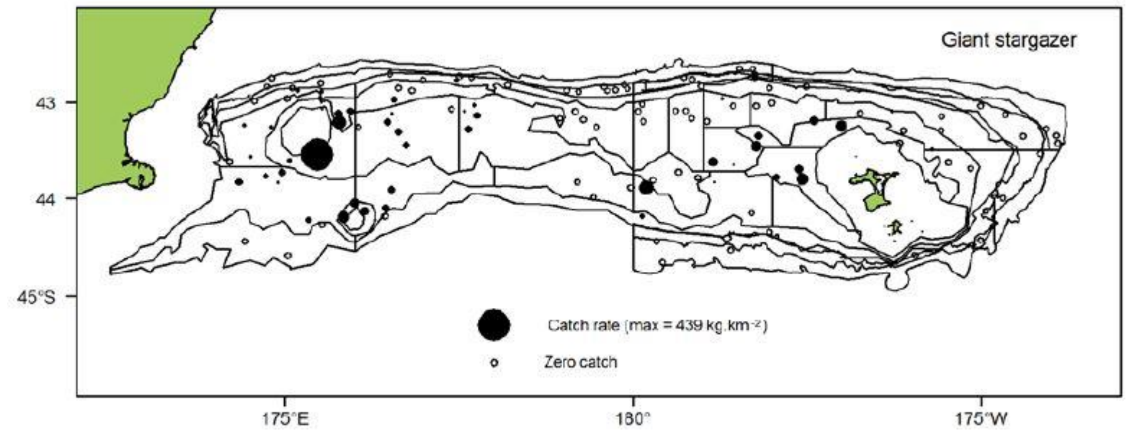


Figure 103: Catch rate and distribution of giant stargazer in 2013. Filled circles are proportional to catch rates and open circles are zero catch (from Stevens et al. 2014).

This species is caught by directed fishing and as by-catch, with the main target fishery on the Stewart-Snares shelf west of Stewart Island. Other target fisheries exist on the west coast of the South Island and off Cape Campbell on the east coast of the South Island. It is also caught by small domestic trawl vessels targeting red cod, terakihi, flatfishes and scampi on the Continental Shelf throughout its range. In deeper waters, large, foreign-licenced and New Zealand-chartered foreign vessels also capture giant stargazer while targeting barracouta, jack mackerel and squid, in particular on the western Chatham Rise and on the continental slope surrounding the Stewart-Snares shelf. On the Chatham Rise (including STA 3 and 4), the giant stargazer is an important by-catch of scampi fishing.

Landings for giant stargazer, reported in MPI (2013e), increased rapidly after 1983, with a peak of 3,426 t in 1990/91, due to increased target fishing in Southland, and changes to the total allowable catch limits and other fisheries management changes. The west coast of the South Island is the most important area for the giant stargazer commercial fishery, as well as STA 5 around Stewart Island and further south, and STA 3 on the inshore region of the eastern South Island. Currently, the Chatham Rise landings contribute a relatively small proportion of the overall catch and are largely caught as by-catch. In 2011/12, landings in STA 4 were 213 t (7 % of total landings) while landings in STA 3 (closer to the east coast of the South Island) were 397 t (13 % of total landings). It is possible that some of the reported catch include misidentified banded stargazers.

6.7.4.10 Dark and pale ghost shark

Based on the distribution and catch rate information (Figure 104), it is likely that dark ghost shark and a smaller amount of pale ghost shark may be commercially caught in the marine consent area. However, higher catch rates are more likely to occur further the west of the Rise away from the marine consent area.

Two species (dark and pale ghost sharks) make up almost all the commercial ghost shark landings. MPI (2013e) provides background on this fishery.

Stevens et al. (2014) presents recent research trawl catch rates of dark and pale ghost sharks on the Chatham Rise (Figure 104). Trawl surveys show that dark and pale ghost shark exhibit niche differentiation, with water depth being the most influential factor, although there is some overlap of habitat. On the Chatham Rise, the main overlap range appears quite compact (from about 340 to 540 m). In the Southland/sub-Antarctic region, the overlap range is wider (about 350 to 770 m).

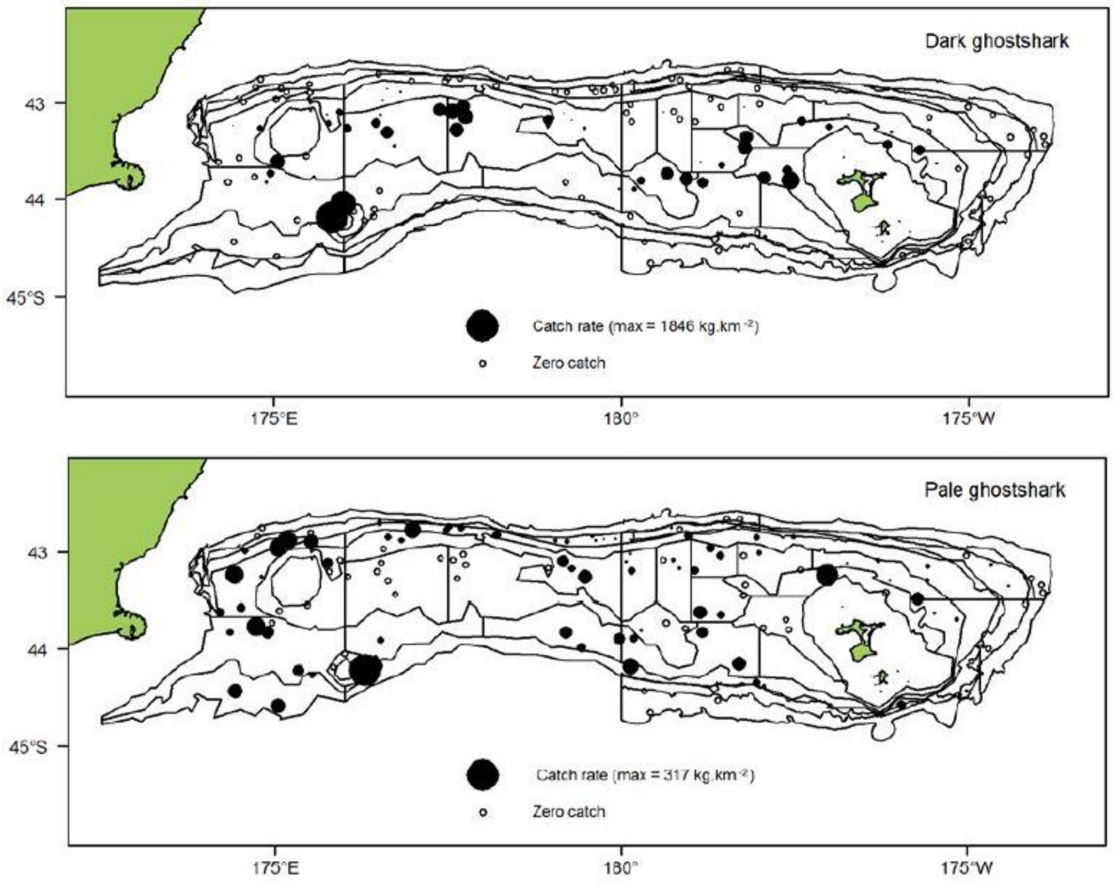


Figure 104: Catch rate and distribution of dark and pale ghost shark in 2013. Filled circles are proportional to catch rates and open circles are zero catch (from Stevens et al. 2014).

Ghost shark was introduced into the QMS from the beginning of the 1998/99 fishing year. Both species are taken almost exclusively as a by-catch of other target trawl fisheries and they were seldom differentiated on catch landing returns prior to the start of the 1998/99 fishing year. In the 1990s, about 43 % of ghost sharks were landed as a by-catch of the hoki fishery, with a further 36 % caught with silver warehou, arrow squid and barracouta fisheries. In 1990/91, significant landing increases were apparent on the Chatham Rise as well as off the southeast coast of the South Island and on the Campbell Plateau, which is likely linked to the development of fisheries for non-spawning hoki in these areas.

Estimated landings for dark ghost shark species in the fisheries management area GSH 4 for 2011/12 was 482 t (21 % of total landings) and was 496 t (22 % of total landings) for GSH 3 further inshore and including the eastern coastline of the South Island. The highest landings of 1,041 t (46 % of total landings) were taken from GSH 7 on the west coast of the South Island. Similar proportions of the catch from each of these management areas have been taken for the previous five or so years, with landings fluctuating by about 100 t occasionally during this time.

In GSP 1, for pale ghost shark, catches are mainly taken on the Chatham Rise while in GSP 5 catches are mainly taken in the sub-Antarctic area, both as by-catch of the hoki trawl fisheries.

6.7.4.11 Alfonsino

It is likely that a small amount of alfonsio may be commercially caught in the marine consent area. However, the majority of fishing effort occurs on a complex of underwater features to the southwest of the Chatham Islands.

The alfonsino fishery is largely confined to the lower east coast of the North Island (BYX 2) and the eastern and southern South Island, including the Chatham Rise (BYX 3). Since 1983 alfonsino has historically supported a major mid-water target trawl fishery off the lower east coast of the North Island and is a minor by-catch of other trawl fisheries around New Zealand. In New Zealand, most landings are *B. splendens*.

Annual landings remained low for alfonsino until 1993/94 then reached a peak in 2001/02. The 2002/03 catch was also substantially large, exceeding the total allowable commercial catch. The marked increase in BYX 3 landings since 1994/95 has been attributed mainly to the development of a targeted trawl fishery exploiting new grounds in the management area, and the discovery of a new ground southeast of the Chatham Islands where a long-line fishery for alfonsino, groper and ling has developed. Most of the BYX 3 catch is taken from the targeted bottom trawl fishery, operating to the southeast of the Chatham Islands. The fishery is comprised of a small number of vessels targeting alfonsino during the summer. The remainder of the catch is taken as a small by-catch of the hoki, orange roughy, and hake target trawl fisheries.

6.7.4.12 Sea perch

Based on the distribution and catch rate information in Figure 105, there is some likelihood of a commercial catch for sea perch in the marine consent area, although higher catch rates are located on the western part of the Rise.

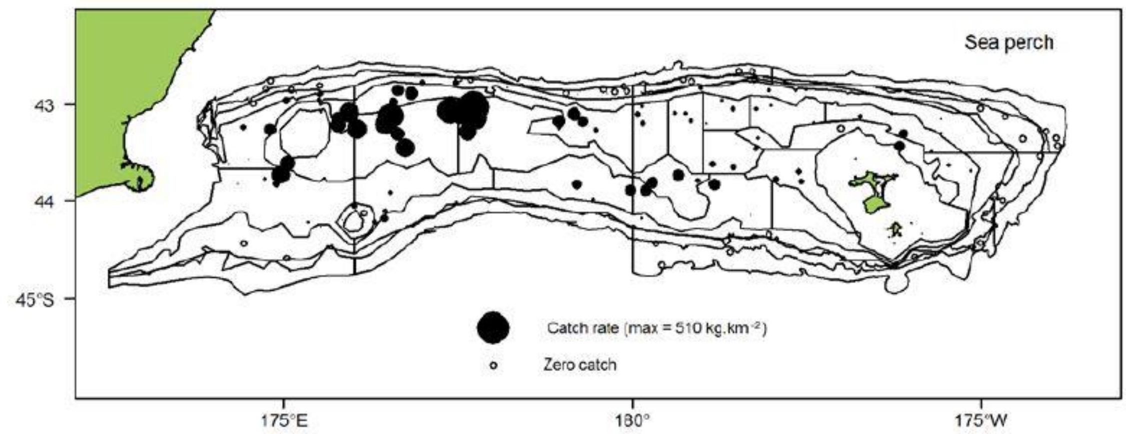


Figure 105: Catch rate and distribution of sea perch in 2013. Filled circles are proportional to catch rates and open circles are zero catch (from Stevens et al. 2014).

Very small quantities of sea perch have been landed for local sale for many years, but are largely unreported. Catches have been made by foreign vessels since the 1960s, but were also not recorded, and most were probably discarded. Despite poor reporting rates, estimated landings are thought to have increased from 400 t in the early 1980s to approximately 2,000 t in recent years. About 75 % of New Zealand's landed sea perch is taken as a by-catch in trawl fisheries off the east coast of the South Island, including the Chatham Rise. A small catch is made in some central and southern line fisheries, e.g., for groper. Therefore, the most important management areas are SPE 3 (east coast South Island) and SPE 4 (Chatham Rise).

The catch from SPE 3 is spread throughout the fishing year and there is a variable seasonal distribution between years. A higher proportion of the catch is taken during April, May and September and catches are lower from December to February and in July. Most of the SPE 3 catch is taken as a by-catch from the red cod and hoki fisheries as well as from the sea perch target fishery. The remainder is taken as a by-catch from the target barracouta, flatfish, ling, squid and tarakihi fisheries. Almost all the SPE 3 catch is taken by bottom trawling, with a small proportion taken by bottom long-line. Catch rates are highest at water depths between 150 to 400 m.

The trawl fisheries operating in SPE 4 catch sea perch along the northern and southern edge of the Chatham Rise, at water depths of 200 to 700 m. The majority of the SPE 4 catch is taken as a by-catch of the hoki target fishery, with the ling and hake fisheries accounting for around 25% and 10% of the total SPE 4 catch, respectively. In 2011/12, the highest catch was in SPE 4 with 555 t landed, followed by the catch in SPE 3 of 349 t, while all other areas has less than 55 t landed during that period.

6.7.4.13 Spiny dogfish

There is a relatively high likelihood of commercial catch for spiny dogfish in the marine consent area, although higher catch rates occur to the northeast part of the Rise and to a lesser degree on the western part of the Rise (Figure 106).

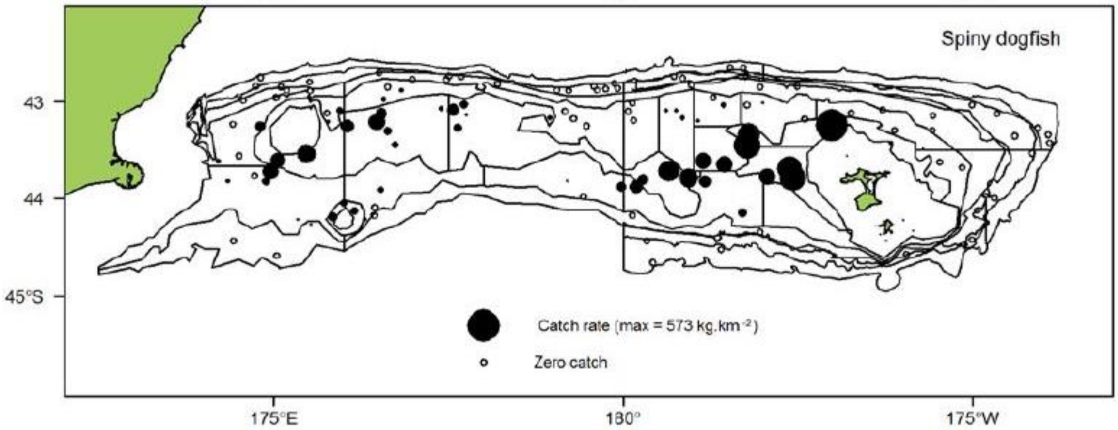


Figure 106: Catch rate and distribution of spiny dogfish in 2013. Filled circles are proportional to catch rates and open circles are zero catch (from Stevens et al. 2014).

Before 1980/81 landings of rig, and both *Squalus* species were included together and catches of the latter were probably small. Since then, the reported catch by the deep water fleet has remained fairly constant with a slight decrease in recent years. Reported catch by the inshore fleet has shown a steady increase and is now at a similar level to the catch from the deep water fleet. Most of the spiny dogfish caught by the deep water fleet are taken as a by-catch in the jack mackerel, barracouta, hoki, red cod, and arrow squid fisheries, in depths of 100 to 500 m.

Spiny dogfish are also taken as by-catch by inshore trawlers, set netters and long-liners targeting flatfish, snapper, tarakihi and gurnard. Catches from SPD 4 (which includes the Chatham Rise) have increased substantially since the mid-1990s, although other areas (SPD 3 and 5) currently had higher catches.

6.7.4.14 Scampi

There is a low to moderate possibility of commercial fishing for scampi in the marine consent area although there are higher catch rates outside of that area.

The fishery, as described in MPI (2013e), is conducted mainly by 20 to 40 m long vessels using light bottom trawl gear. The scampi fishery on the Rise occurs in water depths of 300 to 500 m in fisheries management areas SCI 3 (including the east coast of the South Island and part of the Chatham Rise) and SCI 4 (including part of the Rise and the Chatham Islands).

Highest commercial landings in 2011/12 came from SCI 3. The SCI 3 fishery straddles the boundary between the old QMA 3 and QMA 4W management areas (Figure 107). Within the SCI 3 fishery area, commercial trawling for scampi is concentrated between the Mernoo Bank and the Reserve Bank, and immediately north of the Reserve Bank (Tuck et al. 2011).

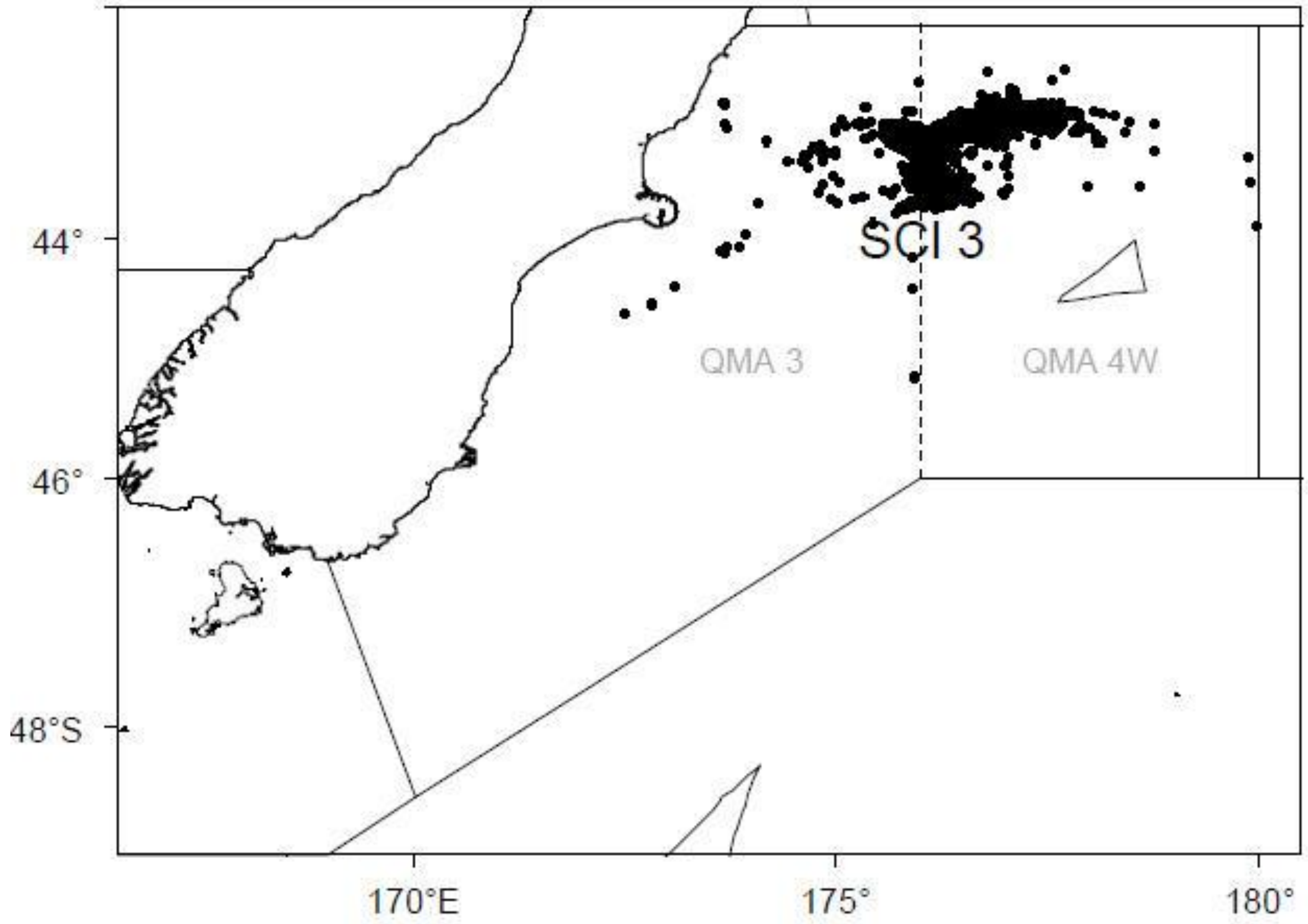


Figure 107: Scampi fishery in management area SCI3 since 1988-89 (QMA 3 and QMA 4W are previous management area designations) (taken from Tuck 2013).

6.8 Marine Mammals (Cetaceans and Pinnipeds)

6.8.1 Cetacean distribution

Twelve species of whales or dolphin and one species group (beaked whales) have been observed in the waters around the Chatham Rise between 1981 and 2007 (Torres et al. 2013a). These animals may occasionally be present within the marine consent area, but there is no evidence that it is a feeding or breeding area.

Distribution patterns of cetaceans on the Chatham Rise are based on two datasets of opportunistic sightings made from July 1987 to November 2007 (Torres et al. 2013a – Appendix 20):

- DOC's cetacean sightings data.
- A dataset provided by Martin Cawthorn of incidental cetacean sightings by transiting ships.

These datasets provide 137 records of 12 whale or dolphin species and one species group (beaked whales) in the wider area of the Chatham Rise, surrounding and including the CRP's proposed mining area. It is noted by Torres et al. (2013a) that although these datasets provide the best available information on cetaceans on the Chatham Rise, there is a lack of standardised observational effort and some data gaps. In other words, sightings only occur when there is vessel activity in the area and therefore a lack of observations for some areas and seasons cannot *de facto* be taken to mean that marine mammals were not present. Therefore, the sighting rate is biased by observational effort and cannot be considered as truly representative of actual temporal distribution of cetaceans over the Rise. Despite these limitations, discernible trends provide an indication of the most likely spatial and temporal distribution patterns of cetaceans in this area.

Whales and dolphins are mobile and dynamic creatures that can travel long distances in search of prey, preferred habitat and breeding grounds. The distribution of cetaceans is described in Torres et al. (2013a) using three spatial boundaries in relation to MPL 50270, based on whether they have been sighted:

- Within the MPL 50270.
- Within a 100 km area around MPL 50270.
- Beyond 100 km from MPL 50270 but still in the Chatham Rise region.

International threat classifications for cetaceans are based on the Red List produced by the IUCN. The national conservation status of cetaceans is based on the Threat Ranking system of Baker et al. (2010). The national threat rankings include 'Threatened' (subdivided into 'nationally vulnerable', 'nationally endangered' or 'nationally critical'), 'At Risk' (subdivided into 'naturally uncommon', 'relict', 'recovering' or 'declining') and 'Not Threatened'. Other native species are ranked as 'Migrant', 'Vagrant' or 'Coloniser' and species that cannot be evaluated are ranked as 'Data Deficient'.

6.8.2 Key distribution patterns of cetaceans on the Chatham Rise

Figure 108 presents the distribution of all cetacean sightings on the Chatham Rise between July 1981 and November 2007 (Torres et al. 2013a – Appendix 20). Table 15 lists details of the whales and dolphins sighted on the Chatham Rise based on the two datasets used by Torres at el. (2013a).

The majority of the sightings were of sperm whales (*Physeter macrocephalus*) and pilot whales (*Globicephala* spp.). These sightings are concentrated along shelf breaks in areas of high slope where they are known to feed primarily on squid (Torres et al. 2013a).

Two threatened species have been sighted on the Chatham Rise but not within the area associated with CRP's proposed marine consent area. These species included the killer whale (*Orcinus orca*), Nationally Critical, and the southern right whale (*Eubalaena australis),* Nationally Endangered (Baker et al. 2010). Pilot whales, sperm whales and false killer whales appear to concentrate near the 1,000 m isobath over the Chatham Rise slope edge, although there have been sightings of sperm whales around the edge of the proposed marine consent area.

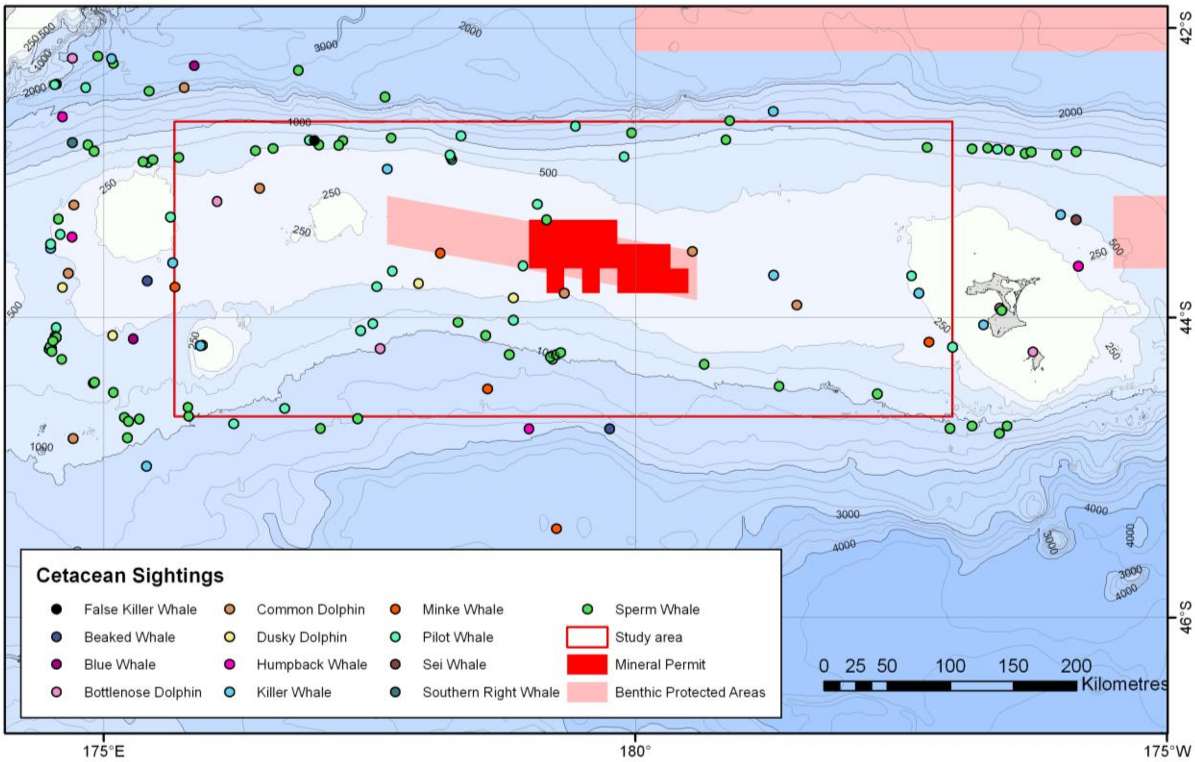


Figure 108: Distribution of all cetacean sighting locations, by species, from DOC and Cawthorn datasets within 100 km of the study area (inside red box). CRP's MPL 502070 shown in red; benthic protected areas shown in pink (from Torres et al. 2013a).

Recent habitat modelling for southern right whales revealed that the southern edge of the Chatham Rise is an important foraging habitat for the whales during summer and autumn (Torres et al. 2013a).

Other baleen whales have been sighted on the Chatham Rise as this area is part of a migration corridor for several species between their northern breeding grounds in tropical waters and their feeding grounds in the Southern Ocean. Minke whales (*Balaenoptera bonaerensis*) were the only baleen whales recorded within 100 km of MPL 50270, on the northern and southern edge of the proposed marine consent area. Dolphins showed no preference for a particular area or water depth within the Chatham Rise area.

Table 15: Whales and dolphins sighted on the Chatham Rise between 1981 and 2007, based on Torres et al. 2013a.

Cetacean species	Threat classification	Sighting information	Key behaviours and population information
Sighted within MPL 50270			
Sperm whale *Physeter macrocephalus*	IUCN - Vulnerable NZ - Not threatened	• 1 sighting within MPL 50270(summer 1985) • 21 sightings within 100 km of MPL 50270, including 2 sightings within (or close to) the proposed marine consent area • Many sightings beyond 100 km • Most sightings in summer • Almost all sightings near slope edge at 1,000 m water depth • Males, females and calves sighted on the Chatham Rise	• Adult males are solitary • Adult females travel in groups with calves • Maternal groups can spread over 1+ km when feeding • Mating at all times of the year • Deep dives to 300 to 800 m depths when foraging • Squid are the main prey
Common dolphin *Delphinus delphis*	IUCN - Least concern NZ - Not threatened	• 1 sighting within MPL 50270 • 3 sightings within 100 km of MPL 50270 • 4 sightings beyond 100 km • No seasonality can be assumed from dataset	• Diet of fish and cephalopods • Predominant prey in other areas of New Zealand are arrow squid, jack mackerel and anchovy
Sighted within 100 km of MPL 50270			
Pilot whale *Globicephala* spp.	IUCN - Data deficient NZ - Not threatened	• 331 whales from 18 sightings within 100 km of MPL 50270 • 2 sightings within 12 km of MPL 50270 • 9 sightings beyond 100 km • Most in western half of 100 km boundary • No seasonality can be assumed from dataset	• In groups of 20 to 90 whales • Deep dives to 1,000 m depths when foraging • Shelf breaks, slope and high topographic relief are common habitat • Abundance in other regions has been correlated with spawning squid
Killer whales (orca) *Orcinus orca*	IUCN - Data deficient NZ - Nationally critical	• 4 sightings of 17 whales in total within 100 km of MPL 50270 • 8 sightings beyond 100 km • Sightings throughout the year	• Foraging strategies and behavioural patterns are flexible • Not benthic foragers away from coast

Cetacean species	Threat classification	Sighting information	Key behaviours and population information
Dusky dolphin *Lagenorhynchus obscurus*	IUCN - Data deficient NZ - Not threatened	• 2 sightings within 100 km of MPL 50270, with 220 dolphins in 1984 and 20 dolphins in 1998 • 2 sightings beyond 100 km • All sightings near 500 m water depth	• Tend to inhabit cool waters off South Island and lower North Island
Bottlenose dolphin *Tursiops* spp.	IUCN - Data deficient NZ - Nationally endangered	• 2 sightings within 100 km of MPL 50270, with 30-50 dolphins per sighting in 2002 and 2005 • 4 sightings beyond 100 km	• Likely to be *T. aduncus*, an offshore ecotype • Unlikely to be *T. truncates*, an inshore ecotype, which is range restricted in inshore New Zealand
False killer whale *Pseudorca crassidens*	IUCN - Data deficient NZ - Not threatened	• 1 sighting on slope area within 100 km of MPL 50270, with 10 to 15 whales in spring 1985	• Typically in deep water habitats (200 to 2,000 m depths)
Minke whale *Balaenoptera bonaerensis*	IUCN - Data deficient NZ - Not threatened	• 4 sightings of 9 whales in total within 100 km of MPL 50270, including 2 sightings within (or close to) the proposed marine consent area • 1 sighting of 5 whales beyond 100 km	• Global population relatively high • Southern Ocean population currently hunted by Japanese whalers
Sighted beyond 100 km of MPL 50270 on the Chatham Rise			
Beaked whales Family Ziphiidae	IUCN - Data deficient NZ - Data deficient	• 3 sightings of 27 whales in total beyond 100 km	• At least 10 species in New Zealand waters • Preference for high slope and canyon habitats • Feed in fish and squid in deep dives (~1,000 m depths)
Blue whale *Balaenoptera musculus*	IUCN - Endangered NZ - Migrant	• 2 sightings beyond 100 km in summer 1984 and 1998	• Typically thought to migrate through New Zealand waters between Antarctic feeding grounds (summer) and equatorial waters (winter), but new evidence points to the South Taranaki Bight being a blue whale foraging habitat (Torres 2013))

Cetacean species	Threat classification	Sighting information	Key behaviours and population information
Humpback whale *Megaptera novaeangliae*	IUCN - Endangered NZ - Migrant	• 4 sightings of 5 whales in total beyond 100 km • Sightings in autumn and summer	• Population is currently recovering • Migrate between Antarctic (summer) and tropics (winter) • Travel along New Zealand coast during May to December
Sei whale *Balaenoptera borealis*	IUCN - Endangered NZ - Migrant	• 1 sighting of 2 whales beyond 100 km east of permit area • Sighting in summer 1983	• Migrate between Antarctic (summer) to northern waters (winter) • Likely travel past New Zealand
Southern right whale *Eubalaena australis*	IUCN - Least concern NZ - Nationally endangered	• 1 sighting of I whale beyond 100 km west of permit area • Sighting in spring 1998 • Lack of sightings attributed to rarity of the species and lack of dedicated sighting effort on Chatham Rise	• Main calving grounds at Auckland and Campbell Islands; recolonising mainland areas (Carroll et al. 2013) • Calvein winter (May-September) • Forage in offshore waters outside of calving season • Forage for zooplankton • Predicted to occur on the Chatham Rise (except winter) • Southern edge of Chatham Rise important during autumn for feeding near Subtropical Front

There is some seasonal variation in the number of cetacean sightings on the Chatham Rise, with a greater number of sightings during summer months (December to February). The main species recorded during summer months include sperm whales and pilot whales. There have also been a large number of sightings in spring (September to November) and winter (June to August) with greater diversity of species at these times. The smallest number of sightings occurred during autumn (March to May). It should be noted that these seasonal abundance patterns may be influenced by observational effort, which is likely to be greater in summer and spring months.

Blue whales have also been noted off the Otago and Canterbury coast, moving north around Banks Peninsula and across the western end of the Chatham Rise (Miller et al 2013).

6.8.3 Key cetacean species on the Chatham Rise

6.8.3.1 Introduction

The following descriptions of key species focus on cetaceans that were sighted within close proximity of the proposed marine consent area, were most frequently sighted, or are of conservation significance in New Zealand.

6.8.3.2 Sperm whales

Sperm whales are the most commonly sighted cetacean on the Chatham Rise (Torres et al. 2013a – Appendix 20). Sperm whales are known to concentrate in deep water habitats near steep continental shelves and areas with a strong temperature gradient that provide optimal conditions for cephalopods, their main prey (Figure 109) (Berzin 1971, Clarke 1996 and Shirihai 2002 in Torres et al. 2013a, Berkenbusch et al. 2013). This type of habitat occurs on the northern and southern slopes of the Chatham Rise, so it is expected that sperm whales may be found in these areas.

Sperm whales forage in mid-water depths and near to the seabed. Sperm whales typically dive to depths of 300 to 800 m for approximately 40 minutes when feeding, with some dives lasting as long as 1.5 hours and down to 1,000 m (Whitehead & Weilgart 2000 in Torres et al. 2013a). At the surface, sperm whales may be travelling, socialising or recovering from a foraging dive. This recovery time is important to the physiology and behaviour of sperm whales because it allows individuals to re-oxygenate blood and recuperate organs that are 'shut-down' during their extreme dives (Kooyman 2009 in Torres et al. 2013a).

Sperm whales are long-lived, living for 60 to 70 years, with low natural mortality and very low fecundity (Whitehead & Weilgart 2000 in Torres et al. 2013a). On average, females have one calf every 5 to 10 years. Little is known of the population's present conservation status, but their low reproduction rates mean they cannot recover from population declines quickly.

Torres et al. (2011) examined historical sperm whale distribution based on 19th century whaling records. The authors developed a predictive habitat model using presence absence data. The habitat prediction maps shown in Figure 110 indicate that the Chatham Rise is one of the areas of habitat utilised by sperm whales in the New Zealand region.

6.8.3.3 Pilot whales

Pilot whales were the next most commonly sighted cetacean on the Chatham Rise, with close to half the number of sightings compared to sperm whale sightings. These whales are wide ranging (Figure 111), and two species are found in New Zealand waters, including the long-finned pilot whale (*Globicephala melas*) and short-finned pilot whale (*G. macrorhynchus*). Long-finned pilot whales inhabit the cold temperate waters of the North Atlantic and Southern Ocean and it is likely to be the species sighted on the Chatham Rise (Torres et al. 2013a – Appendix 20). Pilot whales in the Southern Hemisphere are further recognised as the subspecies *G. melas edwardii*.

The pilot whale diet consists primarily of squid, with lesser amounts of fish (Torres et al. 2013a). Common habitats of pilot whales include shelf breaks, slope waters, and areas of high topographic relief, all features occurring on the Chatham Rise. Pilot whales can make dives up to 1,000 m in search of prey (Shirihai 2002 in Torres et al. 2013a). Pilot whales are generally nomadic and their movements are considered to be related to the distribution of their preferred squid prey (Torres et al. 2013a). Seasonality in their distribution cannot be assessed due to the limitations of the opportunistic sighting data. No sightings have been made in autumn, nine sightings have been made in spring and summer, and five sightings have been made in winter.

Pilot whales have a long life span with delayed maturity and different rates of maturation for males and females (Olson 2009 in Torres et al. 2013a). These whales undertake seasonal mating and produce a single calf at multiyear intervals, one of the longest birth intervals of all the cetaceans. Female pilot whales live past 60 years of age, and males typically reach 35 to 45 years old.

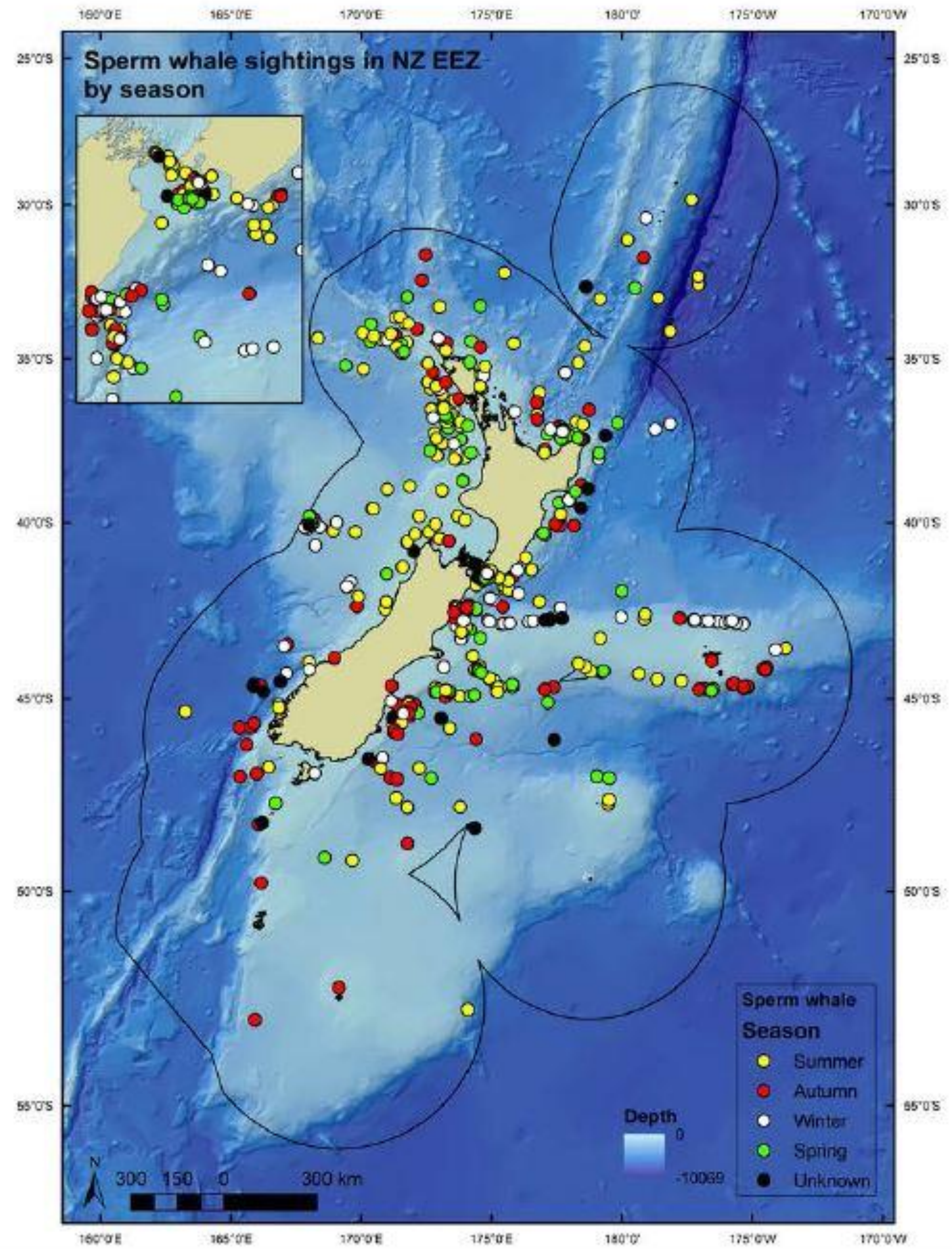


Figure 109: Distribution of sperm whale (Physeter macrocephalus) sightings in New Zealand waters between 1970 and 2013. (Reported sightings are from a variety of sources and need to be considered indicative only, as identifications may not be correct) (from Berkenbusch et al. 2013).

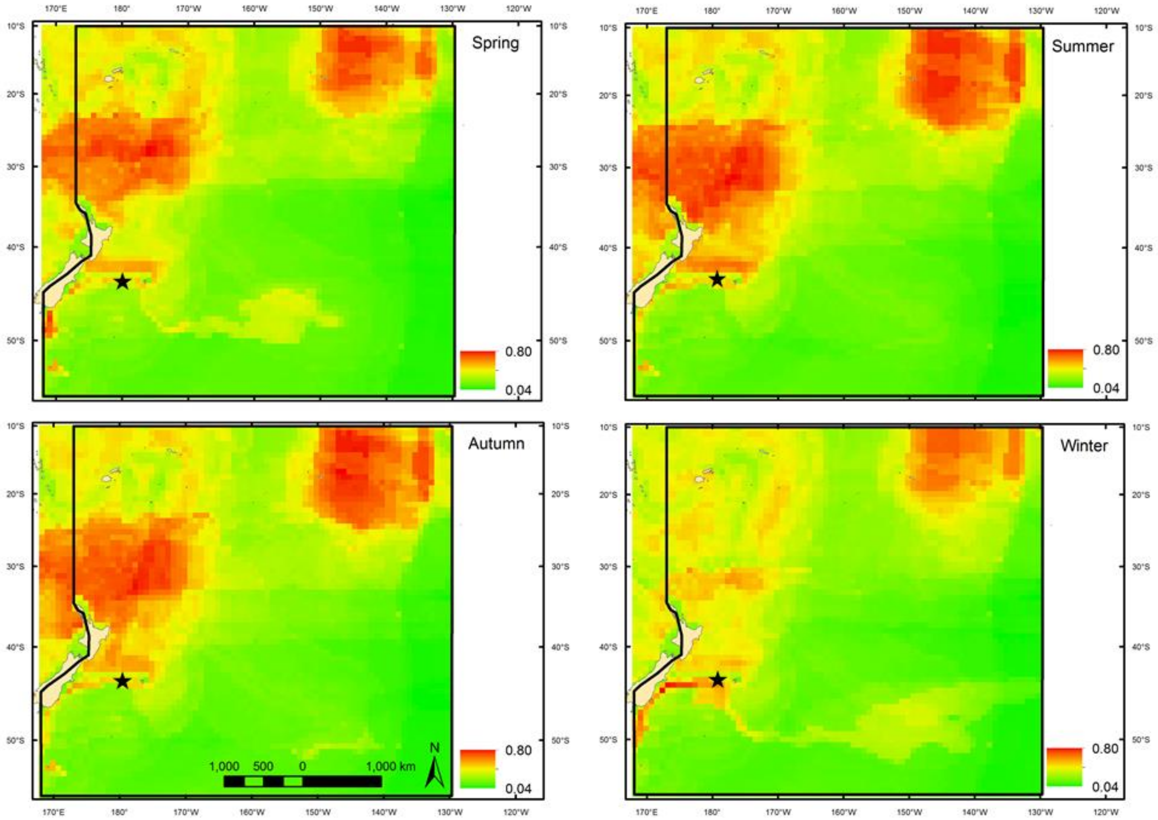


Figure 110: Seasonal habitat prediction maps of sperm whales in the region east of New Zealand, including over the Chatham Rise. Prediction maps derived from habitat models generated using historical whaling data (Torres et al. 2011). Colour ramp indicates high and low values of predicted sperm whale presence and are comparable between seasons. Spring: September, October, November. Summer: December, January, February. Autumn: March, April, May. Winter: June, July, August. Black star shows approximate location of CRP's proposed marine consent area (from Torres et al. 2013b).

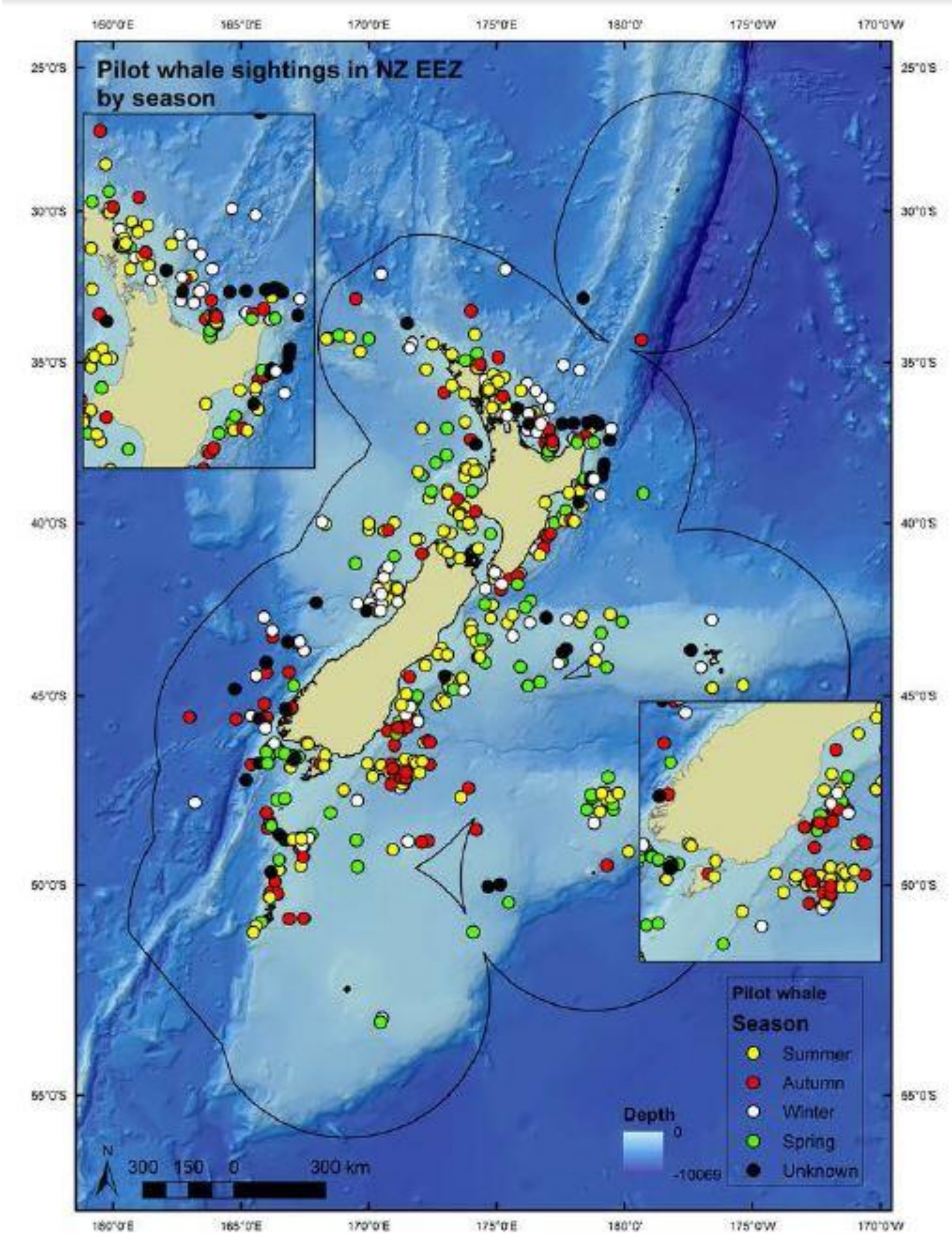


Figure 111: Distribution of pilot whale (Globicephala spp.) sightings in New Zealand waters between 1970 and 2013. (Reported sightings are from a variety of sources and need to be considered indicative only, as identifications may not be correct) (from Berkenbusch et al. 2013).

6.8.3.4 Southern right whales

Southern right whales are Nationally Endangered in New Zealand due to historical whaling that dramatically reduced the population. It is estimated that the current population off New Zealand is 908 whales, and off southern Australia 3,500 (Carroll et al. 2011b in Torres et al. 2013a – Appendix 20, Torres 2013b). Southern right whales are capital breeders that use energy stores accumulated at an earlier time to nurse calves (Houston et al. 2007). This life strategy means that southern right whales spend the winter mating and calving in protected inshore coastal waters, and spend the remainder of the year travelling in offshore waters in search of dense, energetically-profitable prey aggregations to build up a blubber layer to support their winter energy demands.

Southern right whales have a strong migration cycle between winter calving grounds and offshore foraging grounds. Figure 112 shows the distribution of seasonal sightings in New Zealand waters between 1970 and 2013 (Berkenbusch et al. 2013). Seasonal predictions of southern right whale distribution in the New Zealand region (Torres et al. 2013a), based on habitat models of historical whaling data (Figure 113) indicate that the preferred offshore foraging habitats of southern right whales in the eastern area of the Australasian region are associated with the southern flanks of the Chatham Rise in the STF.

Few southern right whales are expected to be in the Chatham Rise area during winter when animals are at coastal calving grounds. However, southern right whales congregate along the southern edge of the Chatham Rise during summer and autumn, where they forage on copepod prey that aggregate as a function of the STF. The dive limit for southern right whales is approximately 300 m (Torres et al. 2013b). This habitat is particularly important during the autumn.

6.8.3.5 Killer whales

Killer whales are Nationally Critical in New Zealand due to their small population size, estimated to be 119 whales (Visser 2000 in Torres et al. 2013a – Appendix 20). The killer whale population in New Zealand has a broad distribution around the North and South Islands (Figure 114). Killer whales do not have a defined migration cycle, but likely travel between preferred habitats in search of seasonally-abundant prey such as fish, other marine mammals, and sharks and rays (Torres et al. 2013a and references therein).

6.8.3.6 Beaked whales

Little is known about these animals and it is still not known if these animals are actually rare or just rarely encountered. They are known to have a preference for shelf edge, high slope and canyon habitats, and are thought to be exceptionally deep divers (to approximately 800-1,000 m deep) where they forage for squid and small fish and therefore spend little time at the surface (Pitman et al. 2006, Thompson et al. 2012, Torres et al. 2013a). They may also be seldom encountered because they inhabit latitudes of notoriously bad weather and strand infrequently because of the reduced land area in the Southern Ocean at those latitudes (Pitman et al. 2006).

Beaked whale species are difficult to distinguish due to similarities in their external morphology and genetic testing is needed to confirm their identity (Dalebout et al. 1998, Thompson et al. 2012). Their presence is often only recorded from strandings. For instance, the only known specimens of the spade-toothed whale include a single mandible with teeth from an adult male collected from the Chatham Islands in 1872, skulls without mandibles from White Island in the 1950s and from Robinson Crusoe Island, Chile in 1989, and a female and juvenile male that stranded and subsequently died on Opape Beach in the North Island in December 2010 (Thompson et al. 2012). Another example is Shepherd's beaked whale that is represented by only approximately 42 stranding records and five unconfirmed live sightings: mostly from New Zealand (including the Chatham Islands) with 24 records, but also the Juan Fernandez Islands (two records), Argentina (seven records), Tristan da Cunha (six records) and Australia (three records) (Pitman et al. 2006).

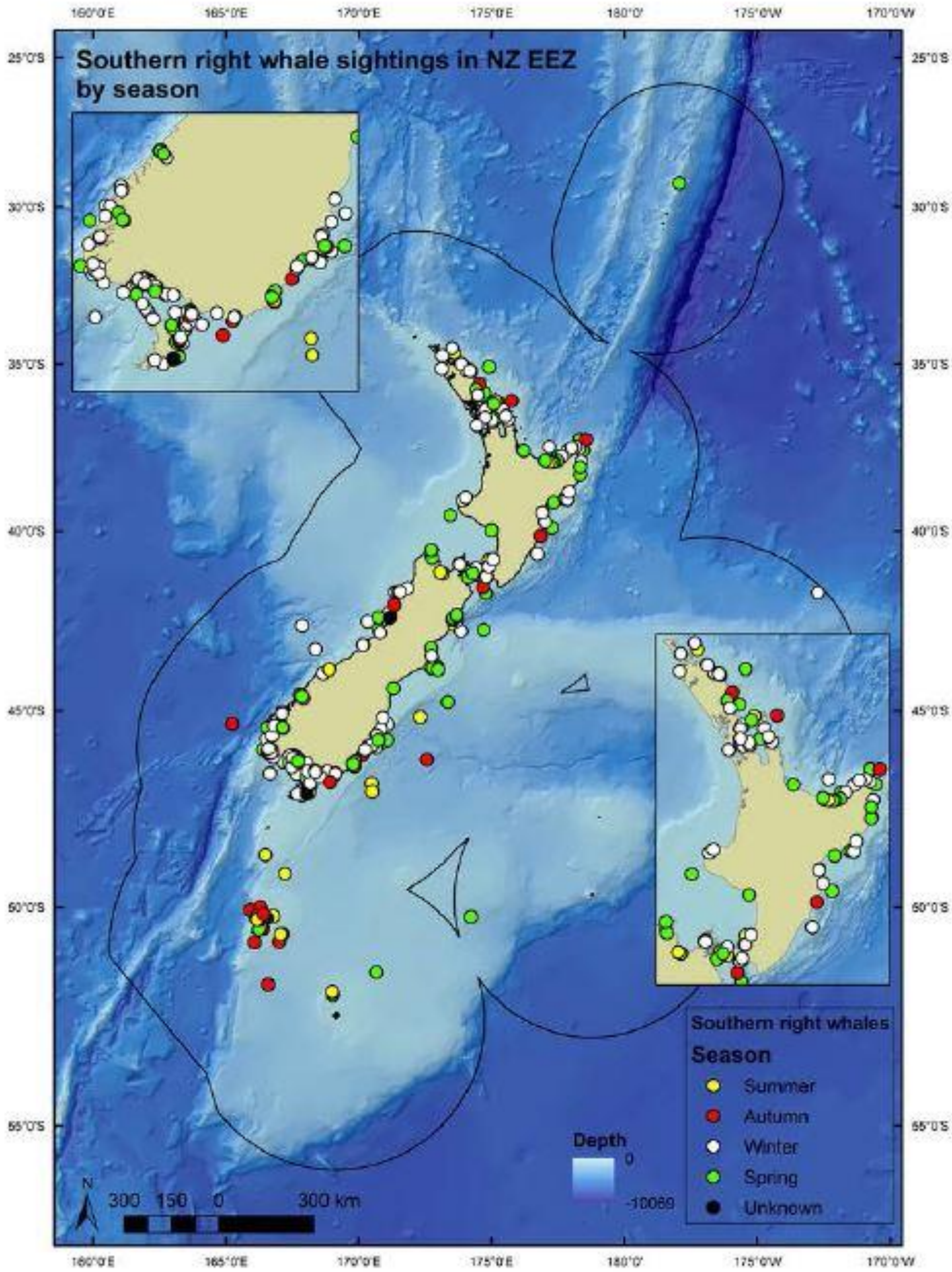


Figure 112: Distribution of southern right whale (Eubalaena australis) sightings in New Zealand waters between 1970 and 2013. (Reported sightings are from a variety of sources and need to be considered indicative only, as identifications may not be correct) (from Berkenbusch et al. 2013).

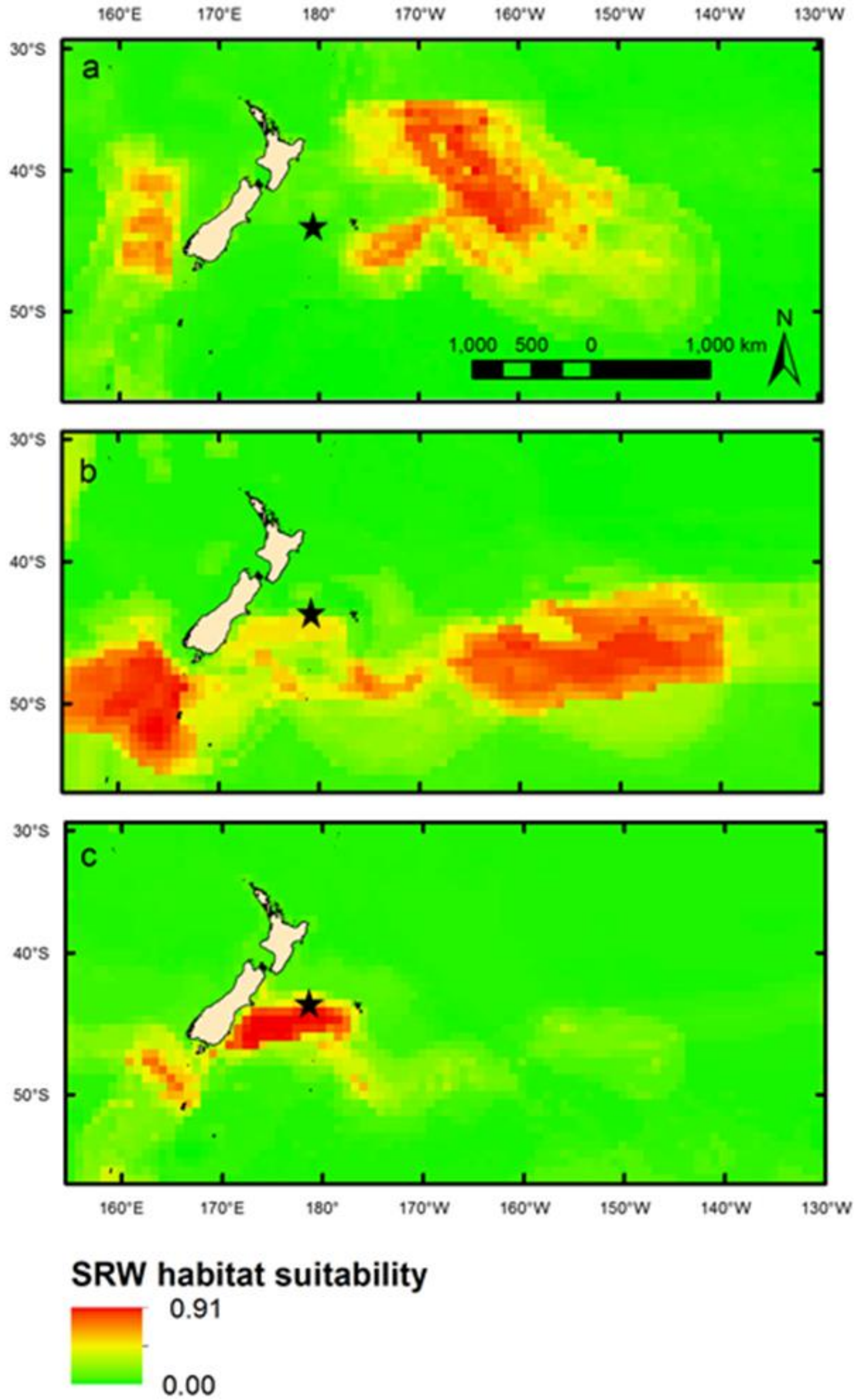


Figure 113: Seasonal habitat prediction maps of southern right whales around New Zealand, including over the Chatham Rise. Prediction maps derived from habitat models generated using historical whaling (Torres et al. 2011). Colour ramp indicates high and low values of predicted sperm whale presence and are comparable between seasons. (a) Spring: September, October, November. (b) Summer: December, January, February. (c) Autumn: March, April, May. No prediction map for winter generated because whales on calving grounds. Black star indicates approximate location of CRP's proposed marine consent area.

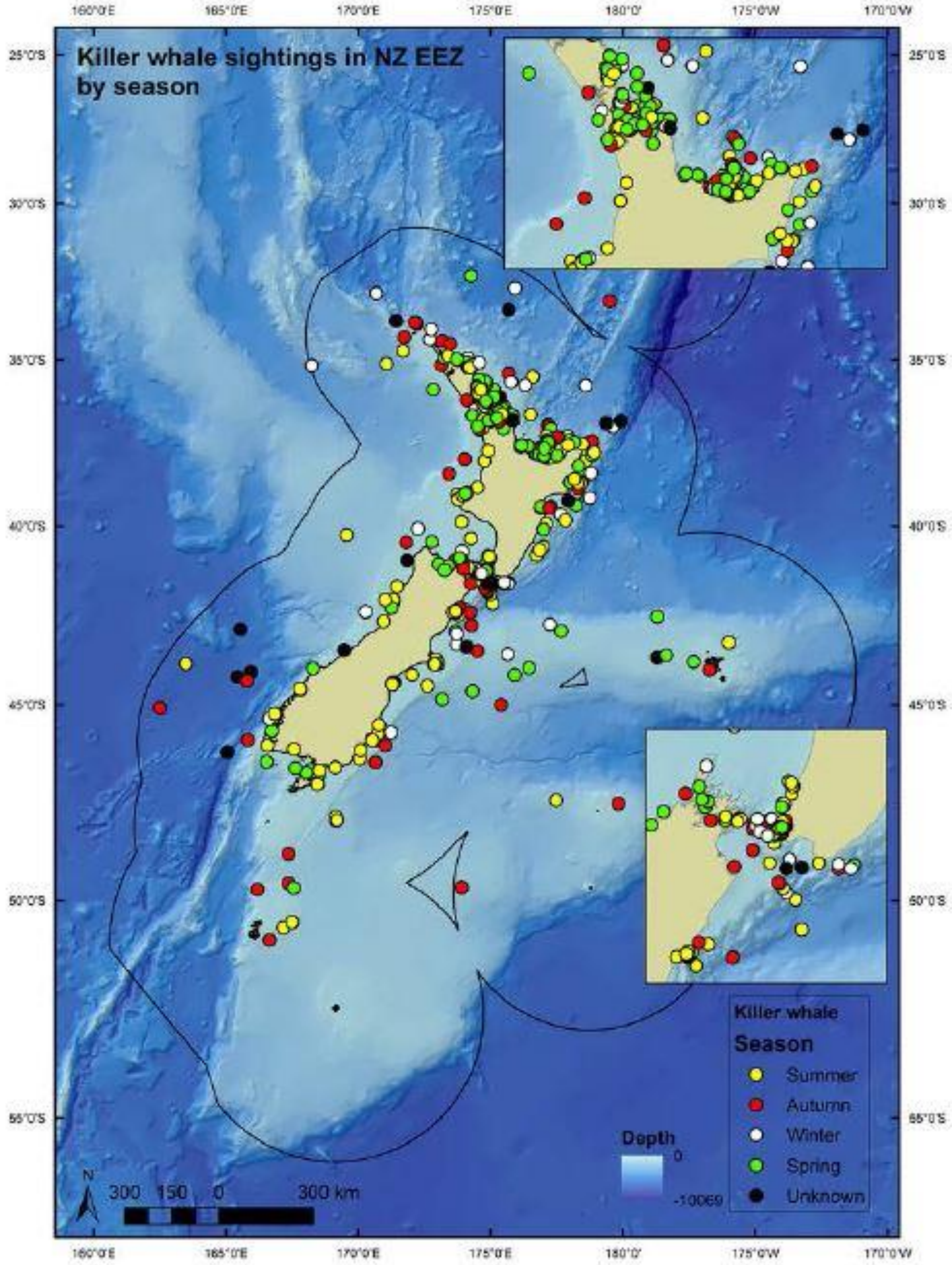


Figure 114: Distribution of killer whale (Orcinus orca) sightings in New Zealand waters between 1970 and 2013. (Reported sightings are from a variety of sources and need to be considered indicative only, as identifications may not be correct) (from Berkenbusch et al. 2013).

An examination of the available reported sighting data indicates that although this group do not appear to have been observed in the marine consent area during marine mammal surveys, a total of 27 individuals were observed in three pods of beaked whales about 100 km to the north of the marine consent area (Torres et al. 2013a). Two of these observations were made in summer and the other was made in winter. A summary of sightings made between 1970 and 2013 have been compiled by Berkenbusch et al. (2013) (Figure 115).

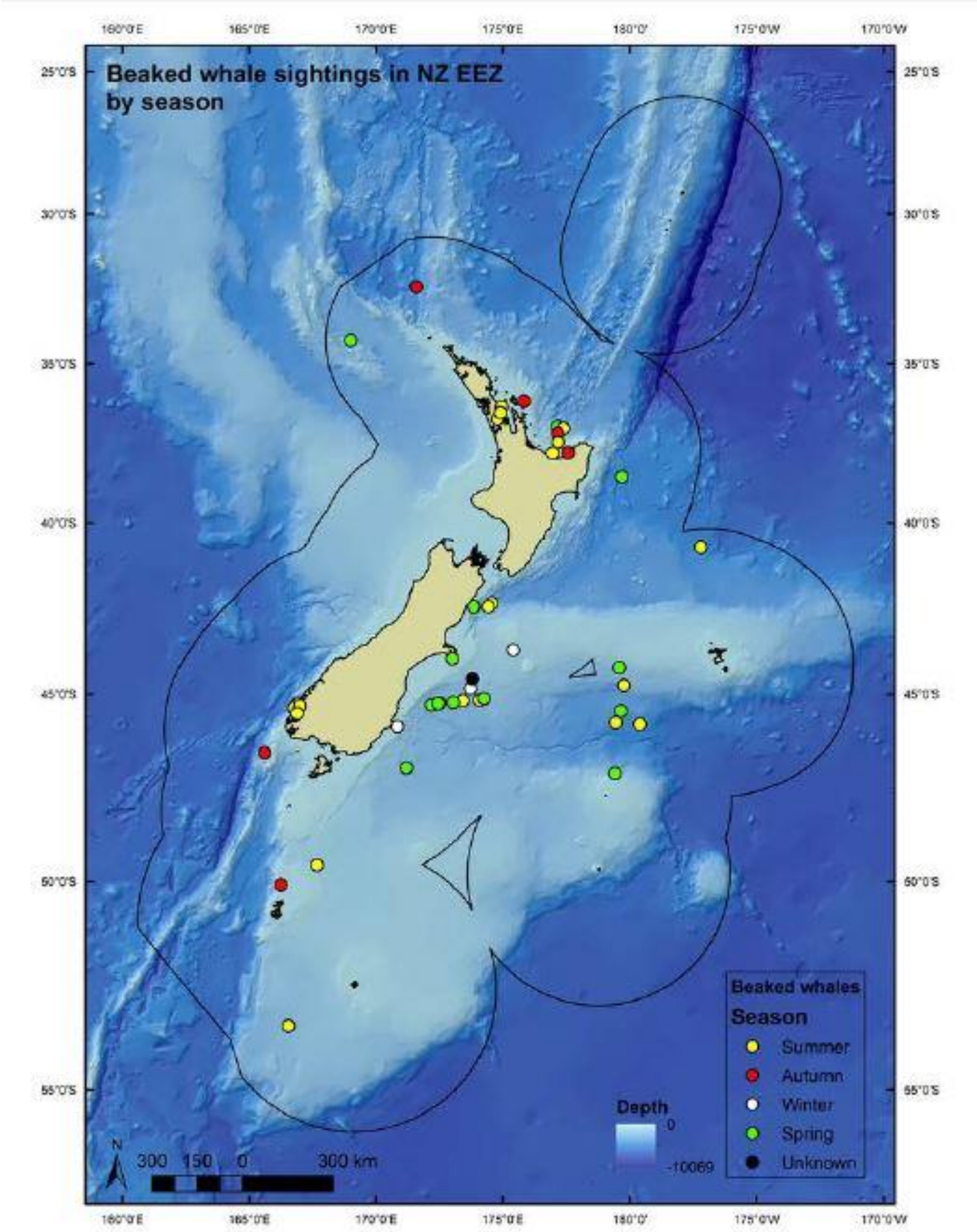


Figure 115: Distribution of beaked whale (species not identified) sightings in New Zealand waters between 1970 and 2013. (Reported sightings are from a variety of sources and need to be considered indicative only, as identifications may not be correct) (from Berkenbusch et al. 2013).

6.8.4 Cetaceans - trophic importance

Cetaceans are considered to be apex predators (along with seals, sea lions and seabirds) (Pinkerton 2013 – Appendix 22). It is generally assumed that whales do not feed during migration or, if they do feed, do so in low intensity. The diet of beaked whales, toothed whales and dolphins is composed mainly of fish (including demersal fish) and squid (Berzin 1972, Brown & Lockyer 1984 in Pinkerton 2013). Baleen whales feed almost exclusively on krill in the Southern Ocean, consuming other pelagic crustaceans (copepods, amphipods) elsewhere.

Within the Chatham Rise tropic model developed by Pinkerton (2013), cetaceans[23] rank low in TI within the Rise trophic structure. Baleen whales ranked 31 and 30 in the TI1 and TI2 models respectively, and toothed whales ranked 29 and 31 respectively in the models.

6.8.5 Pinnipeds

6.8.5.1 Introduction

Several species of seals are found in the New Zealand EEZ. The key species are the New Zealand fur seal (*Arctocephalus forsteri*), which is fairly widely distributed, and the New Zealand sea lion (*Phocartos hookeri*), found predominantly in the southern parts of the EEZ. Southern elephant seals (*Mirounga leonine*) are found within the EEZ but rarely as far north as the Chatham Rise.

Pinkerton (2013) (Appendix 22) provides a summary of the role of pinnipeds in the Chatham Rise ecosystem and this report should be referred to for additional information.

6.8.5.2 New Zealand fur seals

After the significant reduction of its population (estimated to be over one million seals) in the 1800s by sealers the New Zealand fur seal is recolonising the main islands of New Zealand and there are estimated to be over 50,000 within the EEZ.

There are several coastal fur seal colonies near the Chatham Rise. These include colonies on the Chatham Islands, Banks Peninsula, the Kaikoura coast and Cape Palliser (refer Beaumont et al. 2013b – Appendix 14). MPI (2012a) provides an overview of the distribution, ecology, population biology and interaction with the fishing industry of New Zealand fur seals.

Although there is no specific information about the distribution and numbers of seals on the Chatham Rise, an indication can be found from the data collected in foraging studies. Studies using satellite tracking show that fur seals can be found up to 200 km from shore. Although it is likely that most will travel shorter distances, this indicates that fur seals have the capacity to reach the Chatham Rise (Pinkerton 2013 - Appendix 22).

Fur seals have been caught as commercial fishing by-catch on the Chatham Rise, normally during bottom and mid-water trawls (Rowe 2009, MPI 2013a) for hoki, hake, southern blue whiting and squid (Baird 2005, Baird & Smith 2007, Abraham et al. 2010, MPI 2012a). The main areas that contribute to the estimated annual by-catch of New Zealand fur seals (modelled from observed captures) in middle depths and deep water trawl fisheries include the western Chatham Rise hoki fishery (MPI 2012a). It is estimated that between 1 % and 3 % of observed tows that target middle trawl depth fish species catch fur seals.

Although there is little information on the diet of fur seals within and around the Chatham Rise, several diet studies around New Zealand (information is provided in Pinkerton 2013 – Appendix 22) show that fur seals eat a wide range of fish species, dependent upon location and time of year.

[23] In addition to the main cetaceans discussed in Torres et al. (2013a), Pinkerton (2013) includes the following cetaceans in the tropical model for the Chatham Rise: Arnoux's beaked whale (*Berardius arnuxii*), southern bottlenose whale (*Hyperoodon planifrons*), hourglass dolphin (*Lagenorhynchus cruciger*), Andrew's beaked whale (*Mesoplodon bowdoini*), straptoothed beaked whale (*Mesoplodon layardii*), spectacled porpoise (*Phocoena dioptrica*), goosebeak whale (*Ziphius cavirostris*), southern rightwhale dolphin (*Lissodelphus peronii*), harbour porpoise (*Phocoena phocoena*) and fin whales (*Balaenoptera physalus*). Many of these species were grouped as beaked whales in the assessment by Torres et al. (2013a) because it is difficult to distinguish between these species during sightings at sea.

6.8.5.3 Hooker's sea lion

The New Zealand sea lion population (about 12,000 animals) is centred on the Auckland Islands south of the Chatham Rise. About 200 breed on the Otago coast. No interactions have been reported with the fishing industry on the Chatham Rise and the numbers of sea lions on the Chatham Rise is probably very low (Pinkerton 2013 – Appendix 22).

Sea lions have been caught as by-catch by fishing around the sub-Antarctic Islands (MPI 2013c). Pinkerton (2013) (Appendix 22) reports that hooker's sea lion take a broad variety of food, including cephalopods (octopus), crustaceans (e.g., crabs, scampi and crayfish), occasionally penguins, and a wide variety of fish.

6.8.5.4 Trophic importance

Seals rank at about the same level as both groups of whales in the Chatham Rise trophic model developed by Pinkerton (2013) (Appendix 22). Seals on the Chatham Rise do not appear to have any strong dependencies or influences within the trophic system, at least at the spatial and temporal scale of the modelling.

6.9 Seabirds

6.9.1 Overview

The majority of New Zealand's seabirds could be encountered over the course of a year on the Chatham Rise, making this one of the most important areas for seabirds in New Zealand (Thompson 2013 – Appendix 21). The high marine productivity attracts foraging birds from northern subtropical and southern sub-Antarctic environments. For most of these seabirds, their presence on the Chatham Rise is focussed on prey acquisition but some also make a seasonal migration though the area. Some of these birds breed at the Chatham Islands.

There are approximately 28 species that are key members of the Chatham Rise avifauna (Table 16). More detailed information is provided in Thompson (2013). International threat classifications are based on the Red List produced by the IUCN and the national conservation status of each species is based on New Zealand criteria as reported by Miskelly et al. (2009).

The most threatened of these seabirds are noted in this section, and more detailed information of their population status is in Thompson (2013). Pinkerton (2013) (Appendix 22) also provides estimates of the numbers of key species and provides information on breeding locations.

6.9.2 Seabirds exclusive to the Chatham Islands and Chatham Rise

Three seabird species are endemic to the Chatham Islands and likely use the Chatham Rise as their only area for foraging or related activities:

- Magenta petrel (*Pterodroma magneta*).
- Chatham petrel (*Pterodroma axillaris*).
- Chatham albatross (*Thalassarche eremita*).

Figure 116, Figure 117 and Figure 118 provide an indication of the breeding and non-breeding distribution of these species in the region of the Chatham Islands and Chatham Rise.

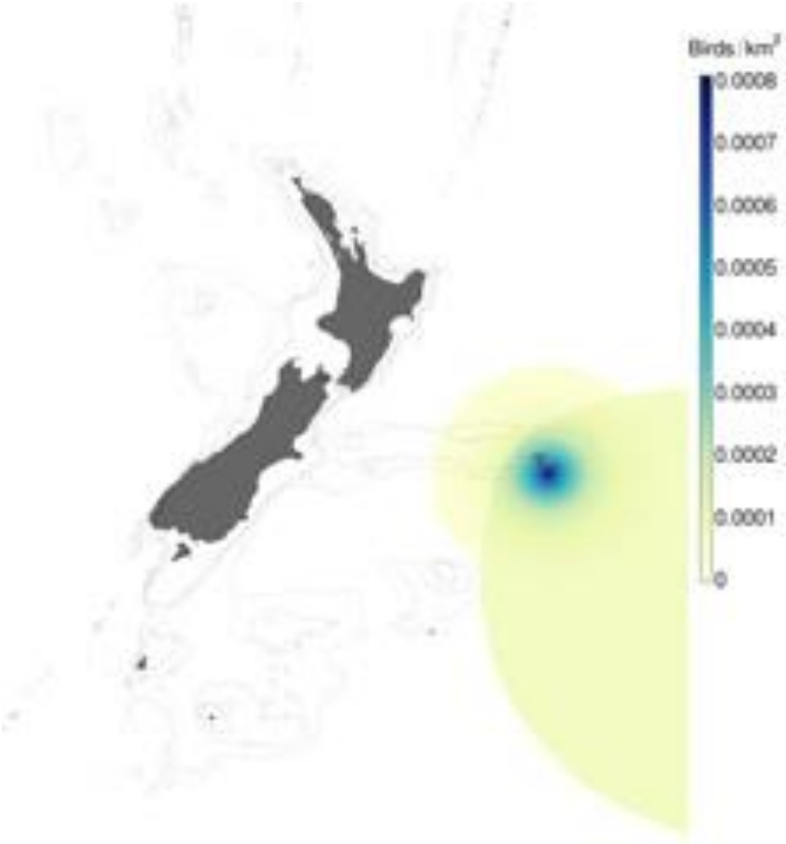
The magenta petrel (also called the Chatham Islands taiko) is critically endangered, with a population estimated at fewer than 150 birds (Anon 2001) and with approximately 15 breeding pairs on Chatham Island (Miskelly et al. 2009). These birds are rarely encountered at sea owing to their rarity but they are likely to travel throughout the Chatham Rise area during foraging trips from their breeding sites (Thompson 2013) (refer to Figure 116).

Table 16: Key members of the seabird assemblage present on the Chatham Rise, based on information presented in Thompson 2013.

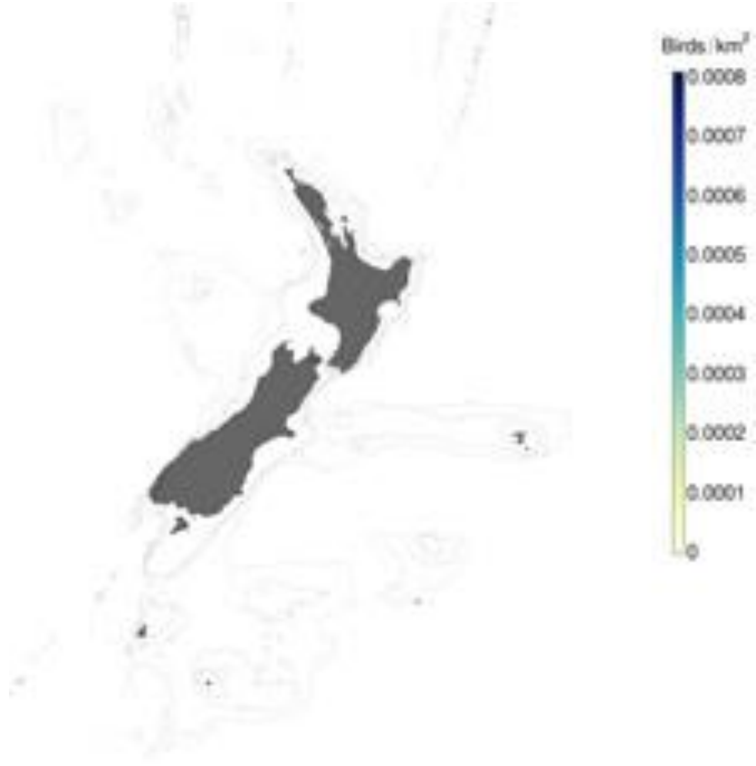
Seabird species	IUCN threat classification	NZ conservation status	Key locations	
			Breeding sites	Foraging activity
Exclusive to Chatham Islands and Chatham Rise				
Magenta petrel *Pterodroma magenta*	Critically endangered	Threatened – nationally critical	Chatham Islands	Likely to traverse Chatham Rise
Chatham petrel *Pterodroma axillaris*	Endangered	Threatened – nationally vulnerable	Chatham Islands	South and southeast of Chatham Islands
Chatham albatross *Thalassarche eremita*	Vulnerable	At risk - naturally uncommon	Only on Chatham Islands (The Pyramid)	Chatham Rise; within 750 km of The Pyramid during incubation and chick rearing
Main breeding sites on Chatham Islands				
Northern royal albatross *Diomedea sandfordi*	Endangered	At risk – naturally uncommon	Primarily on Chatham Islands; small colony on Otago Peninsula	Continental shelf off east NZ
Northern Buller's albatross *Thalassarche bulleri platei*	Near threatened	At risk – naturally uncommon	Primarily on Chatham Islands; small colony on Three Kings Islands	Primarily on Chatham Rise
Northern giant petrel *Macronectes halli*	Least concern	At risk – naturally uncommon	Mainly on Chatham Islands, smaller colonies on Auckland, Campbell and Antipodes Islands	Throughout NZ waters
Main breeding sites elsewhere but including Chatham Islands				
Red-billed gull *Larus scopulinus*	Least concern	Threatened - nationally vulnerable	Throughout NZ	Out to continental shelf
Antipodean albatross *Diomedea antipodensis antipodensis*	Vulnerable	At risk – naturally common	Key sites on Antipodes and Campbell Islands; new sites on Chatham Islands	Includes Chatham Rise
Sooty shearwater *Puffinus griseus*	Near threatened	At risk – declining	Three Kings Islands to Campbell Island	Throughout NZ waters. Migrates to Pacific Ocean in May-September
White-capped albatross *Thalassarche steadi*	Near threatened	At risk – declining	Auckland and Antipodes Islands; occasionally Chatham Islands	Throughout waters of continental shelf

Seabird species	IUCN threat classification	NZ conservation status	Key locations	
			Breeding sites	**Foraging activity**
White-fronted tern *Sterna striata*	Least concern	At risk – declining	Throughout NZ	Out to continental shelf
Fairy prion *Pachyptila turtur*	Least concern	At risk – relict	Poor Knights to sub-Antarctic islands	Poorly documented
Broad-billed prion *Pachyptila vittata*	Least concern	At risk –relict	Common throughout NZ, including Fiordland, Foveaux Strait, off Stewart Island, Snares and Chatham Islands	Throughout NZ waters
Common diving-petrel *Pelecanoides urinatrix*	Least concern	At risk – relict	Three Kings Islands to Campbell Island	Vicinity of breeding sites at least
Grey-backed storm petrel *Garrodia nereis*	Least concern	At risk – relict	Sub-Antarctic islands	Sub-Antarctic waters at least
White-faced storm petrel *Pelagodroma marina*	Least concern	At risk – relict	Offshore islands of North, South and Stewart Islands, Chatham and Auckland Islands	Vicinity of breeding sites at least
Brown skua *Stercorarius lonnbergi*	Least concern	At risk - naturally uncommon	Circumpolar, Fiordland to sub-Antarctic islands in NZ	Vicinity of breeding sites at least
Fulmar prion *Pachyptila crassirostris*	Least concern	At risk – naturally uncommon	Auckland, Bounty and Chatham Islands and Snares Western Chain	Poorly documented but relatively close to breeding colonies
Snares Cape petrel *Daption capense australe*	Least concern	At risk – naturally uncommon	Sub-Antarctic islands; mainly on Snares Islands	Throughout southern seas of NZ
Little shearwater *Puffinus assimilis*	Least concern	At risk – recovering or naturally uncommon (sub-species)	Kermadec, Antipodes and Chatham Islands, islands of Hauraki Gulf and Bay of Plenty	Vicinity of breeding sites at least
Black-backed gull *Larus dominicanus*	Least concern	Not threatened	Throughout NZ	Out to continental shelf

Seabird species	IUCN threat classification	NZ conservation status	Key locations	
Other key seabirds on the Chatham Rise				
Brown-browed albatross *Thalassarche melanophrys*	Endangered	Coloniser	Antipodes and Campbell Islands; uncommon breeding species in NZ but globally relatively abundant	Throughout NZ waters
White-chinned petrel *Procellaria aequinoctialis*	Vulnerable	At risk – declining	Auckland, Campbell and Antipodes Islands	Poorly documented but likely widely throughout NZ waters during summer
Flesh-footed shearwater *Puffinus carneipes*	Least concern	At risk – declining	Islands of North Island and Cook Strait	Continental shelf north of Subtropical Front, off Kaikoura, Foveaux Strait and Chatham Islands
Southern royal albatross *Diomedea epomophora*	Vulnerable	At risk – naturally uncommon	Campbell and Auckland Islands	Chatham Rise to Campbell Plateau
Buller's shearwater *Puffinus bulleri*	Vulnerable	At risk – naturally uncommon	Poor Knights Islands	Continental shelf from North Cape to Banks Peninsula, occasionally as far as 48°S
White-headed petrel *Pterodroma lessonii*	Least concern	Not threatened	Antipodes and Auckland Islands	Poorly documented but likely to disperse widely throughout southern waters
Grey-faced petrel *Pterodroma macroptera gouldi*	Least concern	Not threatened	Islands, stacks and headlands around northern half of North Island	Throughout northern waters and further south to sub-Antarctic waters

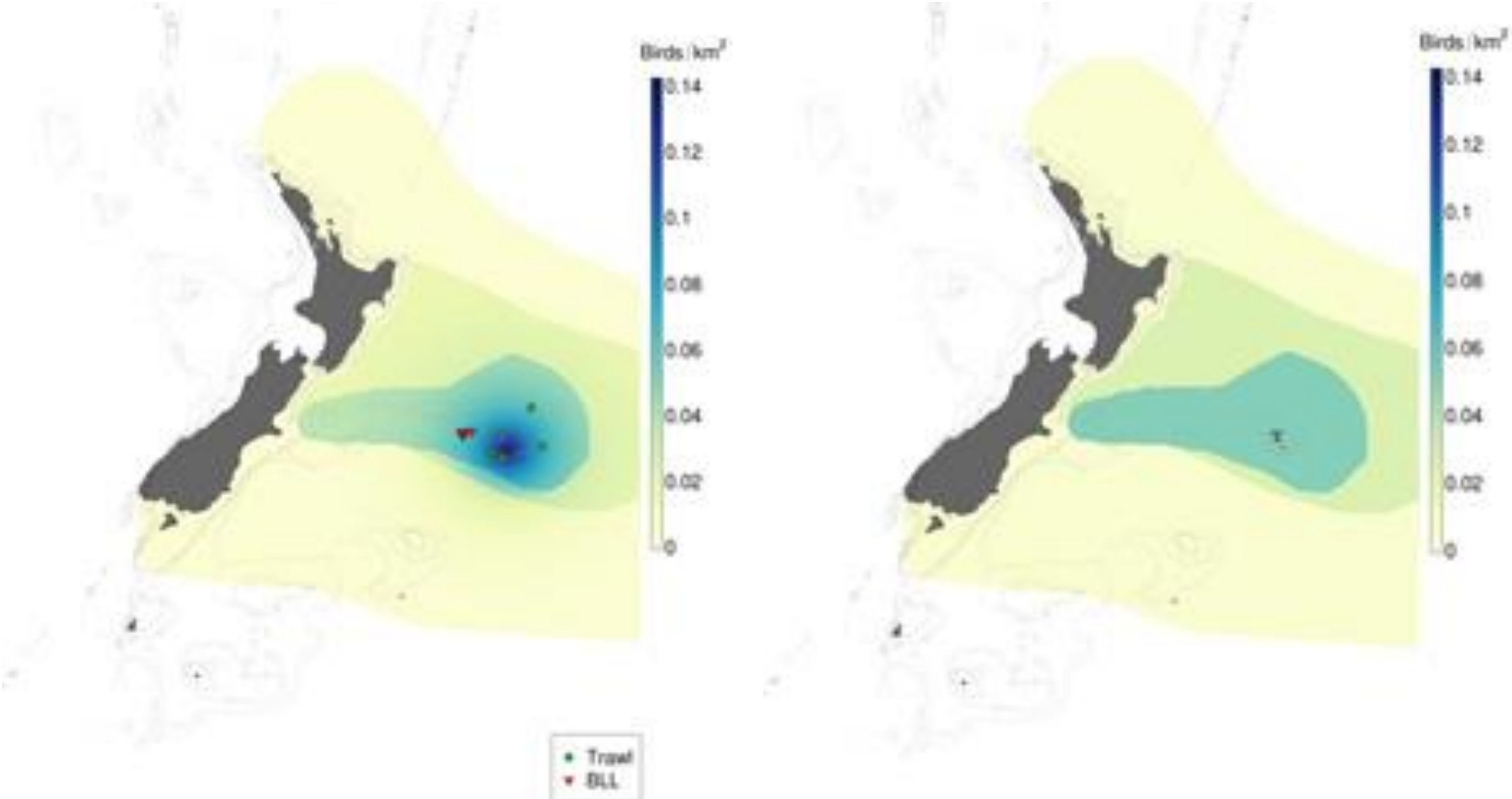


Breeding distribution



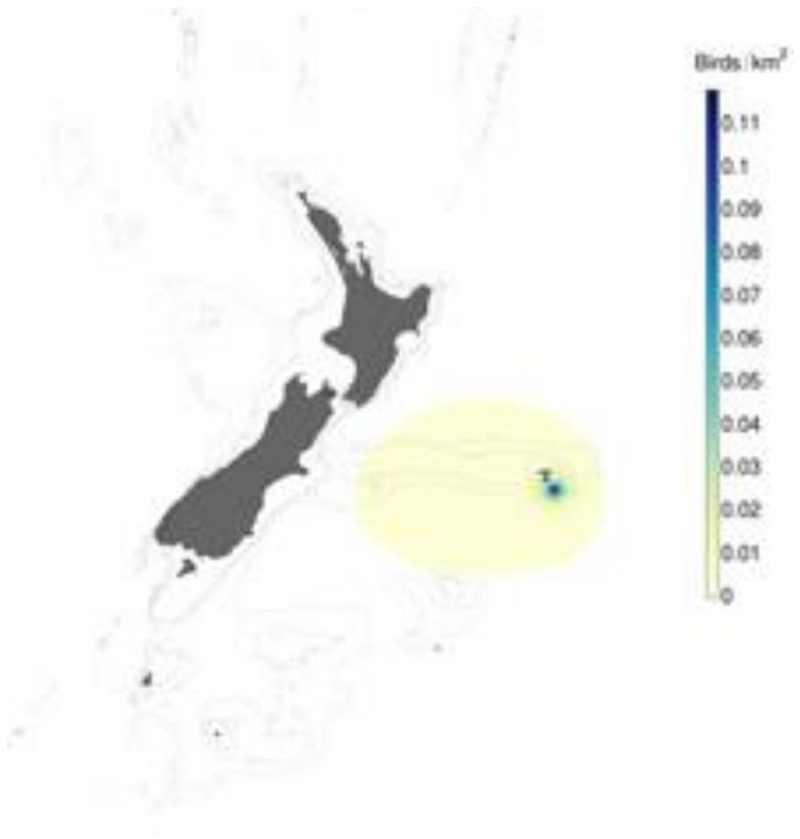
Non-breeding distribution

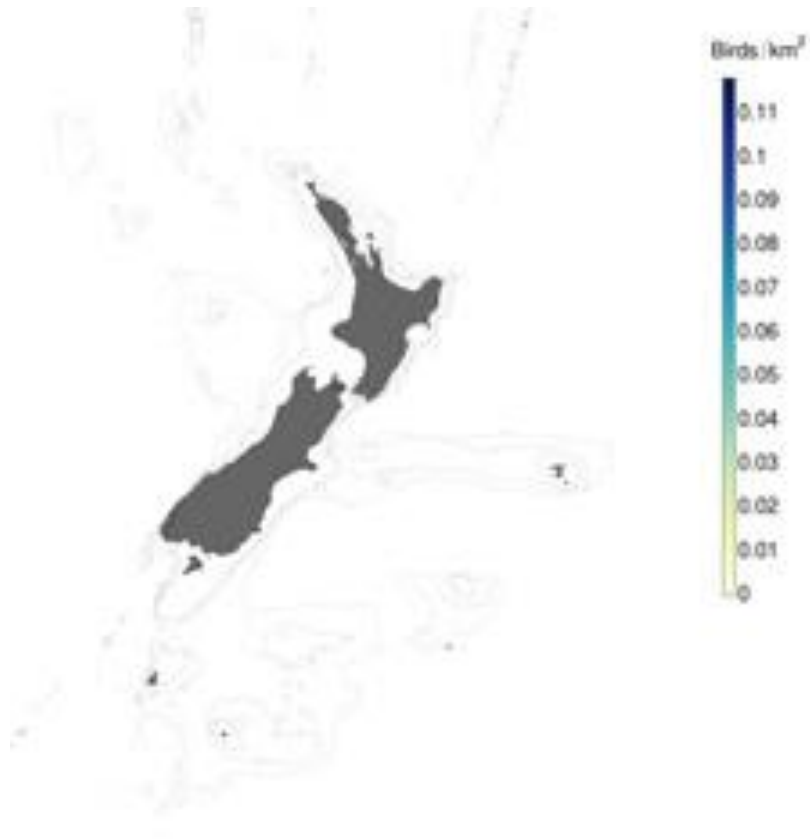
Figure 116: Relative density of Chatham Islands taiko (from Richard & Abraham 2013b).



Breeding distribution **Non-breeding distribution**

Figure 117: Relative density of Chatham Islands albatross (from Richard & Abraham 2013b).





Breeding distribution

Non-breeding distribution

Figure 118: Relative density of Chatham petrel (from Richard & Abraham 2013b).

The Chatham petrel is endangered, with an estimated breeding population of about 250 pairs (Thompson 2013). These birds are likely to be encountered on the Chatham Rise (Thompson 2013) and the area south and southeast of the Chatham Islands is most highly used by this species during chick rearing (Rayner et al. 2012).

The Chatham albatross is vulnerable and at risk. Recent nest counts from the only successful breeding colony (The Pyramid in the Chatham Islands) ranged from 5,194 to 5,407 nests, of which 29 to 41 % were empty (Thompson 2013). The Chatham Rise is a confirmed key foraging area for this albatross (Thompson 2013).

Some seabirds that breed at the Chatham Islands only disperse to areas local to the islands and are unlikely to extend to CRP's proposed mining area. However, these birds could potentially be encountered along the Chatham Rise during foraging. These species include the Chatham Islands shag (critically endangered), Pitt Island shag (endangered), black shag and Chatham Islands blue penguin.

6.9.3 Chatham Islands seabirds that use the Chatham Rise

Other seabirds that have their main breeding sites on the Chatham Islands and are key members of the Chatham Rise avifauna include the northern royal albatross (*Diomedea sandfordi*), the northern Buller's albatross (*Thalassarche bulleri platei*) and the northern giant petrel (*Macronectes halli*). The northern royal albatross is endangered and the northern Buller's albatross is near threatened, and all three species are considered to be at risk.

Seabirds that frequently use the Chatham Rise area and breed in the Chatham Islands but have main breeding sites elsewhere include a variety of albatrosses, shearwaters, prions, petrels (including storm petrels and a diving-petrel), a tern and a skua (Table 16). Most notable of these, due to their threat classifications, are the red-billed gull, Antipodean albatross, sooty shearwater and white-capped albatross. The red-billed gull is threatened and nationally vulnerable in New Zealand (but of lesser concern internationally). The Antipodean albatross is internationally vulnerable and at risk in New Zealand. The sooty shearwater and white-capped albatross are near threatened internationally and at risk as the New Zealand population are in decline.

6.9.4 Seabirds that visit the Chatham Rise

Other albatrosses, petrels and shearwaters are frequent visitors to the Chatham Rise but do breed at the Chatham Islands. Of these species, the brown-browed albatross is internationally endangered, and vulnerable species include the white-chinned petrel, southern royal albatross and Buller's shearwater.

In addition to these frequent visitors, there are at least 16 other seabird species that visit the Chatham Rise area moderately frequently or infrequently. These species include albatrosses, petrels, shearwaters, a shag and a gannet. The most notable of these are the endangered Hutton's shearwater which nests on the seaward Kaikoura Range (east coast South Island near Kaikoura) and the internationally and nationally vulnerable Salvin's albatross from the Bounty and Snares Islands. Other seabird visitors are described in Thompson (2013) (Appendix 21).

Seabirds using the Chatham Rise are occasionally caught as by-catch during fishing. By-catch is described by Thompson (2013) and in recent summaries of by-catch in the EEZ (MPI 2012a, Richard & Abraham (2013a, b). Figure 119 provides an overview of by-catch for a range of marine bird species in the EEZ.

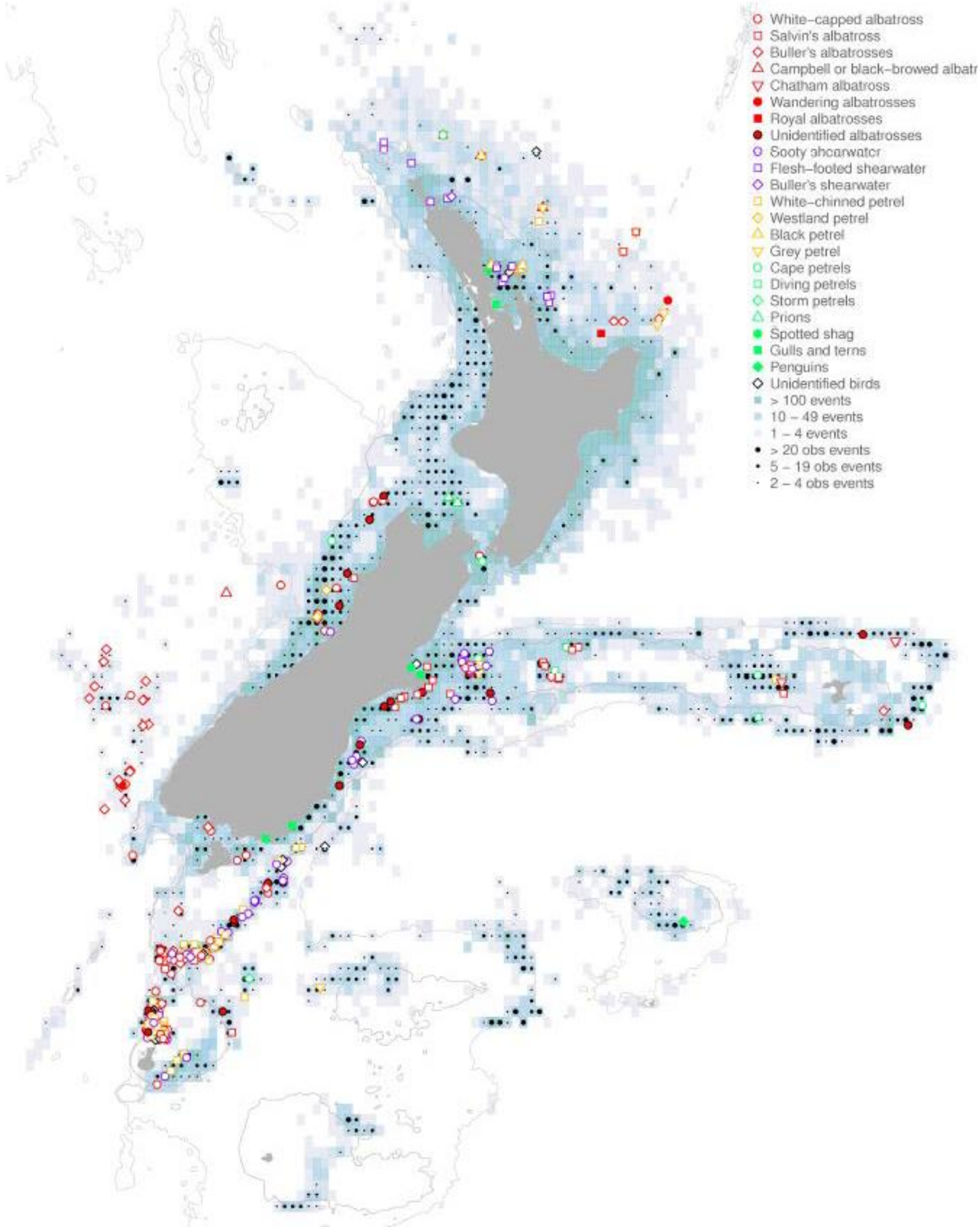


Figure 119: All observed seabird captures in trawl, surface long-line, and bottom long-line fishing within the New Zealand region, between October 2008 and September 2009. The colour within each 0.2 degree cell indicates the number of fishing events (tows and sets, darker colours indicate more fishing) and the black dots indicate the number of observed events (larger dots indicate more observations). The coloured symbols indicate the location of observed seabird captures, randomly jittered by 0.2 degrees (from MPI 2012, source Abraham & Thompson 2011).

6.9.5 Seabirds – trophic importance

Pinkerton (2013) (Appendix 22) describes the relationship of seabirds in the trophic ecology of the Chatham Rise. Seabirds have a relatively low TI in both single step and multi-step impact assessments in the trophic model. This reflects, in part, that seabirds impact few key trophic groups on the Chatham Rise.

Seabirds feed within the very upper part of the water column on the Chatham Rise, in surface water or very near the surface if they plunge for food. In open waters seabirds will normally feed on macro-zooplankton (crustacean), small fish and squid. Species such as petrels consume cephalopods, crustacean and small fish. A number of bird species will feed on fish and remains of other biota if they are on the sea surface, including that thrown overboard by fishing vessels.

Overall, Pinkerton (2013) estimates that much of their diet comprises mid-water fish (mostly myctophids and some juvenile fish, about 46 %), macro and meso-zooplankton (about 44 %), and squid (about 10 %). Refer to Pinkerton (2013) (Appendix 22) for more detail on how birds fit into the Chatham Rise ecosystem.

6.10 Chatham Rise Ecosystem

The key biological components of the Chatham Rise ecosystem have been described in the preceding sections. Pinkerton (2013) (Appendix 22) has developed a model of the food web on the Chatham Rise covering an area that includes the proposed marine consent area. The model allows for an improved understanding of the structure and function of the Chatham Rise ecosystem. As described in Pinkerton (2013) the model is balanced and focuses on the transfer of energy/carbon through the trophic levels in the ecosystem, i.e., it deals with the food levels in the ecosystem, what organisms feed on and how they important they are to each other. It allows educated comment to be made in relation to the dynamics and dependencies identified in the ecosystem, at the scale of the whole Chatham Rise and averaged over an annual period.

Large-scale ecosystems such as the Chatham Rise are inherently complex due to the scale and physical complexity of the physical environment. Ecological structure and function in different parts of the Chatham Rise region and at different times of the year may be very different from the mean. To develop a model of the Chatham Rise ecosystem, Pinkerton (2013) identified 36 key trophic groups:

- **Apex predators (4 groups)** - seabirds, toothed whales and dolphins, baleen whales and seals.
- **Demersal fish** (9 groups, based on the Chatham Rise fish guilds identified in Dunn et al. submitted) – hoki, orange roughy, oreos, warehou species, 'large javelinfish guild' representing pelagic foragers, 'small javelinfish guild' representing benthopelagic invertebrate feeders, 'hake guild' representing benthopelagic predators, 'rattails & ghost sharks guild' representing benthic invertebrate feeders and 'ling guild' representing benthic predators.
- **Mesopelagics** (6 groups) - middle-trophic level groups living predominantly in the water column and include small demersal fish, mesopelagic fishes (dominated by myctophids), cephalopods (mainly pelagic squids but also including benthic octopods), arthropds, hard-bodied macrozooplankton (mainly krill), gelatinous zooplankton (like salps and jellyfishes).
- **Benthic invertebrates** (10 groups) – corals (hard and soft corals), other encrusting invertebrates (including Ascidiacea, Bryozoa, Crinoidea, Hydrozoa, Porifera), starfish and crabs (Asteroidea, Ophiuroidea, Pycnogonida), echinoderms, holothurians (sea cucumbers), decapods, large benthic worms (mainly polychaetes), shelled megabenthos (including

bivalves, gastropods and giant forams), macrobenthos (both infauna and hyperbentic epifauna), meiobenthos (mainly nematodes).

- **Microzooplankton** (3 groups) – mesozooplankton (mainly copepods), heterotrophic microplankton (ciliates) and heterotrophic flagellates.
- **Phytoplankton.**
- **Bacteria** (2 groups) – water column bacteria and benthic bacteria (in soft sediments)
- **Detritus** (3 groups) – particulate and dissolved water column detritus, benthic detritus and carcasses.

Based on this balanced model, Pinkerton (2013) (Appendix 22) estimated the overall trophic importance (TI) of the model groups within it. TI is a measure of the overall effect on food-web structure of changes to the abundance of a species or group. This measure is related to the term 'keystones', relating to keystone species (the importance of a species beyond just its abundance). Pinkerton (2013) sets out in detail how the TI is calculated for the components of the Chatham Rise model.

The model identifies strong negative and positive dependencies in the Chatham Rise ecosystem. Pinkerton (2013) uses two methods of calculating TI. These are TI1, a single step trophic impact method, and TI2, a multiple step method that considers multiple interactions within the ecosystem. There are strong similarities in the two ways of calculating trophic impact. In both, major negative impacts (top-down predation effects) include rattails and ghost sharks on a range of megabenthic invertebrates, echinoderms on corals, meiobenthos on benthic bacteria, mesozooplankton on ciliates, and heterotrophic flagellates on water column bacteria. In the single-step analysis, there are positive (bottom-up, prey driven) impacts of the four key mesopelagic groups (mesopelagic fish, cephalopods hard- and soft-bodied macrozooplankton) on many demersal fish groups, meiobenthos on holothurians, and mesozooplankton on cephalopods and decapods. Most of these bottom-up (prey-driven) interactions are similar in the multiple-step analysis.

Pinkerton (2013) notes that the effect of changes in mesopelagic fish and cephalopods on some demersal fish groups changes between the single-step and multiple-step analysis. This is because the cephalopod groups have a negative single-step effect on mesopelagic fish and hard-bodied macrozooplankton (because cephalopods prey on these groups) and this impact is taken into account in the multiple-step analysis. Figure 120 provides a summary of the TI (in this case TI2) based on the model.

Highlights of the Chatham Rise model (Pinkerton 2013 – Appendix 22) are:

- Mesozooplankton are crucial to the structure and function of the Chatham Rise ecosystem, having the highest (TI1) or third highest (TI2) trophic importance in the model. The level of identified TI is considered to reflect the key role that mesozooplankton play in energy transfer from the lower parts of the food system to middle trophic level predators.
- The TI2 analysis highlights the underpinning role of phytoplankton in the Chatham Rise system.
- The role of the meiobenthos is highlighted by the multistep analysis (TI2), with importance of 8th in the system
- Of the six middle-trophic level groups, small demersal fishes are identified as being the most trophically important. Arthropods (prawns and shrimps) and mesopelagic fish also have high importance in the multi-step analysis (TI2), as do cephalopods and hard- and soft-bodied macrozooplankton.

- The trophic importance analysis based on the balanced model suggests that hoki play a key role in the system (3rd or 4th most important group).

In summary, the model shows that the Chatham Rise ecosystem is heavily reliant on primary production through phytoplankton and the build-up of the mesopelagic food resource, namely mesozooplankton and small mesopelagic fish. There are some direct food dependency between demersal rattail and ghost shark group and benthic fauna.

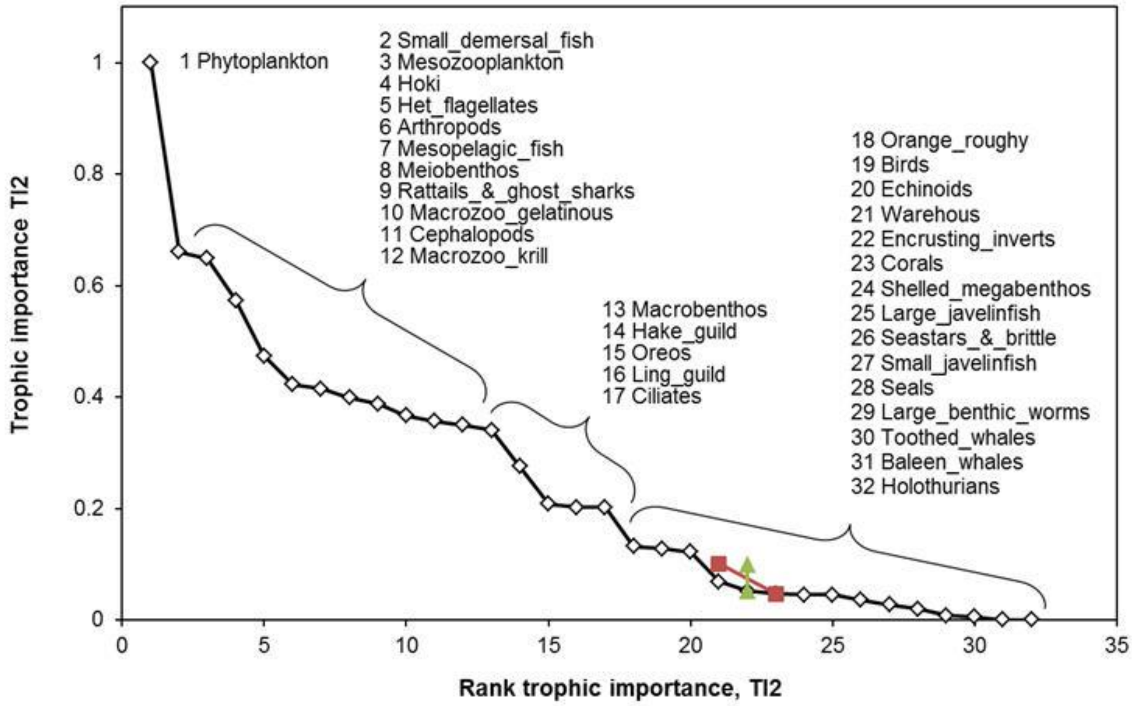


Figure 120: Trophic importance (TI2) from the Chatham Rise model in descending TI2 values (from Pinkerton 2013) The labels are in equivalent descending order of importance, numbers being their rank importance. The coloured lines show the effect of increasing the biomass of corals (square symbols, red lines) and encrusting_inverts (triangle symbols, green lines) by a factor of 10, rebalancing the model and recalculating the indices of trophic importance. This sensitivity analysis was carried out because there were limited data on the biomass of these sessile megafaunal groups available (notes from Pinkerton 2013).

6.11 Summary

The Chatham Rise ecosystem is characterised by high levels of primary production that supports commercially-important populations of demersal and deep water fish. As a result of this productivity, considerable research investment into the Chatham Rise's benthic and pelagic environments has been carried out. Physical habitat and biological environment vary significantly between the flanks and crest of the Chatham Rise and the elevated banks (e.g., Mernoo Bank) and seamounts. The area's major oceanographic currents also have a significant influence on the distribution of biological communities associated with different areas of the Chatham Rise.

The benthic communities on the Chatham Rise are varied in terms of the types of habitat and in the way the organisms in the benthic community feed. Analysis of data and benthic habitat modelling of the proposed marine consent area predicted the distribution of epifaunal and infaunal communities. The distribution of habitat suitable for these communities was explained by seabed characteristics and oceanographic conditions. The extent of the habitats is variable, but none of them is predicted to be unique to the proposed marine consent area.

Of the fish species present on the Chatham Rise, 37 species are predicted to be present within the marine consent area, with many of these species being widespread throughout the Chatham Rise. Commercial fishing of many of the key species, such as hoki, ling, silver warehou, orange roughy and scampi is generally focussed on areas outside of the marine consent area. There are also important local fisheries around the Chatham Islands for paua, rock lobster, blue cod, and hapuku.

The marine consent area is not fished by bottom trawling, but long-lining for ling is an important commercial activity in the eastern part of the area.

Ling spawn north of and in the eastern part of the proposed marine consent area. The marine consent area is not an important spawning site for other species. Juvenile fish of several species are common on the Chatham Rise, although there is no indication that they are concentrated in the proposed marine consent area. Adult ling and scampi are the main commercial species reported on the crest of the Chatham Rise, and most other commercial species are more common in deep water along the flanks of the Rise.

Whales and dolphins have been sighted throughout the Chatham Rise region. Some species of whale have been observed within the proposed marine consent area, but there is no indication that the area is commonly frequented by them.

Three seabird species are endemic to the Chatham Islands and they are likely to use the Chatham Rise for foraging or related activities.

A trophic model of the Chatham Rise has been developed and is represented by 36 key trophic groups. The five most important groups on are (in order): phytoplankton, small demersal fish, mesozooplankton, hoki and flagellates.

7. Consultation

KEY ELEMENTS

- Effective consultation which involves open and respectful dialogue has and will continue to underpin CRP's approach to this project.
- Since the grant of MPL 50270, CRP has consulted persons with existing interests namely the commercial fishing industry and other parties including Iwi and Imi, the Chatham Islands' community, the Government, other political parties and government agencies, non-governmental environmental organisations and other industry groups.
- Broader public consultation has been achieved by providing information through a variety of mechanisms, including CRP's website and via the media.
- Any issues raised during consultation have been considered by CRP. Where it has been possible to do so, changes have been made to the project and where relevant these have been assessed as part of this EIA.

7.1 Introduction

CRP considers that genuine consultation and engagement is critical to the successful development and on-going management of its project. All information and inputs, including that gathered as a result of consultation, help CRP refine the design and management of its proposed mining operations on the Chatham Rise.

In this regard, CRP recognises that consultation is not just a process. Consultation involves open and meaningful dialogue and also enables those with an interest in a project to provide input and have that input considered. Consultation ensures those interested or potentially affected by a proposed activity have an opportunity to be heard and to make a contribution to the development of the project. This is an on-going commitment, continuing after the project has commenced, assuming CRP receives approval to do so.

CRP's approach to consultation involves providing interested parties, including existing interests (as defined by the EEZ Act and discussed in Section 9.2.2), with information, and inviting them to discuss their concerns and ideas. These are considered by the project team, and accommodated as far as practicable as the project develops. The decisions are discussed with the interested parties to keep the process open and transparent. CRP believes that such an approach to consultation plays an important role in achieving successful project outcomes for all parties. However, CRP also recognises that there may be areas of disagreement with consulted parties, and these will have to be resolved by a hearing panel or tribunal set up to consider this EIA and associated marine consent application.

7.2 Consultation Approach

During the consultation process to date, ideas and concerns raised have been incorporated, as far as practicable, into the project's design and planning.

CRP committed early in the project's development to ensuring that the issues of interested parties, including existing interests, were identified by implementing an approach which aimed to achieve meaningful consultation throughout the project's life. A summary of the consultation, and the broader communication via the media, undertaken so far on the Chatham Rise project, and the outcomes of that consultation (up until the lodgement of this EIA), are provided in the following sections of this EIA.

CRP continues to consult with a broad range of interested parties and existing interests. CRP endeavours to work closely with groups and individuals to better understand their issues and, where possible, ensure these views, ideas, or concerns have been addressed as part of project development.

CRP supports the need for defined and comprehensive safeguards for environmental management. The consultation undertaken for the proposed mining operations at the Chatham Rise has assisted in refining those safeguards.

CRP consultation has included the use of its website[24]. The website provides information about the project, a range of likely questions and answers of general interest to interested parties, factsheets, and copies of presentations made by CRP and its technical partners at a range of international conferences as well as shareholder and consultation meetings. The website directs anyone who wishes to discuss the proposal or who has any questions to contact the company, and CRP directors and advisors are always available to anyone who contacts them.

CRP has also utilised the media, including national and international newspapers, radio, magazines and industry magazines, radio, web-based media and television, to inform the public of the proposed mining activity. These approaches have, at times, initiated consultation with some parties.

In addition, CRP and its partner Boskalis, along with the other members of CRP's project team, have provided the latest project information to interested parties as part of its consultation process.

The parties CRP has consulted to date and an outline of the nature of the consultation are provided in Section 7.3 below. The issues raised during consultation, how or where they have been considered, and how they have been addressed are listed in Table 17.

CRP began consulting in relation to this proposal in 2010, immediately after receiving its existing prospecting licence (MPL 50270), and it will continue this consultation during and following the processing of this application for a marine consent. CRP considers that this is a critical on-going part of the project that will continue throughout the operational phase of the project. Consultation is part of the way that CRP does business.

7.3 Parties Consulted

7.3.1 Overview

In developing its consultation approach, CRP recognised that the level of interest in its proposed mining activities on the Chatham Rise was likely to be broad ranging. This is because it is one of New Zealand's first off-shore seabed mining proposal within the EEZ and also one of the first marine consent applications, after Trans-Tasman Resources Limited's iron sand application, to be lodged with the EPA under the EEZ Act.

For this reason, CRP aimed to initiate consultation with all those whom it identified as likely to have an interest in the project. Several of the parties approached CRP following publicity about the project, and were therefore included within the on-going consultation process. The consultation approach adopted by CRP reflects good practice. Therefore, the description of consultation outlined below relates to this broad consultation approach.

[24] http://rockphosphate.co.nz/

It is acknowledged that section 39(1)(e) of the EEZ Act requires impact assessments for marine consents to describe any consultation undertaken with existing interests[25] (as identified by CRP in Section 9.2.2). CRP considers that good practice consultation and associated impact assessment processes should be broader than existing interests as defined by the EEZ Act. For this reason, this section of the EIA describes the consultation carried out with existing interests (i.e., the fishing industry, as discussed below) as well as other interested parties which are not considered by CRP to be within the statutory definition of an existing interest. These other interested parties include Iwi and Imi[26] (in terms of potential impacts on cultural interests and values), the Chatham Islands' community, the Government, other political parties and government agencies, non-governmental environmental organisations and other industry groups (i.e., other than the fishing industry). An overview of these parties and the consultation undertaken is provided below.

7.3.2 Fishing industry

7.3.2.1 Introduction

CRP has consulted with the Chatham Rise deep-water fishing industry (via the Deep Water Group Ltd) and with individual companies, including Iwi / Imi fishing interests, which either hold quota in the area or hold annual catch entitlements. This is in accordance with the requirements of the EEZ Act to identify possible adverse impacts on persons with 'existing interests'. The key existing interests are the quota holders, represented by the companies making up the Deep Water Group, and Iwi fishing companies. The existing interests associated with CRP's mining proposal are discussed in Section 9.2.2.

7.3.2.2 Deep Water Group Limited

Deep Water Group's website says it is committed to the sustainable management of New Zealand's deep-water fisheries. Formed in September 2005, the group is an amalgamation of EEZ fisheries' quota owners. Deep Water Group is working with the MPI (previously the Ministry of Fisheries) and other interest groups to ensure New Zealand gains the maximum economic yields from New Zealand's deep-water fisheries resources, managed within a long-term, sustainable framework. Fisheries managed by MPI and fished by the members of the Deep Water Group include orange roughy, oreo dory, hoki, hake, ling, squid and jack mackerel.

CRP has met with officers and board members of the Deep Water Group on a number of occasions over the past three years. In addition, CRP has maintained an on-going dialogue by phone and email with representatives from the Group.

During the first two years of consulting with the Deep Water Group, CRP received strong signals of support. However, at a presentation to the Board of the Deep Water Group in Auckland in October 2012 several members of the group expressed concerns about potential impacts of the proposed mining activity on fish stocks, habitat and spawning. CRP has followed up by providing more detailed information on the planned areas of mining, their distance to fishing areas, modelling of the sediment plume from proposed mining activities and a discussion of what potential impact the plume might have on the environment. CRP paid for an independent review, commissioned by the Deep Water Group, and carried out by ERM New Zealand Limited (an international consultancy) of the Deltares' plume modelling work (discussed further below).

In July 2013, so it could focus on gaining a mining permit, CRP withdrew the marine consent application that had been lodged with EPA but which had yet been accepted as complete.

Towards the latter half of 2013, CRP and Deep Water Group recommenced dialogue and discussions, focussed initially around the information contained in CRP's withdrawn July 2013 marine consent application (a copy of which was provided to the Deep Water Group). CRP found that attempting to

[25] 'Existing interest' is defined in section 4 of the EEZ Act.

[26] Imi, or Moriori, are the original inhabitants of the Chatham Islands.

engage with interested parties in a meaningful way was difficult without these parties having access to more detailed project information. It seemed that without a better understanding of the project, some parties could not discern how the proposal may potential affect them, and what further information or clarification they required from CRP.

Therefore, on balance, CRP reached the view that in order to provide for effective consultation and engagement it was appropriate to provide the withheld information (i.e., the July 2013 application document as a whole) to the public and interested parties. It was considered that this approach would reduce the continued risk associated with a potentially ineffective consultation approach.

During February 2014, as part of the on-going consultation with Ngai Tahu (refer to Section 7.3.3), CRP agreed to provide Ngai Tahu with a copy of the July 2013 application, along with a summary of reports and information being incorporated into this EIA. A copy of this information was subsequently provided to the Deep Water Group. In return, the Deep Water Group provided CRP with a copy of the peer review report prepared by ERM in relation to the modelling work carried out by Deltares.

CRP is now continuing to consult and engage with the Deep Water Group. This includes undertaking to continue to provide information relating to the project. CRP hope that the information provided will help Deep Water Group to identify its specific concerns and to identify ways that these potential concerns can be resolved or avoided, remedied or mitigated.

7.3.2.3 Ngai Tahu fishing interests

CRP initially met with representatives of Te Runanga o Ngai Tahu, including related fishing companies, in May 2013. While some concerns were raised relating to potential cultural impacts, specifically on taonga species such as marine mammal (which are continuing to be worked through – refer to Section 9.3), the principal area of interest for Ngai Tahu was the potential environmental impacts on its fishing activities. In particular, these concerns related to potential impacts on long-lining on the crest of the Chatham Rise and bottom trawling on the flanks of the Chatham Rise. This has been the focal point of consultation.

In late 2013, Ngai Tahu provided CRP with a written summary of its areas of interest and concerns. While Ngai Tahu provided this information, they advised that they needed access to detailed information to be able to engage in a useful way. In February 2014, after the provision of a response to the area of interest outlined in late 2013, and after a number of discussions and email exchanges, CRP agreed to provide Ngai Tahu with a full copy of the July 2013 marine consent application. Along with the copy of the July 2013 application, CRP also provided a summary of reports and information being incorporated into this EIA.

Following this disclosure, Ngai Tahu refined their summary of their areas of interest. Also, in February and March 2014, a teleconference and a technical meeting were held between Ngai Tahu and CRP to discuss these areas of interest. The main concerns raised by Ngai Tahu relate to the potential impacts from the plume, particularly on commercial fishing stocks and activities in the broader area, including long-line fishing for ling.

7.3.2.4 Other fishing industry representatives

Separately from the meeting with the Deep Water Group, CRP has met with representatives from **Sanford Ltd** (Sanford) and **Talley's Group Ltd** (Talleys) and continues to provide information to them. Their concerns centre on the impacts that CRP activities might have on fish spawning and juveniles, in particular hoki, as well as the implications of CRP operating in a BPA. CRP is continuing to discuss these matters with both Sanford and Talleys.

In addition to Sanford and Talleys, CRP has consulted with:

- **New Zealand Rock Lobster Industry Council.** CRP met members of the Council on Chatham Island in October 2012. Their main concern was any detrimental impact on that fishery arising from the proposed mining operations. Since this meeting, CRP has emailed information to them regularly, including a NIWA report (contained in Appendix 31 (MacDiarmid 2013)) showing that there will be no impact on that fishery.

- **Paua Industry Council Ltd** (PauaMac). CRP met representatives from PauaMac during the Chatham Islands visit in October 2012.

- **Seafood New Zealand** (Seafood NZ). This umbrella organisation representing New Zealand's seafood industry includes representation from five key sectors, and consultation has focused on Deep Water Group, Paua industry and the Rock Lobster industry councils. CRP has talked to the new chief executive and briefed him on the project.

- **Te Ohu Kai Moana** (Maori Fisheries Trust). CRP briefed the trust in 2010 and continues to keep them apprised of progress with the project.

- **Koau Capital.** This organisation advises Maori enterprises on investment, including fishing. CRP has met with the organisation's principals and keeps them appraised of the project's progress.

CRP intend to continue to consult with the above parties, and any other fishing industry parties that wish to discuss CRP's proposed mining operations on the Chatham Rise.

7.3.3 Iwi and Imi

Iwi and Imi who claim the Chatham Islands within their rohe, with whom CRP has engaged and consulted, are:

- **Ngati Mutunga o Wharekauri.** Ngati Mutunga are an iwi in the Chatham Islands. Engagement with Ngati Mutunga has entailed regular visits, emails and phone calls since early 2012. CRP first met local trustees during a visit to the Chatham Island in October 2012. Since that time, CRP has maintained regular contact with Iwi representatives.

- **Moriori (Rekohu).** Moriori are the Imi and original inhabitants of the Chatham Islands. CRP has also maintained contact following initial meetings with representatives in October 2012

CRP has retained Tuia Group (Tuia) to lead this engagement process. Tuia has been principally responsible for organising and managing engagement with Iwi and Imi and their associated fishing interests, although CRP and Tuia have worked (and continue to work) closely together through this engagement process.

An overview of the consultation process relating to Iwi and Imi, and CRP's approach to addressing issues raised, are summarised in Section 9.3. The issues raised by Iwi and Imi during consultation are also outlined in the CIA and letter, prepared in June 2013, appended to this EIA (Appendix 33). In addition, any issues raised during any meetings have been included, and associated comment provided, in Table 17 in Section 7.5 below.

Engagement with Ngati Mutunga and Moriori included visits to the Chatham Islands in April and October 2013 to identify and explore areas of interest. These revolved around fishing, cultural values, sovereignty issues and economic development. Additional matters raised included potential interference with sinkholes and underwater aquifers on the Chatham Rise, as well as any use of chemicals as part of the mining process. During this visit, and from subsequent conversations, CRP has committed to continuing to engage with Ngati Mutunga and Moriori throughout the processing of the marine consent application and once mining commences.

There are other Iwi who have or may have some interest in the project. These Iwi include (in no particular order), **Te Runanga o Ngai Tahu** (refer to Section 7.3.2.3 above), **Ngati Kahungunu**, **Rangitane o Wairarapa** (and related Hapu), **Te Tau Ihu** (particularly **Rangitane o Wairau**), **Ngati Toa Rangatira** and **Taranaki Whanui ki Te Upoko o Te Ika a Maui**. The potential interests of these Iwi are continuing to be explored by CRP and Tuia Group through provision of information and consultation with Iwi representatives. These interests are both fisheries related, as well as potentially at a broader cultural level. As outlined in Section 9.2.2 and 9.3, aside from the Iwi fisheries quota holders, any cultural interest are not an 'existing interest' for the purpose of the EEZ Act.

CRP and Tuia have also consulted informally at various points in time with a number of other Maori interest groups, including Iwi Chairs Forum and the Federation of Maori Authorities.

7.3.4 Chatham Islands' community

CRP has focussed a large part of its community-related consultation on the Chatham Islands. Given this focus, in early October 2012 four CRP representatives spent several days on the Chatham Islands consulting with a range of individuals and organisations. The trip was a fact-finding mission, but also one designed to show the people of the Chatham Islands that CRP are focused on learning about their concerns and identifying possibilities for working together in the future. During this visit CRP listened carefully to the comments and thoughts that were expressed. There have been two follow up visits by CRP (April and October 2013), with a focus of these visits being on Iwi and Imi, fishing, farming and general community interests.

The Chatham Islands community has shown a strong interest in the project. Its community organisations, such as the local Council and Chatham Islands Enterprise Trust, have worked closely with CRP to explore how CRP can help the community and to consider what impacts the proposed mining operations might have on their constituency.

CRP has on-going contact with other Chatham Islanders, from the Mayor and Council Officers to leaders of fishing, farming, Iwi and Imi, conservation and voluntary organisations, including regular visits, phone calls and emails. In addition, CRP has been keeping the Minister responsible for the Chatham Islands, Hon. Chris Finlayson, apprised of the project's progress.

The representatives and interested parties on the Chatham Islands that CRP has consulted with are:

- **Chatham Islands Enterprise Trust** (CIET). This body owns and manages the key infrastructure on the islands. CRP explored the possibility of developing a port on the Chatham Islands that could be used by CRP to land its product prior to export, as well as for other island interests. Investigations included CRP funding an initial study of the viability of a new port. CRP continues to meet regularly by phone with CIET (along with Council representatives as discussed below).
- **Chatham Islands Council**. CRP has met with representatives of this governing body who look after local interests on behalf of the community. In relation to CRP's proposed mining operations, its key focus is identifying how the proposal's activities might assist Chatham Islanders. CRP regularly communicates with Council representatives and meets them when they visit Wellington.
- **Federated Farmers of New Zealand** (Federated Farmers). Federated Farmers is a national body that represents the farming community. Consultation with Federated Farmers has been with the local branch in the Chatham Islands. CRP's main focus during consultation with the local branch has been identifying the potential positive impact of providing inexpensive rock phosphate fertiliser to the Islands' farming sector. Initial figures provided by Federated Farmers suggest that the provision of adequate fertiliser could increase stock units from 65,000 to 700,000, thus increasing annual farm incomes from $4 million to $50

million and adding 350 new farming related jobs to the local economy. This would have the flow on effect of improving the viability of all other infrastructure and transforming the wider local economy. Locally, Federated Farmers also acknowledge that CRP's rock phosphate reduces potential environmental impacts because it does not have the damaging leaching effects of manufactured fertilisers.

- **Chatham Islands Heritage and Restoration Trust**. The Trust aims to preserve the natural and historic features of the Chatham Islands. Its Chair's main concerns were the potential impacts of new industry on the island's resources and landscape, and the on-going depopulation of the islands.
- **Landowners in and around Ocean Bay and Port Hutt**. During the October 2012 consultation trip, Ocean Bay was suggested as a possible port option for CRP. Consultation with these landowners principally focussed on this issue and the feasibility assessment partly funded by CRP. Consultation consisted of an initial meeting with local landowners followed by further meetings and on-going discussions regarding port options.
- **Chatham Islands Conservation Board** and **DOC**. While on the island CRP has met with local DOC staff, as well as the Conservation Board that was meeting on the Island at that time. CRP has also briefed a member of the Conservation Board who was not available at that time but who has strong interests in the Chatham Islands. CRP is continuing to explore how it can contribute to the Chatham Islands' Conservation Management Strategy which is currently being reviewed. As outlined in Section 7.3.5 below, CRP has also met with Wellington based DOC personnel.

During CRP's initial visit to the Chatham Islands in October 2012, a public meeting was held to provide information on the proposed mining project and to give the Islanders an opportunity to share their thoughts. About 60 people attended, and after CRP's Chief Executive gave a presentation the floor was opened for questions. Some attendees expressed their confusion about what was intended, and it was evident that there was some misunderstanding and misgivings about potential impacts. From CRP's perspective the ensuing discussion was very helpful in clarifying issues for both the locals and for CRP.

On each return visit, public meetings have been held, as well as separate meetings with Iwi and Imi, smaller community groups such as at Kaingaoroa and two school groups.

From CRP's interactions with the Chatham Islands community, it is obvious that many people on the Chatham Islands are cynical about outsiders, including CRP, *"once again making money from our resources",* and about the impacts or benefits the proposed mining project might have. CRP consider that the work that has been undertaken since the initial visit in October 2012 has demonstrated CRP's commitment to ensuring that the Chatham Islands reap some benefits from the proposal. CRP is committed to ensuring that the proposed mining operations will cause no detrimental impact to the local environment and associated fishing interests, and that any operations on the Chatham Islands will be of value to the local community.

In a newsletter distributed to all Chatham Island residents in late 2013, CRP committed to supplying unprocessed rock phosphate to local farmers at cost or lower. CRP believes this will have a dramatic positive impact on the economics of farming on the islands as it will significantly increase output in a sustainable (both economic and environmental) way. Increasing production has the potential to create jobs, boost the population and improve the viability of establishing a proposed meat processing plant.

In addition, CRP is considering a number of activities related to its operations, as outlined in Table 17, including:

- Employment opportunities on the mining vessel.
- Basing a rescue helicopter on the island.
- Enabling the people living on the Chatham Islands to assist with providing environmental monitoring.
- Support for local causes, including scholarships.
- Research funding.
- Providing for, through the proposed environmental compensation package, enhancement of conservation values on the Chatham Islands. Ideas so far have ranged from relocating an albatross colony (the Chatham Island Taiko Trust – refer to Section 10.5) to gorse reduction.

7.3.5 Government, other political parties and government agencies

CRP has met regularly with relevant Ministers, MPs from across the political spectrum and a wide range of officials from relevant Government departments. The purpose of this consultation has been to keep these parties fully informed about the status of and plans for the mining proposal and to seek their advice about how to manage the resource and environmental consent process during the transition of legislation governing off-shore mining.

In 2011, CRP briefed the Prime Minister on one occasion and the staff from the Office of the Prime Minister and Cabinet on two occasions. Ministers and/or ministry representatives from MPI (and their relevant predecessor departments), Ministry for Business, Innovation and Employment, New Zealand Trade and Enterprise, DOC, Ministry for the Environment (MfE), Te Puni Kokiri, EPA, and Maritime NZ have also been briefed on the proposal.

Some of these government organisations are being briefed regularly to keep them informed about the progress of the proposal. Given their responsibilities regarding the proposal (as explained later), CRP has regular contact with NZPaM, MfE, MPI, DOC and EPA.

CRP submitted its mining licence application to NZPaM in September 2012. The mining permit (MP 55549) was granted in December 2013. In addition, in November and December 2013, CRP lodged applications for two new prospecting permits and for a time extension on MPL 50270 (including a proposal to relinquish as area of 1,019 m^2). CRP had regular interactions with the EPA throughout the drafting of the EEZ Act Regulations (which came into force in June 2013) and associated policy. Discussions have also regularly taken place with NZPaM, the EPA, DOC (particularly in relation to the need to seek a permit, under the Wildlife Act to remove corals from the seabed) and MfE in relation to the regulatory framework and associated process for the processing of CRP's applications.

CRP has also briefed MPs from the Labour and Green Parties, in particular their spokesmen with interests in the Chatham Islands, mining, conservation, environment, and primary industry. These parties expressed an interest in being briefed by CRP.

7.3.6 Non-government organisations and environmental groups

Several non-government organisations and environment groups have an interest in ensuring the New Zealand environment is protected from activities that have or may have significant environmental impacts. Seabed mining has attracted comment and opposition from several of these organisations.

CRP has consulted, or plans to consult with these organisations. Some of the organisations that CRP has approached have either signalled they are not currently interested in CRP's proposed mining project, or have yet to find a time to meet. This is the case for only a few organisations and an active dialogue has been established with most of them.

The organisations and the status of consultation are described below:

- **ECO**. ECO is a nation-wide group of environmental and conservation organisations, based in Wellington. CRP has made several offers to meet with ECO but as yet a meeting has not taken place.
- **Ecologic.** CRP had a brief discussion with Ecologic and has also sought advice regarding the proposed development of an Environmental Reference Group for the project.
- **Pew Foundation**. CRP made contact but were advised that the organisation's focus is currently elsewhere (the Kermadecs).
- **Kiwis Against Seabed Mining** (KASM). Representatives from KASM attended briefing sessions held in Auckland and Wellington in February 2013. CRP received useful input regarding the proposal at these meetings.
- **Worldwide Fund for Nature**. Regular contact has been maintained over the past few years.
- **Royal Forest and Bird Protection Society** (Forest & Bird). CRP has briefed Forest & Bird on several occasions and received useful input regarding the proposal.
- **Environmental Defence Society** (EDS). CRP has briefed EDS on a number of occasions and received useful input regarding the proposal, including suggestions on biodiversity offsets or environmental compensation.
- **Soil and Health Association** (which includes Organics NZ). This organisation may be an interested party given that the application of phosphate (including a non-processed naturally occurring product) onto land is likely to be an outcome of CRP's proposed mining activity. CRP has not yet consulted directly with this organisation.
- **Greenpeace New Zealand** (Greenpeace). CRP has made several offers to meet but a meeting has not yet taken place due to their other commitments.

7.3.7 Other industry groups

CRP has consulted with other groups that represent a range of interests relevant to this proposal, whether the mining itself or the end use of the mined material. The groups consulted include:

- **Business New Zealand** (Business NZ). CRP attended bi-monthly workshops that Business NZ co-hosted with the EPA to assist with planning associated with the introduction of the new EEZ legislation in 2012 and 2013.
- **Federated Farmers of New Zealand** (Federated Farmers). In addition to consulting with the Chatham Islands' branch of Federated Farmers, CRP has also consulted with the Chief Executive and the General Manager Policy & Advocacy. The Chief Executive also met Boskalis' visiting experts on their visit to New Zealand in February 2013 where he was briefed on the current status of the proposal.
- **Fonterra Co-operative Group Ltd** (Fonterra). As potential end users of the phosphorite, CRP has undertaken email dialogue with various representatives from Fonterra in relation to its proposed mining project.
- **Straterra**. CRP has a close working relationship with Straterra, the mining industry representative group, and all their staff are familiar with the project.

- **Oceans Group.** This group, chaired by Straterra, includes companies with an interest in off-shore mining. The group meets sporadically and several members also attended the EPA and MfE workshops on the proposed EEZ Act Regulations. Members are familiar with each other's projects and work together as required. For example, CRP has regular discussions with Trans Tasman Resources Ltd on a range of issues that both companies face.

7.4 General Communication – News and Information

CRP puts considerable effort into communicating with the public and interested parties, including investors, as well as the groups discussed above.

CRP has established a continually-updated list of people and organisations (including media) that have shown interest in the proposed mining project. Regular announcements and updates are sent to these parties. Many of these announcements result in media coverage that in turn has triggered interest from other parties who often contact CRP for more information.

CRP's communications are focused primarily on:

- Regular announcements.
- On-going contact with national and international media.
- Frequent updating of the website.
- Investor and environmental factsheets – available on CRP's website.
- Frequent presentations at national and international conferences.
- A consultation and engagement programme (as outlined above).
- A newsletter posted on CRP's website. The newsletter, as outlined in Section 7.3.4, was prepared following CRP's visit to the Chatham Islands in October 2013.

A brief summary of the nature of this communications is provided below:

- **Regular announcements**. CRP issues updates and announcements on a regular basis (on average, weekly). These announcements entail emails being sent to shareholders and other interested parties, including media, interested parties and prospective investors. The announcements are also posted on CRP's website and, if relevant, issued to the New Zealand stock exchange.
- **On-going contact with national and international media**. CRP's announcements often attract media interest. For a small company, CRP considers that it has a surprising take up by media. There is interest among financial, farming and science media, depending on the nature of the story. In February 2013, CRP featured in a documentary on Dutch television and has also appeared regularly on Radio New Zealand, on the business pages of the major dailies and in the National Business Review, farming and other specialist media. Articles also appear regularly in a range of international specialist publications and websites.
- **Updating of the website and factsheet**. CRP post links to key media stories as well as any presentations given at major conferences. CRP regularly updates the investment factsheet which is posted on the website and also provided it to interested parties and at investor briefings. CRP has also produced an environmental factsheet, summarising key findings of CRP's scientific research, which has been widely distributed.
- **Frequent presentations at national and international conferences**. In addition to the Chief Executive, CRP also has a team of about 10 key people, experts in science or technical fields,

who are regularly invited to speak in international forums in places as diverse as Russia, China, the United States, and Australia. CRP's technical partner Boskalis presents at industry events several times a year and uses CRP's proposed mining project as an example of one of the world's most advanced undersea mining projects. CRP personnel also regularly present papers at national conferences such as AusIMM.

- **Annual and interim reports**. The annual and interim reports contain a summary of key financial and operational information.
- **Consultation and engagement programme**. CRP's focus from the start of the project has been to talk with any parties with an interest in the proposal. CRP's approach is to meet face to face and to provide interested parties with information and the opportunity to ask questions, and then keep in regular contact. CRP has found almost all discussions to be useful and positive. The company listens to concerns and works to address the issues raised, and where possible adopts ideas for improving the project. Interestingly, one of the comments that CRP representatives receive from observers is how open they are with information.

CRP's website (http://rockphosphate.co.nz/) provides links to a range of information, including: media releases, investor factsheets, the environmental factsheet, updates for shareholders and Chatham Island residents, various presentations, television and video interviews, financial statements and the annual Directors' review.

The wider dissemination of the information provided by CRP is most typically evident in the media coverage about CRP. This includes:

- The Dominion Post, New Zealand Herald, Christchurch Press, TV3, Radio New Zealand, New Zealand Resources, National Business Review and Business Desk.
- Rural, investments and general interest articles in Dominion Post farm pages, Straight Furrow, Rural News and Dairy News, plus science and mining industry publications.
- Radio New Zealand National, which in addition to regularly reporting project milestones, has run extended features.

7.5 Issues Raised During Consultation

The issues raised during consultation are listed in Table 17. The table also notes how and where issues have been addressed and resolved (refer to the 'comments' and 'assessed in the EIA' columns), whether it be within a technical assessment or as part of the proposed avoidance, remediation and mitigation measures.

The issues are generally relatively generic and reflect the potential impacts that were identified by the CRP project team in the early stages of project development (refer to Section 8.2).

Table 17: Issues raised during consultation.

Issues raised	Raised by (where relevant)	Comment	Assessed in the EIA (where)
Potential impacts on the Chatham Island's rock lobster fishery, including sedimentation impacts and impacts on migrating rock lobster.	New Zealand Rock Lobster Industry Council	A report was commissioned from NIWA. This report identifies that CRP's proposed mining operations are located a considerable distance away from the migrating rock lobsters. In addition, modelling shows that the sediment plume associated with the mining operations will not reach the fishery at the Chatham Islands, nor far enough northwards to affect the larval migration from the east coast of the South Island.	The NIWA report is contained in Appendix 31 and the results of modelling reports are summarised in Section 8.4. These issues, namely potential impacts on the rock lobster, are also assessed in Section 8.
Potential impacts on fishing grounds and fishing industry generally	Fishing industry generally	These issues have been discussed with the fishing industry on a regular basis as part of CRP's consultation. Except for the ling fishery, the marine consent area is located away from commercial fishing grounds so there will be no direct impacts. There is a ling fishery located within the eastern prospecting area (PP 55967), which is located away from the initial mining area associated with the mining permit. If mining does occur in this area in the future, it is considered that adverse impacts are of low environmental risk. In relation to indirect impacts (i.e., sediment deposition and potential food chain impacts), including on areas and at times of fish spawning (see below), CRP is aiming to avoid, remedy or mitigate potential impacts through environmental management controls that will be adopted during mining so that any potential impacts are thus unlikely and have a low risk of impact.	The location of the fishing grounds, in relation to CRP's proposed mining operations, is discussed in Section 6.6. The potential impacts, and the related avoidance, remediation or mitigation measures, are assessed in Sections 8, 10 and 11.
Potential environmental benefit related to potential less phosphate leaching into waterways,	Farming and related industries and central government	CRP has briefed a range of parties about the potential benefits of using CRP, in its unprocessed state, rather than manufacturing it as superphosphate. CRP has undertaken desk research and is planning to undertake some field trials of	This EIA concentrates on assessing the potential impacts associated with the proposed mining operations on the

Issues raised	Raised by (where relevant)	Comment	Assessed in the EIA (where)
compared to superphosphate, as a result of direct application of phosphorite		the product.	Chatham Rise. However, Section 9.5 of this EIA does consider the broad range of potential positive impacts associated with the mining proposal as a whole.
What benefits does the proposal have for the Chatham Islands?	Chatham Islands' community and central government	CRP is working with various entities on the Chatham Islands to identify ways that CRP can work together for mutual benefit of the Chatham Islands community. Potential opportunities that have been identified include • subsidised fertiliser for Chatham Island farmers • provision of medi-vac facilities on the Chatham Islands, including a helicopter • possibility of an export port being developed was explored, although the Government does not see this as a viable option • employment opportunities, including potential employment on the mining vessel operated by Boskalis after the operation is well established • scholarships • provision of environmental compensation mechanisms on the Chatham Islands in recognition of the potential mining impacts occurring on the Chatham Rise • environmental monitoring carried out by Chatham Island based people/organisations • bunkering and provisioning services accessed from the Chatham Islands Also, there has been a general discussion with locals about whether a large new industry would put infrastructure under strain (e.g., housing). CRP considers that the opportunities	The potential social and economic impacts of CRP's proposed mining operations are assessed in Section 9 and Appendix 6.

Issues raised	Raised by (where relevant)	Comment	Assessed in the EIA (where)
		identified above do not necessarily reflect the issues associated with ‘a large new industry’ and therefore it is envisaged that no such strain would arise from CRP’s proposal.	
Potential adverse impacts on corals	Generally from parties interested in protecting the environment and DOC regarding a Wildlife Act permit	CRP proposed to include some areas of particular sensitivity and values identified by a marine spatial planning exercise in proposed mining exclusion areas as discussed in Sections 4.4.1 and 8.6.6.4. These areas include cold water coral habitat. However, it is acknowledged that coral colonies outside of the proposed exclusion areas, and which are within the mining blocks will be taken as a result of mining activities.	A report describing the benthic habitat associated with the proposed marine consent area and the crest of the Rise generally is contained in Appendices 15 and 16. As assessment of the potential impacts on benthic habitats, including corals, is provided in Section 8.6.
Potential adverse impacts on marine mammals	Generally from parties interested in protecting the environment, and Ngai Tahu as marine mammals are a taonga species	Potential impacts on marine mammals, whether direct or indirect, have been assessed within this EIA. Operations will be conducted to avoid detrimental impacts on marine mammals.	A report identifying the marine mammals present in the broader area is contained in Appendix 20. Potential impacts are assessed in Section 8.6.6, with potential noise impacts assessed specifically in Section 8.7.
Potential adverse impacts of seabirds, particularly as a result of vessel lighting	Generally from parties interested in protecting the environment	CRP will ensure that all vessel lighting complies with the requirements of the Vessel Lighting Management Plan (LMP). The key purpose of this Plan is to minimise the potential for the mining vessel to attract seabirds to the vessel.	Potential impacts of lighting on seabirds are assessed in Section 8.8. The LMP is contained in Appendix 35(ii).
Potential impacts on the marine environment (benthic as well as pelagic) arising from the	General	A number of technical assessments have been commissioned, including plume modelling, to assess the nature of and extent of any potential impacts on the marine environment as a result of a sediment plume. Based on these reports, an	A summary of the modelling reports is contained in Section 8.4. Potential sediment impacts are assessed in Sections 8.4 and

Issues raised	Raised by (where relevant)	Comment	Assessed in the EIA (where)
sediment plume generated during return of the processed non-phosphatic material to the seabed		assessment of the potential impacts of this component of the proposal has also been assessed within this EIA.	8.6.
Biosecurity risk at the port from the mining vessel	General	CRP, and Boskalis, will ensure that ballast and hull biofouling of the mining vessel complies with all of the requirements of the Biosecurity Act and forthcoming standards following recent amendments to that Act. This will ensure that there are no biosecurity risks at the port arising from CRP's activities.	Sections 4.7 and 8.10 assess the potential biosecurity risks associated with this proposal.
Potential impacts from mining on spawning areas associated with species that are fished commercially	Sanfords and Talleys	CRP's mining operations will not adversely impact on commercial fisheries spawning, juvenile fish or the fisheries as a whole. In relation to indirect impacts (i.e., sediment deposition, loss of benthic fauna), any resultant adverse effects are considered are unlikely and have a low risk of impact.	The location of the spawning areas and timing of spawning for commercially fished species, in relation to CRP's proposed mining operations, is discussed in Section 6.6. The potential impacts, and the related avoidance, remediation or mitigation measures, are assessed in Sections 8.6, 10 and 11.
General concerns about mining within a BPA	General	While CRP acknowledges the presence of the BPA, the restrictions and prohibitions apply specifically to fishing activities not mining activities. Irrespective of this fact, this EIA has assessed the potential impacts of the proposed mining activity on the benthic environment within the mining area and thus the BPA. Relevant to this issue is the fact that CRP has carried out a marine spatial planning exercise. This has resulted in	An assessment of the potential impacts on the benthic environment and fishery are assessed in Section 8.6. Section 8.6.6.4 and Appendix 32 describe the spatial planning exercise, while Section 11.4 discusses CRP's proposed best

Issues raised	Raised by (where relevant)	Comment	Assessed in the EIA (where)
		potential reserves being identified based on consideration of a range of values associated with the area assessed. Within the marine consent area, CRP has identified these areas as mining exclusion areas. However, CRP has volunteered a best endeavours condition whereby it will provide support and advocate for permanent protection of the areas identified by the spatial planning exercise. In relation to the fishing industries' international markets and the possible perception that mining should not occur in the BPA, the Economic Assessment considers that there is little likelihood of significant adverse impacts in terms of ongoing demand for New Zealand fish. CRP acknowledges that the EPA must take the existence of the BPA into account when considering CRP's marine consent application under the EEZ Act. However, this is just one of a number of factors that the decision-makers must consider and balance when deciding whether to grant CRP a marine consent for its mining proposal.	endeavours condition. Appendix 6 contains an evaluation of the likely impacts on international markets. Section 8.6.6.4 discusses the matters considered when establishing the BPA.
Potential impacts on freshwater eels migrating to the Pacific to breed	Chatham Islands' community	From available information it is considered unlikely that eels will be present within or adjacent to CRP's proposed mining area. On this basis, it is unlikely that CRP's proposed mining operations will have an adverse impact on eels.	Potential impacts on longfinned and shortfinned eels are assessed in Section 8.6.7.3.
Mining activities will interfere with sink holes and underwater aquifers present on the Chatham Rise	Iwi and Imi on the Chatham Islands	CRP is not aware of any sinkholes on the Chatham Rise, in the sense that the term is used onshore for features that have formed by dissolution of limestone. Modern swath bathymetry data have revealed a number of circular features on the Chatham Rise, but these have been attributed to methane release from gas hydrates and to iceberg furrows. In addition, CRP is unaware of any evidence of freshwater aquifers on the Chatham Rise. Freshwater aquifers are	-

Issues raised	Raised by (where relevant)	Comment	Assessed in the EIA (where)
		charged from surface waters, and as CRP's proposed mining area has been submerged for at least 40 million years it is highly unlikely that there are any freshwater aquifers in the region. There may be freshwater aquifers under the ocean near the Chatham Islands, but if so then they are more than 300 km from the mining area and would not be affected by the proposed mining activities.	
Use of chemicals, and other potentially harmful agents, as part of the mining process	Iwi and Imi on the Chatham Islands	No chemicals are to be used in the proposed mining operations, including during the on-board processing of the mined material. In relation to other potentially harmful discharges, CRP will ensure that all vessel operations meet the requirements of MARPOL and related New Zealand regulations. On this basis, all such potential discharges will be controlled in a manner that avoids any adverse impacts on the marine environment.	The nature of the mining operation is described in Section 4, while Section 12.4.4.2 describes the reasons for not using chemicals as part of the mining activity. Sections 4.7, 8.9 and 8.11 describe and assess the potential impacts associated with other vessel discharges.
Release of uranium into water and thus the Chatham Rise environment as a result of mining operations	Ngai Tahu	Although uranium is one of the elements present both in seabed sediments on the Chatham Rise and the phosphorite nodules, the uranium does not present a radioactive hazard to the environment and is not considered toxic following dispersion of the return.	Potential impacts of returns disposal on sediment and water quality, including potential impacts associated with uranium, is assessed in Section 8.5.

7.6 Summary

Consultation and engagement with interested parties has underpinned and will continue to underpin CRP's approach to this project. To CRP, effective consultation involves open and respectful dialogue which enables those with an interest in the project to provide input which is then considered. Consultation is part of the way CRP does business.

Accordingly, since the grant of MPL 50270, CRP has consulted and will continue to consult with the commercial fishing including the Iwi fishing industry ('existing interests' under the EEZ Act), Iwi and Imi, the Chatham Islands' community, the Government, other political parties and government agencies, non-governmental environmental organisations and other industry groups.

CRP has also put considerable effort into communication with the broader public by providing information through a variety of mechanisms, including CRP's website and the media.

Issues raised during consultation have been considered by CRP and changes have been made to the project to address these issues where possible. In addition, these issues have been identified and where relevant assessed as part of this EIA (refer to Table 17 above).

8. Environmental Impact Assessment

KEY ELEMENTS

- Potential environmental impacts have been assessed according to their direction (positive, neutral or adverse), extent, duration and reversibility. An environmental risk matrix was then used to derive the consequences and likelihoods of these impacts, both before and after the application of avoidance, remediation or mitigation measures. These were used to determine the level of environmental risk.
- The benthic environment will be adversely affected where phosphorite is removed from the seabed. The coarser material within the sediment will be removed and the finer material returned to the seabed. All organisms within the mining tracks will be removed.
- Drag-head operations during mining will have little impact on water quality.
- The non-phosphatic sediment will be returned at or near the seabed with as little energy as possible to reduce their dispersion. Sand-sized particles will settle to the seabed very close to the point of their release.
- The concentration of silt and clay in the water column is predicted to be relatively high close to the seabed (<10 m) during mining operations but sediment concentrations are predicted to rapidly return to ambient levels between mining cycles. The models predict elevated concentrations of suspended solids greater than 10 mg/L as lasting for more than two days extending no more than 4 km from the mining block. The direction, duration and extent of these plumes depend on tides and currents. The ambient turbidity levels on the Chatham Rise are very low.
- Modelling predicts that deposition will be greatest at the point of disposal and that deposition of 90% of silt- and clay-sized particles will be deposited within 2 km of the mining tracks.
- There is minimal risk of releasing significant amounts of chemical elements found in the sediments into the environment.
- Increased sedimentation and turbidity within the mining area will result in the death of organisms where it exceeds their tolerances. Outside of the mining area and in non-mined parts of the mining area, a range of benthic communities and habitats will remain.
- The primary long term change in habitat arising from seabed mining will consist of a shift from mixed phosphorite nodule/soft-sediment habitat to soft sediment habitats. Recolonisation of the mined area soft sediment habitats is likely to begin very quickly, in particular by mobile sediment dwelling organisms. However, development of a stable epifauna community will take a longer time.
- CRP will evaluate the practicality and feasibility of replacing areas of hard substrate, and if assessed as viable will create such habitat within the marine consent area.
- Vessel operations (e.g., noise, lights, waste) are unlikely to have a significant environmental impact.

8.1 Introduction

In preparing an EIA, a structured process is followed whereby the potential impacts associated with a proposed project are identified, assessed, avoided, remedied or mitigated (if possible), and monitored once the project commences. Such a process has been utilised to quantify the nature and extent of the potential impacts associated with CRP's proposed mining operations on the Chatham Rise. This process also follows the impact assessment requirements of the EEZ Act.

To identify and assess the scale of the likely impacts associated with CRP's proposed mining operations a specific methodology, as outlined in Section 8.2, has been followed. This methodology has involved identifying all of the likely impacts associated with the proposal, undertaking an assessment of the scale (nature and extent) of the potential impact, and then identifying whether measures can be put in place to avoid, remedy or mitigate the potential impact.

Given this process, the following sections, based on specific technical assessments that have been carried out and which are appended to this EIA, assess the potential impacts of mining on water quality and sediment deposition away from the mining areas, and impacts on the values of the Chatham Rise environment and other users. The potential impacts of the proposed mining operations in relation to social (including existing interests), cultural and economic considerations are assessed in Section 9.

8.2 Impact Process and Approach

8.2.1 Scoping of potential impacts

Accepted best practice for EIAs involves an initial scoping of the potential environmental issues associated with a project. This then enables the need, or otherwise, for baseline data gathering and subsequent impact assessments (including specific technical assessments) to be identified.

For CRP's proposed mining project, the scoping exercise consisted of establishing a core project team with the skills and knowledge to identify the potential environmental issues associated with the project. This team then reviewed, in conjunction with NIWA and Deltares (through Boskalis), the existing data and information that were available. This broader team then determined whether sufficient information was available to ascertain the nature of potential impacts associated with the proposed mining operations, or whether it was necessary to commission additional technical assessments or carry out additional consultation to assess the potential impacts of the proposal. This evaluation process has been ongoing throughout the development of the project and the preparation of this EIA. The consultation that has been carried out is described in Section 7. This consultation further informed the evaluation process outlined above.

To supplement the scoping exercise, in early 2011 a Gap Analysis was carried out to identify information gaps relevant to the preparation and completion of this EIA. As a result of these processes, the potential impacts of the proposed mining operations have been identified and assessed as outlined within this EIA (this section as well Section 9) and the appended technical assessments.

8.2.2 Impact assessment approach

The impact assessment approach used for this EIA relies on the outcomes of the specific technical assessment that has been carried out. To determine the significance of the potential impacts, a range of specific criteria related to the direction of the impact, its extent, duration and reversibility of the impact have been considered (refer to Table 18 below).

Table 18: Impact assessment approach.

Direction	Extent	Duration	Reversibility
• Positive • Neutral • Adverse	• Near-source confined (within the mined areas) • Unconfined • Widespread	• Short-term (<6 months) • Medium-term (6 months to 10 years) • Long-term (>10 years)	• Reversible • Irreversible

The assessment criteria that apply to any specific potential impact have been combined to identify a consequence (ranging from minor to catastrophic) and likelihood of the potential impact (ranging from rare to almost certain). These potential consequences and likelihoods of an impact are described as follows:

- Potential consequences are categorised as:
  - **Minor.** Near-source confined and promptly reversible impact on-site, with little or no off-site impact expected (i.e., beyond the mining area).
  - **Medium**. Near-source confined and short-term reversible impact on-site, with little and promptly reversible off-site impact.
  - **Serious**. Near-source confined and medium-term recovery impact on-site, with near-source confined and short-term reversible off-site impact.
  - **Major**. Impact is unconfined and requiring long-term recovery, leaving residual damage on-site with near-source confined and medium-term recovery of off-site impacts.
  - **Catastrophic**. Impact is widespread and requiring long-term recovery, leaving major residual damage on-site with off-site impacts that are unconfined and requiring long-term recovery and leaving residual damage.
- The likelihood of consequences occurring are categorised as:
  - **Rare.** Event that is very unlikely to occur during the lifetime of the project
  - **Unlikely.** Event that is unlikely to occur during the lifetime of a project
  - **Possible.** Event that may occur during the lifetime of the project
  - **Likely.** Event that may occur frequently during the lifetime of the project
  - **Almost certain.** Event that will recur during the lifetime of the project

Using the environmental risk matrix in Table 19, the assigned 'consequence' and 'likelihood' categories, both before and after the application of avoidance, remediation or mitigation measures, have then been used to determine the level of environmental risk (i.e., low to serious risk).

Table 19: Environmental risk matrix.

LIKELIHOOD		CONSEQUENCE				
		Minor	*Medium*	*Serious*	*Major*	*Catastrophic*
LIKELIHOOD	***Almost certain***	H	H	S	S	S
	Likely	M	H	H	S	S
	Possible	L	M	H	S	S
	Unlikely	L	L	M	H	S
	Rare	L	L	M	H	H

Key:

- (green) ***L*** ***Low risk***
- (yellow) ***M*** ***Medium risk***
- (orange) ***H*** ***High risk***
- (red) ***S*** ***Serious risk***

The impact assessment approach outlined above has been utilised within this EIA (Sections 8 and 9) to identify the environmental risk of each potential impact generally before and after the application of avoidance, remediation and mitigation measures.

8.3 Immediate Impacts of Seabed Disturbance from Drag-head Operations

8.3.1 Introduction

This section provides an overview of the seabed disturbance associated with the mining activities at the drag-head (i.e., it excludes the return of the processed non-phosphatic material). This overview of the activities within the immediate vicinity of the drag-head provides context for the assessment of potential impacts discussed in subsequent sections of this EIA.

The mining activities, in the vicinity of the drag-head, are:

- Disturbance and removal of the seabed at the point of mining (i.e., in and around the drag-head).
- Entrainment of biota.
- The generation of a localised suspended sediment plume around the drag-head.
- Localised sedimentation.
- Changes to water quality arising from the removal of seabed material by the drag-head.

These activities will subsequently impact on sediment characteristics, water quality and on ecological resources, and are discussed in Sections 8.5 and 8.6, respectively.

Although the drag-head operations and the return of non-phosphatic material to the seabed are not independent processes in that both generate suspended sediment and sedimentation, the potential physical impacts of the disposal of the returns to the seabed are considered separately (refer to Section 8.4).

In addition, it is noted that the disturbance of the seabed associated with CRP's environmental surveying and monitoring programme (refer to Section 4.4.7) will not be dissimilar to those associated with the drag-head operations. However, the scale of these activities and their impacts are negligible in comparison to those associated with the drag-head operations principally due to the fact that only a very small area of seabed will be disturbed (no more than 2 m^2) at any one time, and the disturbance occurs for a significantly shorter period of time (less than an hour at any one time compared to a number of days).

8.3.2 Disturbance of the seabed during mining

The removal of seabed material to the mining vessel for processing involves the disturbance associated with moving a drag-head across the seabed surface. This activity is described in Section 4.4, and the impacts of the loss of the seabed are assessed in Section 8.6. This information is not repeated within this section of the EIA.

The mining activity requires the loosening of the surface 30 to 50 cm of seabed. Loosening of the sediment will be carried out using water jets but could also be assisted by cutter-teeth within the drag-head. The drag-head is designed to pick up the material loosened inside the drag-head visor[27], but, depending upon the rate of loosening in relation to the suction flow, some seabed material may escape and form a localised sediment plume immediately above the seabed. Minimisation of the disturbance and the size of the plume depends on tuning of the jet pressure and volume, the dredge-pump driven suction flows and the speed of the traverse.

Significant pressures (at least 4 bar) are required to fluidise the phosphorite-bearing surface sediment and the shear stress generated by the drag-head may scour the material underlying the surface sediment (Oligocene chalk). The water for the jets within the drag-head comes from a pump and intake located above the drag-head about 20 m off the seabed.

Boskalis has incorporated measures to minimise the likelihood of these potential impacts into the design of the mining system. These are outlined in Section 8.3.6.

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[27] Material in excess of 150 mm is screened at the drag-head and therefore is not removed from the seabed for processing on-board the mining vessel.

8.3.3 Entrainment of biota

As the drag-head is pulled slowly by the vessel (velocity across the seabed is equal to the vessel speed, about 0.75 m/s), it is expected that any fish within its path will be disturbed as it approaches and they will move away from the drag-head. The drag-head sits firmly on the seabed. Although the drag-head assembly is a large piece of equipment (about 50 t) it is supported by wires from the mining vessel and has a seabed contact pressure of only a few tons.

The drag-head will entrain any biota on the seabed immediately underneath it. This could include any mobile or infaunal organisms in the mining track.

The water intake for the drag-head jets will have moderate velocities but as it is 20 m above the seabed, it have no impact on biota on or immediately above the seabed.

Although some biota can survive conventional suction dredging (e.g., Drabble 2012), it is unlikely that any macro-biota will survive CRP's mining operations. The sediment and nodules are lifted to the vessel by three centrifugal pumps in series which raise the pressure by 20 bar (above the 40 bar natural pressure). The material flows through the 400 m riser pipe, plus a further 50 m of on-board piping at a velocity of about 7.5 m/s. During the travel through the pipes and pumps, the sediment and nodules vigorously collide with other material and the pipework. Once on-board the pressure decreases from 60 to 0 bar and material passes through a series of rotating drums and washers which exert hydraulic and on the material to break up lumps of sediment. The material will also be exposed to air. It is expected that no biota will survive, with most fragile organisms, including corals, being fragmented into relatively small pieces and soft biota broken into smaller pieces and particles.

Drabble (2012) described the characteristics that made biota vulnerable to entrainment while trailing suction hopper dredgers were working. Traits that made species sensitive to being caught by dredging include a low sensitivity to noise, low burst speed (i.e., cannot move away quickly) and burying themselves in sediment when threatened. Entrainment rates have been estimated for a variety of dredging activities. Drabble (2012) presented entrainment data for relatively small drag-heads (1.4 m). Clausner & Jones (2009) have identified that cutter suction drag-heads generate increased velocities in the water adjacent to the drag-head. These increase as the head diameter increases and decrease with distance from the intake such that for a suction pipe with a diameter of about 1 m, the intake velocity at 1 m from the cutterhead was 0.5 m/s but by 2 m the velocity was <0.1 m/s. Drabble (2012) concluded that for a medium sized drag-head an impact zone of about 2 m was realistic for fish that had poor avoidance behaviour. For CRP's operations, as the drag-head utilises water jetting to loosen the seabed, the intake velocities around the skirt of the drag-head are reduced and the area of influence in terms of entraining biota beyond the drag-head footprint is considered to be low, in the order of 0.25 to 0.5 m.

The potential impact of the proposed pump intake on fish and other pelagic biota is dependent on the abundance of fish and other organisms, and their response to noise and disturbance (especially their avoidance response). The zone of influence of the pump intake is determined by the velocity profile adjacent to the intake as water is drawn into the intake pipe. Non-motile biota will be entrained along with larvae and eggs. It is likely that the zone of intake influence will be about 2 m similar to that noted above by the Drabble (2012) study.

Overall, the drag-head will entrain all epifauna and infauna on and in the seabed along the mining track. Any megafauna that enter burrows will be included with the material retrieved by the drag-head. There is a small possibility for the entrainment of fish and other biota immediately adjacent to the skirt of the drag-head. The jet water pump may entrain non-motile biota in the water column about 20 m above the seabed. The ecological impacts associated within this are assessed in Section 8.6.

8.3.4 Local water quality changes from drag-head operations

The principal change in water quality due to drag-head operations will be an increase in suspended sediment concentrations.

As noted in Section 8.3.5, some escape of sediment is expected at the rear of the drag-head. However, as the release occurs within a short distance of the larger post processing return of non-phosphatic material from the mining vessel (about 40 m away and about 10 m above the seabed), the relative scale of potential change is considered minor in comparison. Concentrations of most trace elements in the host sediments are relatively low and/or trace elements in the sediments have not been shown to be readily mobilised relative, therefore water quality changes would be minimal in the vicinity of the drag-head (Golder 2014a).

Disturbance of sediment during dredging results in the mixing of pore water in surface sediments with overlying seawater and the release of surface bound constituent as the suspended particles interact with the seawater above the seabed (within the drag-head). When studies of dredging impacts are carried out the potential for the release of contaminants (trace elements, organic compounds, nutrients, and oxygen demanding substances) are considered. The release is typically assessed using a test called the elutriate test which was developed to provide an estimate of potential water quality changes that might arise during the mixing of sediment with seawater during the dredging process (USACOE 1976, Jones & Lee 1976, PIANC 1986, Ludwig et al. 1988, Digiano et al. 1995).

In relation to CRP's proposed operations, mixing of sediment and seawater occurs within the drag-head and the water is pumped up the riser to the mining vessel. Some changes in water quality may occur in the vicinity of the drag-head, arising from minor physical disturbance and from the loss of sediment at the rear of the drag-head, but these are very minor by comparison with the volume of water and non-phosphatic material returned to the seabed. These impacts are assessed in Section 8.5.

The impacts from the drag-head operations on water quality immediately above the seabed will be:

- An increase in suspended sediment concentrations.
- A corresponding decrease in water clarity.

These potential impacts will be localised, i.e., restricted to the relatively small plume generated by the drag-head. The extent of these impacts will depend upon the degree of seabed disturbance and the amount of leakage produced (refer above). The use of a drag-head connected by a flexible riser to the mining vessel ensures that sediment is not introduced into the middle or upper water column during mining.

Internationally a variety of techniques have been used to monitor the concentrations of suspended sediment generated by seabed dredging. In New Zealand, Priestley (1995) summarised environmental impacts of dredging (suspended solids) and found that a large suction dredger working in the Waitemata Harbour did not increase downdrift suspended solids concentrations significantly. The amount of down-drift total suspended solids is dependent on a range of factors, and published data (e.g., Anchor Environmental (2003)) indicate that 80 % of hydraulic dredging produces suspended solids concentrations of <100 mg/L (Figure 121). While this data is of some interest, it is important to note that the data are only representative of drag-head operations and do not relate to the return of the non-phosphatic material to the seabed from CRP's proposed mining operations.

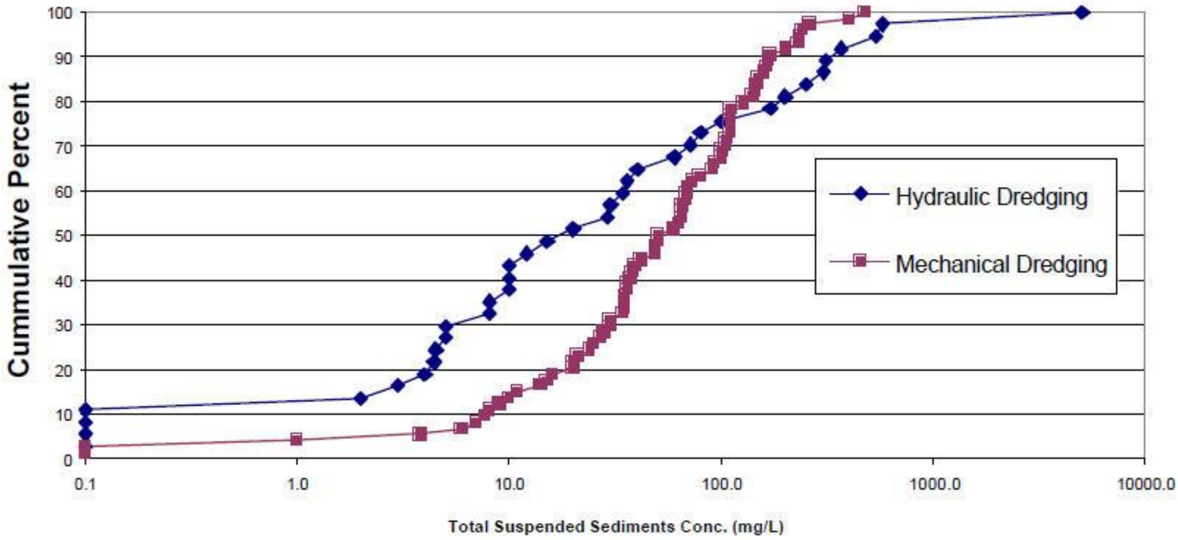

Figure 121: Cumulative percent suspended solids concentrations (above background) for mechanical and hydraulic dredging (From Anchor Environmental 2003). Hydraulic dredging produces lower concentrations of suspended sediments than mechanical dredging.

Drag-head operations will produce some suspended solids, but these concentrations will be minor compared with those of the return of the processed non-phosphatic material to the seabed.

8.3.5 Sedimentation impacts from the operation of the drag-head

Two aspects of the drag-head operations may cause local sedimentation impacts. As outlined in Section 8.3.2, excess fluidising pressures and drag-head stress may disturb sediments underneath the target layers and mobilisation of the Oligocene chalk may affect the behaviour of the return of the non-phosphatic material to the seabed. The other possible local impact is the leakage of mobilised sediments at the drag-head.

Leakage will occur if sediments escape the edges of the drag-head, or if the jet slots do not merge and material is lost through these slots. It is predicted that a maximum of 25 % of material mobilised by mining may be spilled immediately behind the drag-head. Only the finer fraction of this spilled material may be brought into suspension in the wake of the drag-head.

Once released into the water column, the extent of the plume of suspended sediment produced by seabed disturbance (resulting from drag-head operation) may depend on (Deltares 2014b – Appendix 25) the size of the particles in suspension and the currents.

The volume of material spilled from the drag-head will be much smaller than the adjacent disposal of the returns. Based on experience associated with the use of drag-heads within the dredging industry, sediment plumes generated from the drag-head are predicted to be relatively small and restricted to the immediate areas of the mining blocks.

8.3.6 Avoidance, remediation and mitigation measures

Potential localised sedimentation and water quality impacts will be mitigated by the development and implementation of drag-head technology designed to minimise spill and by controlling the excavation and suction rates.

CRP will avoid the potential immediate impacts associated with seabed disturbance and localised sedimentation associated with the proposed mining operations (i.e., operation of the drag-head) through the implementation of the following measures:

- The drag-head will be designed to minimise spill by making it as narrow as possible without adversely affecting the rate of production (approximately 6 m).
- The multi-jet drag-head will be adopted, using a series of lower pressure jets rather than a few high pressure jets (if this is the option adopted for loosening the seabed material).
- Refining the drag-head design to minimise leakage and to ensure that the maximum amount of mobilised material is returned to the mining vessel.

The adoption of these avoidance measures will minimise the impacts described above. By adopting these measures, impacts on the environment are neutral to adverse, near-source confined (almost entirely within the mining tracks), short-term and reversible (water quality will return to ambient). The potential consequences of the impacts are considered to be minor and the likelihood is possible, and therefore the potential environment risk is considered to be low.

8.3.7 Summary

Through the development of avoidance measures incorporated into the mining design (as outlined in Section 8.3.6 above) any localised sedimentation and water quality change impacts associated with drag-head operations are considered to be of low environmental risk (as they occur within the defined mining areas).

8.4 Physical Impacts of the Disposal of the Returns

8.4.1 Introduction

In this section the potential physical impacts of the return of the processed non-phosphatic material to the seabed are described. They are:

- Development and dispersal of a sediment plume.
- Subsequent sedimentation.
- Resuspension of deposited sediments.

The potential impacts on sediment, water quality and ecological resources from the disposal of the non-phosphatic material are assessed in Sections 8.5 and 8.6 respectively.

The nature of the mining activity is described in Section 4 and is not repeated here. However, for this section of the EIA it is important to note that each mining block covers an area of 5 by 2 km, and will take approximately 14 weeks to be mined over a sequence of mining cycles. In each mining cycle the mining vessel works until the holds are full then heads to port before returning to the site to recommence mining. The time spent mining, in transit, and unloading will depend on the final vessel design and the load it is able to transport. There will be approximately 10 mining cycles required to mine each mining block.

To provide context for the modelling results that follow, as outlined in Section 5.7.3, the background total suspended solids (TSS) concentrations in the water near the seabed at the Chatham Rise range from approximately 0.1 to 1 mg/L (mg/L equals g/m^3).

8.4.2 Background - returns plume modelling

8.4.2.1 Introduction

The phosphate resource comprises about 15 % of the seabed sediments, so on average about 85 % of the material processed on the vessel will be returned to the seabed. These returns will consist of the sand, silt and clay fractions of the sediments (smaller than 2 mm diameter). The returns will be released about 10 m above the seabed through a diffuser that reduces their velocity so that when released from the fall pipe they are nearly stationary relative to the seabed. The sand is relatively dense and will settle almost immediately. The silt and clay will remain in suspension longer and their pattern of deposition and dispersal through the water column will be a function of oceanographic conditions.

Numerical modelling assuming summer oceanographic conditions, which are the most variable and widespread in terms of the extent of the plume, and discharge 10 m above the seabed predicts that more than 50 % of the silt and clay fraction will be deposited within 0.5 km of the mining block, 75 % within 1 km and 90 % within 2 km. These models predict that the concentration of suspended sediments will be elevated above ambient levels (> 1 mg/L) in the water layer immediately above the seabed, and may extend at least 15 km from the mining block. It is unlikely that any part of the water column will have significantly elevated levels of suspended sediments for more than a few days at a time. The distribution of areas with elevated levels of suspended sediments will be variable, determined by the oceanographic conditions, but are predicted to always be less than 50 m and usually less than 20 m above the seabed. Areas with higher concentrations are predicted to occur near the mining block and to dissipate rapidly.

Hadfield (2013) and Hadfield et al. (2013) (Appendices 23 and 24) developed the preliminary models to describe the development of sediment plumes created by the return of the non-phosphatic material. Subsequently, extensive modelling has been undertaken by Deltares to understand the effects of the disposal of sediment following the removal of nodules. The modelling examined a several disposal alternatives in a sequence of studies that refined the understanding of the dispersal of suspended solids and the sedimentation arising from the transport of particles. The four scenarios examined for the disposal of the returns by Deltares (2014b) (Appendix 25) were:

- Mid-depth disposal.
- Disposal 5 m above the seabed.
- Disposal 10 m above the seabed.
- Disposal on to the seabed.

The results of Hadfield (2013) and Deltares (2014b) guided the decision to return the processed non-phosphatic material at or near the seabed (i.e., no more than 10 m above the seabed, on average), as outlined in Section 4. An overview of this modelling is provided in this EIA as it assists in identifying the characteristics of the sediment and plume behaviour.

A sequence of hierarchical modelling has been undertaken to develop an understanding of the dispersion and sedimentation of sediment released into the waters on the Chatham Rise following processing on board a surface mining vessel. The modelling undertaken by Deltares of suspended solids and sedimentation used a variety of inter-dependent modelling tools. The primary tool was Delft3D.

Delft3D is a globally recognised integrated modelling suite which simulates two-dimensional (in either the horizontal or a vertical plane) and three-dimensional flow, sediment transport and morphology. The application of this model to the Chatham Rise sediment dispersion and sedimentation fits well within the capability of the software. Modelling specialists from Deltares, NIWA and also from the NIOZ (Netherlands Institute for Sea Research) have reviewed the modelling results.

8.4.2.2 Initial plume modelling (NIWA)

Hadfield (2013) (Appendix 23) used the ROMS model (a widely used ocean/coastal model) to carry out preliminary modelling of sediment disposal. These models highlighted the importance of the height of discharge and local bathymetry on the predicted plume dispersion, and the need for more detailed three-dimensional models to adequately understand the dynamics of plume behaviour.

The modelling examined the discharge of sediment at six points in the water column in a 500 by 440 km domain with a 2 km horizontal resolution. These six points represented discharges at heights of 4, 12.5, 25 and 50 m above the seabed, and 200 and 10 m below the sea surface. Four different sinking-velocities were used: 0, 10^{-3}, 10^{-4} and 10^{-5} m/s and zero (or 86.4, 8.64 and 0.864 m/d). The three non-zero sinking velocities correspond to grain sizes of approximately 500 (medium-coarse-sand), 40 and 20 µm (medium-silt), and the smaller particles below 20 µm.

The modelling indicated that particles released near the sea surface are dispersed by ocean eddies. The patterns (refer figures in Hadfield 2013 – Appendix 23) in the trajectories were due to tidal oscillations which moved the particles in an ellipse approximately 2.5 km in size. Particles released near the seabed followed a similar pattern to the surface discharges but did not move as far and were not so widely dispersed.

The vertical dispersion of particles modelled by Hadfield (2013) showed that:

- Particles with zero sinking velocity released 10 m below the sea surface were mixed rapidly through the surface wind mixed layer, up to 140 m deep.
- Particles released 200 m below the surface remained within a relatively narrow vertical layer. The slight acceleration in the growth of this layer at seven days was not a result of turbulent mixing, but of vertical divergence of particle trajectories as the flow they were in encountered changing bathymetry.
- Particles released within 25 m of the bottom were influenced by a similarly turbulent near-bottom layer, typically 30 m thick, which was driven by shear from tidal currents. Vertical mixing was much weaker between the near-surface and near-bottom turbulent layers.
- Particles released 50 m above the bottom were not immediately affected by the near-bottom turbulence, but some were eventually mixed down (after eight days). Again, much of the vertical growth of the layer of particles (i.e., plume thickness) was a result of bathymetry.
- Of the particles released near the surface, most sank to the bottom after four to six days. The particles that took the longest were the ones detained in the near-surface turbulent layer.
- Particles released at 200 m depth took 2.5 days to reach the bottom. Particles released at ≤50 m above the bottom sank to the bottom within one day, although some were briefly held up by turbulent mixing.

When the sinking rate was reduced by a factor of 10, to 10^{-4} m/s (Figure 9 in Hadfield 2013 – Appendix 23) the effects of sinking were qualitatively similar but much less marked. The plume of particles released at 200 m depth sinks by approximately 80 m over 10 days, as expected. Of the particles released 10 m below the surface, some sank well below the surface turbulent layer, but many remained close to the surface. For particles released within 50 m of the bottom, the plume settled down to a quasi-steady state up to 20 m above the bottom, but was progressively depleted as particles were deposited on the seabed. When the sinking rate was reduced to 10^{-5} m/s, the effect of sinking was barely perceptible in the model outputs (refer Hadfield 2013).

Hadfield (2013) showed that in relation to vertical mixing within the first 50 m above the seabed, the role of internal tides, eddies, and mean flow would have a significant impact on the behaviour of plumes created by the seabed mining. In addition, variance between the fall speeds (settling rates) of different particles meant that the composition of the plume would also affect its behaviour. It was shown that particles would travel relatively long distances with the distance being greater for particles with very low fall velocities and particles released in the upper water column (e.g., release at 10 m below the sea surface would result in particles traveling up to 170 km from the source).

The initial Hadfield (2013) modelling was followed by some additional assessment reported in Hadfield et al. (2013) (Appendix 24). The additional modelling used a fluid dynamics model ('Gerris'[28]). The model was run for four disposal depths (50, 25, 12.5 and 4 m above the seabed). Again, particle settling speeds of 10^{-3}, 10^{-4} and 10^{-5} were used, corresponding to medium-coarse sand (500 µm) to very fine silt (5 µm). Modelling also examined smooth and rough seabed conditions.

The modelling demonstrated the relationship between discharge height and particle size (settlement speed) with the amount of lateral dispersion and sedimentation, recognising that this preliminary modelling was two dimensional and run for only a few tidal cycles. Hadfield et al. (2013) reported a wide range of factors will influence particle dispersion and settling, and the modelling probably captured the key aspects of sediment plume movement following the return of the non-phosphatic material at different depths.

Overall, the key points from this modelling were:

- Uneven bathymetry (in a general sense) may result in more upward movement and down-flow, with the tidal flow producing plumes up to 1,500 m from the source that could be detected up to 90 m above the seabed (for fine sediment particles).
- As release occurs closer to the seabed, coarse material sinks to the seabed at the release point with considerably reduced horizontal dispersion. Finer material remains in suspension but the distances before settling are shorter.
- For the release that was modelled closest to the seabed (4 m), the vertical movement of the plume is lower than identified earlier – about 30 m.

The early modelling reported by Hadfield et al. (2013) provided information on the potential for upward movement of particles within the water column. Hadfield et al. (2013) noted that sediment trap information indicates that naturally increased suspended sediment concentrations have been measured up to 150 m from the seabed (refer to Section 5.7.3.2). This is discussed further in relation to the modelling undertaken by Deltares.

The modelling by Hadfield et al. (2013) indicated that disposal of the returns at or near the seabed would minimise the impacts of the mining, and that additional modelling was required to predict the likely results in more detail.

8.4.2.3 Deltares modelling

The Deltares modelling (2014b) (Appendix 25) expanded on the initial NIWA modelling, primarily using measured bathymetric and oceanographic information from the mining permit area to predict the behaviour and variability of sediment dispersal resulting from mining a 10 km^2 area of seabed (a complete mining block).

[28] http://gfs.sourceforge.net/wiki

The modelling was completed in stages and comprised:

- Examination of two discharge or return scenarios that assumed discharge of sediment at 5 and 200 m above the seabed (Section 3 of Deltares 2014b).
- Examination of a single cycle and a 10 cycle scenario assuming discharge of sediment (the returns) at the seabed and at 10 m. This assessment used data from the moored ADCP resulting in improvements (using site specific project data) from that used in the first set of modelling undertaken (Section 4 of Deltares 2014b).
- Re-evaluation of the modelling used optimised information (Local Delft3D model relocated the centre of the modelled area to the ADCP site, improved sediment size information, etc.). This was initially undertaken for one cycle of the mining operation (i.e., mining until the vessel is fully loaded) with disposal at the seabed and at 10 m above the seabed. This was then followed by running the model for multiple mining cycles (five and ten cycles equating to operation periods of about 45 and 90 days) with disposal at the seabed and at 10 m. This provided a closer approximation of the mining of a complete mining block. Refer to Section 5 of Deltares 2014b for further information.
- Following the optimised modelling a series of validation assessments was carried out to identify how well the model reflected the real world on the Chatham Rise (Section 6 of the Deltares 2014b). The assessments included re-checking the input information used in the modelling.

Plume modelling by Deltares using Jet3D (a near field jet-flow model) and Delft3D used a large scale regional model within which two domains were nested (North and South domains - refer Figure 122). The detail for the northern and southern local domains used in the earlier phases of modelling are in Deltares (2014b) (Appendix 25 - Section 2.3 of that report). The optimised local modelling domain used in the Deltares modelling is shown in Figure 123.

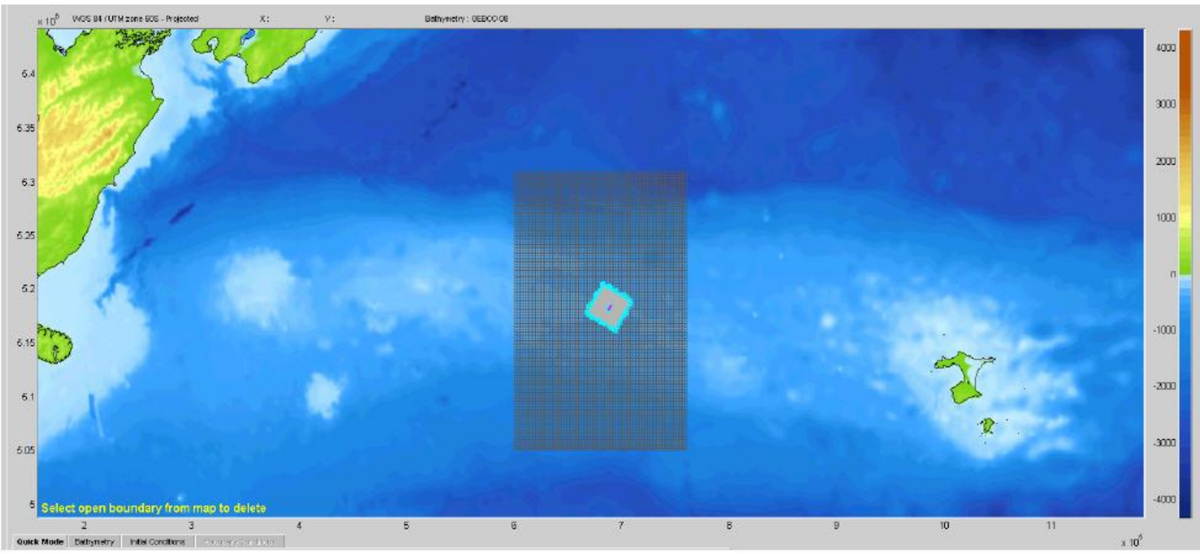

Figure 122: Regional Delft3D modelling domains (within the Delft Dashboard) (from Deltares 2014b).

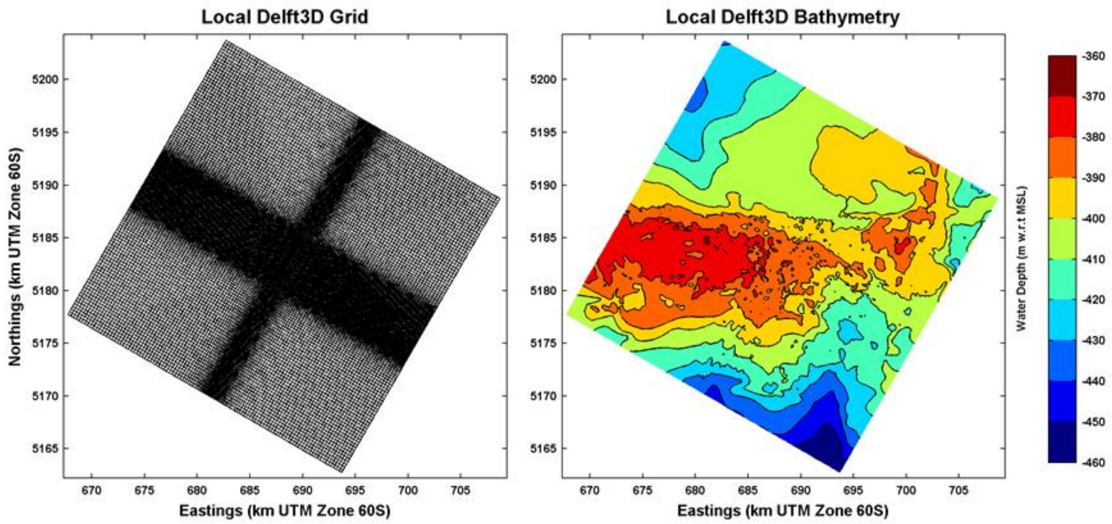

Figure 123: Detailed model grid and bathymetry for the local Delft 3D optimised domain (from Deltares 2014b). The model grid covers an area of 30 by 30 km. Note the varying grid spacing of the model grid. The grid resolution is 75 by 75 m in the mining area, decreasing to 300 by 300 m at the grid boundaries.

Modelling is carried out in three dimensions within areas of the Chatham Rise where mining is expected to occur. For the purposes of modelling, 'local' areas were defined as grids of 30 by 30 km. An average depth of 400 m was assumed (range 360 to 460 m). The progression of modelling included changes in the model inputs and other factors as the modelling was refined and as new local information came to hand. Sediment grain size detail was refined slightly as new information from the 2012 field surveys became available (refer identified adjustments in grain size used in modelling in Deltares 2014b). The local domain was moved following the earliest model runs to be centred on the location where the current data were collected in 2011 (the mooring location).

The modelling includes the water column between the seabed and the sea surface. The vertical resolution of the water column changed between the early modelling and the most recent (i.e., the more recent modelling has five more layers than the earlier model). The 30 layers utilised range from 0.25 % of depth at the surface, to 14.569 % in layer 14 in mid water, to a bottom layer 23 cm thick (i.e., fine layers at the sea surface and seabed and coarser between). Scenarios were run for spring (September 2011), winter (July 2011) and summer (February 2011).

All far-field modelling excluded sand sized particles and larger as it was expected that sand will fall immediately to the seabed if the diffuser is at or near the seabed (i.e., within 10 m of the seabed).

The 10 m disposal option is the designated option at this stage. However, the following sections present the results of the modelling undertaken for disposal at the seabed and at 10 m for comparison. The 'at seabed design' of the diffuser requires further design evaluation due to the higher degree of vertical height control required.

8.4.2.4 Modelling features

In the Deltares (2014b) modelling the mining tracks are located around the ADCP mooring location. For this modelling, the mining process had the following features:

- Mixture outflow 2.15 m^3/s (0.31 m^3/s solids and 1.84 m^3/s water).
- Mixture density 1,265 kg/m^3.
- Sediment release rate is 827 kg/s.

- 44 % and 8 % of sediment mined has a particle size smaller than silt (60 µm) and clay (4 µm) size, respectively.
- Sediments are released on or near the seabed.
- Release velocity is 0.75 m/s (the same as the sailing speed).
- Turns between tracks take 0.28 hours (no production during this time).
- Tracks progressively shift outwards after each round.

Figure 124 illustrates the mining cycles and the model visualisation of the single cycle mining tracks.

As the model cannot resolve the detail in the mining cycle track spacing, single tracks were established running the length of the mining area and these were repeated until the desired amount of sediment had been mined (about 1.2 million m^3).

It is important to note that the modelling outputs from Delft 3D are considered conservative. The conservative assumptions in the modelling are:

- There is no natural flocculation or induced flocculation as the returns are not going to be chemically treated.
- There is no burial of fines by coarser sediments during settlement.
- There is full segregation of all particle sizes.

There are also a number of non-conservative assumptions in Deltares (2014b) (Appendix 25) including: there is no resuspension of sand, the average silt settling velocity is 0.25 mm/s and the silt settling velocities vary by up to ten times depending on particle size and particle properties.

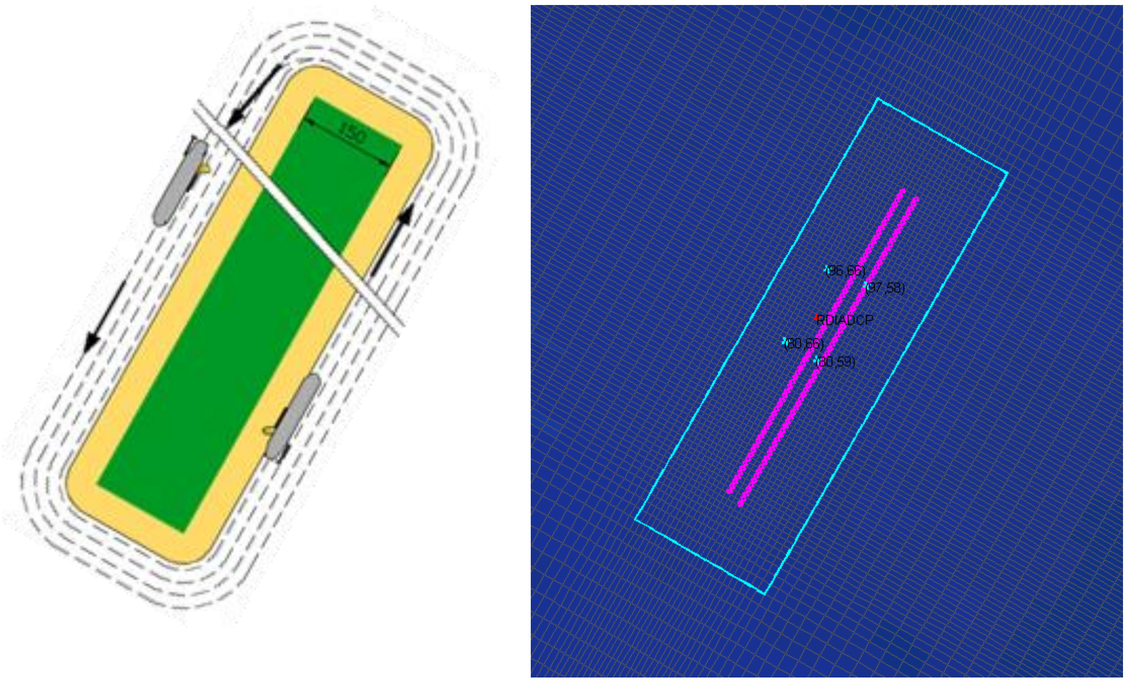

Figure 124: Schematic of mining tracks (left) and model interpretation in the single cycle model (pink line, rights) within a mining block (ADCP mooring is located to the left of the pink lines, approximately half way along – refer to the red cross) (from Deltares 2014b). The green area reflects the unmined strip in the middle and the yellow area is an area of sedimentation predicted when disposal occurs at the seabed.

8.4.3 Suspended sediment

8.4.3.1 Single cycles

Introduction

Deltares (2014b – Section 4) modelling outputs for three modelled seasons (spring, summer and winter) show that the plume dispersion patterns are similar for spring and winter with a north to northwesterly direction of transport. During the summer season dispersion is evident to the northwest and southwest, and the plume spreading is generally larger. This section emphasises the model outputs for the summer season as they are the most variable and widespread, in terms of plume extent, and therefore represent the worst case.

Graphical model outputs are provided in the form of vertical silt and clay distribution in the mining area, snapshots of the spatial distribution of clay and silt in and adjacent to the mining area during the period of mining, and maps that show how often the concentration of silt or clay exceeds a threshold.

Deltares (2014b) presents results for both the discharge at seabed and at 10 m above the seabed. In this section of the EIA, model results for discharge 10 m above the bed are presented. The graphical output for the spring and winter model outputs and for disposal at the seabed are in Deltares (2014b) (Appendix 25).

Vertical changes

Figure 125 illustrates the vertical changes in clay and silt concentration above the seabed during a single summer mining cycle. The effects are predicted to mainly remain close to the seabed as discussed below.

The figure shows silt and clay concentrations at two locations northwest of the disposal tracks. Relatively high sediment concentrations (greater than 20 mg/L, comprising 10 mg/L of both silt and clay) are only predicted during the mining activities and within 10 m of the seabed. The model figure scale is in g/L (0.001 g/L = 1 mg/L and 0.01 g/L = 10 mg/L).

Concentrations of 5 mg/L while mining are predicted to occur infrequently (see lower clay graphic in Figure 125) as high as 15 to 20 m above the seabed for the silt and clay fractions, respectively.

Horizontal changes

Deltares (2014b) illustrates the spatial changes in silt and clay concentrations during a single cycle of mining. Results are presented in graphical form for summer and winter, for discharge at and above the seabed, and for concentrations at the seabed and at 10 m above the seabed. Refer to Deltares (2014b) for complete graphical outputs for the modelling scenarios.

Figure 126 shows the spatial distribution of silt concentrations near the seabed from disposal at about 10 m within the modelling domain in summer. Concentrations are predicted to be high adjacent to the track (100 to 1,000 mg/L) but within about 5 km of the disposal location concentrations are similar to ambient concentrations (< 1 mg/L).

Figure 127 shows the spatial dispersion of clay near the bed during summer from disposal at 10 m. Clay is predicted to disperse farther than silt, with concentrations of 1 to 5 mg/L extending to the edge of the domain (about 15 km from the mining block).

Figure 128 shows the seasonal variation in near bed concentrations of both silt and clay.

Concentrations following multiple cycles of mining within a block are described in the following section.

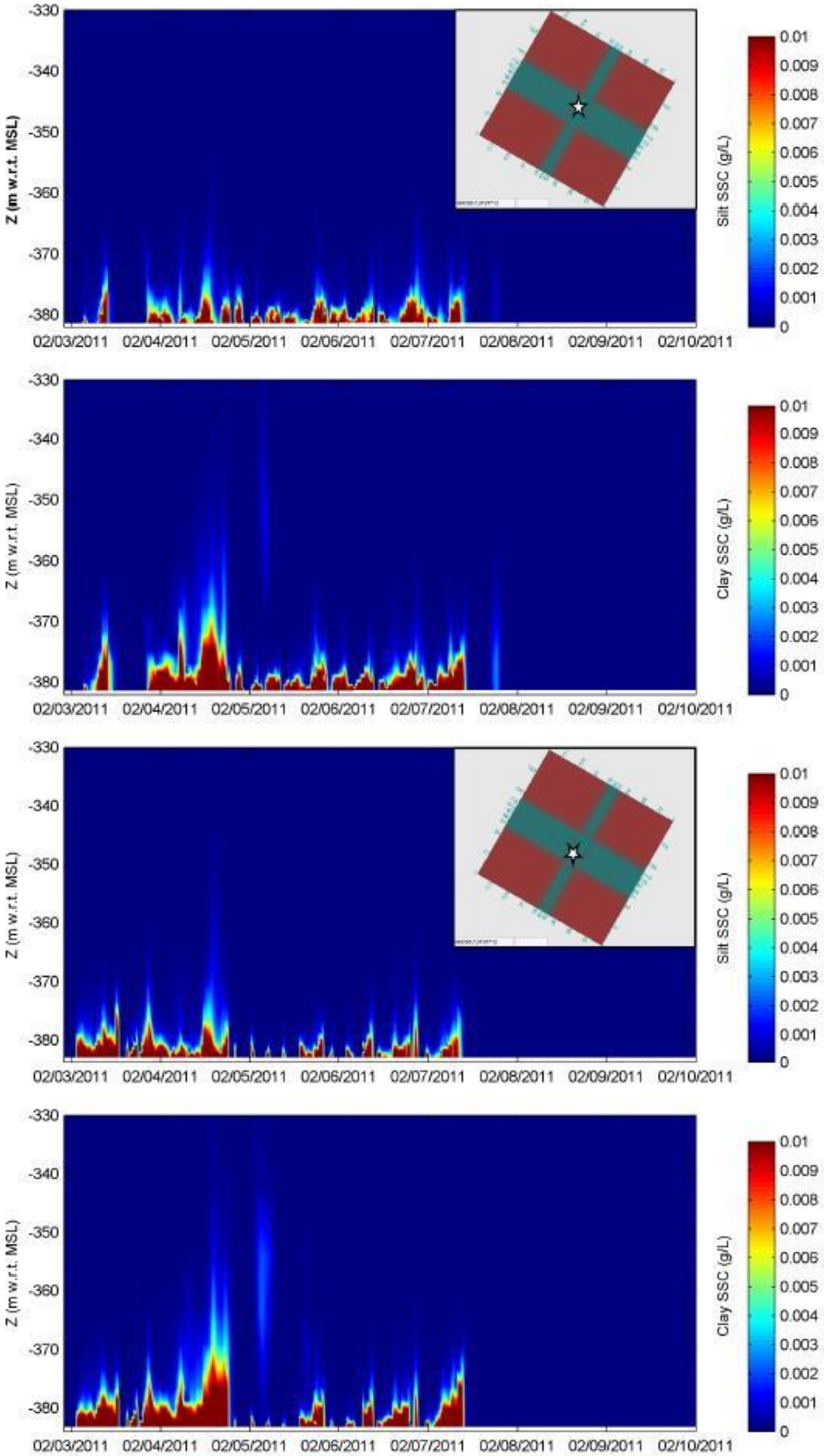

Figure 125: Modelled suspended solids concentrations over a single cycle of seabed mining in summer for silt (top) and clay (top-middle) at the IX-survey mooring location and silt (bottom-middle) and clay (bottom) just NW of the disposal tracks. (all colour data in g/L) (inset shows location of observation points) (from Deltares 2014b).

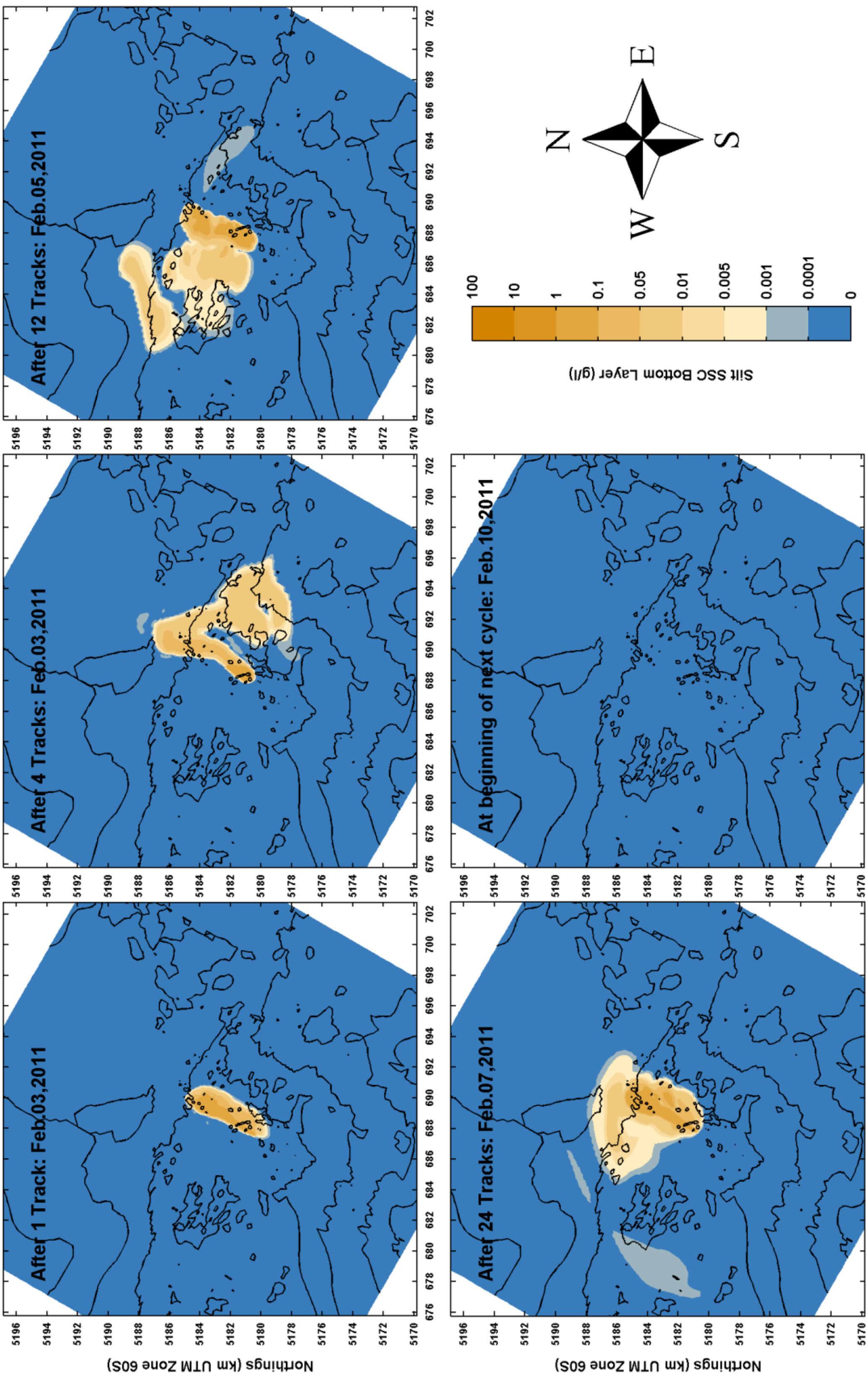

Figure 126: Near-bed suspended silt concentrations over a mining cycle for disposal 10 m above the seabed in summer over 1 track, 4 tracks, 12 tracks, a complete cycle and at the start of a new cycle during summer (from Deltares 2014b). (Note that levels above ambient concentrations (0.001 g/L = 1 mg/L) are in yellow and brown colours).

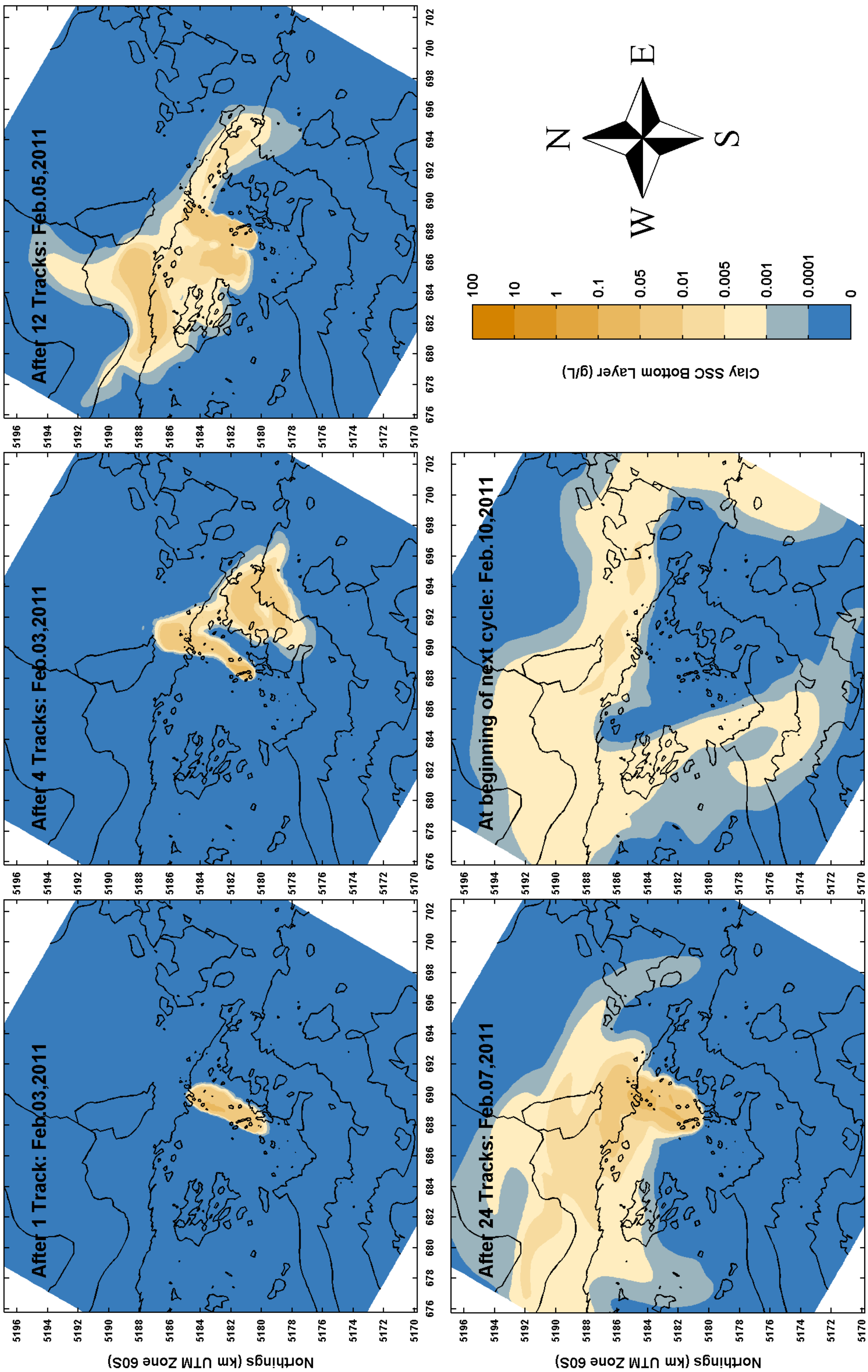

Figure 127: Near-bed suspended clay concentrations over a mining cycle for disposal 10 m above the bed in summer over 1 track, 4 tracks, 12 tracks, a complete cycle and at the start of a new cycle (from Deltares 2014b). (Note that levels above ambient concentrations (0.001 g/L = 1 mg/L) are in yellow and brown colours).

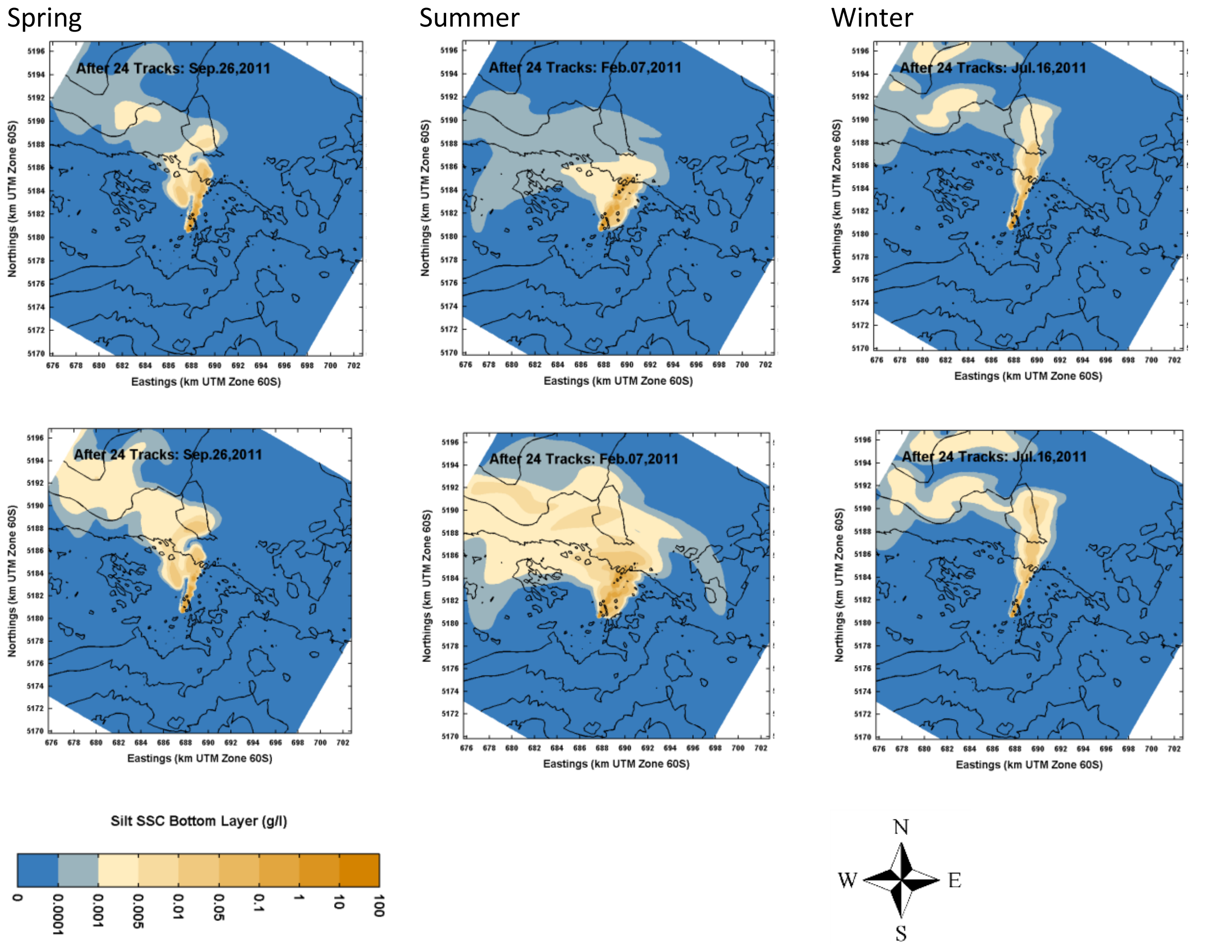

Figure 128: Seasonal variations in near-bed suspended silt (top) and clay (bottom) concentrations at the end of a single cycle of mining (i.e., after track 24). (Note that levels above ambient concentrations (0.001 g/L = 1 mg/L) are in yellow and brown colours).

Thresholds

Figure 129 and Figure 130 illustrate how much of the time concentrations levels for silt and clay are predicted to be exceeded during a single mining cycle. Figure 129 shows that silt concentrations are elevated for only a short period in each cycle at any point near the seabed (discharge at 10 m above the seabed). Figure 130 shows the same information for clay concentrations discharged at 10 m above the seabed. For both silt and clay, the top left figure shows the proportion of time within the plume that the concentration is >1 mg/L.

In the case of silt (Figure 129), the area where the concentration exceeds 1 mg/L more than 15 % of the time is within about 6 km of the mining block and covers less than 5 % of the model domain. That is, for most of the time and most of the area the concentration of suspended silt is <1 mg/L.

For clay (Figure 130) the concentration is >1 mg/L in the outer half of the plume for less than 25 % of the time. As for silt, for most of the time and most of the area the concentration of suspended clay is <1 mg/L.

The sizes of the silt and clay particles result in their different settling and dispersal properties. Silt particles are larger (>4 µm but less that 63 µm) than clay particles (4 µm).

Once mining stops, suspended sediment concentrations decline rapidly as the plume disperses to values below 0.1 mg/L both inside and outside the area where mining occurred. This can be seen in the single cycle shown in Figure 125 where no suspended silt or clay is evident following cessation of mining. The behaviour following completion of a cycle is discussed again in the following section.

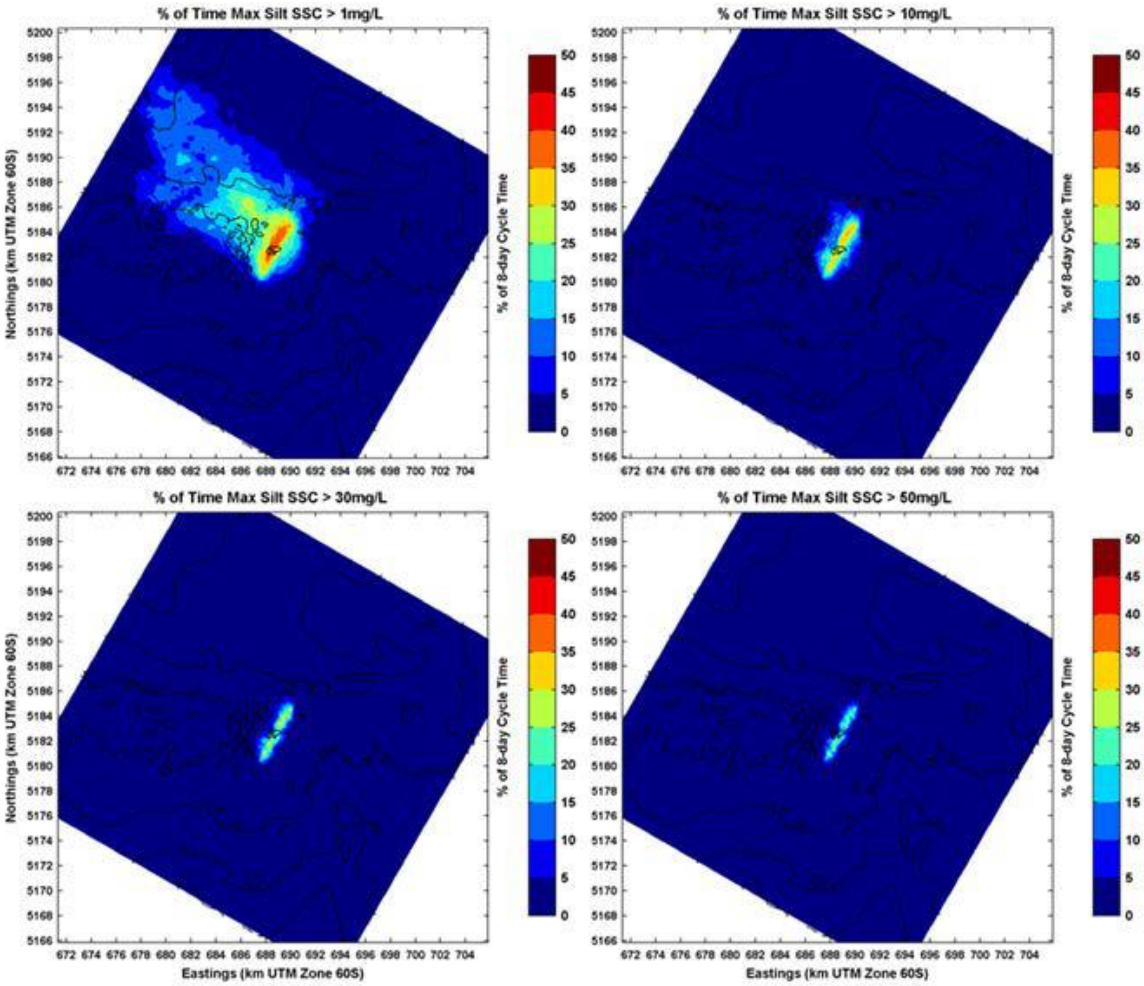

Figure 129: The % time (of the mining cycle in winter) that the observed maximum suspended sediment concentrations over the height of the water column for silt exceeds 1 mg/L (upper left), 10 mg/L (upper right) 30 mg/L (lower left) and 50 mg/L (lower right for discharge at 10 m above seabed) (from Deltares 2014b). (Note that the model assumes an 8 day mining cycle, so 25 % of the cycle equals 2 days (blue to green transition)).

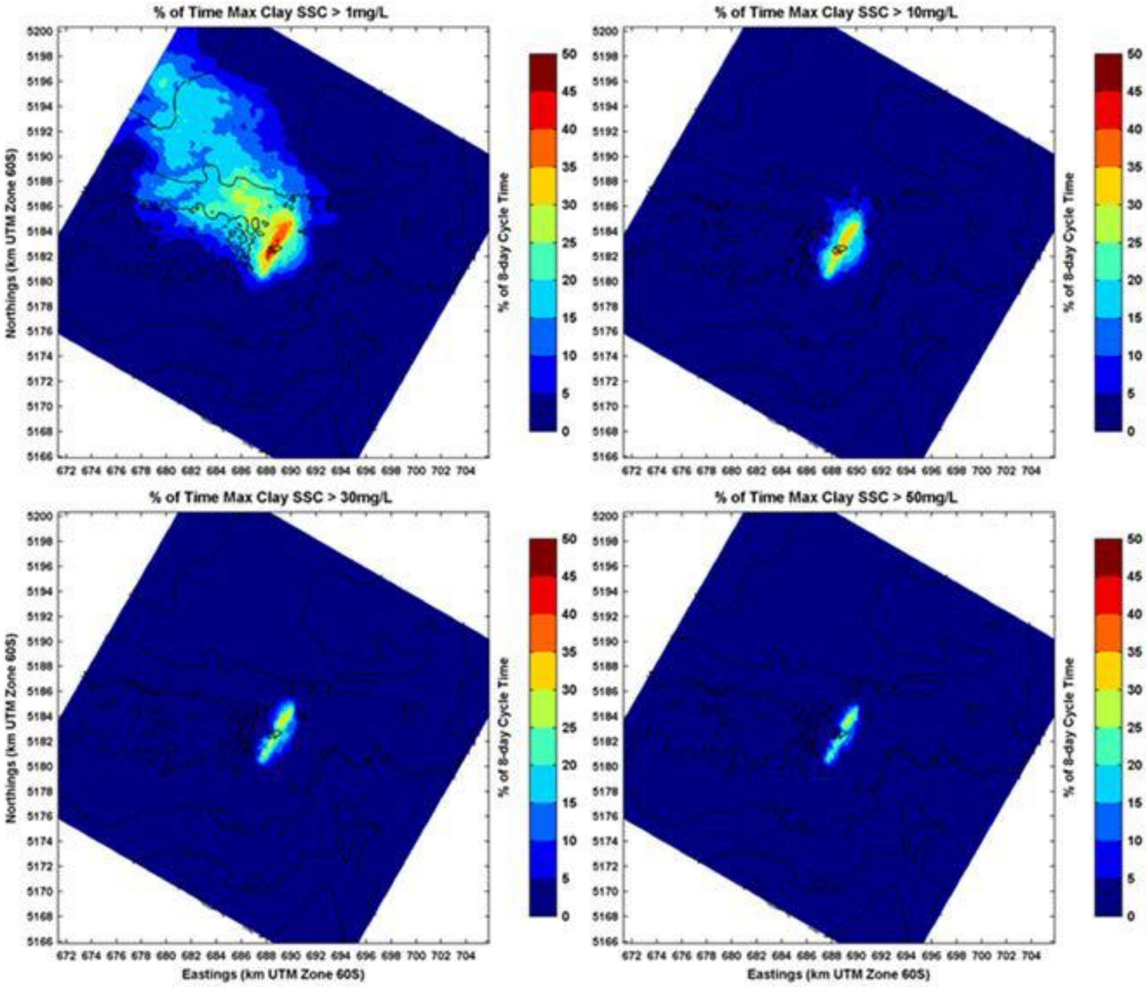

Figure 130: The % time (of the mining cycle in winter) that the observed maximum suspended sediment concentrations over the height of the water column for clay exceeds 1 mg/L (upper left), 10 mg/L (upper right) 30 mg/L (lower left) and 50 mg/L (lower right for discharge at 10 m above seabed) (from Deltares 2014b). (Note that the model assumes an 8 day mining cycle, so 25 % of the cycle equals 2 days (blue to green transition)).

Overall, the data show that both silt and clay concentrations disperse away from the mining tracks. The plume is considered to be above ambient levels if suspended sediment concentrations are >1 mg/L, as indicated by the colour change from blue to brown in the figures. The 1 mg/L cut-off was chosen as this is within the natural range of concentrations close to the seabed (the model outputs include concentrations as low as 0.1 mg/L).

The direction of the plume movement is predicted to vary seasonally, and to be affected by the predominant currents. Based on the three modelled scenarios, plumes are predicted to disperse generally to the northwest in winter and spring, and more to the southeast in summer (Deltares 2014b).

The results predict that the concentration of suspended silt and clay particles declines between cycles to less than 0.1 mg/L (Figure 125).

8.4.3.2 Multiple mining cycles

Introduction

Multiple cycle modelling of suspended sediment generation provided results more representative of real mining operations. The effects of sediment discharge were modelled for four scenarios: disposal of sediment at the seabed and at 10 m above the seabed during winter and summer seasons, based on ocean conditions in 2011. The modelling provided information on how particles moved vertically and horizontally following the disposal of the returns from the mining vessel.

Vertical changes

Deltares (2014b) presents model results for silt and clay in the water column for both the disposal at the seabed and at 10 m above the seabed.

The key elements of these model outputs are:

- Clay and silt concentrations greater than 1 mg/L are predicted to extend less than 20 to 30 m above the seabed.
- Clay concentrations extend higher in the water column than silt concentrations.
- Both silt and clay concentrations extend slightly higher into the water column when the discharge is at 10 m above the seabed.

For disposal 10 m above the seabed, suspended silt concentrations approximately 20 m above the seabed remain below 0.1 mg/L, with peaks on the order of 1 mg/L occurring briefly during each mining cycle between 10 and 20 m above the seabed (Figure 131 and Figure 132). Concentrations return to ambient levels (<0.1 mg/L) between mining cycles, approximately 24 hours after mining has ended.

Clay concentrations are predicted to remain below 1 mg/L more than 30 m above the seabed at the ADCP mooring location, with the highest concentrations within the lowest 10 to 15 m of the water column. The suspended clay concentrations return to less than 0.1 mg/L before the next mining cycle begins (Figure 131 and Figure 132). As noted by Deltares (2014b), suspended clay concentrations can locally be in the order of 1 mg/L between mining cycles due to the sediment transport pathways, but this is a very local effect.

Changes with distance

The maps of silt and clay dispersion illustrate considerable intra-seasonal variation in plume dispersion, similar to the predicted seasonal variation. Concentrations of suspended sediments above ambient levels are predicted to extend to the edge of the model domain (about 15 km from the mining block), but dispersion happens relatively quickly. Levels greater than 10 mg/L are predicted to extend 5 to 10 km from the mining block and to last for no more than a few days.

Figure 133 shows the predicted concentration of clay at the end of each of the 10 cycles required to complete the mining block for the summer season. Each cycle comprises a sequence of vessel mining and loading with phosphorite nodules followed by the vessel going to port, unloading and returning to the Chatham Rise to start the next mining cycle. Figure 134 shows the corresponding information for a block mined in winter. Both figures show results for the disposal at 10 m above the seabed.

The figures show the near-bed (bottom grid cell) suspended clay concentration at the end of mining (track 24) for each mining cycle. Both figures show predominant northwest direction of plume dispersion with some small-scale variations.

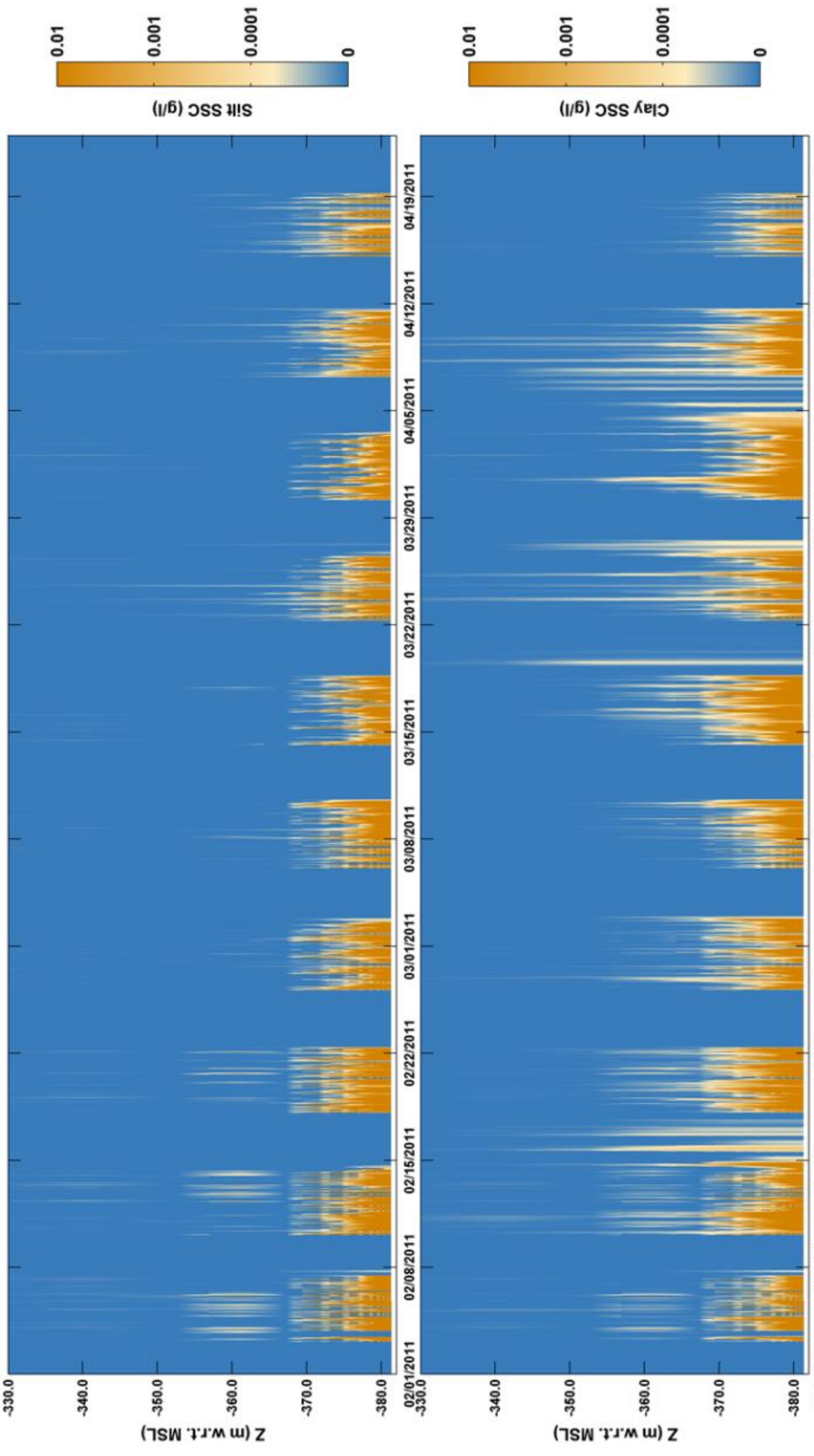

*Figure 131: Time stacks 10-cycle simulation **Summer.** Time stack of suspended silt concentration (top panel) and suspended clay concentration (bottom panel) in the bottom 52 m of the water column at the ADCP mooring location for a discharge at 10 m above the seabed (model layer 23, lower two panels) (Source Deltares 2014b).*

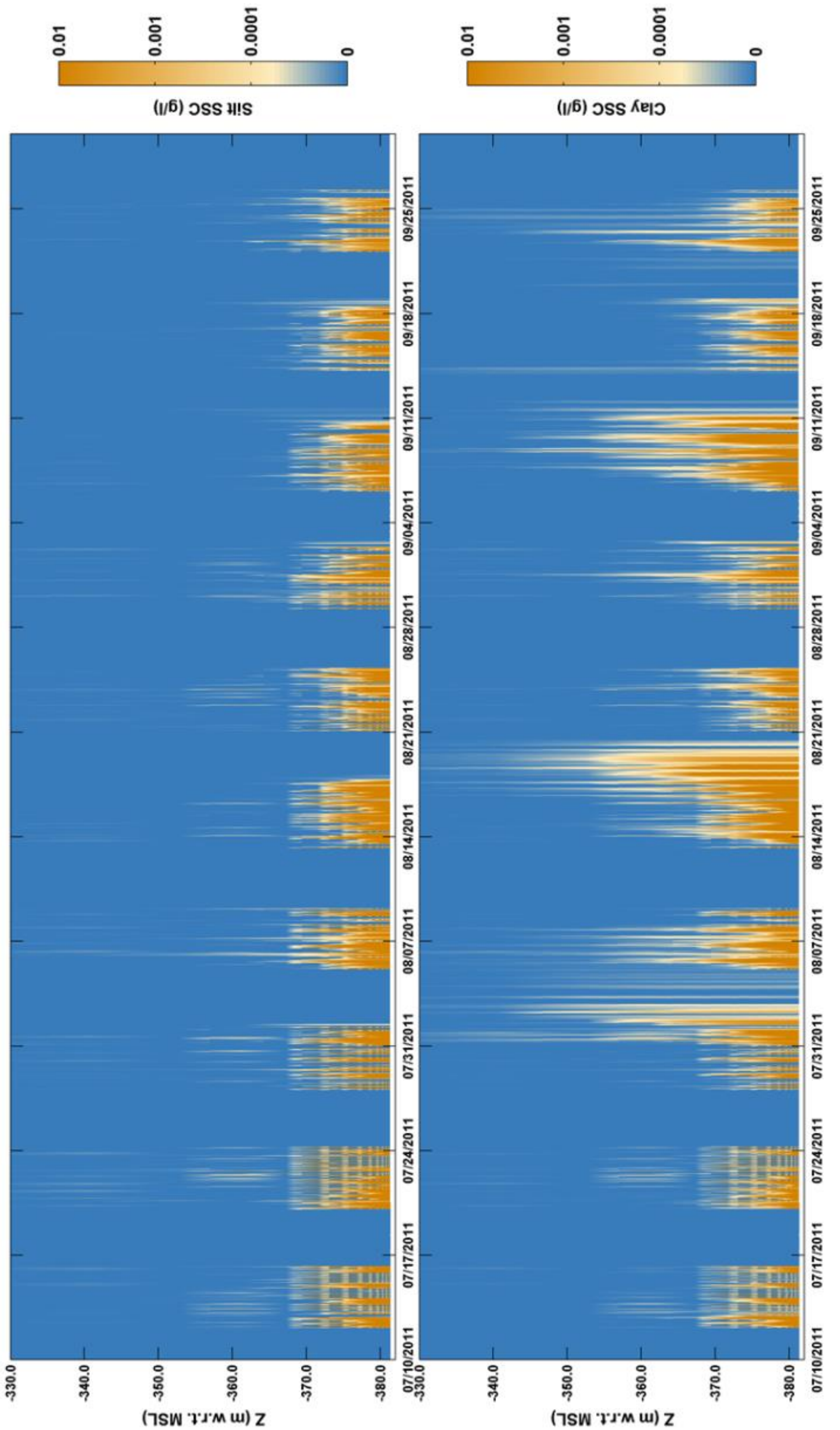

*Figure 132: Time-stacks 10-cycle simulations **Winter**. Time stack of suspended silt concentration (top panel) and suspended clay concentration (bottom panel) in the bottom 52 m of the water column at the ADCP mooring location for disposal at 10 m above the bed (model layer 23, lower two panels) (Source Deltares 2014b).*

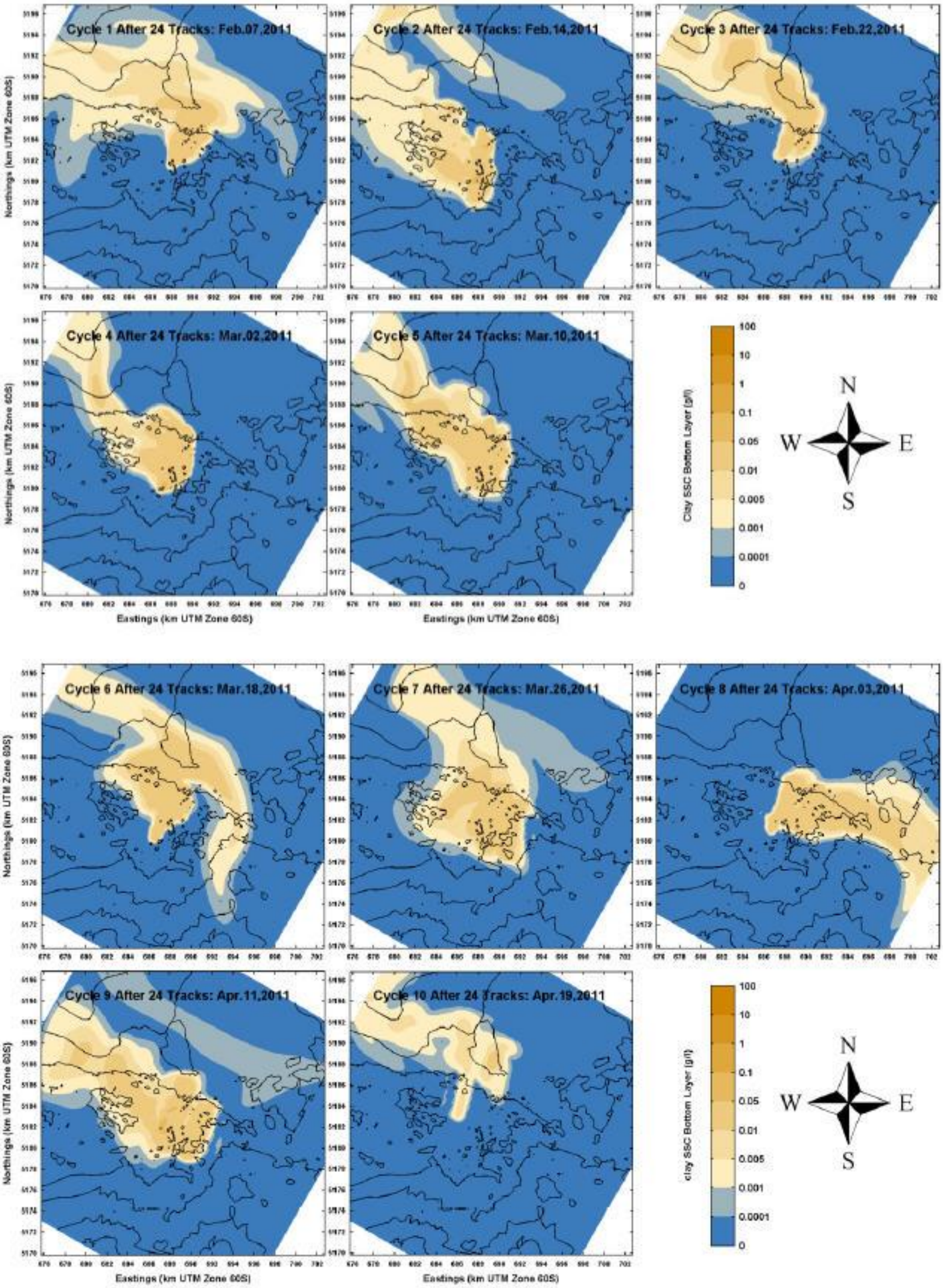

Figure 133: Intra-seasonal variations in near-bed suspended clay concentrations at the end of cycles 1-10 during the 10-cycles simulation for discharging 10 m above the bed. Summer. Optimised Local Model domain. (Source Deltares 2014b).

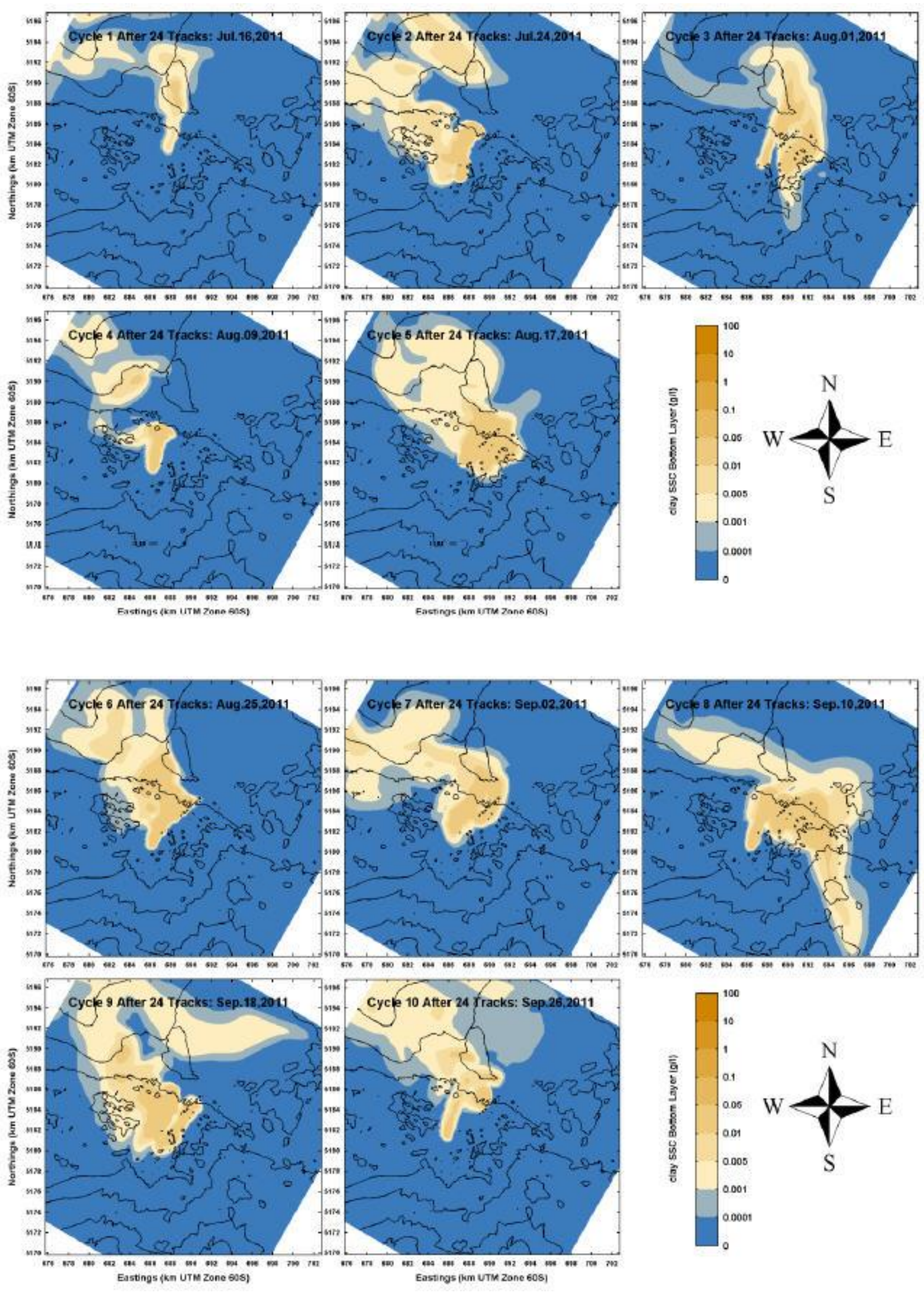

Figure 134: Intra-seasonal variations in near-bed suspended clay concentrations (g/L) at the end of cycles 1-10 during the 10-cycles simulation for discharging 10 m above the seabed. Winter. Optimised Local Model domain.(Source Deltares 2014b).

Changes with time

Vertical changes in concentration over time as a block is mined are illustrated in Figure 133 and Figure 134. They show a systematic pattern in vertical concentration with elevated levels of suspended sediment during mining with elevated concentrations predicted to disperse rapidly and return to near ambient levels between mining cycles. For example, typical concentrations greater than 10 mg/L lasting more than two days are predicted to extend no more than 4 km from the mining block (Figure 135).

Overview and assessment scenario

In the summer scenario the plumes exhibit a somewhat larger spreading and higher concentrations compared to the winter scenario. This is most likely due to smaller vertical velocity gradients and hence less vertical mixing during summer, which results in a larger horizontal plume dispersion. More stratified summer conditions and therefore larger vertical density gradients may also play a role in vertical mixing and horizontal dispersion of the returns plume.

The summer and winter model outputs show that the main proportion of the plume leaving the model domain boundary has concentrations of clay in the range 0.1 to 1 mg/L, occasionally exceeding concentrations of 10 mg/L.

Figure 136 and Figure 137 show average plume concentrations over 10 mining cycles during the summer and winter seasons. For both seasons data are presented for the combined silt and clay concentrations, for discharges at the seabed and at a height of 10 m above the seabed. The concentrations in the plume are shown for the water layer closest to the seabed and for a water layer 10 m above the seabed. The plume associated with a discharge 10 m above the seabed shows that:

- During summer and winter, at 10 m above the seabed, elevated concentration in the plume are confined to the mining block. Outside of the mining block, concentrations are predicted to be slightly elevated, but less than 5 mg/L. By 15 km away from the mining block concentrations have returned to ambient levels.
- During summer and winter, at the seabed, concentrations between 1 and 5 mg/L occur outside the mining block. By 15 km away from the mining block concentrations have returned to ambient levels.
- Higher concentrations of 10 to 50 mg/L are on average confined to the edge of the mining block.

The impact assessment that follows utilises the results outlined above. Although total suspended solids concentrations vary over the series of mining cycles required to mine a block, the patterns are considered to be relatively consistent.

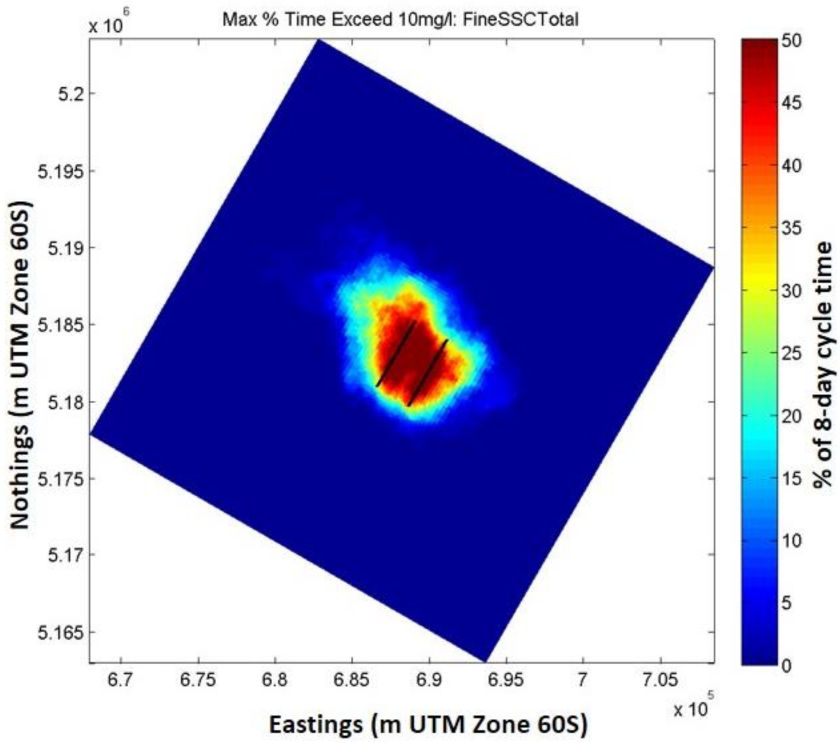

Figure 135: The % of time of the summer mining cycle that the observed maximum suspended sediment concentrations over the height of the water column for the silt and clay fractions exceeds 10 mg/L (discharge at 10 m above the seabed) (from Deltares 2014b). Note that the model assumes an 8 day mining cycle, so 25 % of the cycle equals 2 days (blue to green transition).

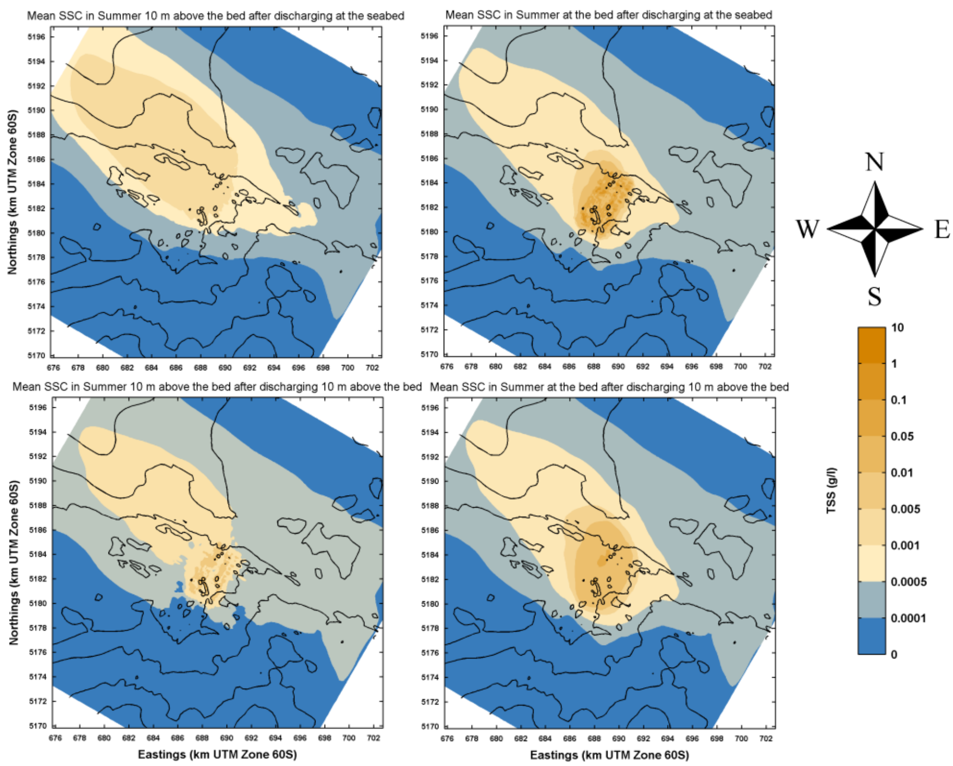

Figure 136: Mean concentrations of silt plus clay at the seabed and at 10 m above the seabed for discharges occurring at the bed and 10 m above the bed (summer season after 10 mining cycles).

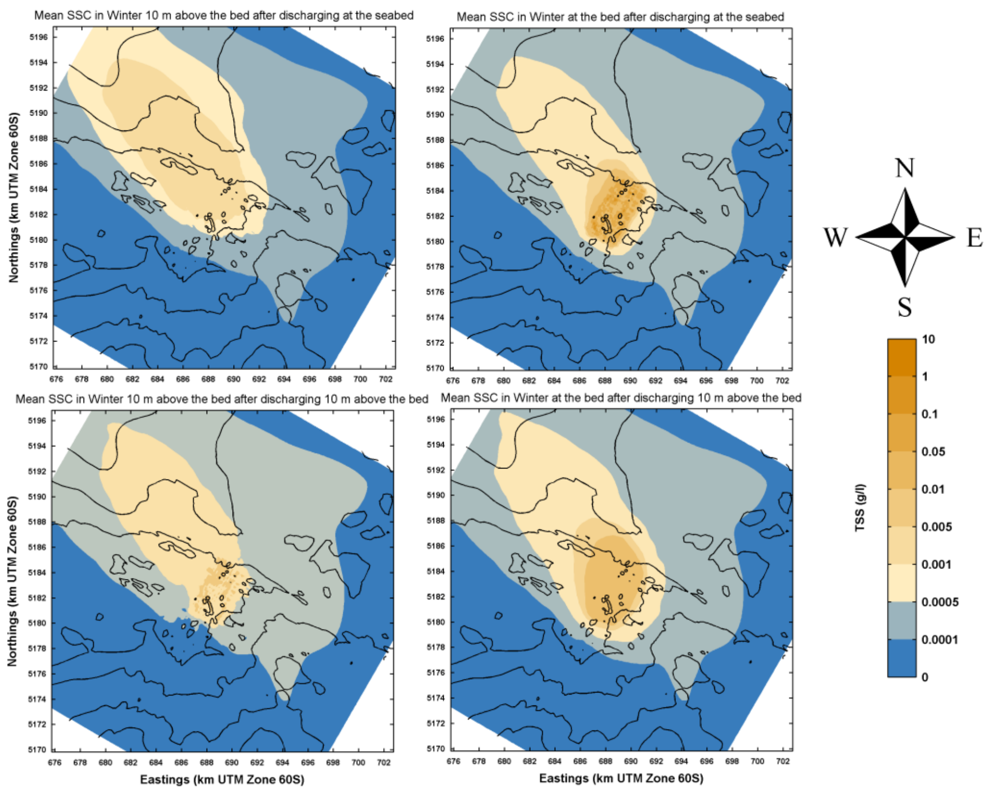

Figure 137: Mean concentrations of silt plus clay at the seabed and at 10 m above the seabed for discharges occurring at the bed and 10 m above the bed (winter season after 10 mining cycles).

8.4.4 Sedimentation

8.4.4.1 Introduction

The primary area of sedimentation occurs along the mining tracks as the sand component of the discharge will be deposited immediately adjacent to the point of disposal. The finer sediment component (silt and clay) has a broader depositional pattern. As the vessel travels around the mining block, fine sediment is predicted to settle onto previously mined tracks within the interior of the block and to some extent outside the mining block. The direction and extent of this deposition depends on the oceanographic conditions that prevail at the time that mining is occurring.

The modelling predicts that more than 50 % of the total silt and clay returns from one mining block will be deposited within 0.5 km of the block, 75 % within 1 km and 90 % within 2 km.

Deltares (2014b) presents the results of modelling sedimentation following a single cycle of mining and following 10 cycles of mining.

8.4.4.2 Single cycle

Figure 140 compares the results of silt and clay sedimentation modelling for a single mining cycle for the disposal of the non-phosphatic material at the seabed and above the seabed. The footprint for disposal 10 m above seabed is more dispersed than that for seabed disposal, but the contours show that for both cases the deposition is concentrated near the mining block and drops off rapidly with distance.

The sedimentation modelling for a single cycle shows that the maximum thickness of silt and clay is predicted to be 25 mm for disposal at 10 m above the seabed. This depth of sedimentation occurs principally within the mining block. Figure 138 shows the predicted sedimentation bands ranging from 5 to 10 mm, then 1 to 5 mm and then finally as illustrated by the yellow bands, sedimentation of 0.5 to 1 mm and less than 0.1 mm. If this sedimentation were to occur over a period of four days, then this pattern of deposition would correspond to daily settlement rates of approximately 1.2 to 2.5 mm/d, 0.25-1.25 mm/d and the 0.125 to 0.25 mm/d and less than 0.25 mm/d.

Figure 139 shows sedimentation during a single mining cycle at a point 3.3 km to the northwest of the mining block (within the orange band of Figure 138). Examination of a specific point within the sedimentation footprint shows that not all locations are subject to sedimentation for the entire period of the mining cycle. The model predicts 1.8 mm of sediment over a period of two days (i.e., about 1 mm/d) at that location. This rate is similar to the range of 0.25 to 1.25 mm/d identified above.

The predicted patterns are consistent with the modelled distribution of TSS concentration.

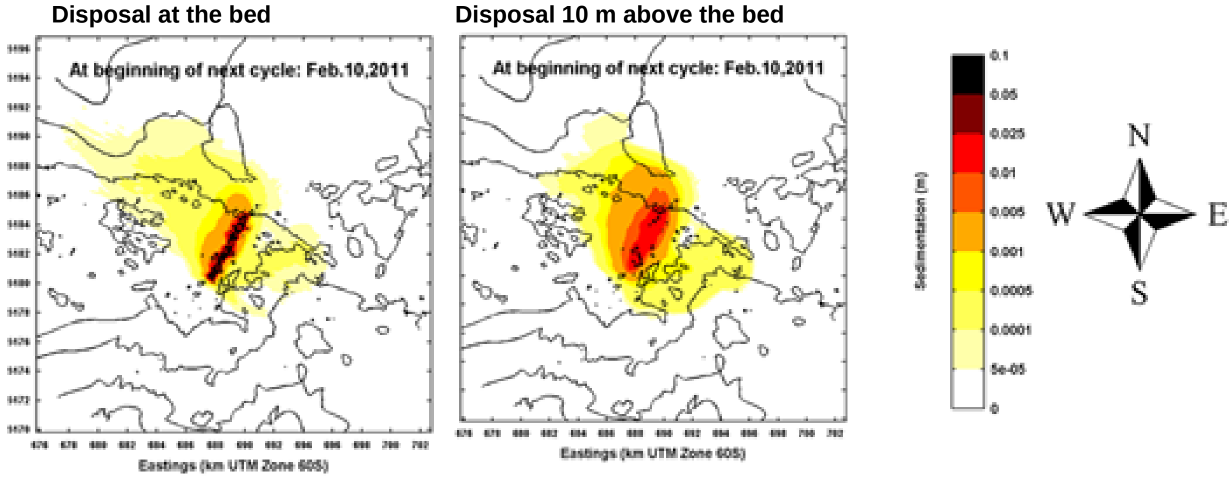

Figure 138: Effect of discharge release height on sedimentation footprint of silt and clay (m) at the end of a cycle and the start of a new cycle during summer. Note that this sedimentation is assumed to occur on top of the sand deposition (from Deltares 2014b).

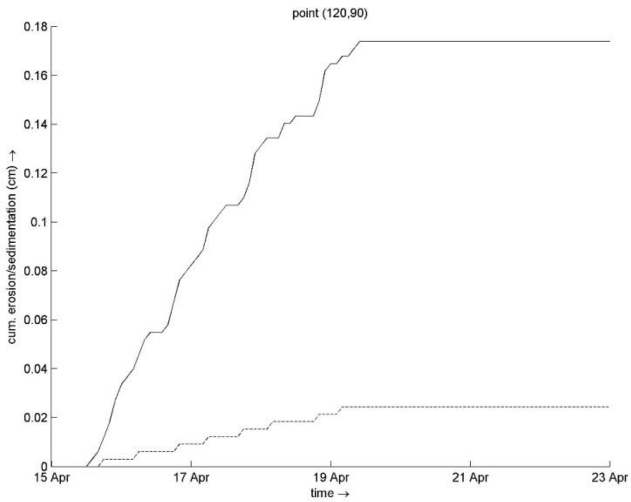

Figure 139: Cumulative sediment deposition at a point about 3.3 km northwest of the mining block for discharge at 10 m (solid line) and at the seabed (dashed line). Summer model, 1 cycle.

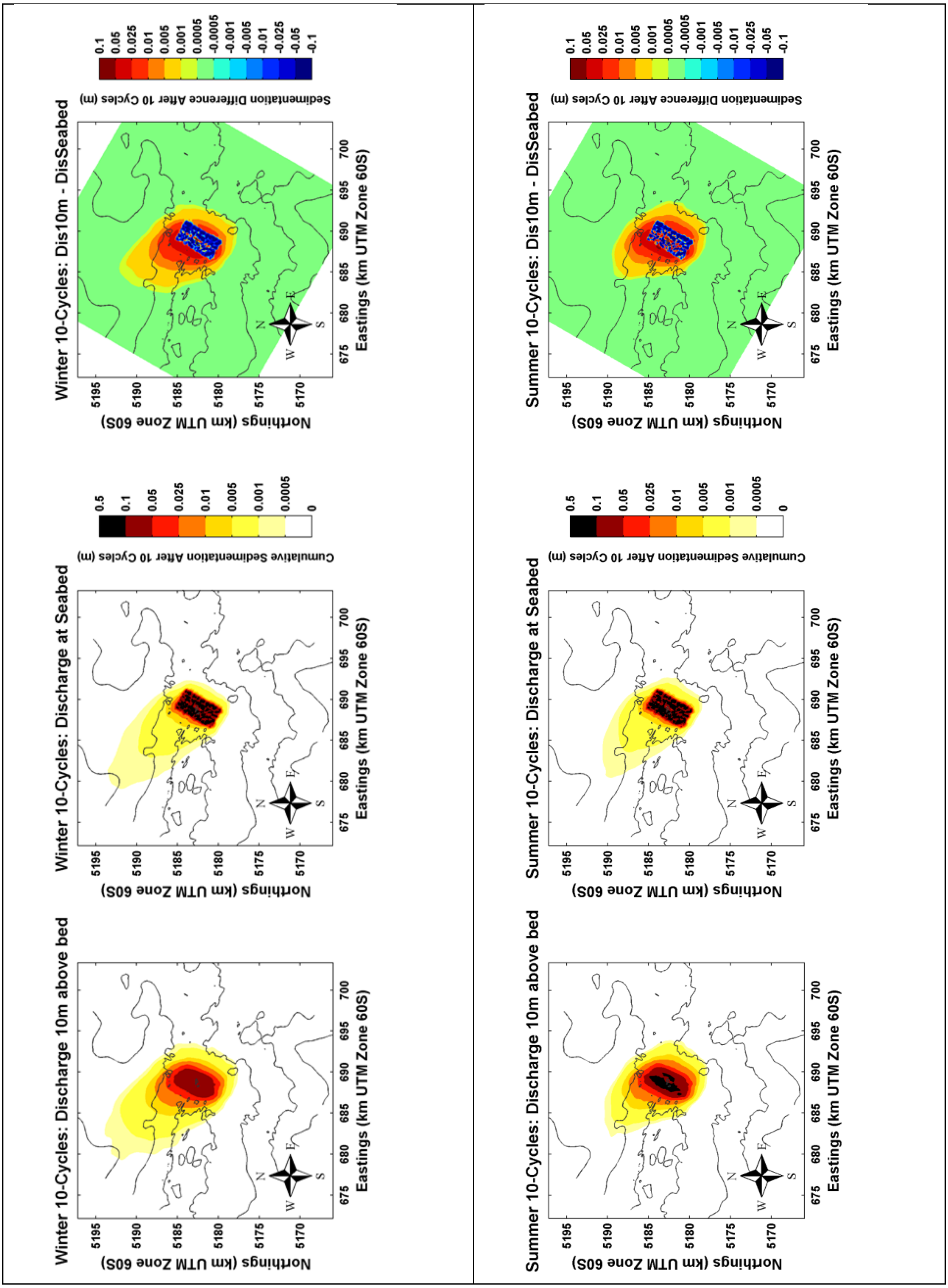

Figure 140: Cumulative sedimentation for both winter (left) and summer (right) 10-cycle scenarios (bottom panels) and their difference in sedimentation (top panels) (from Deltares 2014b).

8.4.4.3 Multiple cycle modelling

As with the single cycle modelling, the multiple cycle (10 cycles) modelling of silt and clay sedimentation during winter and summer examined the return of sediment from the mining vessel at the seabed and at 10 m above the seabed.

The modelled sedimentation for the two discharge scenarios is shown in Figure 140 for the winter and summer modelling period. As for the single cycle model, the footprint for disposal 10 m above seabed is more dispersed than that for seabed discharge.

Figure 141 shows that the predicted thickness of sand and silt sediment along a transect across the mining block is not linear, but decreases rapidly away from the mining block. There is a slight asymmetry in the distribution reflecting a northwest-trending residual current during this period. Figure 139 also shows that the predicted rates of deposition in the mining block are different for the two release heights, with a more uniform rate for the 10 m discharge. The far-field (about 3.5 km from the mining block) rates of deposition for both discharge heights are much lower and relatively uniform.

Deltares (2014b) summarises that after 10 cycles of mining with a 10 m above the seabed disposal of the returns:

- Sedimentation of 2.5 cm would be expected 1 km northwest of the mining block.
- Sedimentation of 1 mm would be expected at a distance of 7 km northeast of the mining block.
- In the southeast direction, the corresponding distance at which 1 mm of sedimentation occurs is estimated to be 4 km.

The predicted sedimentation occurs over 10 cycles, each of four days duration. This corresponds to at least 20 to 40 days of effective sedimentation days with 27 to 47 days of no sedimentation (three days between each cycle as the vessel goes to unload plus two days when sedimentation may not occur at a given point during a cycle). This corresponds to:

- Average sedimentation rates of 0.6 to 1.25 mm/d at 1 km to the northwest.
- Average sedimentation rates of 0.025 to 0.05 mm/d at 7 km to the northwest.

8.4.4.4 Summary - sedimentation

In summary, the multiple cycle modelling (mining of an entire mining block) with disposal of the returns at 10 m above the seabed shows that:

- Sedimentation of silt and clay is predicted to cover a greater area during winter than in summer although the difference is not large
- Sedimentation is more confined to the mining area when disposal is at the seabed but even for the 10 m disposal scenario the thickest sedimentation (>25 cm) is within about 1 km of the mining block.
- Sedimentation covers the unmined strip within the mining blocks to a greater extent when discharge is at 10 m compared to discharge at the seabed.
- Sediment thickness greater than 1 cm is confined to within approximately 1 km of the mining block towards the southeast and 4 km to the northwest.
- Sediment thickness greater than 1 mm within about 7 km of the mining block (towards the northwest) and within about 4 km to the southeast.

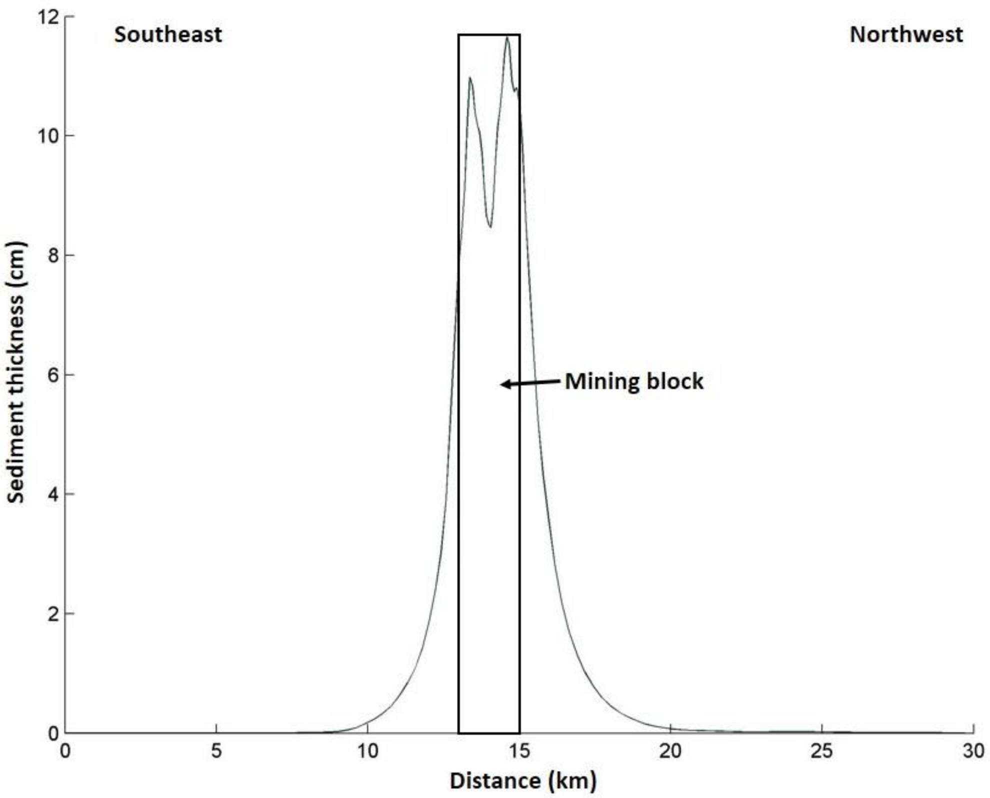

Figure 141: Cross-section of total fine sediment deposition from 10 cycles, with deposition 10 m above the seabed.

8.4.5 Modelling of uncontrolled sediment releases

Consideration of potential incidents involving the riser identified that if the riser became clogged then the material in the riser would need to be released to the seabed. A blockage could result from a pump failure or from an unexpected, extensive, major change in the composition of the seabed sediments. The impact of this release would be very small compared to that of the normal disposal of the returns.

The sinker returns pipe has no in-line pumps or components that could provide an opportunity for blockage and therefore, the potential for uncontrolled release of processed sediment is considered to be remote.

The effects of a sudden release of sediment in the riser 10 to 20 m above the seabed were considered in Section 7 of Deltares (2014b) (Appendix 25).

Given the size of the riser and the concentration of the material in it, as well as the back-up systems that CRP will ensure are in place to minimise the potential for such events, it was estimated that no more than 20 m^3 sediment would need to be released due to a blockage in the riser. The material would be released via a relieve valve located in the lower section of the riser.

As the result of such an event, the modelling predicts that a plume with a density of 1,037 kg/m^3 and a diameter of 10 m would form and contact the seabed within 40 m of its release. Sediment thickness in this area is estimated to be about 5 cm. The spill will not cause resuspension of already deposited material.

Compared to the size of the plume generated by the normal mining and disposal operation, such a plume is considered to be insignificant (i.e., it may be adverse, but it is near-source confined, short-term and reversible) and therefore the potential consequence is minor. Such an event is unlikely, and the environmental risk associated with it is considered to be low.

8.4.6 Resuspension

Modelling predicts that some resuspension of the returned sediments is possible, but is unlikely for normal oceanographic conditions.

Deltares (2014c) (Appendix 26) undertook an evaluation of the potential for resuspension of sediment following the discharge of sediments from the return of the processed non-phosphatic material. Deltares (2014c) found that the critical erosion shear stress required to erode the cohesive surface sediments (clay and silt fractions) is predicted to be higher than the bed shear stresses under ambient conditions. This agreed with findings from near bed turbidity measurements that show that although elevated turbidity maxima occur in proximity to the seabed the values both near the seabed and in the water column are relatively low.

Tidal analysis of near-bed values predicts minor, tidally-induced resuspension of bed material may occur, although it is predicted to be around 10 times less than the background values of turbidity (1 FTU). Fine, non-cohesive sediments will be eroded more easily, but the critical shear stress for these sediments is predicted to be only occasionally exceeded in winter. The critical threshold for erosion of the discharged sediment after settling is lower than for the in-situ sediment because it has a lower density, but it remains greater than the expected ambient bed shear stress. However, because of uncertainties in the bed shear stress and the critical bed shear stress, erosion of deposited sediment may occur (especially during winter, when bed shear stresses are larger), particularly if the density of some of the returns is significantly lower than that of the in-situ sediments.

Cyclones and storms do not increase the bed shear stresses dramatically at the depths that sediment is being deposited, so natural surface weather events will not result in seabed resuspension.

8.4.7 Summary – modelling results

8.4.7.1 Suspended sediment

Modelling over ten cycles of seabed mining showed that changes in suspended sediment concentration only occurred close to the seabed, and there were only small changes in suspended sediment concentration more than 10 to 20 m above the seabed. Excursions above 20 m above the seabed occur for only short periods of time.

Single cycle modelling explored the range of seasonal and the depth related factors associated with disposal. Silt and clay dispersal data showed that clay, as expected due to its smaller size, travelled further than silt. Concentrations of silt above ambient levels remained in the modelling domain, but for clay the modelling predicted that elevated concentrations occasionally extended beyond the edge of the model domain. However, the concentration of clay predicted at the domain edge (about 15 km from the release points) is slightly elevated but less than 5 mg/L.

Plume modelling also explored the temporary distribution and variability of the suspended sediments. Concentrations of 1 mg/L of clay at the outer parts of the plume occurred for less than 25 % of the time. Areas with higher concentrations do not extend far from the mining block. Typical concentrations of 10 mg/L of silt and clay for periods lasting more than one day (during a mining cycle) are predicted to occur within 5 km of the mining block, and for more than two days within about 3 km of the mining block.

These results are used in the impact assessment in Sections 8.5 and 8.6.

8.4.7.2 Sedimentation

The sedimentation modelling showed that a significant portion of the returns will be deposited within the mining blocks, with a silt/clay layer up to 12 cm thick overlaying the sand deposit of about

10 cm. Sedimentation during a single cycle of mining is estimated to be less than 1 mm within 1 to 2 km of the point of disposal.

The multiple cycle modelling predicted that sediment deposition patterns differ slightly between disposal at the seabed and 10 m above the seabed. The overall pattern of sedimentation is similar, but sediment discharge at 10 m above the seabed is predicted to result in thinner sediments within the mined block and a somewhat thicker cover of sediment outside the mined block.

For both discharge heights, the thickness of sediment decreases rapidly with distance from the mining block. A sediment thickness of about 1 mm is predicted at a distance of about 7 km to the northwest from the mining block and 4 km to the southeast. A thickness of 2.5 cm is predicted at a distance of 1 km in a northwest direction.

These results are used in the impact assessment in Sections 8.5 and 8.6.

8.4.7.3 Potential for disturbance of deposited sediment

The models predict little or no resuspension of the returned sediment for most of the year.

The deposited sediment will consist of layers of sands, silts and clays. If these sediments are less cohesive than the original seabed surface, then they may be resuspended more easily than currently observed for seabed sediments on the Chatham Rise.

The critical stress of the deposited sediments is predicted to be higher than the shear stress caused by ambient currents for most of the year, and therefore little or no resuspension is predicted to occur. However, in winter during periods of stronger than usual internal tides (and thus higher than usual shear stresses), some erosion of mined sediments may occur and the suspended particles may become entrained into the water column (Deltares 2014c).

8.5 Impacts of Returns Disposal on Sediment and Water Quality

8.5.1 Introduction

This section of the EIA assesses the discharge of the processed non-phosphatic material (returns) following mining and processing of sediment on sediment and water quality. Included in this assessment are the potential impacts on sediment and water quality associated with localised seabed disturbance and sedimentation associated with the operation of the drag-head on the seabed.

This section of the EIA summarises information presented in Golder (2014a) (Appendix 11).

8.5.2 Impacts on sediment quality

8.5.2.1 Overview

Observations of sediment samples collected during CRP's March 2012 survey on the Dorado Discovery indicated there was no evidence of anoxic horizons[29] within the first 0.5 m of the surface sediments (i.e., the target sedimentary layer). Other work on the Chatham Rise just north of MPL 50270 (Leduc & Pilditch 2013) reported no obvious vertical gradients to a depth of at least 10.5 cm in sediment colouration in sediments used in laboratory experiments they conducted (relating to the effects of disturbance on meiofauna).

It is therefore likely that the disturbance of these sediments during mining will not expose sulfidic (i.e., anoxic) sediments to relatively oxygen-rich waters, and thus none of the potential impacts associated with such exposure (pH change, substantial releases of trace elements, etc.) are likely.

[29] This is where there is a lack of oxygen. In anoxic sediments, any organic matter in the sediments will be breaking down under anaerobic (without oxygen) conditions rather than aerobic (with oxygen).

Changes in sediment quality that might occur are:

- Changes in composition arising from the removal of phosphorite.
- Changes in organic matter content of sediment at the sediment surface.
- Effects of dredging and returns disposal of human-made constituents such as isotopes and organic contaminants.

8.5.2.2 Compositional changes

Sediment is typically characterised as material less than 2 mm in size (the sand-gravel cut-off) and the characterisation of sediment chemistry is typically undertaken on materials <2 mm. Technically as the material being extracted is >2 mm in size (the gravels) the 'sediment' composition will not change significantly.

Phosphorite nodules are relatively enriched in phosphorus, copper, molybdenum, strontium, thallium, and uranium compared to their host sediments, but the nodules contain less barium and chromium.

However, considering potential composition changes based on the difference in composition between nodules and sediment, the removal of phosphorite nodules could result in minor decreases in the concentrations of the former set of elements and there may be a slight increase in the concentration of the latter in the returns. However, the amount of material that will be removed is small relative to the amount of processed non-phosphatic material that will be returned, and the net impacts of these changes on sediment chemistry are likely to be small.

Macronutrient and trace element abundances in Chatham Rise sediments are low relative to environmental sediment quality guidelines (e.g., ANZECC 2000).

Anticipated changes in sediment quality will principally arise due to the change in the physical properties of sediment being deposited compared to the in-situ sediment being mined. The physical changes occur as a result of the sedimentological properties of different grain size fractions. That is, the sand fraction will be deposited first with silt deposited on top within and close to the mining block. Clay will then be deposited with and on top of the silt close to and further away from the mining block.

The changes arise because of the relatively minor differences in geochemistry between fine and coarse sediment. The change in physical composition will not result in any changes in sediment composition and chemistry that could be considered environmentally significant.

8.5.2.3 Organic matter

The potentially greatest impact on sediment quality is likely to be associated with changes to organic carbon loads, given that benthic biota will be incorporated into the mined sediment from the seabed which will then be included in the material returned to the seabed. It is unlikely that this impact will be significant because the discharge of biological matter as organic carbon will result in the carbon being widely dispersed (i.e., outside the area modelled for suspended solids) because of its small size and low specific gravity. It is predicted that the dissolved and very small particles will be assimilated into the background environment away from the mining area.

Organic matter enters the seabed environment naturally through the death of biota (e.g., phyto- and zoo plankton, benthic species, fish, cetaceans and pinnepeds), discards from fishing vessels, and other sources such as faecal matter. Section 6 reported that fishing vessel discards are a key part of the diet of ling.

Golder (2014a) provides very conservative estimates of changes in local carbon deposition based on all of the material being deposited within the mined area. If all benthic organisms in the mining areas are included in the material discharged back to the seabed, then local carbon accumulation rates may temporarily increase by as much as 80 % within the mined area. However, this level of local change is not expected.

Substantial deposition of organic matter in a single location has the potential to generate local anoxia. The potential impact associated with such an occurrence is a function of amount deposited, rate of consumption by larger organisms, the rate of decomposition and the influence of local currents. Should such deposition occur, its breakdown might induce local anoxia at the immediate sediment surface. However, it is unlikely that substantial accumulation of particulate organic matter will occur because most of the material will disperse within the water column and thus deposit over a much larger area than considered in the model.

8.5.2.4 Man-made organic compounds and isotopes

Seabed sediments within the New Zealand EEZ contain both radionuclides and man-made organic compounds. Man-made organic compounds, especially those that are persistent (commonly referred to as POPs – persistent organic compounds), are found in marine sediments because they are discharged into the air and transported to the marine environment or are present in run-off to the sea from land (both urban and rural).

POPs such as DDT (used historically in agriculture) are known to be present in low concentrations in sediments on the Continental Shelf (e.g., in the Hauraki Gulf, in Pegasus Bay - refer Golder 2014a). As the distance increases from shore such concentrations are predicted to decrease markedly and concentrations of compounds that might be detectable in inshore areas of New Zealand are expected to be non-detectable in the proposed marine consent area. In addition, there is little sediment deposition on the crest of the Chatham Rise so it is likely that any of these compounds that reached this region would be transported by currents and deposited on the flanks of the Rise. Therefore, it is not expected that the disruption of sediment by phosphorite mining would result in any significant change in POP flux on the Chatham Rise.

Radioisotopes are present in sediments throughout the world's oceans as a consequence of the historic testing of nuclear weapons. Long lived radioisotopes such as strontium-90 (^{90}Sr) and caesium-137 (^{137}Cs) can be detected because of their very long half life. Also, naturally occurring isotopes of some elements such as polonium-210 (^{210}Po) and lead-210 (^{210}Pb) are present and are the key source of radioisotopes to marine biota and then humans.

Hermanspahn (2014) (appended to Golder 2014a - Appendix 11) discusses the occurrence of the long-lived radioisotopes on the Chatham Rise. Although there is no specific information on the distribution of isotopes such as ^{90}Sr in New Zealand coastal sediments, deposition has been measured continuously in New Zealand since 1959. Concentrations in water and sediment are assessed as being very low.

The modelling undertaken by Deltares (2014b) (Appendix 25) of sediment particles has shown that most sediment is deposited at or close to the site of mining. A proportion of the clay is transported off-site to settle well away from the point of disposal. As the particles are not advected up into the water column, the sediment is retained within the environment from which it was mined. As such, for sediment dwelling biota or sediment feeding biota the change in isotope distribution is considered to be neutral.

8.5.2.5 Summary

The principal potential impact of mining and the disposal of the processed non-phosphatic material on sediment quality is likely to be a short term and localised in increased carbon loading within the mining area. Impacts relating to other sediment constituents are considered minor.

On this basis, the potential impacts of CRP's proposed mining operations on sediment quality are considered to be generally neutral, near-source confined, short-term and. in the case of changes in carbon distribution and flux, reversible. The potential consequence of such impacts is minor and the likelihood is possible, and the potential environmental risk is low.

8.5.3 Impacts on water quality

8.5.3.1 Introduction

Elutriation testing provides information on changes in water quality when mined sediment is vigorously mixed with seawater. The mixing of in-situ sediment with seawater can change the concentration of a range of constituents as the sediment water mixture is pumped up the riser, the sediment and water mixture processed on-board, and the fine sediment and water mixture discharged back at the seabed via the returns pipe.

The changes that are often assessed in relation to sediment release during dredging and dredged material disposal, as assessed below, are:

- The release of trace elements.
- The release of nutrients and organic matter.

8.5.3.2 Release of trace elements

Golder (2014a) (Appendix 11) indicates that a range of elements will be released due to the vigorous mixing associated with mining and returns disposal, including nutrients (e.g., nitrogen and phosphorus) and trace elements (e.g., arsenic, nickel and uranium). The amount of an element released will depend, in part, upon the type of sediment (e.g., only chalks released copper, whereas iron was only released from surface host sediments).

To assess the significance of any increases in concentrations that occur as a result of their release from the sediment, the elutriate concentrations are first compared with water quality guidelines (acute, chronic or no effects guidelines depending upon the circumstances) for the protection of marine biota (Table 20). This is only a first step as it is an 'artificial' comparison, but does provide a preliminary screen to see if any releases to the seawater from the mixing of the sediment with water needs to be assessed further.

Of the elements released from the sediments:

- Chromium, lead, mercury and zinc were not detected or were released in concentrations lower than ANZECC (2000) environmental guidance for pristine marine environments (99 % trigger values).
- Arsenic, cadmium, copper and nickel were released in quantities sufficient that elutriate concentrations were greater than environmental guidance for pristine marine environments (99 % trigger values in ANZECC 2000).
- There is no guidance for uranium in marine waters (discussed below).

Identifying that these elements have concentrations in the elutriate higher than the ANZECC (2000) guidance values does not imply that adverse impacts will occur, only that further assessment is required.

Table 20: Trace element concentrations in Chatham Rise sediment elutriate experiments.

Parameter	Seawater#	Surface*	Sub-surface**	Chalk***	ANZECC (2000)
pH (unitless)	8.1 (8.0)	7.8-8.1	7.8-8.0	7.8-7.9	8.0-8.4
Ammonical-nitrogen	<10 (<10)	190 ± 50	140 ± 40	50 ± 20	500
Nitrate-nitrogen	3.0 (3)	48 ± 14	8.2 ± 2.9	9.2 ± 7.2	700[2]
Soluble inorganic nitrogen	<11 (11)	230 ± 50	150 ± 40	58 ± 25	-
Dissolved reactive phosphorus	<4 (5)	96 ± 5	78 ± 10	110 ± 22	-
Iron	<4 (6)	28 ± 20	<4	<4	-
Manganese	<1 (7.4)	3.1 ± 0.9	1.7 ± 0.5	1.7 ± 0.6	80[2]
Arsenic	<4 (<4)	<4	14 ± 2	7 ± 2	2.3-4.5[2]
Cadmium	<0.2 (<0.2)	0.22 ± 0.20	1.1 ± 0.7	1.2 ± 0.3	0.7
Chromium	<1 (<1)	<1	<1	<1	7.7
Copper	1.1 (7.1)	1.2 ± 0.3	1.0 ± 0.3	3.9 ± 3.2	0.3
Lead	<1 (<1)	<1	<1	<1	2.2
Mercury	<0.08 (<0.08)	<0.08	<0.08	<0.08	0.1
Nickel	<6 (9)	10 ± 1	12 ± 1	13 ± 4	7.0
Uranium	3.4 (3.3)	16 ± 2	70 ± 13	73 ± 16	-
Zinc	<4 (39)	<4	<4	<4	7.0

Notes: All units mg/m^3 unless otherwise stated. All data are means ± standard errors except pH for which ranges are presented. * n = 12. ** n = 7. *** n = 5. # n = 1. Results represent seawater used for elutriation purposes collected off Raglan. Values in parentheses represent data from Chatham Rise survey, which were contaminated. ANZECC (2000) values presented are for the protection of 99 % of species. Results shaded indicate mean values greater than the respective trigger value. [1] As NH_3. [2] Low reliability value.

When the water from the returns pipe is discharged at 10 m above the seabed, it is subject to dispersion and dilution. The near field dilution (that occurring immediately following discharge as a result of the momentum of the discharge) and far field dilution (that occurring as a result of the natural water movement down current) means that actual concentrations of these elements will be reduced. Therefore the concentrations in the environment will be much lower than the ANZECC (2000) guidance for the protection of marine biota, and thus are unlikely to significantly affect ambient water concentrations.

Golder (2014a) describes a likely dilution scenario of 200 times in the near field (within the mining block and adjacent) and 2,000 times within 15 km of the returns discharge. These dispersions represent an initial dilution of 200 to 2,000 times between the mining strip and up to 15 km from the returns disposal.

Utilising a dilution of 200 times (adjacent to the mining block), the following observations can be made:

- Arsenic concentrations in the elutriate would be reduced to 0.07 mg/m^3 following initial dilution. The addition to local seawater is small given the natural concentration of arsenic in seawater.
- Cadmium concentrations in elutriate will be reduced to 0.006 mg/m^3 following initial dilution. This reduces any addition to well below the ANZECC (2000) guidance.
- Copper concentrations in elutriate will be reduced to 0.02 mg/m^3 following initial dilution. This reduces any addition to well below the ANZECC (2000) guidance
- Nickel concentrations in elutriate will be reduced to 0.065 mg/m^3 following initial dilution. This reduces any addition to well below the ANZECC (2000) guidance
- Elutriate uranium concentrations following initial dilution would be reduced to 0.365 mg/m^3. This corresponds to a near-field concentration increase of 10 % of the natural concentration. Concentrations decline away from the mining area to be within the range of variation seen in the natural concentrations in seawater.

Following far-field dispersion and dilution the addition to seawater of arsenic, cadmium, copper, nickel and uranium will be extremely small. For all elements, where a guidance is provided by ANZECC (2000), concentrations will be below the 99 % trigger guidance value for the protection of marine biota.

For uranium, the concentration increases that occur in seawater due to the release from sediment during the passage of sediment through the mining process will be very small within a short distance of the discharge point. By the time water has dispersed as it travels with the sediment plume, the concentrations of uranium are unlikely to be distinguishable from normal concentrations uranium in seawater. The presence of uranium in the returns discharge and on the Chatham Rise is discussed further in Golder (2014a).

Bio-magnification (accumulation in aquatic biota) of contaminants such as arsenic, or cadmium or uranium will not occur as a result of the proposed activities (refer to Golder 2014a – Appendix 11). In relation to uranium, Golder (2014a) outlines that, it is unlikely that any significant change in the concentration of uranium in fish muscle tissue would be expected, due to the dilution of uranium with distance from the discharge, released uranium being present as carbonate complexes, and uptake in fish occurring mainly in bony tissues.

The release of radioisotopes (e.g., caesium-137, strontium-90) is expected to increase near-field radioactivity by a factor of 10. However, even after such increases, these values are more than 100 times less than benchmark values for the protection of aquatic biota (refer to Hermanspahn (2014) – appended to Golder 2014a (Appendix 11)).

8.5.3.3 Nutrients and organic matter

The elutriate chemistry showed that mixing of sediments with seawater due to it passing up the riser and through the separation process results in the release of dissolved nitrogen and phosphorous when the returns are discharged.

This mixing results in the release of ammoniacal-nitrogen to the seawater. As the sediments are sub-oxic, the release concentration is relatively low (about 190 mg/m^3). Although ammoniacal-nitrogen is toxic in high concentrations (the ANZECC (2000) moderate reliability trigger value to provide 95 % protection is 910 mg/m^3), the elutriate concentration will reduce to <1 mg/m^3 following initial dilution. As such the addition of dissolved inorganic nitrogen in this form is unlikely to result in toxicity to marine biota near the returns discharge point.

The discharge will release about 230 mg/m^3 of dissolved inorganic nitrogen (the ammoniacal-nitrogen plus nitrate-nitrogen). Overall, the addition will be about 1 mg/m^3 after initial dilution and <0.1 mg/m^3 at the edge of the sediment plume.

For dissolved reactive phosphorus, additions to the local near seabed environment will be about 0.5 mg/m^3 after near-field dispersion and dilution. This is a very small addition.

The nutrient contributions remain in the mesopelagic zone and therefore the addition of nitrogen and phosphorus from the returns disposal cannot result in enhanced phytoplankton growth within the euphotic zone.

The increased rate of carbon accumulation on the Chatham Rise after mining may lead to an increase in oxygen consumption at the sediment-water interface as organic carbon is converted to CO_2 by bacteria and recolonising benthic organisms. Dissolved oxygen concentrations at depth on the Chatham Rise are relatively high (>7 mg/L) which represent oxic (oxygenated) conditions at the seabed on the Rise. Although oxygen demand may be increased as a result of disposal of the returns, any increase will be temporary and will not result in anoxia at the water-sediment interface (Golder 2014a – Appendix 11).

The potential impacts of CRP's proposed mining operations on water quality in terms of nutrients and trace elements are neutral, near-source confined, short-term and reversible. The potential consequence of such impacts is minor and the likelihood of any impact is unlikely, meaning that the potential environmental risk is low.

8.5.4 Summary

The disturbance of the seabed, and the discharge of sediment (returns) will result in some changes to both sediment and water quality within the mining area, but the predicted enhanced carbon loading and release of nutrients and trace elements from sediments as a result of mining operations will not be significant.

The geochemistry of the deposited sediments will be slightly different to those mined as a result of the removal of the course fraction and the physical properties of the deposited sediment will also be somewhat different. These changes are not considered environmentally significant.

The discharge of organic matter due to the incorporation of benthic biota in the mined sediment will result in the re-distribution of that organic matter. As the organic material will include dissolved and small particulates, the organic component of the returns will be dispersed over large distances and add to the regional flux of carbon. Depending on their size, larger organic particles will be dispersed and may settle within the mining area.

In the unlikely event that all carbon settled within the mined block, then the local carbon flux may increase. Although accumulation of particulate organic matter could result in local anoxia at the sediment surface, the overall risk of potential impacts on sediment and water quality as a result of CRP's proposed mining operations have been assessed as low.

To summarise, enhanced carbon loading and the release of nutrients and trace elements from sediments as a result of mining will not affect water quality as the potential impacts on water quality are predicted to be negligible.

On this basis, the potential impacts of CRP's proposed mining operations on water quality in terms of nutrients and trace elements are neutral, near-source confined, short-term and reversible. The potential consequence of such impacts is minor and the likelihood of any impact is unlikely, meaning that the potential environmental risk is low.

8.6 Impacts of Mining and Sedimentation on Ecological Resources

8.6.1 Introduction

In this section, the potential impacts of mining and the disposal of the processed non-phosphatic material (returns) on ecological resources on the Chatham Rise are considered. Also, as the marine consent being sought by CRP includes activities associated with its environmental surveying and monitoring programme, the impact assessment provided below is also of relevance to these components of the mining operations.

The matters assessed in this section are:

- Loss and changes to benthic habitats from seabed mining.
- Impacts of sedimentation and suspended solids on benthic biota.
- Recolonisation and recovery of benthic biota from the impacts of seabed mining.
- Impacts of increased suspended solids in the water column on pelagic biota.
- Impacts on conservation values, including marine mammals and seabirds.
- Impacts on the Chatham Rise ecosystem and fisheries.

The assessment of the impacts on the Chatham Rise environment is based on a synthesis of the potential impacts outlined in the previous sections.

The following technical assessments, appended to this EIA, have contributed to the assessment of potential impacts on ecological resources:

- An assessment of sedimentation impacts on the values of the Chatham Rise (Hewitt & Lohrer 2013) (Appendix 29).
- An assessment of the benthic communities' recolonisaton and recovery following mining (Beaumont & Rowden 2013) (Appendix 30).
- An assessment of the potential impacts of suspended solids on fish eggs (Page 2014a) (Appendix 27).
- An assessment of the potential impacts of suspended solids on fish (Page 2014b) (Appendix 28).
- An ecosystem modelling assessment of the Chatham Rise (Pinkerton 2013) (Appendix 22).
- A summary of the available information on the probability of capture of the key fish species present on the Chatham Rise. This information is presented principally in figures that show the likely distribution of fish species in relation to the marine consent area (Golder 2014b) (Appendix 17).
- A summary of the hoki fishery on the Chatham Rise adjacent to the marine consent area (O'Driscoll 2014) (Appendix 18).
- A summary of the ling fishery on the Chatham Rise adjacent to the marine consent area (Baird 2014) (Appendix 19).
- An assessment of potential mining impacts on red rock lobsters around the Chatham Islands (MacDiarmid 2012) (Appendix 31).
- An assessment of potential impacts on the seabirds of the Chatham Rise (Thompson 2013) (Appendix 21).

- The development of spatial management options for the central Chatham Rise crest to identify areas to protect benthic biodiversity from the effects of phosphorite nodule mining (Rowden et al. 2014b) (Appendix 32).

8.6.2 Impacts on benthic habitat

8.6.2.1 Introduction

Sections 6.2 and 6.3 provide an overview of the habitats and benthic fauna within the proposed marine consent area. That information was derived from recent and historic seabed biological surveys that provided information on the wider benthic communities from the Chatham Rise, and also within parts of the proposed mining area.

The composition of benthic habitats and communities vary over small distances (tens to hundreds of metres) but their distribution is also observed to be regionally distinct and controlled by large scale physical and oceanographic factors.

The information obtained in the OS20/20 marine biodiversity surveys showed a variety of biological communities on the Chatham Rise (Hewitt et al. 2011, and refer to reviews of existing biology in Appendices 13 to 16). The range of community types reflects the variety of physical environments across the Rise, especially the physical effects of depth (via light) and SST gradient. In particular, as discussed in Section 6 this EIA, communities on the north and south flanks of the Chatham Rise differ due to the influence of the different water masses flowing up and across them (sub-tropical and sub-Antarctic).

Sections 5 and 6 describe the substantive dataset of the physical and biological nature of the seabed collected for this project and other research projects. Rowden et al. (2014a) reports on and compares the results of these data, particularly the data collected on the OS20/20 voyages and the data collected with the ROV, to expand the description of epifaunal communities on the Chatham Rise and in the mining permit area.

The review of seabed physical information (Nodder et al. 2013 – Appendix 9) coupled with the review of epifauna and infauna data (Rowden et al. 2013, 2014a) provided input to predict probable biological community distribution throughout the proposed marine consent area.

The examination of physical habitat and epifauna and infauna biological data identified several benthic communities across the marine consent area. As described earlier (and refer Rowden et al. 2013, 2014a), eight key epifaunal communities were identified. The infaunal organisms inhabiting the sediment were grouped into five key communities. These groups were dominated by polychaete worms and amphipods.

Notable epifaunal communities included high abundances of the stony coral *Goniocorella dumosa*, from a family of corals listed in Schedule 7A of the Wildlife Act (refer to Section 2.4.7), along with the grouping of encrusting bryozoan/sponge/ascidian (Communities *n* and *o*). Other epifaunal communities were characterised by the predominance (but not always high abundance) of irregular urchins (Community *g*), sea anemones and hermit crabs (Community *j*), and lamp shells (Community *m*) as well as varying abundances of encrusting bryozoan/sponge/ascidian and branching bryozoan/hydroid/other components.

Table 21 summarises the physical factors that were identified as influencing the distribution of epifaunal communities within the initial mining area (Rowden et al. 2014a – Appendix 16). The assessment indicated that primary drivers were depth, sea surface temperature and dissolved organic matter for most communities.

Table 21: Key physical descriptors* for epibenthic community groups (image-level) and *Goniocorella dumosa* (from Rowden et al. 2014a).

Epifaunal community	Factor 1	Factor 2	Factor 3	Factor 4	Nodule content factor	Mud factor	Sand factor	Gravel factor
Community *f*	Depth 52.2 %	Bottom current speed 11.1 %	Nodule content 10.2 %	Slope 6.4 %	10.2 %	<2.6 %	<2.6 %	<2.6 %
Community *g*	Depth 11.5 %	Aspect 11.3 %	Profile curvature 9.5 %	DOM 9.0 %	8.8 %	<5.1 %	<5.1 %	<5.1 %
Community *j*	DOM 17.1 %	SST gradient 15.7 %	POC 11.9 %	Tidal current speed 10.9 %	<3.6 %	<3.6 %	<3.6 %	6.8 %
Community *m*	SST gradient 16.5 %	Rugosity 15.0 %	Dynamic topography 12.0 %	Nodule content 10.8 %	10.8 %	<6.1 %	6.1 %	6.1 %
Community *n*	SST gradient 22.6 %	Mud 18.6 %	Depth range 8.6 %	Bottom current speed 8.5 %	<3.0 %	18.6 %	3.0 %	6.7 %
Community *o*	Depth 21.3 %	SST gradient 17.6 %	Aspect 9.7 %	DOM 9.7 %	<5.6 %	<5.6 %	8.4 %	<5.6 %
Community *p*	Depth 27.9 %	Slope 17.3 %	Plan curvature 15.6 %	Nodule content 13.3 %	13.3 %	< 7.7 %	< 7.7 %	< 7.7 %
Community *q*	DOM 29.4 %	SST gradient 16.4 %	Sand 12.1 %	Tidal current speed 11.0 %	6.1 %	<6.1 %	12.1 %	<6.1 %
Goniocorella dumosa	SST gradient 23.2 %	Depth 15.3 %	Slope SD 8.1 %	DOM 8.0 %	<4.9 %	7.4 %	<4.6 %	6.5 %

Note: * First four primary drivers providing the greatest contribution identified. SD – standard deviation. DOM – dissolved organic matter. SST – sea surface temperature. POC – particulate organic carbon.

The evaluation resulted in the identification of a community distribution based on the probability of the occurrence of suitable habitat. Overall, spatial variation in epifaunal communities was reflected in the distribution of soft sediment (Communities *g* and *j*) and patches of hard substrate (Communities *m*, *n*, *o*, *p*, *f* and *p*). Figure 57 to Figure 64 in Section 6 showed the distribution of communities based on epifauna data and Figure 68 to Figure 71 the key communities based on infauna data.

Seabed sampling showed that the benthic communities and species within the marine consent area are not unique, and the benthic habitat modelling identified the likely distributions of habitats supporting these communities and species. The modelling predicts that suitable habitat for *G. dumosa*, which is widely distributed throughout the EEZ, is likely to occur in a large area to the northwest of the marine consent area, as well as smaller patches distributed across the marine consent area (Figure 67). This prediction is most strongly related to SST gradient with the most suitable habitat for this coral occurring where SST is highest (Table 21) as it relates to oceanographic fronts and concentrated surface productivity.

As described in Section 4.4.1, CRP proposes to introduce mining exclusion areas to provide protection for benthic biodiversity features including those associated with iceberg furrows[30].

8.6.2.2 Disturbance of benthic habitat

The principal benthic habitat changes arising from CRP's proposed mining operations relate to the removal of surface habitat and associated biota through sediment extraction, and to sedimentation arising from the return of processed sediment to the seabed. Seabed sampling as part of CRP's environmental surveying and monitoring programme also results in the removal of habitat and biota, albeit at a negligible scale in comparison to the mining operations, and can be assumed to be acceptable given that the activity is permitted by the EEZ Act Regulations. The most significant impacts are confined to the immediate area of the mining blocks, although minor impacts associated with the sediment return can extend several kilometres from the mining blocks.

These habitat changes are described in relation to two broad types of habitat: hard substrate and phosphorite nodules in soft sediment.

The primary long-term change in habitat will consist of a shift from mixed phosphorite nodule/soft-sediment habitat to soft sediment habitats, primarily in or near the mining blocks. The loss of the phosphorite nodule/soft sediment habitat through mining is a direct loss and is a consequence of recovering the phosphorite. The implications of this habitat loss, in terms of potential impacts on ecological resources, are assessed in Sections 8.6.3 and 8.6.4. The immediate loss of habitat from mining in the first year will be about 30 km^2, or 3.7 % of the mining permit area. At the end of three years of mining, the extent of habitat change (or loss of particular habitat types) will be about 90 km^2, or 11 % of the mining permit area (less than 0.1 % of the Chatham Rise shallower than 500 m). The loss of habitat associated with seabed sampling is minor in comparison and can be assumed to be acceptable given that the activity is permitted by the EEZ Act Regulations.

The impact on benthic organisms from burial by sediments returned to the seabed is predicted to be a function of distance to the mining activity and the sensitivity of the organisms. This is discussed in Section 8.6.3.

[30] The iceberg furrows that characterise this part of the Chatham Rise have not been reported elsewhere in New Zealand's marine territory. Some of these features merit preservation and are part of CRP's proposed mining exclusion area as outlined in Section 4.4.1.

8.6.2.3 Hard substrate

Large areas of hard substrate were not observed or mapped in MPL 50270, but some areas of basement outcrop have been mapped in the proposed marine consent area, east and west of MPL 50270 (Falconer et al. 1984)

Areas of hard substrate in the proposed marine consent area are localised, usually consisting of patches of phosphorite nodules on the seabed, erratics on the sediment surface, and areas of exposed hardened chalk occasionally observed along the edge of significant iceberg furrows and as outcrops with no overlying phosphatic sediment.

These local areas of hard substrate can support communities dominated by echinoids, anemones and a range of attaching biota.

Some areas of concentrated phosphorite nodules provide habitat for cold water corals, but not all exposed nodules support these communities. Following mining it is unlikely that significant numbers of phosphorite nodules will remain on the sediment surface as any that escape the drag-head will probably be covered by the returns.

Mining will remove phosphorite nodules at the surface, but it will avoid areas of exposed hardened chalk and will not remove significant erratics as they will not be recoverable by the drag-head. These areas in the mining blocks that will not be mined will be affected by the deposition of the sediment returns, but as both the hardened chalk exposed on the edges of furrows and the erratics are relatively large and steep-sided it is likely that in the medium-term they will be available for recolonisation. Other areas of hard substrate, such as exposed basement rock outcrops, may be affected by sedimentation from the returns if they are close to mining blocks and are relatively smooth.

8.6.2.4 Soft sediment

Mining activity will focus on areas of phosphorite nodules in soft sediment. Mining in these areas will result in the loss of a significant portion of the current nodule habitat within the proposed mining blocks.

As described in Section 6, soft sediment without surface phosphorite nodules is a common substratum on the Chatham Rise although the nature of the soft sediment is variable throughout the area. Soft sediments are known to vary in thickness, from a few centimetres to several metres. Observations of the seabed and samples of the subsurface show areas of soft sediment often have phosphorite nodules in the subsurface.

Within the mining blocks, sedimentation will create a relatively homogenous surface sediment layer comprising fine sediment (silt) over sand. Over time, bioturbation will mix the sediment and bring some of the coarser sandy material to the surface, but in the short-term sediment surfaces in the mining areas will be dominated by fine sediments and will favour the establishment of biota that prefer fine sediment habitats (refer to Section 8.6.4). Benthic community modelling (Rowden et al. 2014a – Appendix 16) suggests that this change could result in a shift from Communities *f*, *m* and *p* to Community *n* or other community types, largely depending on the depth and SST gradient (Table 21).

Modelling predicts that deposition of 1 cm or more of sediment returns could extend about 3 km from the mining blocks, and deposition of 2 cm is expected to be within about 1.6 km of the blocks. It is likely that deposition of several centimetres of sediment will have site specific impacts that relate to the rate of deposition (per day), the size of the species and whether they are sessile. Changes in community structure within the areas of significant plume deposition are likely to be patchy.

The potential for recolonisation of this habitat is considered in Section 8.6.4 below.

8.6.2.5 Avoidance, remediation and mitigation measures

Avoidance, remediation and mitigation measures for the removal of seabed habitat consist of operational plans to avoid area of hard substrate such as exposed chalk, erratics and basement outcrops as described in Section 4.4.1, the identification of mining exclusion areas as identified in Section 4.4.1 and described in Section 8.6.6.4, and a trial to determine if it is possible to replace areas of hard substrate to encourage recolonisation as described in Section 8.6.4.

The exclusion areas protect areas of and conservation and scientific (e.g., an iceberg furrow) sensitivity or value, including but not limited to the predicted occurrence of the coral *Goniocorella dumosa*. Other factors included in the analysis included mineral prospectively and demersal fish assemblages (Rowden et al. 2014b - Appendix 32).

As described in Section 8.6.6.4, the proposed mining exclusion areas should be considered as a first step in the mitigation process. To this end, CRP has committed to use it best endeavours to promote, in conjunction with interested parties, formal protection of areas identified through the spatial planning exercise, both inside and outside the marine consent area, from all seabed disturbance activities in accordance with appropriate legal mechanisms.

The benthic fauna and seabed features in these mining exclusion areas include significant representative area of biodiversity within the proposed marine consent area and they will be protected from adverse impacts associated with CRP's mining operations.

8.6.3 Impacts on benthic biota

8.6.3.1 Overview

The potential direct impacts of sediment on benthic biota are relatively well understood in many environments and include:

- Physical burial where biota are sessile (i.e., not mobile) and the thickness of sediment is greater than their height.
- Physical impacts on filter feeders and impacts on their food availability (i.e., they filter more sediment than food).
- Changes in the quality of food for infauna sediment feeders.
- Changes in sediment physical properties leading to less suitable habitat for some burrowing species.
- Changes in pore water geochemistry, leading to unsuitable environments for some species.

The potential indirect impacts of sedimentation on benthic biota include:

- Impacts resulting from species dependencies, i.e., a detrimental impact on one benthic species may affect a species dependent on the impacted species for food or shelter (e.g., living in or on a coral).
- Trophic impacts affecting available food for other components of the ecosystem (e.g., demersal fish species).
- Biogeochemical impacts related to changes in sediment physical and biogeochemical properties that influence trophic components such as microbiology.

The potential direct impacts are discussed below. Indirect impacts are considered in Sections 8.6.5 and 8.6.7.2. Hewitt & Lohrer (2013) summarises the potential impacts of sedimentation (Appendix 29).

The overall effects of sedimentation are dependent on the composition of the biological communities and their distance from the mining activity. Factors such as feeding mode, mobility, habitat niche, size and whether organisms hibernate will determine the significance of impacts (Hewitt & Lohrer 2013). As noted by Hewitt & Lohrer (2013), the impacts within benthic communities are determined by the interplay of a range of physical factors.

Work undertaken within the mining permit area on habitat and the composition of the benthic epifauna has shown that there are relationships between the physical nature of habitat and the community composition. A key feature is the association of notable sessile epifauna such as cold water corals with hard substrate (in particular the occurrence of *Goniocorella* in relation to depth and high SST gradient.

8.6.3.2 Predicted sedimentation from the return of the non-phosphatic material to the seabed

The scale of sedimentation from the proposed mining is determined by:

- The rate of disposal.
- The particle size of the sediment.
- The distance from the mining track where deposition occurs (within and outside the mining area).

In Section 8.4, the local deposition occurring as a result of sediment disposal was described in relation to single and multiple mining cycles. Within the mining area there will be deposition of sand to a depth of at least 10 to 30 cm. Virtually all of the sand component of the returns will be deposited within the mining blocks and over areas that have just had surface sediment removed. The majority of the fine sediment (mainly silt within the mining block) will be over the sand with the maximum thickness (5-10 cm) of fine sediment occurring principally within the mining blocks.

Modelling the cumulative sedimentation over ten mining cycles in a mining block shows that the total sedimentation pattern varies depending upon the height above the seabed of the return of the non-phosphatic material (i.e., at the seabed or at 10 m).

The sedimentation modelling for disposal at 10 m and seabed disposal (described in Section 8.4.4) indicates that disposal at 10 m results in a generally similar sedimentation footprint but the sedimentation profile (i.e., depth with distance) differs between the two scenarios. As illustrated in Figure 142, the extent of sediment > 1 mm is predicted to be similar for the two release heights (about 6 km from the mining block), but the sediment are more dispersed with disposal of the returns at 10 m above the seabed. Sediment deposition >5 cm thick is confined to the mining block where the returns are released at the seabed, and extends 0.5 km beyond the mining block if sediment is released 10 m above the seabed. These distances are maxima, measured in the current direction for the sedimentation model, distances in other directions are much shorter (refer Deltares 2014b for more detail).

During the mining of a block, sedimentation occurs outside of the block in a down-drift direction during the ten cycles with a period of no sedimentation in between (when the mining vessel returns to port). At a point where the sedimentation totalled 1 cm (about 1.6 km from the edge of the mining block), for example, the single cycle deposition would be about 1 mm, or about 0.25 mm/day. Close to the edge of the mining block, the rate of sedimentation is <1 mm/event. Figure 142 illustrates the predicted sedimentation pattern for the two disposal options modelled. Figure 141, in Section 8.4.4, shows a cross section of the distribution of the sedimentation for 10 m discharge.

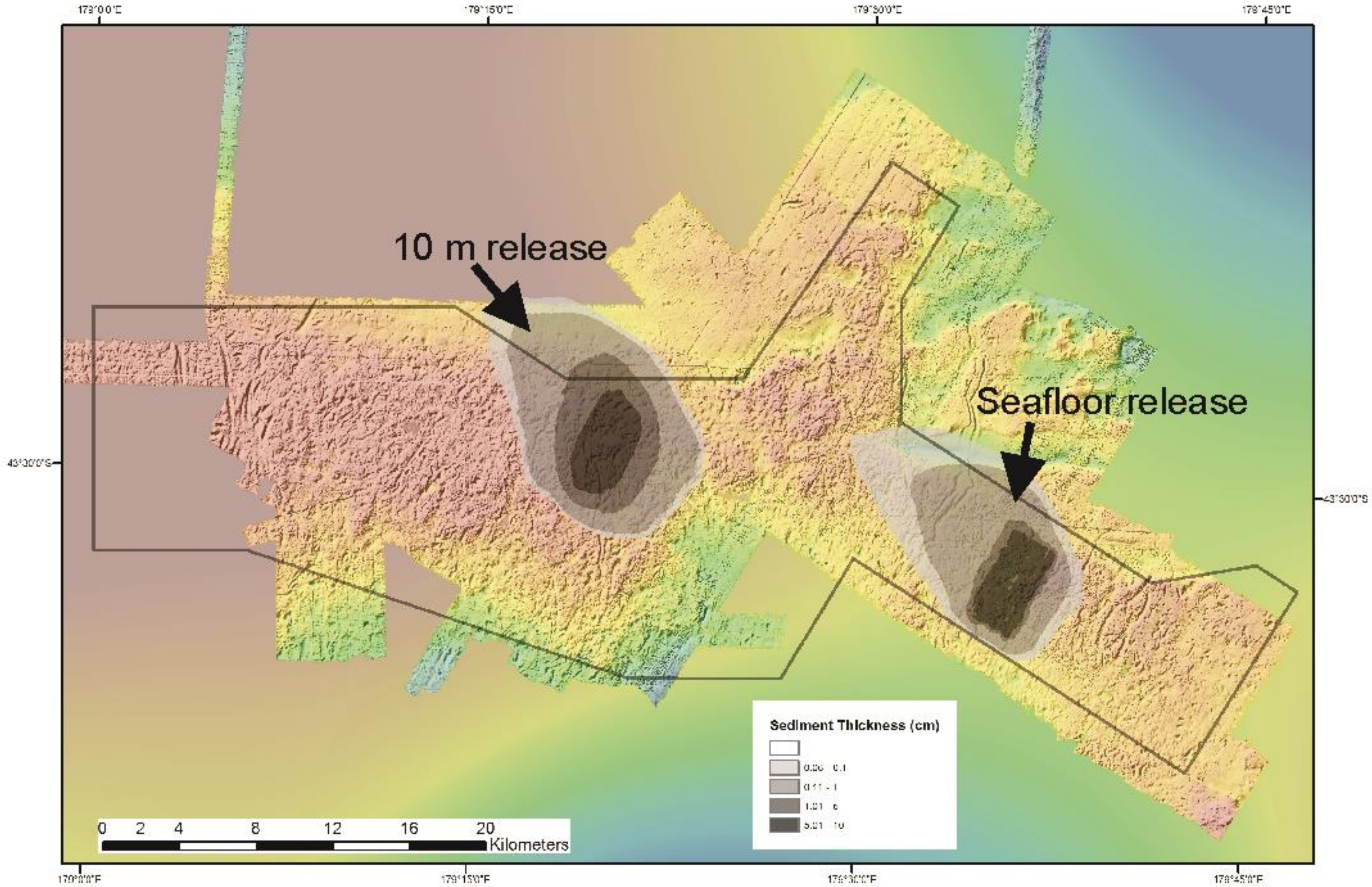

Figure 142: Predicted sediment distribution arising from mining of a single block with discharge at the seabed and at 10 m from the seabed.

8.6.3.3 Sedimentation impacts on benthic biota

Sedimentation impacts on benthic biota within the mining blocks are not assessed as the benthic fauna will be removed as a consequence of mining.

Hewitt & Lohrer (2013) examined the relative sensitivity to sedimentation of benthic biota within taxonomic groups on the Chatham Rise. They concluded:

- Within the polychaeta some species are likely to be highly sensitive and some species moderately sensitive.
- Within the crustacea/arthropoda some shrimps and amphipods are moderately sensitive.
- Some ascidians (sea squirts), bryozoans, echinoderms (crinoids, urchins, brittlestars and sea cucumbers) are moderately sensitive.
- The cnidarians are likely to have a wide range of sensitivities, with some moderately to highly sensitive (some anemones), highly sensitive (some anemones and hydroids) and very highly sensitive (cup corals).
- Molluscs are expected to be moderately to very highly sensitive for some groups (gastropods, bivalves etc.).

Comparison of predicted disturbance of sedimentation (Deltares 2014b – Appendix 25) with the expected sensitivity of benthic organisms (Hewitt & Lohrer – Appendix 29) predicts that the maximum impacts on benthic organisms is likely to be within 0.5 km of the mining blocks, although impacts on some sensitive organisms could extend 7 km beyond the mining blocks.

Hewitt & Lohrer (2013) (Appendix 29) discuss the sensitivities of epifaunal biota to sedimentation. Based on the benthic epifaunal community information provided by Rowden et al. (2013, 2014a – Appendices 15 and 16) they predicted that, with the exception of Community *I*, communities were likely to be sensitive to smothering. In those areas where sedimentation had adverse impacts, recolonisation would be expected to take several years. Hewitt & Lohrer (2013) note that infaunal communities appear to be less sensitive than epifaunal communities to sedimentation.

In considering the potential impacts of sedimentation on benthic fauna, both depth and duration of burial are important.

As multiple mining blocks are to be mined, there is potential for overlap of sedimentation patterns. However, the impacts of sedimentation outside a mining block are not relevant if the area is mined in a subsequent year.

Hewitt & Lohrer (2013) (Appendix 29) identified that the MarLIN website utilised a threshold depth of 5 cm sedimentation as being a determinant of adverse sedimentation effects. They also identified that a number of studies have shown adverse impacts of sedimentation at depths of <5 cm and that depths of sedimentation as low as 1 mm might have impacts on some organisms. Other factors can influence whether shallow depths of sedimentation might have adverse effects. Several communities identified as occurring on the Chatham Rise in proximity of proposed mining areas were identified by Hewitt & Lohrer (2013) as being sensitive to smothering.

In summary, deposition of 5 cm of sediment or more is expected to smother most benthic organisms, but this impact is predicted to extend less than 0.5 km from the mining blocks. Less significant adverse impacts of sedimentation are expected from deposition of as little as 1 mm of sediment, and these are predicted to extend no more than 6 km from the mining blocks.

8.6.3.4 Modelled suspended solids and impacts on benthic biota

The sensitivities to increased suspended solids will vary among organisms, but Hewitt & Lohrer (2013) (Appendix 29) concluded that a concentration of 100 mg/L for a period of at least a month is required to have a significant adverse impact on the benthic organisms observed in the marine consent area. This level is never predicted to be reached outside of the mining blocks as a result of the proposed mining operations (Deltares 2014b).

Modelling predicts that the direction of the dispersal of the plume of suspended solids may vary somewhat with the seasons. The modelling predicts that the sediment plume will remain within tens of metres of the seabed, and that the concentration of the suspended solids in the plume will rapidly decrease with distance from the mining block and with time after the end of each phase of mining (Deltares 2014b – Appendix 25).

The modelling has shown that concentrations of 50 mg/L are confined to areas within the mining blocks. Concentrations less than this threshold may have some impacts on benthic organisms (physiological stress, etc.). The distribution of water with lower suspended solids concentrations is dynamic and non-uniform, controlled by currents and tides. Information on suspended solids concentrations of 50 mg/L and 5 mg/L are described in Sections 8.6.5 (Impacts on pelagic biota).

Hewitt & Lohrer (2013) (Appendix 29) provides information on the relative sensitivities of the range of biota encountered in the benthic communities present within the marine consent area. Immediately adjacent to mining blocks, organisms on the seabed will be exposed to increased concentrations of particles as the plume moves past in the water layer close to the seabed. Exposure to increased suspended solids will occur for several days before the concentration returns to ambient levels prior to the start of the next mining cycle. This exposure will occur ten times before the mining vessel moves to a new mining block.

Modelling indicates that within the down-drift region where the non-phosphatic material is disposed, the suspended sediment concentrations decrease progressively to <1 mg/L (at the edge of the modelling domain).

For these reasons no adverse impact associated with increased suspended solids concentrations are predicted on benthic organisms within a short distance of areas that are being mined.

8.6.3.5 Avoidance, remediation and mitigation measures

Avoidance, remediation and mitigation measures consist of a mining plan that minimises the overlap of sedimentation of mining blocks in any year, for at least the first five years of mining (refer to Section 4.4.2). That is, sedimentation impacts from one mining block will not immediately compound impacts from mining another block.

To quantify the actual impacts on the benthic habitats adjoining the mining blocks, CRP is proposing to monitor the turbidity, the abundance of organisms, and the rate of recolonisation of the biota at sites near and remote to the mining operations. A monitoring programme is outlined in Section 11 and also in the EMMP (Appendix 35(i)).

8.6.4 Recolonisation of benthic communities

8.6.4.1 Introduction

Recolonisation of disturbed seabed occurs as a result of both natural and anthropogenic events. Natural events include changes in oceanographic conditions, sediment deposition from storm derived riverine flood deposits, undersea slumping and landslides and iceberg scouring (as has historically occurred on the crest of the Chatham Rise). Human disturbance of the seabed in the marine environment includes dredging for harbour approaches, dredging for sand and aggregate, dredging for other marine minerals, sediment deposition from seabed dredging and tailings disposal, and fishing operations particularly bottom trawling.

Studies of recolonisation have been carried out following seabed disturbance and also experimental studies involving the placement of sediment devoid of fauna. Beaumont & Rowden (2013) (Appendix 30) reviews literature on the recolonisation of benthic communities in both inshore coastal waters and deep water environments.

Key factors driving and affecting recolonisation in any location include:

- The scale of seabed disturbance or removal.
- The changes in physical seabed characteristics (e.g., particle size) following disturbance and/or sedimentation.
- The hydrodynamics at the seabed undergoing recolonisation.
- The distance from healthy biological communities, sources of propagules or immigrants, from the affected seabed.
- The mobility of macro- and megafaunal species.
- The fecundity of species producing colonists (i.e., numbers of larval colonisers and the effectiveness of their dispersal).
- The 'life strategy' of the species (e.g., longevity, time to maturity).

The theory of recolonisation processes in the marine environment, as has been described by Beaumont & Rowden (2013) in relation to CRP's proposed mining operations, is the basis of the following sections.

In relation to CRP's proposed mining operations, factors that affect assessment of recolonisation include:

- It is proposed that mining will occur in 2 by 5 km blocks. Although adjoining unmined areas will be impacted by sedimentation, it is likely that some components of the biological community will remain to provide colonists for the mined areas. With sediment discharge proposed using the 10 m option, it is likely that mobile megafauna may remain within the unmined areas but there is considered to be a low probability that sessile biota will survive.
- About 30 km^2 will be mined each year (i.e., it is currently estimates that 90 km^2 will be mined during the first three years).
- In the first five years of mining, as outlined in Section 8.6.3.5 above, the mining blocks will be separated by sufficient distance to minimise the impacts of mining in other blocks.

The benthic habitats and communities on the Chatham Rise are described in Section 6. To assist in understanding the recolonisation process, the recolonisation implications for the habitats and communities are briefly described below, as the rates and potential for recolonisation differ among them. The recolonisation process that is anticipated following CRP's proposed mining activities is outlined in Section 8.6.4.6.

8.6.4.2 Recolonisation studies

Overview

International studies on recolonisation of seabed following dredging and sediment extraction have shown that recolonisation of dredged seabed can begin relatively quickly (e.g., 12–24 months). During this time macro-faunal abundance can return to pre-dredging conditions but the recovery of the composition and structure of the community can take longer (Newell et al. 1998).

Recolonisation is a function of the presence of mobile adults in adjacent areas to move into the area and the settlement of larvae from adjacent areas up-current (van Dalfsen et al. 2000).

Recolonisation in areas where biota has been removed (defaunated) includes a random element. This element relates to season and substrate suitability and the availability of larvae in the water column following the defaunation event. Consequently the initial fauna settling on the new sediment surface will be the opportunistic species that passes overhead, finds the surface suitable and settles.

Sand and aggregate mining is a major industry worldwide that disrupts benthic communities, and observations of recolonisation after those activities may be instructive.

Coastal sand mining in New Zealand for the construction industry occurs in the Kaipara Harbour and in the area from Pakari to Te Arai Pt (producing about 100,000 t/annum). Dredging for sand and aggregate is a significant activity in coastal areas around the United Kingdom, particularly in the southeast of England. Boyd et al. (2004) and Hill et al. (2011) report that about 23 Mt of aggregate resources were recovered around the coastline of England and Wales. Hill et al. (2011) note that that there are over 70 production licenses (0.15 % of the seabed of the United Kingdom). About 11 % of the license areas (123.6 km^2) are actively dredged in a given year. The bulk of dredging is carried out by trailing suction hopper dredges.

Boyd et al. (2004) reported on studies at a number of aggregate mining sites around the United Kingdom. The physical effects (e.g., dredge tracks) can be seen from three to 10 years following cessation of dredging. Dredging was also found to produce changes in the physical characteristics of the seabed, typically resulting in higher proportions of sand (due to the returns in aggregate mining areas having more sand).

Several studies have indicated that restoration of the benthic communities can be expected within two to three years after dredging has been completed. Areas where repeat dredging has been undertaken would be expected to recover over periods of the order of six to seven years. However, this time period is dependent on the nature of the post dredging substrate (i.e., its similarity to the pre-dredging physical conditions) and a range of other factors including water depth, productivity and temperature and the species involved.

Hill et al. (2011) reviewed studies on changes in benthic fauna communities as a result of dredging. Under stable conditions benthic habitats are likely to be dominated by climax communities containing a number of species that have a long life span and reach large body size. These species may not be dominant in number but they often dominate the biomass due to their large body size. Highly disturbed habitats are rarely able to support climax communities and are instead dominated by large numbers of 'opportunistic' species that are tolerant of high levels of disturbance. Opportunistic species are generally small, short-lived, fast growing animals that rapidly colonise newly disturbed habitats. Aggregate dredging increases levels of disturbance and is therefore often associated with a shift, at least in the short term, towards a community dominated by opportunistic species that are more tolerant of disturbance.

Enhancement of filter-feeders (including polychates and other taxa) between 500 and 1000 m downstream of the centre of dredging activity has been recorded (Newell et al. 2004, Boyd & Rees 2003). This enhancement may result from organic enrichment caused by damaged and fragmented animals discharged during dredging.

Most studies of marine aggregate extraction on the benthic fauna examined the rates and processes of macrobenthic recolonisation when dredging was completed (e.g., Cressard and Dubyser 1975, Kenny et al. 1998, Desprez 2000, van Dalfsen et al. 2000, Sardá et al. 2000, van Dalfsen & Essink 2001). The estimated time required for 'recovery' of the benthic fauna following marine aggregate extraction may vary depending on the nature of the habitat, the scale and duration of disturbance, hydrodynamics and associated bed load transport processes, the topography of the area and the degree of similarity of the habitat to that which existed prior to dredging (for review see Newell et al., 1998).

Most studies show that dredging causes an initial reduction in the abundance, species diversity and biomass of the benthic community and that substantial progress towards full restoration of the fauna and sediments can be expected within approximately 2 to 3 years following cessation (Kenny et al. 1998, van Dalfsen et al. 2000, Sardá et al. 2000, van Dalfsen and Essink 2001, Newell et al. 2002). van Dalfsen et al. (2000) suggested that recolonisation of a dredged area by polychaete worms occurred within 5 to 10 months after the cessation of dredging in a site in the North Sea, with restoration of biomass to pre- dredge levels anticipated to occur within 2 to 3 years.

New Zealand studies

There have been few studies of recolonisation following disturbance in the New Zealand marine environment. POAL (1995) examined recolonisation of soft sediments deposited in the Hauraki Gulf following the disposal of sandy mud from maintenance dredging in the Port of Auckland. Surface sediments at the site decreased from 82.5 % mud to about 60 %. Immediately post disposal the new sediment surface showed evidence of Stage 1 pioneering communities comprising polychaete worms (typically shallow dwelling). As expected, the organism-sediment index (OSI) decreased significantly in the new sediment surface. Polychaete worm and bivalve mollusc densities peaked immediately after disposal then declined to numbers similar to control sites. Some sediment samples collected two and three years after disposal displayed characteristics of areas unaffected by disposal. The occurrence of horse mussels within the disposal area aided in increasing diversity as a result of the habitat they created.

Recently Leduc & Pilditch (2013) carried out laboratory experiments on the impacts of disturbance on meiofaunal communities using sediment cores collected from a depth of 345 m on the Chatham Rise (just north of the proposed marine consent area). The study found that the laboratory disturbance did not have any noticeable impact on sediment characteristics, sediment community oxygen consumption, or nematode species richness. It was found to cause changes in vertical distribution patterns and also changes in nematode community structure. The authors reported that the main impact of disturbance on nematode vertical distribution patterns and community structure appeared to be related to a vertical re-shuffling of nematodes in the sediments rather than mortality. They did not observe substantial increases in the abundance of nematode genera that were considered disturbance-tolerant. Reductions in some groups of nematode were identified - typically long and slender nematodes which may be easily damaged by physical disturbance. It was concluded by the study that the limited impact of physical disturbance on benthic community structure and function suggests that the Chatham Rise nematode community is relatively resilient to sediment deposition. This resilience may have arisen from frequent exposure to disturbance in the field (e.g., from strong currents), or may be a more widespread feature of nematode communities.

Deep water studies

Studies of recolonisation in the deep ocean, usually associated with areas of interest for mining manganese nodules, show that some impacts can be long-lasting but also highlight the natural variability of some aspects of the ecosystems.

Studies examining disturbance and recolonisation in deep sea environments include the German DISturbance and reCOLonization experiment (DISCOL) in the Peru Basin (South Pacific) which started in 1989 with follow up work seven years later (Thiel 1992a, Borowski & Thiel 1998, Borowski 2001, Ahnert & Schriever 2001, Thiel et al. 2001, Vopel & Thiel 2001). In 1994, the Japan Deep-sea Impact Experiment (JET) was carried out in the western Clarion Clipperton Fracture Zone (CCFZ) with sampling in the years that followed (Barnett & Yamauchi 1995, Fukushima 1995, Kaneko et al. 1997, Shirayama 1999, Shirayama et al. 2001). Another study, the Inter Ocean Metal Benthic Impact Experiment (IOMBIE), was conducted in the eastern CCFZ in 1995 with sampling two years later (Brockett 1994, Radziejewska et al 2001a,b, Radziejewska 2002).

As a part of the environmental impact assessment studies for polymetallic nodule mining under the INdian Deep-sea Environment eXperiment (INDEX), the impact of simulated disturbance was studied in the Central Indian Basin in 1997. The disturbance was caused by a combination of fluidising pump and suction pump to dislodge and discharge the sediment into the water column 5 m above the seabed. Sediment slurry was pumped and discharged by this system along 26 tracks for 9 days, with an estimated sediment resuspension of 6,100 m^3 (Sharma 2000). The restoration of benthic environment was monitored for four years (2001-2005) at five locations in and around the test site and at three reference stations (20-80 km) from the test site.

The immediate impact of disturbance was observed on sediment characteristics (Sharma et al. 2001, Valsangkar 2001) and macrobenthos (Ingole et al. 2001). Raghukumar et al. (2001) estimated bacterial numbers, bulk measures of labile organic matter (LOM) (consisting mainly of carbohydrates, protein and lipids), total organic matter (TOM) and ATP carbon (indicating carbon contributed by living biomass) in the pre-disturbance (May–July 1997) and post-disturbance (July–August 1997) periods.

These results indicate that the seasonal changes, apparently natural, far outweighed (in many cases, by orders of magnitude) anything caused by the disturbance. The data showed a decrease in bacterial numbers, ATP, carbohydrate and lipid and an increase in protein concentration in the two box-core samples taken at the reference site 54 months after the initial baseline sampling and in the nine cores from the disturbance site in the second post-disturbance phase. During the Japan deep-sea impact experiment in the eastern equatorial Pacific, Kaneko & Maejima (1997) reported bacterial numbers to be much higher 1 year after the benthic disturbance than in pre disturbance samples, suggesting that recolonisation after a disturbance may vary from site to site.

Rodrigues et al. (2001) examine magafaunal impacts arising from INDEX using photographs and video. They identified an overall reduction (32 %) in the total megafaunal population after disturbance. Groups such as xenophyophores, sea anemones, shrimps, starfish, brittle stars, holothurians and fish show different degrees of reduction (21–48 %) in their numbers, depending upon their ability to withstand increased turbidity and sedimentation rates due to disturbance. Faunal groups such as protobranch molluscs, polychaete worms, squids, observed before the disturbance, were not seen after disturbance, whereas populations of some taxa increased after the disturbance. Increased numbers of mobile taxa were considered by the authors to arise from increased levels of organic carbon due to re-sedimentation. The authors concluded that monitoring of megafauna can be used to effectively evaluate the potential impacts of large-scale mining or other disturbance on the seabed.

Ingole et al. (2001) reported that there was a significant change in the composition and biomass of macrofauna after the INDEX disturbance. Post-disturbance vertical profiles indicated a 63 % reduction in the numerical count in the top 0 to 2-cm layer and high aggregation of macrofauna in deeper (5 to 10 cm) sediment layer. The impact of the disturbance was severe, as the mean biomass of macrofauna was significantly reduced in the disturbed area, probably due to the displacement and /or mortality caused by the benthic disturber.

A study investigated total meiofaunal density four years after the disturbance was carried out in 1997 (Sharma 2001, Ingole et al. 1999, 2001, Ingole et al. 2005).

Sharma et al. (2007) concluded that much of the data collected in the INDEX experiments pointed to natural variation as a factor in much of the observed post disturbance variation. They noted:

- Sediment organic matter and pore-water chemical data indicated partial restoration of geochemical properties after the experiment and cyclic changes during the monitoring period.
- Following the initial reduction after the experiment the mean meiofaunal density reduced substantially in subsequent monitoring phases, indicating influence of some natural process in the area.
- Density of macrofauna, which had reduced after the experiment, showed a further reduction in subsequent monitoring phases which was attributed to natural variations.

DISCOL was the first attempt to simulate the effects of large scale sediment disturbance on the deep-sea bottom (4,150 m deep) expected from industrial activities in the deep sea, such as manganese nodule mining. The goal of DISCOL was to determine the long-term impacts of a severe disturbance on community structure by monitoring the reaction of indicator taxa, a selection of taxa which it was believed would best indicate changes (Thiel 1992b). A specially constructed, 8 m disturber was towed 78 times through a 10.8 km^2 experimental field.

The reestablishment of the impacted macrofaunal assemblages in the disturber tracks was monitored three times over a three year period (Borowski & Thiel 1998). After the impact, the animal abundances in the plow tracks were reduced to 39 % of undisturbed densities. Polychaeta were less impacted than tanaidacea, isopoda, and bivalvia. Abundances of most higher taxa increased rapidly in the tracks, and after three years were comparable to those of undisturbed sediments. Diversity was still significantly reduced after three years. The reestablishment of a semi-liquid surface sediment layer is proposed as a potentially controlling factor for the reestablishment of the macrofaunal community after physical disturbance. The increased dominance of cirratulid polychaeta in the tracks half a year after the disturbance suggests opportunistic abundance increase of certain species.

Borowski & Thiel (1998) concluded that the recolonisation of DISCOL tracks by macrofauna took less time than predicted by traditional concepts of slow biological processes in the deep sea. It appeared that the main process of macrofaunal recolonisation in the DISCOL tracks was lateral migration. As a result they concluded that the experiment, although designed on a large scale, resulted in only small-scale disturbed patches (as it related to macro-fauna). This appears to have left sufficient nearby undisturbed areas to facilitate recolonisation from lateral migration (refer also Bluhm et al. 1995 and Borowski 2001).

Bluhm (2001) showed that even seven years after the benthic impact, megafauna had not returned to their original density. It was concluded that the local conditions, such as the prevailing currents and the topography and the seasonality, make the impact of benthic disturbance very site specific.

Overview and summary

Studies undertaken to examine the impacts of disturbance in deep sea environments were all in much deeper environments than the Chatham Rise. The results of experiments that endeavoured to mimic aspects of manganese nodule mining reflect the small scale of the experiments. However, the results have shown that the influence of natural variation may have been under-estimated and natural change is at times responsible for significant benthic biological variation (in both abundance and diversity).

The key elements of change that are expected to occur following the mining of phosphorite nodules are:

- Effective removal of most epifaunal and infaunal biota along mining tracks with minor potential for biota to remain if parallel tracks do not pass immediately alongside each other.
- Changes in the physical characteristics of the sediment following removal of the nodules and deposition of finer sediments over sands.
- The settlement of organic matter during the settlement of finer sediments, with the organic material being incorporated into sediment profile and or deposited on the sediment surface.
- Recolonisation by opportunistic larval species that find the deposited sediment a suitable habitat.
- Movement of mobile macrofauna and megafauna from the areas immediately adjacent to mining blocks where sedimentation has not impacted fauna.
- Recolonisation towards the development of a community is likely to begin in the first 1 to 2 years.
- Long term recolonisation towards a more complex benthic community will be site and time specific dependent on the compaction of deposited sediment and migration and settlement of new fauna into mined areas.

Recolonisation within soft sediment following mining is not predicted to be a fast process and it is likely to take more than five years for initial community development, and potentially at least 10 years or longer to attain the degree of community complexity that would be expected for the type of substrate remaining following mining.

8.6.4.3 Fauna associated with hard substrates

Work has been undertaken to study recolonisation of seabed disturbed by trawling. In areas where trawling has removed fauna from hard substrate on seamounts in deeper waters on the flanks of the Chatham Rise, Williams et al. (2010) found no recovery of communities after 10 years.

Williams et al. (2010) also examined key aspects of recolonisation. Many of the species they studied are widespread on the Chatham Rise and are also found on areas of hard substrate within the proposed marine consent area. Williams et al. (2010) found that of the taxa observed in the proposed mining area:

- Anemones, brisingids, crinoids and bryozoans were all rated as having a low recovery ability.
- Scleractinians, asteroids and sponges were rated as having a medium recovery potential.
- Echinoids, gastropods, ascidiacea, polychaetes and crustaceans were rated as having a high recovery potential.

However, these ratings were determined with respect to the recolonisation of bare hard substrates typically left behind after trawling. They were also based on the assumption that nearby source populations would be unaffected by the disturbance of substrate and sedimentation.

For hard substrate species such as cold-water corals (e.g., *G. dumosa*, *Flabellum sp.),* porifera, bryozoa, and ascidiacea, a substantial reduction in hard substrate suitable for settlement is likely to significantly reduce their recovery rate. This is particularly true where the hard substrates are dominated by coral species such as *G. dumosa*, thought to have limited dispersal ability and slow growth rates.

If hard surfaces become available within the mining area (e.g., as a result of habitat creation) or recolonisation occurs in locations where hard surfaces have been impacted by sedimentation, then recolonisation would be expected to be slow. The rate of recolonisation is expected to be faster where the location is close to living fauna. Thus the initial phases of recolonisation of disturbed hard substrate habitat in the proposed mining area are expected to take at least months or years, primarily depending on the proximity of sources of recolonizing organisms.

New hard substrata have the potential to support a similar community to that present on hard substrate areas that were present the mining area, including the phosphorite nodules. However, complete recovery to form a community with a structure similar to those present today is dependent on the availability of larvae and the growth of the slowest growing species. It is assumed in the case of the cold water corals that recovery will take ten or more years. Given that similar communities are considered likely to be present within distances of a few kilometres, providing a source of larvae for colonisation, recovery of community assemblages similar to the pre-mining assemblages is possible.

Hard substrate habitats found on the Chatham Rise include small isolated erratics (rocks left by icebergs), outcrops of greywacke and schist (significant areas of these are not present within the mining permit area but have been mapped in the marine consent area), and areas of exposed hard chalk and limestone (Beaumont & Rowden 2013 – Appendix 30). The latter habitat can be seen as surface exposures or ledges associated with some iceberg furrows.

The main epibenthic species associated with hard substrates include the cnidaria (including anemones, the cold-water coral *Goniocorella dumosa* and the cup coral *Flabellum sp*.), porifera, bryozoa, ascidiacea, some mollusca and some annelida (refer Section 6.3). The key taxa in this habitat are sessile filter feeders. The community also contains mobile macro and mega-fauna including echinodermata, crustacea, some annelida, and some mollusca.

Hard substrates that, if possible, will be avoided by the mining activity include:

- Large erratics on the sediment surface.
- Areas of exposed hard chalk along the edge of significant iceberg furrows.
- Large patches of hard ground (basement rocks, chalk and limestones).

Erratics and large areas of hard substrate (> 2 km^2), will be identified prior to mining commencing and set aside as features that will not be mined. A proposed condition reflecting this is outlined in Section 11.4.

If localised areas of exposed chalk are mined, the previous seabed surface will be covered by finer sediments and the seabed surface in that location will become more homogenous (i.e., any patchiness created by the exposed chalk will be lost). It is likely that areas with exposed chalk will be covered by up to 10 to 20 cm of sand and silt.

8.6.4.4 Fauna associated with soft sediment

Soft sediment fauna are a key component of the Chatham Rise, including areas where phosphorite nodules are present (Beaumont & Rowden 2013 – Appendix 30). Of the major epi-benthic taxa observed in the mining area, the echinodermata, crustacea, annelida and mollusca are all relatively mobile fauna and are capable of inhabiting soft-sediment environments. Taxa in these groups are scavengers, predators and deposit feeders.

Mobile megafauna are often the first biota to be seen on new sediment surfaces. Some rapid recolonisation of the new sediment surfaces within the mining blocks is expected as a result of lateral migration from the immediate adjacent unmined areas. However, in numeric terms the numbers may initially be relatively low, depending upon the densities in the adjacent areas.

Recolonisation involving planktonic larvae is dependent on:

- Availability of planktonic biota transported onto the mined sediment (season, current direction, etc.).
- Whether the sediment surface is suitable for the organisms that settle (grain size, density, etc.).
- The re-suspension of surface sediments and its effect on colonists.

Physical factors such as surface sediment instability and biological factors such as megafauna that disturb the sediment may impair recolonisation processes. As described in Section 8.6.4.4, the fauna in the soft sediment communities are likely to contain organisms that have a range of sensitivities to suspended sediment. Given that there is an element of natural suspended sediment at the seabed, it is likely that soft sediment inhabitants on the Chatham Rise may be less sensitive to suspended sediment than biota inhabiting communities on hard substrates. Generally, newly settled larvae have a higher sensitivity to suspended sediment than their adult counterparts.

Any of these factors can also change the direction of the short-term and medium-term community composition.

Overall, recolonisation of disturbed soft sediment habitat within the mining bocks would be expected to start within days of an area being mined. However, this is only the beginning of a complex and dynamic process that would be expected to take several annual cycles. Further aspects of recolonisation are described in Section 8.6.4.6.

8.6.4.5 Fauna associated with phosphorite nodules in soft sediment

It is unlikely that recolonisation of phosphorite nodules exposed at the surface of the seabed will occur as they will be either removed or buried by the returns.

As described earlier, surface phosphorite nodules exposed at the seabed provide habitat for sessile hard substrate fauna. The fauna assemblage utilising the nodule surface is dependent upon the size of the nodules, that is the larger the nodules the larger the organism that can be supported on the nodule. Infauna are also present within the soft sediments that contain nodules.

As described in Section 8.6.2, this habitat will be altered within a mining block. Some nodules will remain in mining tracks, but they will probably be beneath the new seabed.

The return of phosphorite nodule-soft sediment habitat and associated benthic communities to their original state is only possible if some surface nodules remain following mining. The near total removal of phosphorite nodules from this habitat will result in an altered ‘stable-state’, and the new benthic community is predicted to be more similar to that of soft sediment habitats (see above). Due to the likely lower nodule density, recovery of a community with the structure of the pre-mining community that was based on high nodule density will not occur.

As described earlier in Section 8.6.2, habitat shifts from soft sediment/nodules to soft sediment will result in a transition to communities dominated by fauna that prefer soft sediments.

8.6.4.6 Recolonisation process

Recolonisation of disturbed communities seldom results in recovery to a community that is a replica of what was present before the disturbance occurred. Recolonisation to an ‘altered state’ or an equivalent state is the result of both physical and biological factors.

New Zealand studies such as those of Thrush et al. (1996), although carried out on intertidal sand flats, show that factors such as patch size, emigration, recovery time, and interactions between hydrodynamic conditions and habitat stability are important influences on recovery processes in soft sediment habitats.

Therefore, recolonisation is a function of the available pool of mobile organisms (able to move into an area), their rate of migration, the distance required (i.e., the scale of disturbance or patch size), the composition of adjacent biological resources (the availability of mobile macro and megafauna, the sessile biota and their contribution to available larval colonists) and the nature of larval colonists from the greater area.

Species on the Chatham Rise have differing strategies for colonisation, some have short range dispersal strategies and some disperse their larvae over large distances (hundreds of kilometres) (Beaumont & Rowden 2013 – Appendix 30). In many, if not most cases the distances over which larvae are able to disperse are large compared to the scale of CRP's proposed mining disturbance. The exception may be corals which in general have relatively short dispersal distances (tens to hundreds of metres).

The patch size of the mining blocks is relatively large (10 km^2) compared to the dispersal distance of some organisms. However, during the first five years when mining blocks are separated, the distance to the closest un-mined edge is relatively small. Recolonisation by larval dispersal is likely to be more important for many species than lateral migration of adults.

Distance is a factor that affects colonisation potential differently for each species in an ecosystem. Patch size theory indicates that in areas of small disturbance recruitment to the disturbed area will occur over shorter distances by adult immigration (mobile species) and that recruitment over longer distances will primarily occur from water borne larvae (from a range of groups, and those larvae with higher survival rates and ability to be carried over longer distances). Those larvae that settle and succeed are expected to be those with preferences for softer sediments and those with a higher tolerance for resuspension of sediment.

As noted in Beaumont & Rowden (2013) several studies have observed that short-term communities can often include a relatively immediate phase involving mobile scavengers that feed on detritus. This may be the case within the mining blocks as the returned sediment will include some organic matter from biota processed with the mined sediment.

Deep water recolonisation studies (refer Section 3.3 in Beaumont & Rowden 2013 – Appendix 30) have typically involved small scale disturbances and the patch scale issues are not directly comparable to the other disturbance studies. However, there appears to be a consensus that recovery of benthic communities in deep sea environments following disturbance is likely to be slower than in coastal communities (e.g., Clark & Rowden 2009, Cryer et al. 2002, Jones 1992).

Following mining disturbance it is likely that there will be some relatively rapid (days to months) lateral migration of mobile adults and juveniles from surrounding, undisturbed, soft sediments into the disturbed areas, if the sediment properties remain similar. Recovery of these areas through recolonisation by larval dispersal could take months to years. The time required for those larvae to become adults is dependent on life history and lifespan. It is also anticipated that edge zones of benthic communities associated with both hard substrates and soft sediments surrounding the mined areas will be impacted by a reduction in available settlement area and reduced feeding efficiency due to increased sedimentation. These impacts of sedimentation will also influence recolonisation by communities in these areas as well as the recolonisation of the directly disturbed communities, as sites immediately adjacent to mined areas provide sources of propagules for recolonisation.

8.6.4.7 Avoidance, remediation and mitigation measures

Decisions about habitat restoration as a mitigation measure, as being considered by CRP, need to consider the nature and area of habitat loss and the occurrence of similar habitats outside the mining area. If no hard substrate creation is attempted by CRP and the seabed is allowed to recover naturally, then the nature of the benthic communities will depend on local conditions and is likely to result in the creation of communities similar to those in areas of the Chatham Rise with soft sediment. These communities would be different to the existing communities associated with dense concentrations of phosphorite nodules.

Based on an understanding of the nature and scale of the changes, it may be possible to identify habitat creation options and techniques that may restore the physical properties of the seabed. From this the cost effectiveness of remediation measures can be evaluated. This assessment needs to include an analysis of the ecosystem services and goods/benefits produced by the site to determine whether intervention is justified.

There have been few published studies examining seabed restoration. One of the earliest was Collins & Mallinson in Newell & Garner (2006) who examined the potential for use of waste shell material from the shellfish processing industry for seabed restoration. The changes evident following the placement of the waste shell was similar to the expected patterns of colonisation and succession (refer Newell et al. 1998). Collins (2011) examined the effects of a larger scale gravel seeding into an area of aggregate mining where seabed characteristics had become sandier and concluded that the seeding returned the fauna to a state more similar to the gravely reference site. Collins et al. (2013) subsequently discussed restoration in the United Kingdom aggregate extraction industry noting that whilst small-scale experimental studies have shown that it may be possible to mitigate such impacts, it is unclear whether the costs of restoration are justified on an industrial scale.

Van Dover et al. (2014) provide a discussion about ecological restoration in the deep sea. They recognised that restoration costs in the deep sea will be high (likely orders of magnitude higher) compared to those in shallow coastal areas. The authors considered a hypothetical restoration project involving an area of patchy stony coral habitat of the Darwin Mounds (UK) that has been historically damaged by bottom trawling. The estimated costs, which did not include any seabed re-engineering for a 600 m^2 area of corals, were estimated at $4.8 million (80 % of the costs are ship and ROV/AUV costs). The project considered the propagation of fragments of corals (in this case the cold water coral *Lophelia pertusa*) which would be attached to substrates and placed on the seabed.

As part of its monitoring programme (refer to Section 11.3), CRP has proposed trials to assess the technical feasibility of replacing hard substrate in the mining blocks. If hard material can be returned to the seabed in a cost-effective manner, then it will be placed in several locations and monitored to assess natural recolonisation timelines. The overall impact of these recolonisation trials are positive, not adverse. The results of these experiments will provide the information necessary to consider, in consultation with the ERG (refer to the proposed marine consent conditions in Section 11.4), the environmental benefits and economic costs of restoration and to decide if and how restoration should proceed.

8.6.5 Impacts on pelagic biota

8.6.5.1 Introduction

As summarised in Section 8.4, modelling the dispersion of suspended particles from the disposal of mined sediment has shown that:

- No suspended solids derived from the disposal of sediment will reach the upper mixed layer or euphotic zone. As a result, there is no potential for suspended solids to impact on phytoplankton and biota in the upper water column and this is not discussed further within this section of the EIA.
- Suspended solids from the mining operations (predominantly disposal of the processed non-phosphatic material) occur very close to the seabed. The majority of the suspended solids will be present within the bottom 10 m of the water column.
- The duration of elevated levels of suspended solids at any point is predicted to be a maximum of a few hours or days.

This section provides an overview of the effects of suspended solids on marine biota. The focus of the section is to describe the relationship between the modelled sediment plumes and key species of the Chatham Rise fishery.

The modelling of plume dispersion at the seabed identified that increased concentrations of suspended sediment will be generated close to the seabed and that increased concentrations are likely to extend beyond the boundary of a mining block. The maximum distance from the centre of a mining block to the domain edge, given the alignment of the mining block and plume within the domain (refer to Section 8.4), is about 15 km in the models reported in Deltares (2014b) (Appendix 25).

The modelling showed that during mining suspended solids were retained close to the seabed and that:

- Suspended sediment is predicted to be present at the edge of the mining blocks at concentrations of up to 50 mg/L during mining. The distribution and concentration of the sediment plume will depend on the season and the currents (refer to Section 8.4.3).
- Adjacent to the mining block, concentrations of clay are predicted to be of the order of 1 to 5 mg/L, depending on physical conditions (seabed roughness, currents, etc.).
- At the boundary of the modelling domain (about 15 km from the mining activity), fine sediment is predicted to be ambient concentrations (<1 mg/L) but may range up to 5 mg/L at times. During mining the period of time that concentrations will be at the upper end of this range are predicted to be low.
- Particles in suspension at the edge of the model domain (15 km from the mining area) will typically be clays. These particles will be transported by regional, large scale oceanographic features such as eddies away from the Chatham Rise.

Biota that inhabit the water column over the Chatham Rise (refer Section 6) include phytoplankton, fish larvae, jellyfish, small fish and larger biota such as fish and squid. Page (2014a,b) (Appendices 27 and 28) provides an overview of the effects of total suspended solids (TSS) on fish eggs and fish, respectively. The focus on fish eggs and fish reflects the importance of the fishery resource on the Chatham Rise.

8.6.5.2 Impacts on fish eggs and larvae

Introduction

Fish eggs and larva can be adversely affected by suspended sediment. Eggs may be affected by sediment particles and larvae can be affected if suspended sediment reaches their gills (Page 2014a – Appendix 27). Eggs may also be affected by sedimentation if they are laid on the seabed.

Fish eggs

Suspended solids concentrations outside the mining area are not expected to adversely impact fish eggs because the eggs and larvae of most of the key commercial fish species occur in waters well above the seabed and remote from the mining area. Also, marine fish eggs appear to be tolerant of elevated suspended solids concentrations (Page 2014a).

Page (2014a) (Appendix 27) reviewed information on fish egg distribution on the Chatham Rise and the occurrence of running-ripe fish that were likely to spawn. He noted that most deep-water and pelagic fish species on the Chatham Rise spawn planktonic eggs (refer to Section 8.6.5.3 for where spawning occurs for key species).

Zeldis et al. (1995) identified a spawning site for orange roughy at the seamounts north of the Chatham Rise in water depths of 700 to 1,500 m. Page (2014a) noted that the orange roughy eggs are moved horizontally by currents away from the spawning location, but the distances are relatively short. In addition, the occurrence of 0+ and 1+ annual cohort juveniles 50 to 175 km west of the spawning area also suggests a limited distance of orange roughy egg dispersal (refer Mace et al. 1990).

A similar pattern to orange roughy has been observed for hoki in Cook Strait where eggs are advected to inshore waters by complex hydrodynamic conditions (Murdoch et al. 1990).

Changes in egg buoyancy are a common developmental feature in the early life stages of many marine fish, including several key species on the Chatham Rise including: hoki, orange roughy, hake, mackerel and horse mackerel (refer Page et al. 1989 and references in Page 2014a). The developing eggs rise to the mixed layer, which is typically at about 50 m depth in summer although it can extend to 300 m in depth (refer Appendix 7), and are advected vertically and horizontally by tidal currents and oceanic fronts before hatching into larvae. Larvae start feeding immediately as they resorb the yolk sac and need to be located near an adequate food source to survive. Orange roughy eggs are initially positively buoyant and rise to the mixed layer where they become neutrally buoyant. As the eggs develop they become negatively buoyant and sink to deeper water (600 to 700 m).

The impacts of fine sediment on fish eggs and larvae have been examined in a number of studies (refer Page 2014a – Appendix 27).

Partridge & Michael (2010) examined the direct and indirect impacts of a simulated dredge material on eggs of pink snapper *Pagrus auratus*. Direct impacts were assessed by measuring hatch rate or survival of eggs over a range of concentrations and exposure durations. Exposure of eggs to particles up to 10,000 mg/L for 24 hours did not affect egg buoyancy or hatch rate, despite sediment adherence occurring at the two highest concentrations tested.

Michael & Partridge (2011) examined the effects of TSS on fertilised barramundi eggs, exposed to concentrations from 20 to 2,000 mg/L suspended solids. No adherence of sediment was found for the eggs. No impact of suspended solids concentration was identified on egg viability or hatch rates indicating that barramundi eggs were very tolerant of particles. The authors noted that tolerance of eggs to suspended solids is generally high and this has been reported for a number of species.

Morgan et al. (1983) reported that white perch (a demersal species) egg hatching were unaffected by high suspended solids concentrations but embryonic development was affected by concentrations of 1,300 mg/L. The eggs are demersal and covering them with 2 mm of sediment resulted in 100 % mortality but sediment 0.45 mm thick had no effect.

It is unlikely that suspended solids from the mining operations will have a significant impact on eggs or larvae of key commercial fish species on the Chatham Rise. To have a significant impact, suspended solids have to be present within the geographic area and within the part of the water column occupied by a significant number of eggs or larvae.

The following comments can be made in relation to key species that spawn on the Chatham Rise:

- Ling are running ripe and spawn on the Chatham Rise (as well at other locations) in depths shallower than 1,000 m in particular in the shallower areas around Mernoo and Veryan Banks. Ling are present throughout the proposed marine consent area (refer Appendix 19) and are commercially caught in the eastern prospecting area. Ling appear to spawn at the seabed. Their eggs may remain at the seabed but may also float up through the water column as they develop. Juveniles have been recorded on the crest of the Chatham Rise.

- Hake spawn at a number of locations in the EEZ (Section 6.6.5.1) and are known to run ripe and spawn on the north and south flanks of the mid-Chatham Rise in depths less than 1,000 m during December. The data on ripe and running ripe female hake suggest that there is a preference for deeper waters around the edge of the Chatham Rise. Hake are also thought to spawn higher in the water column (e.g., more than 50 m above the seabed - refer to Section 4 of Page 2014a).

- Those key fish species around the Chatham Rise that spawn on the slopes of the Rise in depths well below the crest are not likely to be affected during sensitive stages (e.g., spawning) by suspended sediment near the seabed. These include hoki, orange roughy, oreo species and silver warehou.

Suspended solids have the ability to attach to the outside of eggs, changing their buoyancy in some species, but it is likely that only benthic spawners with eggs in the few metres above the seabed would potentially be affected by the proposed mining operations. The modelling (Deltares 2014b – Appendix 25) predicts that as the suspended sediment plume extends away from the mining area the concentration of suspended solids (clay) is <5 mg/L within 15 km of the mining operations and that the plume only influences the local environment for a limited period during the mining cycle. Clay concentrations of 5 mg/L at the outer edge of the plume are predicted to be present at a given location for less than 25 % of the time.

There is no information that indicates that the eggs of any key fish species are susceptible to sediment adhesion. The available information for key New Zealand species such as snapper indicates that fish eggs may be tolerant of suspended solids concentrations that are higher than predicted to occur through much of the discharge plume. Should any impacts arise, they are limited to the area of the plume where concentrations are high and the impact is determined by the proportion of eggs affected. Should such an impact occur it is unlikely that the proportion of eggs present within affected area would be significant (probably a fraction of a percent).

To impact eggs of key commercial fish species on the Chatham Rise, suspended solids have to be present within the geographic area and within the part of the water column they occupy. Key commercial species such as orange roughy that spawn on the slopes of the Chatham Rise to the northeast of the marine consent area will not be affected by seabed plumes generated by mining activity. The modelling has shown that the disposal of sediment at or above the seabed will only result in increased suspended solids in the lower few metres of the water column above the seabed and, as described above, concentrations will have reduced below 10 mg/L within a few kilometres of the mining block.

For a species such as ling where eggs are laid on the seabed, the impacts on eggs will be related to the proportion of egg stock lost in a given year due to mining activity. The area of seabed disturbed and affecting ling eggs will depend on timing of egg laying, and period of egg development prior to their movement higher in the water column. At the worst, the impact on ling eggs will be related to one mining block in given year (the mining block that corresponds to the spawning period). Ling lay eggs over areas of the Chatham Rise greater in extent than the proposed marine consent area (greater area than 10,192 km^2). Disturbance of 10 km^2 corresponds to a potential loss of <0.1 % of the marine consent area. The proportional of the area where ling eggs are laid that is affected by mining activities and therefore the potential proportion of ling egg stock lost in any year is likely to be less than 0.01 %.

Larvae

Concentrations of suspended solids sufficient to have significant adverse impacts on larvae are predicted to only occur within the immediate mining area and only within a few metres of the seabed.

Michael & Partridge (2011) examined the effects of TSS (20 to 2,000 mg/L) on larvae of barramundi. Mouth-closed larvae (i.e., newly hatched) were exposed for 12 hours and open-mouthed larvae were exposed for 6, 12, 18 hours. Significant differences were found in the survival of mouth-closed larvae with different TSS exposures. No adverse effects were observed at exposure levels between 0 and 500 mg/L. Those exposed to 750 mg/L and higher had lower survival rate. The lowest observable effects concentration for a 12 hour exposure was identified as 750 mg/L. For open-mouthed larvae both TSS concentration and length of exposure were important. For each exposure time, no effects were seen on larvae at concentrations below 250 mg/L. Mortality at 6 and 12 hours was lower than 18 hour exposure. These findings are similar to those described by sediment exposed snapper by Partridge & Michael (2010). As such, the data for both species indicates that as the larvae develop they become more sensitive to TSS increases in the water column.

Partridge & Michael (2010) examined the direct and indirect impacts of a simulated dredge material on larvae of pink snapper *Pagrus auratus*. Direct impacts were assessed by measuring survival of pre-feeding larvae, over a range of concentrations and exposure durations. Newly hatched larvae, whose mouths were still closed, were relatively tolerant of suspended solids, with a 12 hour lethal concentration resulting in 50 % mortality at 2,020 mg/L and a first observable impacts concentration of 150 mg/L. Once the larvae's mouths opened, tolerance was significantly reduced, with a 12 h 50 % mortality of 157 mg/L and a first observable effect concentration of 4 mg/L.

The work on snapper larvae indicates that mouth-closed larva are not affected by suspended solids. When they have open mouths and gills are therefore exposed, concentrations having significant adverse effects are lower. The concentrations identified as having significant adverse impacts in the snapper studies are predicted to only occur within the immediate mining area and only within a few metres of the seabed.

Impacts on the larvae of any commercial fish species will be limited to those larvae that cannot avoid the plume. As described, this is a water volume corresponding to the first few metres above the seabed and the area where the plume is present at one period of time. Although there is little information regarding the distribution of the larvae of commercial fish species on the Chatham Rise, the impacts are considered to be volumetric in nature as most larvae are either moved by currents or remain relatively close to where they hatch. To provide perspective, a plume of 30 km^2 with a height of 10 m equates to <0.01 % of the volume of the water above the seabed of the marine consent area. As only part of the plume will have concentrations higher than thresholds identified earlier and the marine consent area is a small part of the Chatham Rise, the proportional seawater volume is very small, and the proportion of fish larvae contributing to fish stocks of any commercial fish species potentially affected by the plume will be even smaller.

Summary

Surveys show that the marine consent area is not a major spawning site for key fish species on the Chatham Rise other than ling, and that any eggs and larvae in the water column over the central Chatham Rise are unlikely to be significantly affected by the increased suspended solids concentrations arising from disposal of sediment.

8.6.5.3 Impacts on fish and fish stocks

Introduction

Impacts on fish or fish stocks can occur through impacts on eggs, larvae, juvenile or adult fish. The extent of impacts are dependent on the location of eggs and larvae of fish species and the location of juvenile and adult fish. The degree of impacts depends on whether the organism (egg, larvae or fish) are mobile and can avoid the plume. The impacts on fish eggs and larvae were described above. Impacts on the eggs of commercial fish species are likely to be primarily limited to those eggs that are laid on the seabed, and these impacts are minor.

Page (2014b) describes that elevated concentrations of TSS in water can have lethal or sub-lethal effects on fish and can cause fish to avoid water containing elevated concentrations. Increased concentrations of TSS can have a variety of physical effect on fish ranging from behavioural (reducing visual acuity when hunting prey) to physiological stress (e.g., from clogging of gills) which can potentially lead to reduced growth and reproductive fitness. Page (2014b) summarises impacts that can occur in wider ecosystems. In the case of the disposal of the non-phosphatic material on the Chatham Rise, the impacts are limited to the near bottom environment (refer Section 8.4).

Page (2014b) summarises threshold concentrations for a range of impacts on pelagic, demersal and benthic fish species. The key findings of the review were:

- Avoidance behaviours have been identified in both demersal and pelagic species for increased concentrations of suspended solids. These include 3 to 5 mg/L (adult Atlantic cod, Atlantic herring), 5 mg/L (avoidance Japanese horse mackerel), 9 to 12 mg/L (avoidance behaviour Atlantic herring), 10 mg/L (juvenile and adult Atlantic cod, Atlantic herring), 19 mg/L (avoidance adult Atlantic herring), 35 mg/L (altered foraging in juvenile snapper).
- Avoidance behaviour in benthic fish species is expected to be triggered by higher than concentrations for pelagic and demersal species. A concentration threshold of 50 mg/L was recommended by FeBEC (2013).
- Sub-lethal impacts were identified for benthic and pelagic species at a wide range of concentrations with the lowest being 580 mg/L (refer Section 3.1.2 in Page (2014b)).

Page (2014b) identified that the threshold concentration responses of related New Zealand species on the Chatham Rise to TSS may be similar to those of the northern hemisphere species studied. Herring are closely related to sprats, pilchards and anchovies that are important prey for larger pelagic and coastal species. The Atlantic cod is a relative of the New Zealand southern blue whiting that is present in the marine consent area, and Murphy's mackerel (*Trachurus murphyi*) has also been caught in the region.

In the following parts of this section, the thresholds identified above are discussed in relation to mesopelagic fish and biota, key pelagic and demersal fish and benthic fish. For the purpose of this assessment, a threshold of 50 mg/L is used to illustrate the scale of areas involved in potential effects.

Mesopelagic fish

Mesopelagic fish and cephalopods have high ecological importance in the Chatham Rise ecosystem (Pinkerton 2013) especially in relation to fish stocks. Any small change in these groups will cause large changes in other groups such as demersal and benthic fishes. However, the probability that mesopelagic species will be significantly influenced by a sediment plume 50 m from the seabed is relatively low (as discussed below). Modelling has shown levels of suspended solids greater than 50 mg/L are limited to an area within or very close to the mining block during mining (estimated to be about 1 km^2). In a typical plume, concentrations at 10 m above the seabed are predicted to be no more than 10 mg/L.

Pelagic fish species

Commercial fish species in the water column above the seabed are unlikely to be influenced by sediment plumes generated during seabed mining. Impacts are likely to involve local displacement should a species be in proximity of the plume, although this will only occur within and immediately adjacent to a mining block. Given the proximity of the plume to the seabed and the rapid decline in suspended solids concentrations above the seabed (see above), its geographical location and the spatial area involved the likely influence on any commercial pelagic species is likely to be minor.

Demersal fish species

Demersal fish species include those species that spend all their time on the seabed and those that occur on and above the seabed. Appendix 17 (Golder 2014b) provides information on the distribution of a wide range of fish species caught in trawls on the Chatham Rise. The data presented have been derived from a large number of research trawls on the Chatham Rise and represents the likelihood of capturing a fish species at various locations on the Rise. Examination of that information shows that there are a wide range of fish species that are caught on the slopes of the Chatham Rise but not within the proposed marine consent area. These include fish such as orange roughy and these species will not be affected by the mining activity within the marine consent area.

A number of fish species are known to be distributed across the Chatham Rise, and based on the information in Appendix 17, to have a moderate to high probability of capture within the proposed marine consent area. As described above, direct adverse impacts from the plume are not anticipated on commercial fisheries as higher total suspended solid concentrations are expected to occur over a limited area (50 mg/L occurring over the mining block). As the suspended solids concentrations in the plume decrease, the plume area increases proportionally (the area affected by 30 mg/L or higher is estimated to be about 20 km^2). General avoidance behaviour has been noted in some species at low suspended solid concentrations. These spatial areas are a very small proportion of the proposed marine consent area and a smaller area of the wider Chatham Rise.

Concentrations of 5 or 10 mg/L affect larger areas on average during the mining cycles. These do not occur constantly in a given area and are predicted to occur at any given location for 25 % of the time during a mining cycle.

A range of demersal fish species will be affected by the suspended sediment plume. Impacts will be limited to an area mainly located within and adjacent to the mining block. Some avoidance behaviour is predicted down current as the plume disperses and the suspended solids concentrations decline and dissipate.

The limited vertical, horizontal and temporal distribution of suspended particles, as outlined in Section 8.4.3, limits the influence on fish stocks on the Chatham Rise. For demersal or benthic species, it is likely that fish will be disturbed by the activity at the seabed and that the plume will result in local avoidance. Based on the lower thresholds identified by Page (2014b), the predicted concentration of suspended sediment in the plume more than a few kilometres from mining blocks will be at or below the levels identified as having disturbing impacts on fish (5 to 10 mg/L). The plume is not expected to have any adverse impacts on fish at the distances where fishing occurs.

The ling fishing in the eastern part of the marine consent area is the closest commercial activity to the proposed mining activity. Most of this fishing occurs 70 to 80 km from the mining permit. Plumes generated within the initial mining permit area are predicted to be within ambient levels (0.1 to 1 mg/L) at these distances and are not expected to disturb fish or the fishing activity.

Further considerations of the potential impacts arising from CRP's proposed mining operations on the Chatham Rise fisheries are assessed in Section 8.6.7.

8.6.6 Impacts on conservation values

8.6.6.1 Introduction

New Zealand's oceanic environment and ecosystems are often unique and highly regionalised, with a globally significant level of biodiversity (refer Gordon et al. 2010).

In New Zealand there has been substantial work to evaluate the conservation values of species. The main focus has been on terrestrial plants and birds and freshwater fish but some effort has extended to marine species. The New Zealand Threat Classification System (NZTCS) is used to assess the threat status of NZ taxa (species, subspecies, varieties and forma), with the status of each taxon group being assessed over a three-year cycle by DOC.

Conservation values on the Chatham Rise can be grouped into three areas. These values include national conservation values, values not limited to the Chatham Rise area. The second group includes conservation issues that have a focus on the Chatham Islands, and the third group are the conservation values that have a direct Chatham Rise focus.

8.6.6.2 National conservation values – marine mammals

The key faunal group that fits within the national conservation value category are marine mammals. The potential impacts of the proposed mining operations on marine mammals include disruption of migration and feeding due to the presence of the mining equipment, disruption of food sources, and introduction of pollutants into the environment.

There are several marine mammal species of significant conservation status that utilise the greater Chatham Rise marine environment as migratory passage or as a feeding area. Section 6.8 identified these as killer whales (*Orcinus orca*) (nationally critical) and bottlenose dolphin (*Tursiops species*) (nationally endangered). For both species, sightings have occurred within 100 km of the proposed marine consent area, but not within the mining permit area.

Other species which are migrants to New Zealand waters such as sei whales, blue whales and humpback whales have been sighted in the Chatham Rise region are identified as globally endangered by the IUCN. Beaked whales are so infrequently sighted alive that their presence and status is considered to be data deficient. All species have only been sighted occasionally and well away from the proposed marine consent area.

Although these marine mammal species are globally significant (given their conservation status), potential interactions with the mining vessel, including behavioural disturbance or ship strike, in the proposed marine consent area is considered to be unlikely and avoidable. As described in Section 8.7.4, pre-start observations will be made to avoid impacts on marine mammals. While mining, the vessel speed is expected to be approximately 1 knot, allowing sufficient time to react if marine mammals appear in the path of the vessel. All other marine vessel movements associated with mining will adhere to the requirements of the MMP Regulations which includes minimising disruption to the normal movement and behaviour of marine mammals, and manoeuvring of vessels including speed and safe distances (as described further in Section 2.4.4). Marine traffic movement will be along designated routes to and from port or in the marine consent area.

Other large species of conservation interest, such as sperm whales, have been observed on the flanks of the Chatham Rise while feeding, this has occurred some distance from the proposed marine consent area. Therefore, neither potential direct impacts (e.g., vessel interaction) nor indirect physical impacts (regional alteration to their food source) are considered likely as a result of mining operations.

Interference from noise emissions generated by mining activities is also a potential impact on marine mammal populations, as discussed in more detail in Section 8.7.

Interactions with the mining vessel are considered to be unlikely, of short duration and local, and the resulting environmental risk considered to be low. Although unlikely to occur, all interactions with marine mammals will be recorded and reported as required by MMP Regulations.

8.6.6.3 Conservation values of the Chatham Islands - seabirds

The potential impacts of the proposed mining operations on seabird species of conservation significance include interaction with the mining vessel, disruption of their food source (i.e., trophic changes), and the introduction of pollutants into the environment.

The Chatham Islands is home to several bird species of significant conservation value specific to the Chatham Islands area. Many of these are terrestrial (e.g., the Chatham Island pigeon - *Hemiphaga chathamensis*) or coastal (e.g., the Chatham Island oystercatcher - *Haematopus chathamensis*) which are listed as Nationally Critical in the current bird threat rankings. The listing also includes several seabird species that may utilise the Chatham Rise and waters around it. These species are identified in Section 6.9 and include two Nationally Critical species, the Chatham Island Taiko or magenta petrel (*Pterodroma magenta*) and the Grey-headed mollymawk (*Thalassarche chrysostoma*). Other species and their threat categories are identified in Section 6.9.

Potential interaction between the mining vessel and seabird species include lighting impacts, assessed in Section 8.8, and associated pollution (e.g., vessel waste, oil spills), discussed Sections 8.9 and 8.11. The assessment of lighting impacts concludes that, provided the avoidance measures outlined in the LMP (Appendix 35(ii)) are implemented then the potential for bird strike is of low to medium environmental risk. The LMP also outlines actions that are to be taken if bird strikes occur: reassess the adequacy of vessel lighting, if a bird is injured CRP will discuss the required actions with DOC, and if a bird is critically injured then the bird is to be frozen and handed over to DOC when the vessel returns to New Zealand.

Pollutants from marine vessels that may affect seabirds can include hydrocarbons, heavy metals, hydrophobic persistent organic pollutants, and small plastic debris. Direct mortality is the most obvious impact, particularly when it is related to point-source pollution such as oil spills, which can kill large numbers of birds in a short time period (Thompson 2013). However, sub-lethal effects can also be very important, affecting development, physiology and behaviour, and ultimately reproductive performance and survival rates of seabirds (Finkelstein et al. 2006 in Thompson 2013). There is some potential for the presence of a mining vessel to impact seabirds but that threat is the same for any similar vessel at sea on the Chatham Rise or within New Zealand's EEZ. The most significant threat is loss of fuel or other material from the vessel while at sea. Such impacts are avoided through management of vessel wastes and spill management measures as described in Sections 8.9 and 8.11. In relation to the management of vessel wastes, they are considered to be of low to medium environmental risk.

An evaluation of oil spill loss from working dredgers operated by Boskalis has shown that over the last two years there have been no incidents.

Larger-scale oil spills, such as from a ship-wreck, can affect seabirds directly through coating the plumage of birds and reducing the water-proofing properties of the feathers, as well as ingestion of the oil (Taylor 2000). The potential for this to occur is managed through mandated navigational safety practices and international and marine oil spill prevention and, if needed, spill response measures, including an IOPPC and SOPEP, as described further in Section 8.11. The risk from this event is considered to be low to medium, as the chance of a large-scale oil spill is rare but would require medium-term recovery at the immediate location.

No notable trophic impacts (as seen through trophic linkages) were identified for seabirds in relation to potential changes in biomass of other trophic groups as modelled by Pinkerton (2013) (refer Figures 3 and 4 in Appendix 22). In the model, the four mesopelagic middle-trophic level groups together supply 99 % of the prey for air-breathing predators (including seabirds, whales, dolphins, seals and sea lions), in proportions mesopelagic fishes (44 %), krill (35 %), cephalopods (14 %) and salps (6 %). Furthermore, seabirds are generally not one of the most important parameters for a trophic model, as seabirds tend to have few direct predators and their biomass is very low compared to other sources of carcasses (Pinkerton 2013).

As the potential impacts on the Chatham Rise's fisheries resource have been assessed as of a low environmental risk (refer to Section 8.6.8), then the potential consequence on the food available for seabirds is also minor resulting in a low environmental risk.

8.6.6.4 Conservation values of the Chatham Rise, benthic protection area and marine spatial planning

Conservation Values

There has been no strategic environmental assessment of the Chatham Rise that identifies economic, cultural and conservation values for the region and establishes a systematic decision support process to guide policy decisions.

The most significant conservation management system within the greater Chatham Rise ecosystem occurs through the fisheries QMS and the associated BPAs, which includes the Mid Chatham Rise BPA (Figure 6 in Section 2.4.3). Together these initiatives aim to support the sustainable management of New Zealand's fisheries. Other conservation initiatives relevant to the management of commercial fishing activities on the Chatham Rise include work being undertaken by conservation organisations, the government and the fishing industry to decrease the level of non-fish by-catch through the use of bird-scaring devices and sea lion exclusion devices.

Benthic Protection Area

Approximately half of CRP's existing and proposed prospecting and mining licence / permit area lies within the eastern part of this BPA (Figure 6 in Section 2.4.3) and represents approximately 59 % of the BPA. The Mid-Chatham Rise BPA is one of 17 BPAs established by the Government with the cooperation of the deep water fishing sector (refer to Section 2.4.3). The seabed in this area is protected from fishing by benthic trawling or dredging.

The purpose of the BPAs was to set aside a broadly representative sample of benthic habitats in the EEZ (Helson et al. 2010). BPAs protect those organisms (and their habitat structure) that live in or on the seabed or that have a direct relationship with it. These areas would preserve a large portion of New Zealand's marine environment while allowing fishing to continue in other areas or in a way that did not modify benthic habitats within the BPAs. All trawling within a BPA is subject to tight controls under the BPA Regulations to ensure that there is a low risk of fishing gear touching the seabed.

Benthic protection areas were selected on the basis of four criteria: BPAs were to be large, relatively unfished, have simple boundaries and include representative portions of the main environmental classification areas identified in the simplified marine environment classification (MEC) developed by NIWA (Snelder et al. 2005, Helson et al. 2010). BPAs were also selected to protect the benthic habitat in three depth classes: 200 to 750, 750 to 1,500 and >1,500 m. The process to implement BPAs did not follow the process to establish marine protected areas set out in the Marine Protected Areas (MPA) Policy.

The BPA initiative sought to avoid (as opposed to remedy or mitigate) the adverse effects of fishing by setting aside large areas of the EEZ. Unfished areas were selected as areas that are largely unfished have been subject to minimal effect from bottom-trawl gear and therefore these areas should be in a relatively pristine condition and should have a higher biodiversity value than similar habitats that have been exposed to trawling (Helson et al. (2010).

BPAs are primarily a deep water protection initiative, with all protected areas outside the Territorial Sea, and in waters deeper than 200 m.

The MEC was developed by NIWA (Snelder et al. 2005) with public funding with the aim of providing a spatial framework to facilitate the conservation and management of indigenous marine biodiversity by subdividing the marine environment into units with similar environmental characteristics. Due to a lack of consistent biological data, the MEC uses predominantly physical variables (for example, depth, sea surface temperature, seabed slope and annual solar radiation) to create proxies for marine environments and groups them into broadly similar areas, called 'environment classes'[31]. Therefore, the MEC is not a fine-scale classification system nor is it a habitat map. It does not predict the biota that is present in an area, but rather uses the pattern of physical variables to indicate broad-scale environments that are likely to influence the biota associated with the environment classes.

The BPAs were designed to protect oceanic environment classes in the EEZ (Helson et al. 2010). The biodiversity value of BPAs can be assessed by reference to known biodiversity 'hotspots'. In 2004,

[31] For information purposes, the marine consent area covers approximately 2.4 % of the EEZ's MEC 20 Class 63 and 0.2% of the total MEC 20. It also covers 5.2% of MEC class 128, 0.9 % of MEC class 98 and 0.1% of the total MEC 50 area.

WWF-New Zealand published an independent, scientific assessment of New Zealand's biodiversity. The report identified 15 biodiversity hotspots that have more than half their area in the EEZ. Although several of the hotspots are small, BPAs cover nine of them (Helson et al. 2010).

Leathwick et al. (2006) used the distribution of fish species (as a proxy for marine benthic biodiversity) to assess the conservation value of BPAs. Their report describes results of an exploratory analysis using reserve selection software (called Zonation) to evaluate several possible configurations of Marine Protected Areas in New Zealand's EEZ. Data layers describe environment-based prediction of the standardised catch of 122 demersal fish species from approximately 21,000 bottom trawls, and the geographic distribution of a set of BPAs. Leathwick et al. (2006) concluded that the current system of marine protected areas were not very representative, and do not provide protection for a large number of fish species, and that the BPAs, as currently configured, provide a much lower level of protection for demersal fish than did any other scenario examined in their study.

Helson et al. (2010) countered this conclusion by suggesting that a number of the 122 fish species used in the initial analysis have little association with benthic habitat in the EEZ (e.g., blue cod, kahawai and kingfish), although the analysis was subsequently refined to include 96 species. Leathwick et al. (2008) further described the use of recent advances in statistical learning and conservation prioritisation to produce MPA scenarios with varying costs and benefits for New Zealand's EEZ, based on the analyses of distributions of 96 demersal fish species.

The authors concluded that alternative reserve management scenarios deliver substantially greater conservation benefits than the BPAs, as they provide representative protection across the EEZ and avoid important fishing sites. Helson et al. (2010) reiterated that the BPAs were not implemented to protect fish species, although those species with a close association with the seabed are afforded protection.

Establishment of BPAs was considered to be a notable step in New Zealand's marine conservation effort. However, most proponents and critics of the BPAs agree that the goal of protecting representative benthic habitats could be significantly improved if a broader assessment of data was carried out. The following section discusses this matter further.

Marine Spatial Planning

Several reports (e.g., Kudrass 1984, Wood et al. 1989) have discussed aspects of the prospectivity of the physical resources on the Chatham Rise, and numerous publications by MPI, industry bodies and other organisations have discussed the value of the commercial fisheries associated with the Rise. However, there has been no effort to integrate and organise this information so it can be used to guide decisions about conservation and resource development (i.e., marine spatial planning).

As outlined above, the Mid Chatham Rise BPA was established through the BPA Regulations (2007). These Regulations restrict some fishing activities within the BPA. The goal of BPAs was to preserve representative benthic habitats in the EEZ from bottom trawling and dredge fishing, and given the level of information about the benthic habitats available at the time and the other principles that guided their creations (i.e., large, simple shapes) it is possible that they may have achieved that goal. However, research has shown that it is likely that alternative reserve management schemes or spatial planning approaches can deliver substantially greater conservation benefits than the BPAs have (Leathwick et al. 2006).

CRP is conscious of the conservation and resource utilisation dilemma that arises from the overlap of its proposed marine consent area with the BPA. An initial effort to address this challenge only considered the conservation and economic values in the mining permit area. However, it quickly became obvious that this was inappropriate as it was impossible to put these values in a regional context (i.e., are the corals and phosphorite in the mining permit area the only corals or phosphate on the Chatham Rise, or are they widespread?).

CRP recognised that a more robust approach to marine spatial or reserve planning was required. It also realised that sufficient data and software tools are available to support such an approach. Therefore, the objective of the marine spatial planning exercise that CRP commissioned was expanded to identify areas of high conservation values and areas of high economic values throughout the marine consent area (and a broader area of the crest of the Chatham Rise), and to derive a development plan that allowed mining while minimising environmental and economic losses.

Globally, there is an increasing recognition of the need for marine spatial planning, and a variety of approaches have been developed and utilised to assist conservation planning and the development of MPAs. As an example, the International Seabed Authority (ISA) (2008) presented recommendations from a workshop on the establishment of preservation areas for nodule mining in the Clarion Clipperton Fracture Zone. Wedding et al. (2013) reported the results of an expert-driven systematic conservation planning process applied to inform science-based recommendations to the ISA for a system of deep-sea MPAs to safeguard biodiversity and ecosystem function. The geospatial analysis and expert opinion allowed the preservation areas to be stratified by biophysical gradients, maximise the number of biologically unique areas (in this case, seamounts) within each sub-region, and minimise potential socioeconomic impacts. The outputs were seen as an example of how available information could be utilised to inform the selection of areas to exclude or protect from seabed mining.

Given this international recognition, along with CRP's objective for a more robust approach to marine spatial planning for the Chatham Rise, CRP commissioned NIWA to undertake such an exercise with the outputs then being used to identify mining exclusion areas within the proposed marine consent area. The identification of potential mining exclusion areas was carried out using the spatial management software tool 'Zonation'. The outcomes of this process are reported in Rowden et al. (2014b) (Appendix 32).

Rowden et al. (2014b) utilised a large number of factors in the spatial analysis, including:

- Benthic biodiversity (using information from Rowden et al. 2013, 2014a – Appendices 15 and 16).
- The distribution of one infaunal community and two epifaunal communities potentially unique to the central Rise crest (data from Rowden et al. 2013, 2014a).
- Demersal fish assemblages (data from Leathwick et al. 2006).
- Fishing trawl intensity data (from MPI).
- Mining prospectively (i.e., resource presence).

The Zonation tool was selected because it directly uses the kind of datasets that were available for the study area, and because it has been used extensively in New Zealand contexts (Rowden et al. 2014b and references therein). Zonation uses an algorithm to identify solutions that have both high value for conservation, and low cost in terms of foregone resources, and that are also balanced with respect to representation of species or habitats and connectivity between protected areas (Moilanen 2007). The zonation methodology is described in detail in Rowden et al. (2014b).

Zonation outputs include maps of biodiversity priority, illustrating areas ranked from highest to lowest priority in terms of biodiversity preservation for a particular model scenario. Rowden et al. (2014b) presents model outputs as maps that identify areas with biodiversity priorities greater than 90 %, greater than 80 %, greater than 70 %, and the lowest priority areas for biodiversity protection (less than 70 %). Figure 143 shows the prioritisation results greater than 70% superimposed on the regional bathymetry and CRP's proposed marine consent area.

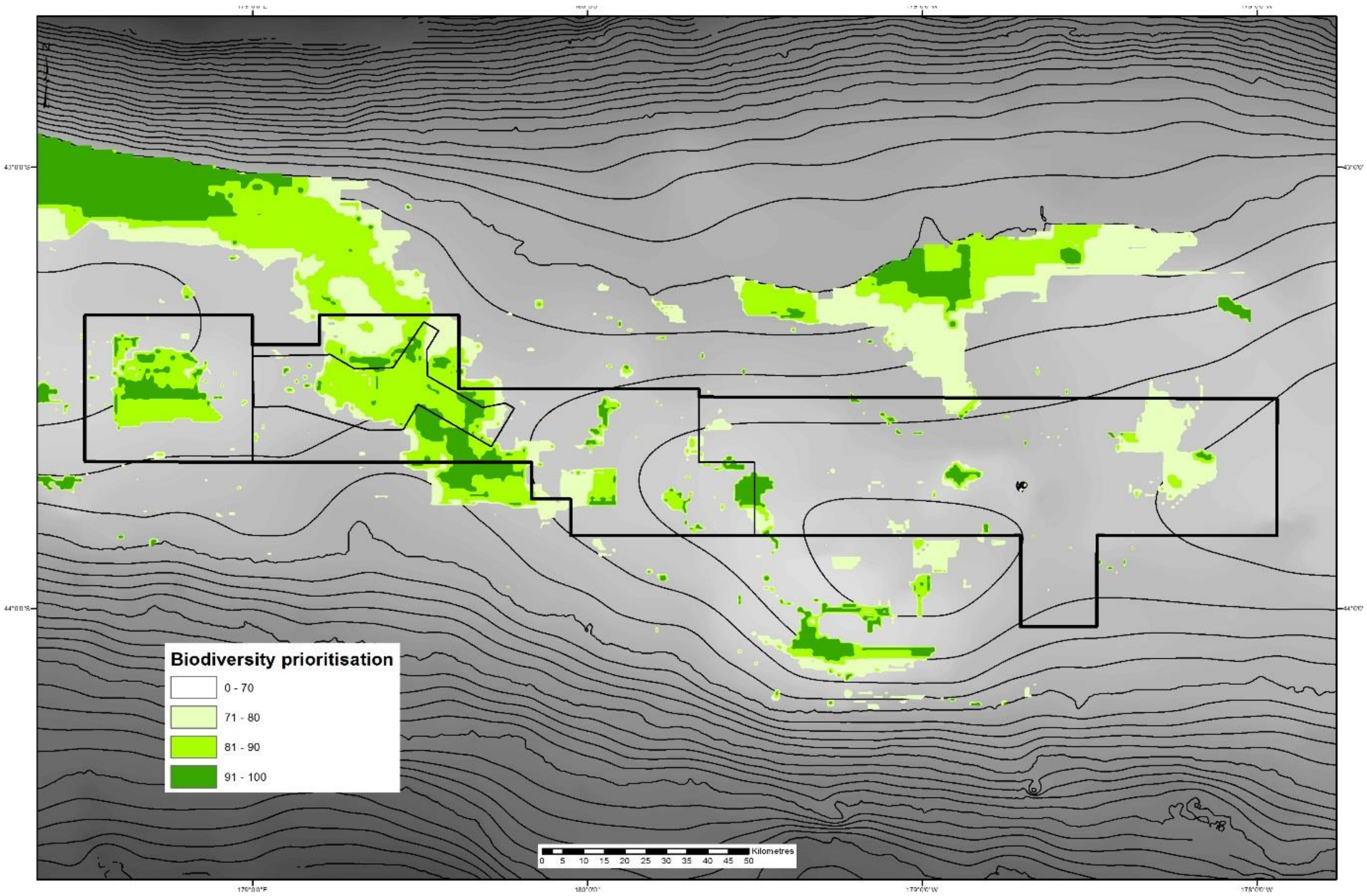

Figure 143: Biodiversity priority ranking areas based on Zonation spatial planning output (data from Rowden et al. 2014b). The areas of low probability (<70 %) are not shaded on the figure. Note that the model stopped at the 500 m contour.

As described in more detail in Section 6, higher value epifaunal communities such as those dominated by the protected coral *Goniocorella dumosa* are dependent upon the phosphorite nodules or other similar hard substrate for attachment and development (Dawson 1984, Kudrass & von Rad 1984b, Rowden et al. 2013, 2014a). As such, these communities are particularly vulnerable and will not be able to recover if all the relatively large phosphorite nodules are removed by the mining process, leaving only soft sediment habitat for benthic fauna (Beaumount & Rowden 2013 – Appendix 30).

The presence of hard substrate is not by itself sufficient to predict the distribution of these attaching species. Analysis of their observed distributions shows that their occurrence is also influenced by environmental variables such as high SST gradients and depth (Rowden et al. 2014a – Appendix 16).

By combining information on the known or predicted distribution of benthic communities and taxa with data on the known or predicted distribution of phosphorite nodules (i.e., mining prospectivity), the Zonation software produced outputs can be used to guide the choice of areas that can be closed to mining so as protect biodiversity while still enabling mining to occur in other areas. A total of 14 scenarios using various weights for the input layers were examined to identify major shifts in the highest priority areas for biodiversity, and to identify and eliminate any bias towards a data layer. Figure 143 shows the final biodiversity prioritisation layer that combined epibenthic and infaunal communities, protected corals (including *Goniocorella dumosa*), and demersal fish assemblages.

In addition to the areas with high conservation values, several other factors guided the identification of CRP's proposed mining exclusion areas. The iceberg furrows that characterise this part of the Chatham Rise also merit preservation as geomorphological areas of interest. Iceberg furrows are common on other continental margins, but they have not been reported elsewhere in New Zealand's EEZ. Also, analysis of seismic reflection data from the region identified areas where basement rocks (schist or greywacke) are likely to be exposed at the seabed (Falconer et al. 1984) and offer large areas of hard substrate for organisms such as *Goniocorella dumosa*. Some of these were not highlighted by the biodiversity prioritisation process, but were nevertheless included in the proposed mining exclusion areas. Finally, a more refined version of the MEC system than that used for the BPA analysis is now available. Four of the 200 MEC classes lie on the crest of the Chatham Rise in the region encompassing the marine consent area. The proposed mining exclusion areas include parts of all four of these MEC classes.

CRP's proposed 15 mining exclusion areas within the marine consent area are shown in Figure 18 in Section 4.4.1 and are also shown in Figure 144 below.

The complete analysis of the predicted value of the proposed mining exclusion areas is in Rowden et al. (2014b). As an example, the results for the predicted distribution of habitat suitable for the stony coral *Goniocorella dumosa* are discussed in the following paragraphs.

The biodiversity modelling covered an area of almost 37,000 km^2 on the crest of the central Chatham Rise, including most of the area proposed to be covered by this marine consent (Table 22). About 225 km^2 at the far eastern end of the marine consent area was not included in the model because of a lack of suitable input data. The total proposed mining exclusion areas cover about 18% of the marine consent area.

Rowden et al. (2013, 2014a – Appendices 15 and 16) identified two benthic communities in the proposed marine consent area that are characterised by the stony coral *Goniocorella dumosa* (communities *n* and *o*). Baird et al. (2012) predicted the distribution of protected coral throughout New Zealand's EEZ, including the distribution of stony corals like *Goniocorella dumosa* on the Chatham Rise (Figure 144). These layers were among those used to derive the biodiversity priorities in Rowden et al. (2014b) (Appendix 32). The results of that analysis were used to estimate the effectiveness of various mining exclusion area scenarios for preserving biodiversity, as represented by the input layers to the spatial planning modelling.

Table 22: Predicted biodiversity priorities for relevant areas associated with the crest of the Chatham Rise and CRP's mining proposal.

Relevant area	Area (km^2)
Area modelled (Rowden et al. 2014b)	36,937
Total marine consent area	10,192
Proposed mining exclusion areas	1,822
Mid Chatham Rise BPA	8,732
Marine consent area within the BPA	5,236
Proposed mining exclusion areas within the BPA	1,002

Table 23 summarises the predicted distribution of habitats suitable for the two benthic communities associated with *Goniocorella dumosa* and for stony corals (at an EEZ scale). Most of the predicted suitable habitat areas lie outside the marine consent area, but almost 30% of the marine consent area may provide suitable habitat for *Goniocorella dumosa*.

Table 23 also shows that the proposed mining exclusions areas are expected to effectively protect habitat for Communities *n* and *o*, protecting at least 80 % of the suitable habitat for these communities predicted to occur in the marine consent area. The modelling predicts that about 22 % of the habitat suitable for *Goniocorella dumosa* inside the marine consent area will be protected by the mining exclusion areas. This percentage is not significantly greater than the percentage of the model area (associated with the spatial planning exercise – Rowden et al. 2014b) covered by the marine consent area (18 %), suggesting the proposed mining exclusion areas offer little additional protection. However, Figure 144 shows that there is relatively little predicted variation in the distribution of stony corals across this part of the Chatham Rise when mapped at the EEZ scale, so any proposed mining exclusion area distribution would have a similar result.

Table 23: Summary of distribution and potential protection of *Goniocorella dumosa* habitat.

Areas	Community *n*	Community *o*	Stony corals
Outside marine consent area	84%	81%	71%
Inside marine consent area	16%	19%	29%
Inside marine consent area and mining exclusion areas	100%	80%	22%
Inside area modelled and mining exclusion areas	16%	15%	6%

This outcome demonstrates the usefulness of developing appropriate spatial management options, and should be considered as the first step in the mitigation process, such that the definition of mining exclusion areas may be iterated from those selected by CRP with other stakeholders and environmental managers. From the output and information associated with this spatial planning exercise, a series of areas over the whole study area (not just the marine consent area) for protection from seabed disturbance activities could be developed that are likely to provide more effective protection of benthic habitats than is provided by the BPA. CRP has committed to use its best endeavours, in conjunction with other interested parties, to protect, under an appropriate legal mechanism, areas identified through this or a similar spatial planning exercise from all seabed disturbance activities.

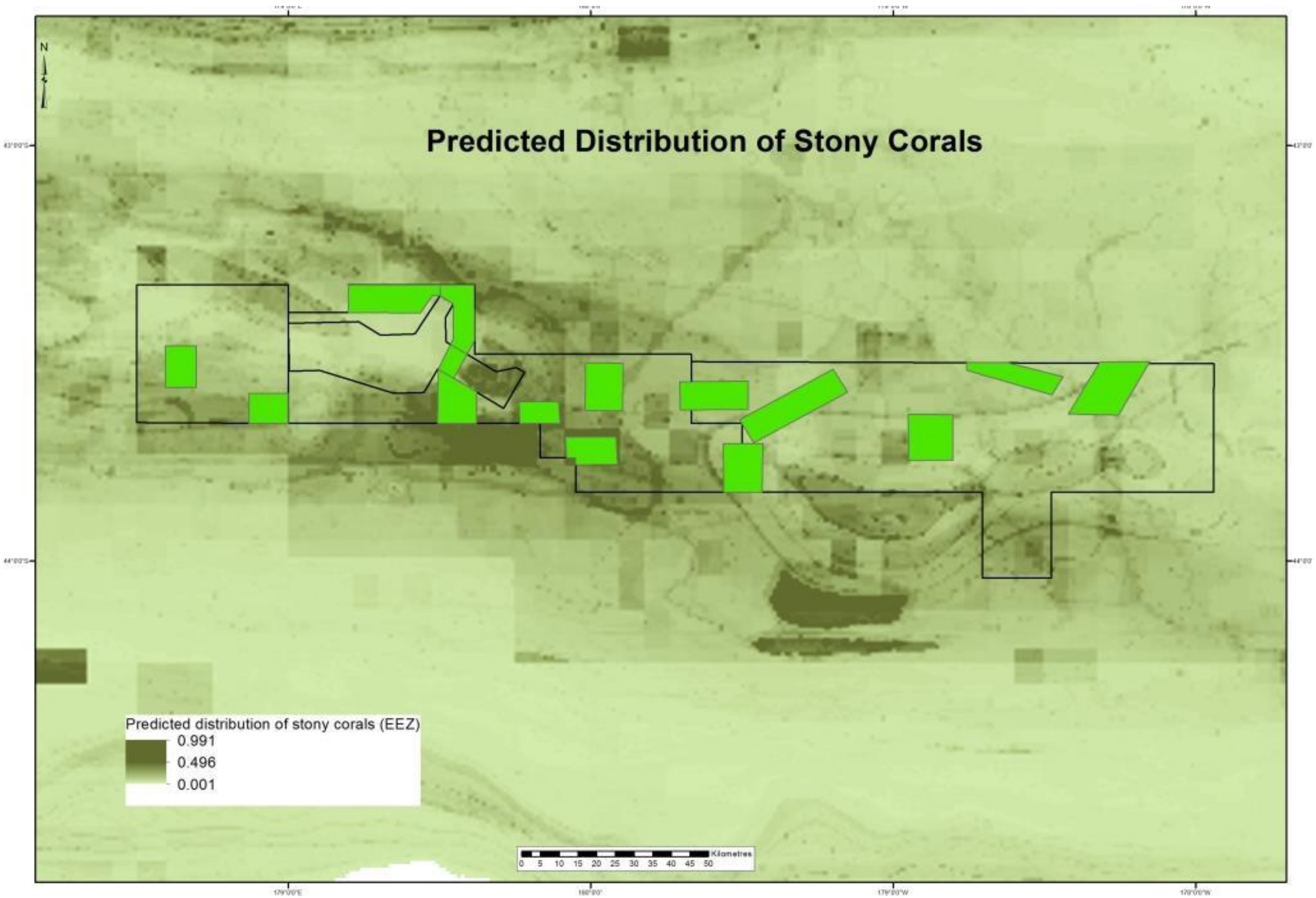

Figure 144: Predicted distribution of stony corals (data from Baird et al. 2012). About 7 km^2 in the marine consent area are predicted to be habitat suitable for stony corals with a probability greater than 50%. Note the non-linear colour scale. The green boxes are the proposed mining exclusion zones.

Summary

While CRP has committed to participate in the proposed broader spatial planning process, the processing of the marine consent being sought by CRP does not rely on the completion of this broader process. CRP's proposed mining operations identifies mining exclusion areas (refer to Figure 18 in Section 4.4.1) that have been developed using a balanced tool that considers a range of values, and as a result, areas of particular scientific and conservation value, including areas associated with the protected cold-water corals, will not be directly affected by CRP's proposed mining operations.

8.6.7 Impacts on the Chatham Rise ecosystem and fisheries

8.6.7.1 Direct impacts on fisheries

Introduction

A number of potential direct impacts have been identified:

- Disturbance of fish by the mining equipment at the seabed.
- Disturbance of key fish species by the plume.
- Disturbance of scampi and removal of scampi remaining within burrows.
- Disturbance to spawning behaviour and eggs of key species.

Disturbance of fish by equipment

The mining vessel and the mining system will move at about 1 knot, very slow compared to the mobility of fish. For comparison, trawling is usually done at 3 to 4 knots. Therefore, impacts on fish from the motion of the vessel and mining system will be localised and temporary.

Very little water is sucked into the system at the drag-head and it is highly unlikely that fish will be caught there (except for those buried in the seabed under the drag-head). The water intake for the drag-head jets is about 20 m above the seabed, and it will suck in about 1 m^3/s. The area of possible capture for fish for this intake is estimated to be a radius of about 2 m and therefore some fish may be caught by the intake. However, based on the estimated relatively low density of fish in the region and expected local avoidance response to the mining operations, the number is likely to be very low.

The impacts of lights on the drag-head on the ecosystem will be negligible as they will be used infrequently, for relatively short periods, and will have a limited range (approximately 2 to 5 m around the drag-head). Additionally, the areas exposed to light will be subject to more significant impacts from seabed mining (including impacts that are likely to cause fish to avoid the drag-head area). It is not anticipated that the lights will attract fish. During the 2012 environmental survey, the extensive ROV footage (77 km and 150 hours) identified few fish, indicating no obvious evidence that fish were attracted to the ROV lights.

Potentially the most significant impact from operations will be from noise, discussed in more detail in Section 8.7.

Disturbance by the sediment plume

The suspended solids concentrations in the sediment plume generated by mining is likely to cause local avoidance by fish very close to the seabed. The most significant disturbance is expected to extend primarily to the edge of the mining block.

Outside of the mining block, the level of suspended solids will reduces rapidly. If a concentration of 5 mg/L was sufficient to disturb normal fish activity close to the seabed then some disturbance is expected within 2 to 3 km of the mining block. Beyond this distance, as discussed in Section 8.4, the concentrations are predicted to rapidly dilute and no significant disturbance to fish is expected.

Disturbance and loss of scampi

Mining will destroy current scampi burrows, but it is likely that the impact will be minor as the scampi population is spread widely throughout the Chatham Rise and proportionally the population in the mining blocks is relatively small. Also, the soft sediment of the seabed after mining will be suitable habitat for scampi.

The epifauna survey identified scampi were present in some areas where sediment was suitable for their burrows. Examination of images collected along transects showed scampi are present in the mining permit area. Mining operations will result in the loss of any scampi encountered within the mining blocks, but the population is not as large as in areas commercially trawled west of the proposed marine consent area.

Disturbance of key fish species at key times

Ling spawn in the vicinity of the marine consent area. In most cases, fish spawn at water depths well above the potential influence of suspended sediment (e.g., hake) and a significant distance away from the impacts of the proposed mining operation (e.g., hoki and orange roughy).

Ling spawn north of the marine consent area and possibly within the eastern prospecting licence. Although activities in the mining permit area are sufficiently far away that they are unlikely to affect ling spawning, if mining were to take place in the eastern area then the spawning behaviour might be disturbed by the operations. Mining could be undertaken in other parts of the marine consent area, such as the current mining permit area, during the ling spawning season.

Although this is an identifiable impact, it is not considered significant or adverse as the total active mining area at any one time is small compared to the area utilised by ling on the Chatham Rise, and the impacts could be avoided by adapting the mining plan to accommodate ling spawning if mining were to occur within this eastern area.

8.6.7.2 Changes to the Chatham Rise ecosystem

Overview

The trophic importance analysis provides information on the interaction between benthic components and the pelagic component of the Chatham Rise ecosystem. The analysis provides a useful indication of the relationships between the key commercial fish species and the ecosystem.

As described in Section 6.10, Pinkerton (2013) (Appendix 22) has developed a trophic model of the food web on the Chatham Rise that integrates our understanding of the functioning of the ecosystem on the Chatham Rise. The model has been developed from a significant amount of research undertaken on the Chatham Rise and adjacent waters over a period of over 30 years.

As described by Pinkerton (2013) the ecosystem model:

- Has resulted in the integration of a large amount of data on all components of the ecosystem in a form that allows them to be compared. The model tests whether our current understanding of the ecosystem structure and function is complete and consistent. In assessing completeness, the model allows identification of critical gaps in knowledge, data, or approach.
- Acts as a basis for future ecosystem modelling, such as the development of models that are seasonally resolved, spatially resolved, and capable of being run dynamically. The model may also allow identification of sub-systems (e.g., groups of interconnected species) that should subsequently be modelled in more detail.

- Formalises the conceptual model of ecosystem interconnectedness giving a quantitative model of energy flow through the system. This may be useful for suggesting system-level characteristics or properties of the system. For example, the model is used to identify key species or groups on which the system depends. Mixed Trophic Impact assessment is used for this analysis.
- Summarises the structure of the food-web of the Chatham Rise which can then be used to facilitate discussion by stakeholders in the Chatham Rise ecosystem.
- May in the future assist to identify candidate indicators of ecosystem state, which will be useful in monitoring changes in the Chatham Rise ecosystem.

The trophic model is not advanced sufficiently to quantitatively assess the ecological impacts of seabed mining on the ecosystem. A coherent and consistent picture of ecosystem function, once developed, can be used to explore relative sensitivities of the ecosystem to potential and actual impacts of mining (Pinkerton 2013). However, the model at this stage provides valuable information on linkages from which it is possible to assert strengths of relationships that may be affected by changes arising from CRP's proposed mining operations.

Key features of the Chatham Rise trophic model include:

- The Chatham Rise ecosystem has a net primary production (NPP) that is slightly below the mean for 14 large marine ecosystems around the world that support significant large scale fisheries.
- Of the total NPP in the Chatham Rise model, about half was grazed by heterotrophic flagellates, mesozooplankton and ciliates. The other half entered the system as dissolved and particulate detritus to be consumed by water column bacteria. Bacterial production in the upper water column was about 25 % of NPP. The bacterial production was consumed by flagellates that were consumed by ciliates and mesozooplankton.
- Respiration in the benthic environment is dominated by meiofauna (29 %) and bacteria (57 %).
- Benthic macrofauna take most of their food from benthic sources (97 %) and the remainder from the water column.
- The most important fish within the Chatham Rise model system appear to be hoki, orange roughy, oreos, warehou, the hake guild, the rattails and ghost shark guild, and the ling guild (these groups are responsible for 94 % of the assessed carbon consumption).
- The food of demersal fish came from middle level trophic level biota including arthropods (20 %), small demersal fish (18 %), gelatinous macrozooplankton (4 %), mesopelagic fish (14 %), other demersal fish (10 %), cephalopods (8 %) and other benthic invertebrates (5 %) (overall these groups contribute 89 %).
- The six middle-trophic level groups in the model were small demersal fishes, mesopelagic fishes, cephalopods, arthropods and hard and soft-bodied macrozooplankton. Of the total carbon consumption by these groups in the model (refer Pinkerton 2013) the proportions consumed were: mesopelagic fishes (25 %), arthropods (22 %), gelatinous zooplankton (16 %), hard-bodied macrozooplankton (16 %), small demersal fishes (12 %), and cephalopods (9 %). These groups supply 81 % of the prey for demersal fish.
- In the model, the four mesopelagic middle-trophic level groups (cephalopods, mesopelagic fish and two macrozooplankton groups) together supply 99 % of the prey for air-breathing predators, in proportions mesopelagic fishes (44 %), krill (35 %), cephalopods (14 %) and salps (6 %).

- In the model, the four mesopelagic groups feed principally on mesozooplankton (64 % of their prey). The remainder of the prey of the four mesopelagic groups is small zooplankton (9 %), phytoplankton (8 %), other mesopelagic groups (13 %) and detritus/bacteria in the water column (5 %).
- Of the apex predators, consumption of lower trophic levels is dominated by seabirds (92 %), then toothed whales and dolphins (4.6 %), seals (3.0 %) and baleen whales (0.3 %).

The development of the trophic model for the Chatham Rise described in Section 6.10 (Pinkerton 2013), and the examination of trophic importance has shown that:

- Mesozooplankton are crucial to the structure and function of the Chatham Rise ecosystem, having the highest (TI1) or 3rd highest (TI2) trophic importance in the system.
- The multiple-step TI2 analysis also highlights the underpinning role of phytoplankton in the system. Phytoplankton are responsible for all initial formation of organic matter in the ecosystem.
- Of the six middle-trophic level groups, small demersal fishes are identified as being the most trophically important by this analysis. Arthropods and mesopelagic fish also have high importance in the multi-step analysis (TI2), as do cephalopods and hard- and soft-bodied macrozooplankton).
- The trophic importance analysis based on the balanced model suggests that hoki play a key role in the system (3rd or 4th most important group). The fish guild of rattails and ghost sharks are the most important demersal fish guild in the multi-step analysis. The role of the meiobenthos is highlighted by the multistep analysis (TI2), 8th in importance in the system.

The model has shown that there are positive (bottom-up, prey driven) impacts of the four key mesopelagic groups (mesopelagic fish, cephalopods hard- and soft-bodied macrozooplankton) on many demersal fish groups, meiobenthos on holothurians, and mesozooplankton on cephalopods and decapods. Most of these bottom-up interactions are similar in the multiple-step analysis.

Having the improved understanding of the trophic systems on the Chatham Rise, it is important to realise the limitations when using the model to interpret the significance of changes on the Chatham Rise associated with CRP’s proposed mining operations. The model is an averaged annual model that has been applied across the Chatham Rise for what Pinkerton (2013) considers is a relatively small number of trophic groups and focuses on the major species and guilds on the Chatham Rise.

There is a substantial amount of research work being undertaken currently (refer Section 4 of Pinkerton 2013) that will further refine the model. This includes work on the mesopelagic and hyperbenthic biota of the Chatham Rise from the two Fisheries Oceanography II voyages to the Chatham Rise (TAN0806 and TAN1116) which may allow better resolution of key groups in the mesozooplankton, macrozooplankton, mesopelagic fish, and decapod trophic groups. The work also includes processing of large numbers of benthic invertebrate, mesopelagic and demersal fish and macro- and meiobenthic samples from the Chatham Rise for their stable isotopic composition (carbon and nitrogen).

Summary of model results

Examination of the overall trophic importance shows that phytoplankton and mesozooplankton and mesopelagic fish provide much of the food for key fish species on and adjacent to the Chatham Rise. These groups and species are in an environment that will be unaffected by seabed mining as sediment suspended during disposal will not be entrained into the upper water column.

The model indicates that the fish guild of rattails and ghost sharks is the most important demersal fish group in the model (3rd or 4th order of TI – refer Figure 120). The group is the major predator of many of the groups of benthic invertebrates. The potential impacts on this group/guild from CRP's mining operations will be primarily displacement during the active mining phase within a mining block. This guild may move to areas around the mining block to avoid mining activity, but the worst potential impact on this group of demersal fish is expected to be proportional to the period that the mining block does not provide food for this group.

Pinkerton's (2013) initial sensitivity analysis within the model included an assessment of changes in biomass of megafaunal benthic invertebrate groups (encrusting corals and encrusting invertebrates) on their TI. This was done in part due to the lack of data on the biomass of this group. The initial estimates of the biomass of corals and encrusting invertebrates were increased tenfold, the model rebalanced and indices of trophic importance, TI1 and TI2, recalculated (Figure 5 and Figure 6 of Pinkerton 2013). The effects of substantially increasing the biomasses of these groups on their TIs were small. Even with 10 times more biomass of corals and encrusting invertebrates in the model, the trophic importance of corals and encrusting invertebrates did not change significantly.

The understanding of the Chatham Rise ecosystem developed through the model indicates that much of the Chatham Rise fisheries resource is heavily reliant on primary production through phytoplankton and the build-up of mesopelagic food resource (in mesozooplankton and small mesopelagic fish). Although there is some direct food dependency between the demersal rattail and ghost shark group and benthic fauna, the short-term trophic impacts associated with removing benthic fauna in a mining block are minor when considered across the proposed marine consent area or a sub–region of the Chatham Rise.

8.6.7.3 Other fisheries issues

Impacts on red rock lobster fishery

Red rock lobster (*Jasus edwardii*) is a key crustacean in the New Zealand and Chatham Island commercial and recreational fishery. During consultation, concern was raised in relation to the potential impacts of CRP's proposed mining operations on the red rock lobster around the Chatham Islands. Records of the distribution and life cycle of red rock lobster show that there will be no impact on red rock lobster by this project.

An assessment of the potential for mining to affect larvae, post larval puerulus and adult stages of red rock lobster was commissioned by CRP (MacDiarmid 2013 – Appendix 31).

Settlement of the puerulus stage of the red rock lobster occurs in shallow waters (shallower than 50 m but typically around 10 m). Juvenile lobsters occur in quite shallow waters and adults occur in rocky habitat typically less than 50 m deep but they can be found as deep as 250 m. As such, depth and habitat preclude the use of the Chatham Rise as a habitat (or migration route) for lobsters. There are no records of lobsters being caught on the Rise in the proposed marine consent area.

Research on rock lobster larval sources and settlement localities strongly suggests that the Chatham Islands do not contribute significantly to the pool of lobster pueruli settling around mainland New Zealand (refer MacDiarmid 2013 and references therein). Research using models of larvae transport by ocean currents indicated that the Chatham Islands lobster fishery is heavily dependent on the east coast of New Zealand as a source of larvae, with the coast from Kaikoura to Cape Kidnappers being particularly important (Chiswell & Booth 2008). To get to the Chatham Islands, most of the larvae are transported in the surface waters of the Wairarapa Eddy, an oceanographic feature which rotates anti-clockwise from the Wairarapa coast and is far north of the proposed marine consent area on the Chatham Rise.

Larvae within the Wairarapa Eddy are unlikely to be affected by the proposed mining operations due to their distance from the Chatham Rise and their transport in the upper part of the water column.

A concern was also raised about the potential for the mining operation to interfere with seabed migration of adult rock lobsters. McDiarmid (2013) however notes that adult rock lobsters have never been recorded in water deeper than 250 m, and as well no lobsters were observed in the video and photographic record associated with CRP's baseline research. The potential for mining operations to directly affect adult rock lobsters in the marine consent area is therefore zero.

These data show that CRP's proposed mining operations on the Chatham Rise will not impact the red rock lobster fishery on the Chatham Islands.

Impacts on longfinned and shortfinned eels

During consultation, a concern was raised in relation to the effects of the proposed activity on freshwater eels. Records of the distribution and life cycle of longfinned or shortfinned eels show that there will be no impact on them by this project.

Longfinned eel (*Anguilla dieffenbachia*) and shortfinned eel (A*. australis*) both occur on the Chatham Islands (McDowall 1978). Longfinned eels are endemic to New Zealand and the species has been classified as in 'gradual decline' following a review of the threat status of native flora and fauna undertaken by DOC.

To complete their lifecycle, eel breed when mature in the marine environment somewhere in the mid-Pacific. Eggs are fertilised at sea and the spawned adult eels die. The larvae are then transported by ocean currents back to New Zealand, although there is also evidence that larvae actively swim (up to 10 to 15 cm/s). Irrespective of this swimming ability, given the existence of the Wairarapa Eddy (see above), the use of this current by the larvae means that they would be kept from passing over or through the proposed marine consent area and would instead become entrained within the current to the northern and western coasts of the Chatham Islands (Jellyman & Bowen 2009).

During adult migration, Jellyman & Tsukamoto (2010) showed that longfinned eels swim at depths typically 200 to 300 m at night and at depths of 600 to 900 m during the day. Larvae of other species of eel are known to be present at water depths of between 80 to 250 m during the day and 30 and 100 m at night (i.e., above the depths at which mining will occur).

The only record of an eel caught at sea is recorded by Todd (1973) off Kaikoura. There is no record of adult eels being caught in by-catch on the Chatham Rise or its flanks (J. Helson, MPI pers. comm) although there is some doubt if trawl nets would retain eels if they encountered them.

There is nothing that suggests eels are likely to be present within or adjacent to CRP's proposed mining area on the Chatham Rise. Their spawning grounds are north of New Zealand in the sub-tropical Pacific, and it is unlikely that significant numbers of spawning eels would cross to the Chatham Rise.

8.6.8 Summary

The potential environmental impacts associated with seabed removal, sediment transport and sedimentation associated with CRP's proposed mining operations have been assessed at the local (mining block), nearby (within the proposed marine consent area) and regional levels. The impacts associated with the placement of mooring landers, seabed sampling and recolonisation trials as part of CRP's environmental surveying and monitoring programme are negligible in comparison to the impacts associated with the mining operations.

Loss of benthic habitat will occur within each mining block. The benthic habitats most significantly affected are the areas of phosphorite nodule/soft sediment seabed. This loss cannot be avoided. However, CRP has proposed several options for environmental compensation in recognition of these impacts.

Mining is predicted to have no impact on the euphotic zone (protecting phytoplankton), or on the upper mesopelagic zone or the biota within it (protecting key resources such as small mesopelagic fish, mesozooplankton and key fisheries resources) because the plume from the sediment returns is predicted to be concentrated at 10 m above the seabed, although occasionally it will reach 50 m above the seabed albeit it at very low suspended solid concentrations (~0.1 mg/L).

Modelled sedimentation patterns generally follow that of suspended solids. Some changes to benthic habitats will occur in areas immediately adjacent to mining blocks where significant sedimentation is predicted. Changes will be dependent upon the sensitivity of the organisms and the amount of sediment deposited. The impacts are predicted to decline from death of many benthic organisms (especially sessile species) within about 500 m of the mining block to death of a few sensitive organisms at a distance of about 7 km. This change is potentially reversible over time for many of these organisms.

The proposed mining concept identifies that about three mining blocks will be mined each year. These blocks will be located so that that they do not generate overlapping impacts in any year, at least during the first five years of mining. This will maximise the ability for unmined and previously mined areas, to contribute to the recolonisation of recently mined blocks.

Recolonisation of the new seabed within mining blocks will occur over a timeframe influenced by a range of factors. Recolonisation will form a community that reflects the nature of the soft sediments within the area, in part dependent on the natural compaction of recently deposited sediment. Recolonisation will not replace the lost nodule/soft sediment community. For this reason, CRP is evaluating the feasibility and value of adding supplementary hard substrate to the seabed to replace some of the hard substrate or nodule-soft sediment type habitat areas. If the trials show that habitat creation is viable, then in consultation with the ERG, CRP will strive to create such areas.

Consideration of the potential impacts on fisheries resources on and adjacent to the Chatham Rise is complex as it involves fish species with different life cycles. The commercial fisheries associated with the Chatham Rise are found both on the crest of the Rise and its flanks. No significant impacts are identified that affect key spawning, juvenile and young fish habitat off the main crest of the Rise and within a short distance of any mining block.

Loss of benthic habitat results in loss of benthic biota and food for a range of biota. The trophic model for the Chatham Rise identifies the ecological linkages and dependencies between the components of the Chatham Rise ecosystem and their Trophic Importance. The Chatham Rise ecosystem is driven by primary productivity associated with phytoplankton growth. The seabed with its benthic ecosystem plays an important role in the overall biology of the Rise as it provides habitat and food that support key trophic components such as rattails and ghost sharks. The trophic model suggests that the potential impacts on the Chatham Rise ecosystem associated with the removal of benthic fauna from the mining blocks is minor when taken in the context of the marine consent area and the Chatham Rise environment as a whole.

There will be no adverse impacts associated with CRP's proposed mining on the red rock lobster fishery or on longfinned and shortfinned eels. Potential impacts on conservation values, specifically marine mammals and seabirds, given the proposed implementation of avoidance, remediation and mitigation measures (particularly those associated with noise and lighting as discussed in Sections 8.7 and 8.8) are considered to be minor and the environmental risk is low.

There will be some loss of cold water corals and other benthic fauna within and adjacent to the mining blocks.

Based on consideration to the potential impacts of mining and sedimentation on ecological and conservation values and other interests (fishing), and recognising the avoidance, remediation and mitigation measures outlined within this section of the EIA, the environmental risk related to the potential impacts are:

- **Benthic habitat and fauna loss within the mining blocks**. Potential impacts will be adverse, near-source confined, medium-term to long-term but potentially reversible. Therefore the potential consequence is serious and likelihood is certain. This potential impact is a serious environmental risk.
- **Sedimentation impacts on benthic habitats**. Potential impacts are adverse, near-source confined (i.e., within the mining blocks and areas immediately adjacent), medium-term but ultimately reversible. Therefore the potential consequence is medium and the likelihood is almost certain. On this basis, the potential impact is a high environmental risk.
- **Impacts on conservation values, namely marine mammals and seabirds.** Potential impacts are neutral to adverse, near-source confined (i.e., generally where and when mining is occurring), short-term and reversible. Therefore, the potential consequence is minor and the likelihood is unlikely. The potential impact is of a low environmental risk.
- **Impacts on seabirds from oil spills.** Potential impacts, if a spill were to occur, are adverse, near-source confined (given the management mechanisms that are in place), medium-term and reversible. The potential consequence is serious but the likelihood is rare. The potential impact is considered a low to medium environmental risk.
- **Impacts on conservation values, namely cold water corals**. Potential impacts are effectively neutral to locally adverse (adverse related to the localised loss within the mining blocks) given the known and predicted distribution of the coral throughout the Chatham Rise and elsewhere within the EEZ.
- **Impacts on fisheries resources.** Potential impacts are adverse, near-source confined (i.e., within the mining areas), short-term and reversible. The potential consequence is medium and the likelihood is unlikely. The potential impact is considered a low environmental risk.

The implications of these environmental risks in terms of on-going mitigation measures and environmental management and monitoring are discussed in Sections 10 and 11.

8.7 Vessel and Mining Related Noise

8.7.1 Introduction

CRP's proposed mining operations on the Chatham Rise will generate noise which has the potential to adversely impact marine life. The noise sources and the nature of the noise generated from the mining vessel and the related mining equipment are discussed in Section 8.7.3. The potential impacts of noise on marine mammals and on fish are assessed and avoidance, remediation or mitigation measures proposed (where relevant) in Sections 8.7.4 and 8.7.5.

8.7.2 Underwater sound and noise

8.7.2.1 Overview

Underwater noise can propagate over large distances dependant on the frequency (Hz) and local oceanographic conditions. Changes in the vertical profiles of temperature and salinity through the water column will affect the speed of sound and the degree to which the sound is refracted vertically. The seabed type will also alter the rate of transmission loss (TL) of propagated sound, with softer muddy sediments tending to absorb sound whereas hard rocky surfaces will cause reflection and hence less absorption. Water depth is also a key factor altering the propagation of underwater sound, in shallow water (< 200 m) propagated sound will dissipate more quickly than in deeper water due to numerous interactions with the surface and the seabed.

Measurements of underwater noise intensity are expressed as decibels (dB) re 1µPa, a logarithmic measure of pressure due to the noise energy being a pressure wave which moves through the water column. The sound pressure levels (SPLs) measured in water are used to describe source levels at 1 m from a noise source. Other terms used to describe underwater noise are provided in Table 24.

Table 24: Terms used to describe underwater noise.

Term	Explanation
Transmission Loss (TL)	The loss of sound pressure due to geometric spreading and attenuation as it moves away from a sound source.
Received Level (RL)	The level of sound received by a species for a given frequency and SPL. Given as dB re 1µPa.
dB re 1 µPa	The decibel scale used in underwater acoustics is referenced to 1 µPa (in air it is referenced to 20 µPa, the threshold of human hearing).
Sound Exposure Level (SEL)	The amount of sound a species is exposed to in dB re 1µPa over a set time period. This value will depend on the SPL and the time over which the species is exposed.
Sound Pressure Level (SPL)	The peak pressure of sound for a given frequency given as dB re 1µPa
Ambient sound	The sound present in the marine environment due to wind, waves, surf and other anthropogenic sources not related to a given project

Different frequencies of underwater noise will be of importance to different species, and it is important to consider both the frequency (Hz) and the decibel level of the noise before making an assessment of whether a noise can be detected and if it may cause an adverse impact. It is also important to understand how the propagation distance varies for different frequencies. The frequency of sound is related to the wavelength of the sound wave – lower frequencies have longer wavelengths and vice versa. In deep water (greater than several hundred metres), it is usual to assume that lower frequencies will tend to travel further than higher frequencies since they are absorbed less by the water. In shallow water depths (less than a few hundred metres), the opposite occurs due to the tendency for low frequencies (particularly less than a few hundred Hz to be absorbed more by the bed sediments.

8.7.2.2 Legislation and guidance

Currently, in New Zealand, the only environmental guidance for the evaluation and monitoring of underwater noise into the marine environment from an anthropogenic source is set out DOC's 2013 'Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations' (Seismic Code). The concepts and methods for mitigation and monitoring in the Seismic Code can be adapted for use during mining activities such as CRP's proposed mining operations. However, the noise source levels from the mining vessel and associated mining equipment will be significantly less than the source level of a seismic airgun array. A single pulse from an airgun can be 220 to 230 dB re 1µPa, whereas dredging vessel's, similar to the mining vessel, source noise is usually around 180 to 190 dB re 1µPa, although this will vary between vessels (Kongsberg Maritime

2010). Therefore, the guidance on how loud noise should be at 200 m from an airgun (186 dB re 1µPa) is hardly relevant to an assessment of underwater noise emissions from the mining vessel.

Looking internationally, underwater noise has been recognised as a pollutant by the European Union in their Marine Strategy Framework Directive which states that no energy can be added to the marine environment that will have a detrimental effect, with one of those energies being underwater noise. This has led to the development of several guidance documents for monitoring and assessment of underwater noise in member states. The USA have also developed guidance for pile driving, along with seismic airgun surveys, and the International Maritime Organisation (IMO) have recently (2014) issued guidance for the reduction of underwater noise emissions from shipping vessels. In Australia guidance for the noise emitted during pile driving operations has been published (2012) which suggests that a SEL of 150 dB re 1µPa at 100 m or 300 m, dependant on the sensitivity of the species, should be the upper limit of noise before a shutdown of activities if an animal is seen within a certain monitoring zone.

Although there is no specific guidance or legislative framework for monitoring, or limiting, the noise from dredging operations in New Zealand, the World Organisation of Dredging Associations (WODA) has issued some guidance on how to assess the risk of noise from dredging vessels (2013). The guidance suggests that a full risk assessment be carried out with the sensitive species of interest from the study area in mind, following the framework outlined.

As the proposed mining operations will be carried out by a trailing suction hopper dredger, the guidelines from WODA (2013) are considered the most applicable guidelines and will be used to carry out the assessment of underwater noise on marine life in CRP's proposed mining area.

8.7.3 Potential noise sources

The mining operation activities will generate underwater noise (CEDA 2011) include:

- The drag-head and underwater pump.
- The transverse thrusters and the water jets (possibly assisted by cutting teeth within the drag-head).
- The vertical transport of the mined material through the riser.
- The return of processed non-phosphatic material through the sinker.
- The inboard pumps.
- Internally located engines and associated propeller.
- Other equipment mounted on the vessel.

Measurements of noise from dredging vessels have not often been carried out but there is a growing body of scientific and grey literature which has documented noise from aggregate and maintenance dredging activities using different types of dredger (see Robinson et al. 2011, GHD 2012, Reine et al. 2012, WODA 2013 and references therein).

Noise associated with a trailing suction dredger, similar to the proposed mining vessel, can range from 186 to 188 dB re 1 µPa at 1 m. This is similar to the noise generated by a large shipping vessel (180 to 190 dB re 1 µPa at 1 m), depending on the frequency measured and the size of the vessel (Thomsen et al. 2009, in CEDA 2011).

Published data indicate that the noise sources associated with the operation of a trailing suction hopper dredger are relatively constant and continuous. The frequency range over which noise is emitted varies according to whether the drag-head is on the seabed and operating or whether it is raised and not operating (Robinson et al. 2011). The majority of noise emitted from a trailing suction head dredger is of a low frequency range (up to a few kHz), and often at its highest dB re 1 µPa at approximately 1 kHz (Robinson et al. 2011). However, higher frequency noise up to approximately 40 kHz has been recorded from several dredging vessels. This is thought to be associated with the movement of material through the riser to the vessel (Robinson et al. 2011).

There are no published data that specifically quantify noise generated by the drag-head (including the thrusters and fluidising water jets and possibly cutting teeth), the pump unit, the riser and the sinker. Also, the actual mining vessel for CRP's project has not yet been confirmed. No source level for the emitted noise for these sources is known from any of the identified literature (Robinson et al. 2011, GHD 2012, Reine et al. 2012 and references therein).

The assessment of underwater noise propagation from these devices has therefore been carried out based on the following assumptions:

- There will be some variation in the noise source levels according to the vessel which will be used by CRP.
- The noise source levels provided in published research are for dredging operations so that all data can be compared (unless indicated otherwise).
- Received noise levels from the dredgers up to frequencies of 1 kHz are approximately the same during operation and when pumps are off.
- There has been a recorded difference in received noise level when active dredging is taking place and when the pump is raised and not active (Robinson et al. 2011). However, there are no published source levels for only the drag-head and associated jets (and associated cutting teeth, within the drag-head, if used). It has therefore been assumed that those noise recordings taken during dredging operations represent both the noise of the engine and the noise of the drag-head and associated jets (and cutting teeth if used).
- Two sources of noise have been assumed, the engine at the surface and the pump on the drag-head at (or just above) the seabed. The difference in total noise produced by the drag-head with difference features such as fluidising water jets alone or water jets assisted by cutting teeth, is likely to be negligible in comparison to the noise generated by the pumps.
- The same value source level for a given frequency has been used for the engine (including propeller) noise and the drag-head noise. This is because no distinction between the two noise sources has been made in the published studies such that only one value can be used for each source.
- Only the noise of the operational dredger and drag-head were assessed.
- The type of material being dredged by vessels in the various reports has not always been reported, although it was assumed to be usually a coarse material. As such it has been assumed that any noise from the dredged material ascending the suction pipe is included in the values presented in the various studies.

8.7.4 Impact on marine mammals

8.7.4.1 Introduction

As discussed in Section 6, marine mammals including sperm whales, pilot whales, southern right whales, killer whales, and dolphins have been sighted in or near the proposed marine consent area. Rarely-sighted beaked whales have also been observed just over a 100 km from the proposed mining area.

Transitory species of whale (blue and humpback) have also been identified from sightings at the edge of Chatham Rise, and outside of the proposed marine consent area. However, as discussed in Section 6, the distribution of these species has been established from opportunistic data reported in two studies. As such there are data gaps and it is possible that these species may traverse CRP's proposed mining area.

There is no information about the distribution and numbers of seals on the Chatham Rise, but data indicates that fur seals have the capacity to reach the Rise (refer to Section 6.8) and therefore the potential impact of underwater noise on these species has also been considered below.

8.7.4.2 Acoustic sensitivity of marine mammals

Marine mammals are acoustically sensitive at certain frequencies and sound is important for navigation, communication, foraging and orientation (Southall et al. 2007, Pinet et al. 2010, Parks et al. 2011, Erbe 2012). The hearing range of marine mammals is wide, and each species will differ slightly in the frequency of greatest sensitivity. In general, the baleen whales such as the blue, humpback and southern right whale hear the lowest frequency range, dolphins and toothed whales hear in the mid-range and porpoises and their relations hear in the highest frequency range. Seals and sealions have different hearing abilities dependant on whether they are underwater or not, with a greater hearing range underwater than in air.

Southall at al. (2007) divided marine mammals into four distinct groups based on their known, or assumed, auditory ranges – low-frequency cetaceans, mid-frequency cetaceans, high frequency cetaceans and pinnipeds (in air and in water). This information is summarised in Table 25.

Table 25: Functional marine mammal hearing groups, auditory bandwidth (estimated lower to upper frequency hearing cut-off) and genera represented in each group (Southall et al. 2007).

Functional hearing group	Estimated auditory bandwidth	Genera represented (Number species/subspecies)
Low-frequency cetaceans	7 Hz to 22 kHz	Bowhead whale, pygmy right whale, gray whale, humpback whale, *Balaenoptera* spp. (nine baleen whales) (13 species/subspecies)
Mid-frequency cetaceans	150 Hz to 160 kHz	Rough-toothed dolphin, humpback dolphins, costero and tucuxi dolphins, bottlenose dolphins, *Stenella* spp. (five oceanic dolphins), common dolphins, Fraser's dolphin, *Lagenorhynchus* spp.(six oceanic dolphins), right whale dolphins, Risso's dolphin, melon-headed whale, pygmy killer whale, false killer whale, killer whale, pilot whales, snubfin dolphins, sperm whale, beluga whale, narwhal, Cuvier's, Baird's, Arnoux's and Shepherd's beaked whales, bottlenose whales, *Mesoplodon* spp. (fourteen beaked whales) (57 species/subspecies)
High-frequency cetaceans	200 Hz to 180 kHz	*Phocoena* spp. (four porpoises), finless porpoise, Dall's porpoise, South Asian river dolphin, Amazon river dolphins, pygmy and dwarf sperm whales, baiji, La Planta dolphin, *Cephalorhynchus* spp. (four dolphins) (20 species/subspecies)

Functional hearing group	Estimated auditory bandwidth	Genera represented (Number species/subspecies)
Pinnipeds in water	75 Hz to 75 kHz	Fur seals (all species), *Zalophus* spp. (three sea lions), northern sea lion, Australian sea lion, New Zealand sea lion, South American sea lion, bearded seal, earless seals, Arctic earless seals, grey seal, ribbon seal, harp seal, hooded seal, monk seals, elephant seals, Weddell seal, Ross seal, crabeater seal, leopard seal, walrus (41 species/subspecies)
Pinnipeds in air	75 Hz to 30 kHz	Same species as pinnipeds in water (41 species/subspecies)

Toothed whales and dolphins (Odontocetes) fall into the mid- and high- frequency cetacean categories in Table 25 and are known to communicate at frequencies from 1 kHz into the tens of kHz (Southall et al. 2007). They also have a sophisticated echolocation ability which uses frequencies from the tens of kHz into the hundreds of kHz (Southall et al. 2007). Baleen whales are low-frequency cetaceans and differ from toothed whales in that they lack a high-frequency echolocation system, communicate using lower frequencies and are most sensitive to a lower frequency range than the toothed odontocetes (Croll et al. 2001, Southall et al. 2007, Simard et al. 2008, Clark et al. 2009).

Fur seals (*Arctocephalus*) have not been well studied with regards to their underwater hearing capabilities, although their vocalisations during breeding and between mother and pup have been (Page et al. 2002, Charrier et al. 2003, Tripovich et al. 2008, 2009). Recent research on closely related species, the northern fur seal (*Callorhinus ursinus*) and the California sea lion (*Zalophus californianus*) has suggested that the seal family Otariidae, within which the *Arctocephalus* sit, are a single functional group with regards to hearing and vocalisation range and sensitivity (Mulsow & Reichmuth 2010). Therefore, vocalisation and hearing sensitivities of related species in the family can be used to assess the potential impacts of underwater noise on fur seals in relation to CRP's proposal. Otariids can hear within the range of 100 to 100 kHz and are most sensitive to noise about 4 to 20 kHz (Babushina et al. 1991, Finneran et al. 2011, Mulsow et al. 2012).

8.7.4.3 Mining noise emissions and risks to marine mammals

Overview

Marine mammals use sound and respond to conspecific, natural, and anthropogenic noise in a variety of ways. Most of the responses are adaptive, which means that behaviour and physiology may change (Boyd 2008). Noise that disrupts communication or echolocation channels could have a potential adverse impact on marine mammals, for example stranding and mortality of beaked whales in other parts of the world have been attributed to sonar (2-10 kHz) from naval exercises (Barlow & Gisiner 2006, Cox et al. 2006). The potential impacts on marine mammals can range from behavioural responses of brief interruption of normal activities, to short or long-term displacement from noisy areas, masking of communications by noise emitted from anthropogenic sources or physical impacts of temporary or permanent deafness or physical injury (Southall et al. 2007, Kastelein et al. 2008a, Jensen et al. 2009, Ellison et al. 2012, Kastelein et al. 2012, Kastelein et al. 2013).

Underwater noise emissions can create hazards for marine mammals including, masking (i.e., when a noise is obscured or interfered with by background noise), habitat displacement and behavioural change from vessel noise and dredging operations (Boyd 2008). Factors for consideration when assessing the risk of noise emissions for marine mammal populations of the Chatham Rise include (after Boyd 2008):

- The range of frequencies, intensities and duration of exposure.
- The degree of overlap between species distributions and noise sources.
- The likely physiological or psychological response by the species.
- Whether behavioural changes by the species will modulate exposure.
- Whether there is habitat displacement and over what temporal or spatial scales.
- Estimating the likely proportion of the population that is impacted.
- Whether recovery is possible and likely.

Figure 145 also provides context for some marine mammals in terms of frequencies from shipping and dredging noise in the marine environment. This overview suggests that some dredging activities and shipping noise may overlap with the frequency levels of some whales and, to a lesser degree, dolphins.

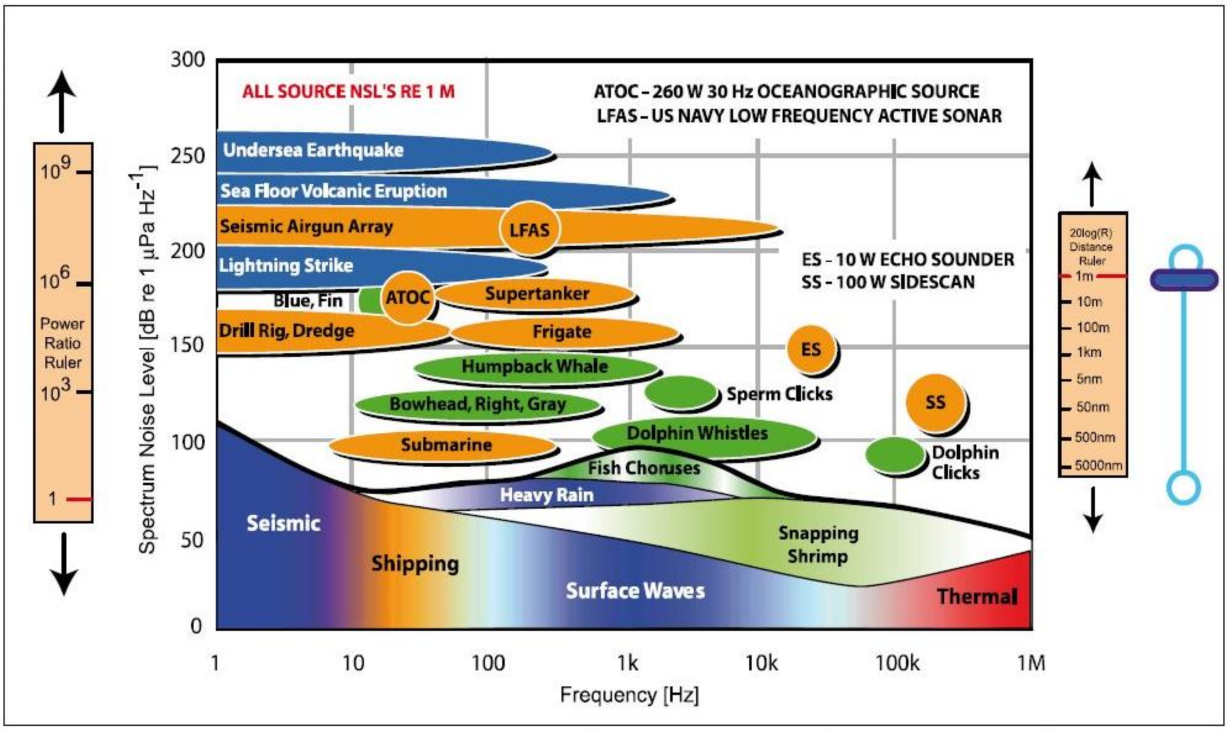

Figure 145: Noise levels and frequencies of anthropogenic and naturally occurring sound sources in the marine environment (from Boyd 2008).

Masking

Torres et al. (2013a) (Appendix 20) provides information on the vocalisation ranges of different marine mammal species which can be used to understand whether masking impacts of mammal communications by anthropogenic noise may occur. A summary of the vocalisation ranges of the key marine species sighted in and near the proposed marine consent area is in Table 26.

Table 26: Vocalisation ranges of whales and dolphins sighted within and near CRP's proposed marine consent area (based on Torres et al. 2013a).

Cetacean species	Vocalisation frequency range (kHz)
Sperm whale (*Physeter macrocephalus)*	0.1 to 30 kHz
Common dolphin (*Delphinus delphis)*	0.2 to 150 kHz
Killer whales (orca) (*Orcinus orca)*	0.1 to 35 kHz
Dusky dolphin (*Lagenorhynchus obscurus)*	1 to 27 kHz
Bottlenose dolphin (*Tursiops* spp.)	0.2 to 150 kHz
Minke whale (*Balaenoptera bonaerensis)*	0.06 to 6 kHz

Although a vocalisation range for the false killer whale (*Psuedorca crassidens*) was not provided in Torres et al. (2013a) a maximum frequency for the loudest vocalisations documented was. For the false killer whale a maximum click frequency of 25 to 130 kHz was recorded at an intensity of 220 to 228 dB re 1µPa.

There is some overlap in the dredger noise spectrum and the functional auditory range of dolphins, but GHD (2012) indicated that interference with dolphins' bio-sonar and communication is only possible at distances less than 500 m from a dredger vessel.

Threshold shifts

WODA (2013) suggests that permanent threshold shift in hearing (i.e. deafness, or physical injury) were extremely unlikely to occur due to the low noise emissions from a dredging vessel as measured by various studies globally.

As such, behavioural responses and temporary threshold shift are the most serious effects that might arise from dredging noise on marine mammals in the CRP proposed mining area. Temporary threshold shift will also only occur if the marine mammals stay within a certain range of the vessel for an extended period of time. This will vary depending on the intensity of the anthropogenic noise and the hearing sensitivity of the individual species, but should only last a short period of time.

The noise emissions from the proposed mining operations are likely to be loudest below and around 1 kHz, outside the range of greatest sensitivity of dolphin and toothed whale species found on the Chatham Rise. For the baleen whales in the area, the greatest range of sensitivity is not clearly known due to the difficulties of collecting a useful audiogram from these species. However, threshold shift is not expected unless an individual remains close to the mining operations for an extended period of time.

GHD's (2012) predictions based on likely noise impacts from a trailing suction hopper dredger system (including the vessel and all components of the dredging system) indicate that it is unlikely that dolphins will be impacted by dredging operations such that the predicted noise exposure level is more than 183 dB re 1 μPa^2-s at a distance of 1 m, half that specified by the Seismic Code at 200 m

(186 dB re 1 μPa^2-s)[32]. For context, Appendix 1 of New Zealand's Seismic Code specifies that if noise levels are predicted to exceed this level then consideration should be given to either extending the radius of the mitigation zone (discussed below) or limiting acoustic source power.

Behavioural response

It is possible that noise from a drag-head and vessel could result in a behavioural displacement response of marine mammals, i.e., moving away from the noise source (GHD 2012), but the likelihood of this response is dependent on the degree of overlap of species' spatial distributions (refer Section 6.9) and the noise source. In the case of the trailing suction hopper dredger system assessed by GHD (2012), notable impacts were only predicted to occur if a marine animal were to remain within 50 m of the dredge for 12 hours per day, considered highly unlikely for CRP's mining operations.

The duration of the disturbance would also be limited to the mining area for approximately 4 to 5 days during mining operations. Displacement, should it occur, is therefore expected to be of short temporal duration over a small area that is limited to the location of the vessel during the 4 to 5 day mining period. On this basis, it is unlikely that marine mammals will be adversely impacted by the proposed mining operation.

If there is any impact, it will be near-source, short-term and reversible and, therefore, the potential environmental consequence is considered to be minor. The likelihood of this potential impact occurring is possible. Potential impacts of noise on marine mammals is of a low environmental risk (refer to Section 8.2).

However, this risk determination is made in light of the limited research into noise emissions for the mining system to be employed and the range of potential impacts on marine mammals in the region. Mitigation measures are therefore proposed as a precautionary approach in the following section.

8.7.4.4 Avoidance, remediation and mitigation measures

The potential for significant, prolonged overlap of marine mammals with the mining operations is low, the percentage of the population that could be affected is small to negligible, and the impacts are recoverable and unlikely to affect marine mammal species at the population level.

The likelihood of overlap is mitigated by the inclusion of pre-start observations to avoid interactions with marine mammals, and regular observations for their presence in the vicinity of the mining vessel. Mining operations are expected to occur for 4 to 5 days, followed by about 6 days when the vessel is in transit or in port, limiting the time when marine mammals could be affected by the mining operations. The observations of marine mammals along the Chatham Rise indicate that a significant proportion of a species' population is unlikely to pass close to the mining operations. Avoiding areas with high noise levels is likely to provide effective mitigation to mobile marine mammals and cumulative injury is unlikely to occur (Nedwell et al. 2007 and references therein).

Although this assessment indicates there is a low environmental risk of an adverse impact on marine mammals, a mitigation zone around the mining vessel will be employed as a matter of good practice. A mitigation zone of 200 m radius will be scanned around the vessel for at least 10 minutes prior to the start of mining. If marine mammals are observed in the mitigation zone, mining will not commence until they have left the area (i.e., having not been observed for at least 30 minutes). This mitigation will ensure that the area in and around the mining vessel, and thus the mining activity on the seabed, is clear of marine mammals prior to commencement of mining operations.

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[32] Under the Seismic Code both southern right and killer whales, which have been sighted in CRP's proposed marine consent area, are classified as species of concern (refer to Schedule 2 of the Seismic Code). For seismic surveys, species of concern have larger mitigation zones than other marine mammals. Appendix 1 identifies a lower sound level of 171 dB re 1 μPa^2-s, associated with the relevant mitigation zone, as applying when such species are present. Given that the sound level specified for other marine mammals will be met in the immediate vicinity of the mining activity, and that the activity is not a seismic survey, the lower sound level has not been considered further.

The potential impact, following the utilisation of this proposed avoidance measure, remains a low environmental risk.

8.7.5 Impact on fish species

8.7.5.1 Introduction

As discussed in Section 6, several commercially important fish species and groups such as hoki, orange roughy, ling and oreos are found on and around the Chatham Rise. In addition, many species of deep water sharks, including dogfish and rattails (including javelin fish) and slickhead also commonly occur in and around the Chatham Rise.

8.7.5.2 Acoustic sensitivity

A fish may be able to detect a sound but that does not mean that it will react, as fish sensitivity to noise varies. Audiograms of marine fish species indicate that their highest sensitivity to noise falls within the 0.1 to 2 kHz range and that a threshold level within this range needs to be reached before a behavioural response will occur. Response can range from visible startle behaviour to avoidance of an area to raised respiration rates (Smith et al. 2004, Wahlberg & Westerberg 2005, Nedwell et al. 2006, Hovem et al. 2012). There is also variation in the hearing abilities of fish, for example audiograms of hearing thresholds for dab and cod as being limited to <1 kHz and herring up towards 10 kHz (Kikuchi 2010). Some fish are able to detect the direction from which a sound originates, for example cod (Schuijf 1975, Hawkins & Sand 1977, Buwalda et al. 1983), or are highly sensitive to noise, for example Atlantic herring (Doksæter et al. 2009, Sivle et al. 2012).

Kastelein et al. (2008b) summarised research on impacts of specific noise on marine fish. Kastelein et al. (2008b) examined the behavioural reaction threshold levels of eight fish species from the North Sea to pure tones in the frequency range 0.1 to 64 kHz. The fish included sea bass, mullet, pout, Atlantic cod, common eel, Pollack, horse mackerel and Atlantic herring. The fish species were found to respond to noise at varying frequencies. With some showing no startle response above 0.1 kHz (the lowest frequency in the experiments). Some species displayed responses at 0.1 kHz and just above, suggesting they may respond to noise below that frequency.

In a review Kikuchi (2010) summarised that in areas where seismic exploration was being conducted catch rates of species such as cod and haddock declined in areas where air guns were used but increased 30 to 50 km away suggesting area avoidance. Wind turbine noise up to 2 kHz can be detected by fish up to 4 km away for hearing specialist fish and probably up to 1 km away for generalist fish. It was considered that behavioural responses may occur within these distances.

Popper et al. (2006) determined that protection from physical damage on fish species from impulse noise can be provided by limits of SEL 187 dB and L_{peak} 208 dB at 10 m. The noise generated from the mining operations is relatively constant and continuous and it is very unlikely that underwater noise from CRP's proposed mining could cause injury to fish.

8.7.5.3 Potential impacts

Given that various mechanical components of the mining process will emit noise that can be detected by fish, it is possible that noise may be detected a few kilometres away by hearing specialist fish). This potential zone of influence is considered comparable in scale to the zone of other potential impacts created by the project, such as the sediment plume.

Direct damage to fish from emitted noise is not expected. Whilst there is little direct observation research to draw on, it is likely that the impacts of noise from dredging will result in interruption of normal behavioural activities and possibly short-term displacement from noisy areas. Therefore, any potential impact on fish species associated with noise will be near-source, short-term and reversible and therefore the potential environmental consequence is considered minor. Overall, any disturbance impacts on fish are considered to be extremely local in nature. The likelihood of this potential local impact occurring is 'possible'. Potential impacts of noise on fish species are a low environmental risk.

On the basis of the available data, no avoidance, remediation or mitigation measures are considered necessary to protect fish species from the potential adverse effects of noise arising from CRP's proposed mining operations.

8.7.6 Summary

Given the nature of the noise that is likely to be generated as a result of CRP's proposed mining operations, it is unlikely that either marine mammals or fish species in the vicinity of the mining areas and mining vessel will be significantly impacted by mining-related noise. There is a very low likelihood of permanent damage, whilst any temporary impacts are likely to be local to the mining site (within a few kilometres). The potential impact has therefore been assessed as being of low environmental risk.

However, as a precautionary approach to avoid impacts on marine mammals, CRP proposes to undertake its mining operations utilising a 200 m radius mitigation zone (centred on the mining vessel) whereby if marine mammals are observed prior to the start of mining then mining will be delayed until the marine mammals have moved beyond the 200 m mitigation zone.

As the risk determination has been made in light of the limited research into noise emissions from the actual mining system, CRP proposes to carry out a round of noise monitoring when mining commences in accordance with guidance outlined in WODA (2013).

8.8 Vessel Lighting Impacts

8.8.1 Introduction

Light can adversely affect seabirds at sea or on land. Major sources of lighting can be associated with coastal urban towns, coastal infrastructure and offshore marine infrastructure (e.g., oil platforms), and vessels at sea.

Section 6.9 and Thompson (2013) (Appendix 21) describe the seabirds found on the Chatham Rise. The seabird assemblage includes species present in large numbers and species of varying conservation significance. The latter include several species that have very high conservation values and that are present in low numbers in the Chatham region.

Given the presence of seabirds on the Chatham Rise, and the potential for these seabirds to be attracted to CRP's mining vessel (which will operate 24 hours a day), this section of the EIA assesses the potential impact on seabirds from CRP's proposed mining operations. To establish a context for assessing the potential environmental risk, factors influencing seabird attraction to facilities are discussed in Section 8.8.2. International experiences with off-shore installations acting as attraction and the nature of lights, and associated wavelengths that influence this potential impact are discussed in Section 8.8.3, along with proposed avoidance, remediation and mitigation measures that will be implemented by CRP to minimise this impact.

8.8.2 Factors involved

Seabirds are known to become disoriented at night in the presence of artificial light. Gauthreaux & Belser (2006) discuss the possibility that artificial lighting interferes with the bird's magnetic compass. It is assumed that migrating birds use visual cues as well as a magnetic compass mechanism for orientation (refer summary of literature in Poot et al. 2008).

Light is an important factor for bird's visual cues. It has also been shown that magnetic orientation is probably based on specific light receptors in the eye and to be not only light dependent (Ritz et al.

2000) but also wavelength dependent. That is, migratory birds require light from the blue-green part of the spectrum for magnetic compass orientation (Wiltschko & Wiltschko 1995b, 2001, Muheim et al. 2002) whereas red light, the long-wavelength component of light, disrupts magnetic orientation at least in laboratory conditions (Wiltschko et al. 1993).

It is well established that during overcast nights birds are more affected by artificial lights than on clear nights. During overcast nights, birds cannot use celestial cues and may be more dependent on the magnetic compass for orientation.

8.8.3 Lighting impacts on seabirds

8.8.3.1 Lights and wavelength

Poot et al. (2008) summarised the laboratory studies undertaken showing that birds are only disoriented by specific wavelengths (Wiltschko & Wiltschko 1995b, 1999, 2001, Muheim et al. 2002). These and other studies showed that red light caused disorientation by impairing magneto-reception (Wiltschko et al. 1993). Poot et al. (2008) undertook experiments to assess field response to lights showing that birds were oriented in the seasonally appropriate migratory direction in blue light (Wiltschko et al. 1993, Wiltschko & Wiltschko 2001). They then found that green light caused no or minor disturbance of orientation, as was found in earlier studies (Wiltschko & Wiltschko 1995b, Wiltschko et al. 2000, 2001, Wiltschko & Wiltschko 2001).

Merkel & Johansen (2011) citing other work reported that experiments using red filters in front of floodlights on tall constructions have been shown capable of reducing avian casualties by up to 80 %.

Laboratory and field data indicate that seabirds respond differently under field conditions to various colours (wavelengths) of artificial light. Migratory birds react strongest to white and red light (long wavelength), little to green light (shorter wavelength), and hardly at all to blue light (short wavelength).

The use of different light wavelengths on board offshore installations and vessels requires consideration of on-board health and safety. The light used on vessels must be visible to people on board. Ultraviolet light is not visible and blue light is not a safe light to work under, and so neither can be used for on-board lights.

Based on research, a green light is the best option to minimise bird disorientation and maintain safe working conditions.

8.8.3.2 Off-shore facilities - international bird strike experience

Merkel & Johansen (2011) reported a total of 480 individuals belonging to five different seabird species killed or injured in 42 incidents of bird strikes associated with off-shore vessel movements over the three winters 2006/07 to 2008/09 (1 October to 31 March) throughout southwest Greenland. The vast majority of the birds involved were common eiders (the most common seabird in the survey area), accounting for 95 % of the individuals killed or injured over this three year period. Variation in bird strike frequency between years and between vessels was large. Bird strikes were reported in 14 cases despite good visibility. However, the number of birds involved in these bird strikes was significantly smaller compared to incidents that occurred when visibility was poor.

Poot et al. (2008) reported unpublished work undertaken by Marquenie & van de Laar (2004) who examined bird behaviour around off-shore oil installations in the North Sea during the period 1992 to 2002. To assess whether lighting on off-shore installations attracted seabirds, they carried out a number of experiments during which they manipulated the lighting of a production platform (platform L5, 70 km offshore of the Dutch coast). When the lights were on, bird numbers on and around the platform increased. When the lights were switched off, the birds rapidly dispersed from the platform, showing that it was indeed the artificial lighting that attracted the birds. A further experiment also demonstrated that the impacts of lights increase with intensity (power) and direction of the lighting. Their study indicated that full lighting (30 kW in that study) extends 3 to 5 km.

A survey of Boskalis dredging vessel masters showed that in their experience bird strike frequency was low. This is expected as vessel bird strike frequency will be dependent on a variety of factors including local bird population and species involved.

Locally, anecdotal evidence from the manned Maui-A production platform off-shore from Taranaki notes that bird strike is rare. The main issue, although uncommon, is that apparently-tired seabirds use the warmth and stability of the platform to rest (Shell Todd Oil Services Ltd pers. comm.).

Based on the above information, without considering specific approaches that may minimise bird strike impacts (as discussed below), the impact has the potential to be adverse, near-source confined (any bird strike will occur on the vessel), long-term (as long as the mining occurs) and reversible (if the vessel is not present, or lights are not being used, seabirds will not be attracted to the mining vessel). Therefore, the potential environmental consequence is considered medium to serious (depending upon the species involved), with the likelihood of this potential impact occurring being 'possible'. This means that the potential impact of vessel lighting on seabirds is considered to range from medium to high environmental risk, depending on the species.

8.8.3.3 Avoidance, remediation and mitigation measures

Based on work undertaken in the laboratory and in the field, the risk of bird strike on vessels can be reduced significantly by reducing and shielding light sources on-board and ensuring that the wavelengths of the lights are dominated by green light (subject to ensuring that vessel and crew safety needs are met).

Therefore, CRP proposes to adopt the following key management policy on board its mining vessel:

- White light sources will be replaced with green light sources where possible.
- Where possible lighting will be shielded or downward facing.
- Where lighting is not required on deck at night, it will be switched off.
- Deck equipment will be structured wherever possible to minimise the number of vertical wires and objects to decrease the collision risk for seabirds.
- The vessel crew will be made aware of the potential for bird strike and the conservation values associated with Chatham Rise seabird species, and required to keep records of bird strike records that include bird species, number, and environmental conditions.

A draft Vessel Lighting Management Plan (LMP) is in Appendix 35(ii). The LMP is a preliminary draft to be finalised during vessel fit-out. The LMP will provide the basis for ensuring that lighting is managed in a bird-friendly manner (reflecting the key management approaches listed above) and that records are maintained to provide data on the effectiveness of the bird strike minimisation efforts made by the mining vessel. Bird strike events, if they do occur, may require different actions depending on the nature of the bird strike event.

Adoption and implementation of these measures will reduce, the environmental risk from medium/high to low/medium as it is unlikely that bird strike events will be significant.

8.8.4 Summary

A variety of seabird species are found on the Chatham Rise and these species could potentially be attracted to the lighting on CRP's mining vessel. However, by adopting avoidance measures and ensuring that vessel lighting is managed in a bird-friendly manner as outlined in the draft LMP, the potential impact of bird strike from vessel lighting has been assessed as being of low to medium environmental risk.

8.9 Waste Discharges from Vessel

8.9.1 Introduction

All seagoing vessels have waste discharges. Discharges from commercial vessels within the New Zealand EEZ potentially include:

- Oily water and waste.
- Wastewater (sewage and greywater).
- Garbage (solid waste).

As described in Section 4.7.4, all of these are managed through a combination of the Resource Management (Marine Pollution) Regulations 1998, Maritime Protection Rules and MARPOL. The management approaches that will be followed by CRP's mining vessel to ensure that adverse impacts from these discharges are avoided are outlined below.

8.9.2 Oily water and waste

New Zealand is a party to MARPOL, Annex I of which includes regulations for the prevention of pollution by oil. Oily wastes such as bilge water and machinery waste can only be discharged to sea if the hydrocarbon content is less than 15 mg/L.

CRP's mining vessel will have an approved treatment system for oily waters and waste, which will be operated and maintained to ensure that MARPOL requirements are met and all limits for hydrocarbon concentrations in discharges (e.g., bilge water) are met. The vessel will be required to hold an International Oil Pollution Prevention Certificate, which is inspected for currency by Maritime NZ when the vessel is in a New Zealand port.

Specific requirements relating to oil spill contingency planning are discussed in Section 8.11.

8.9.3 Wastewater

The Resource Management (Marine Pollution) Regulations (1998) outline treatment standards that specify where wastewater can be discharged into the Territorial Sea. These Regulations restrict the disposal of untreated wastewater near marine farms, mataitai, or marine reserves. The Marine Pollution Regulations are a good basis for managing wastewater on-board the mining vessel.

Systems that treat wastewater to the Grade A standard are outlined in Schedule 6 of the Regulations. Despite operating beyond the Territorial Sea, CRP's proposed mining vessel will include and operate a wastewater treatment facility that meets the Grade A standard, and will also hold an International Sewage Pollution Prevention Certificate.

The discharge of treated wastewater from the mining vessel into the marine environment (whether on the Chatham Rise or in transit to and from a port) will have no adverse environmental impacts.

8.9.4 Garbage (solid waste)

Garbage (solid waste) generated on board the vessel will be managed through a management plan that fulfils the requirements of the Marine Protection Rules Part 170. A draft Waste Management Plan (WMP) is provided in Appendix 35(iii). The WMP provides for minimisation of the generation of waste materials through recycling and materials management, with all recyclables and waste, except that permitted to be discharged under MARPOL (only ground and comminuted food waste) being returned to the vessel's operating port.

Except for the discharges permitted by MARPOL, the mining vessel will not discharge garbage to sea. The discharge of ground and comminuted food waste from the mining vessel is permitted under MARPOL as such discharges are considered to have no adverse environmental impacts.

8.9.5 Summary

Operation of the mining vessel will have no adverse impacts on the Chatham Rise as a result of the discharge of waters that might contain oil (hydrocarbons), garbage or wastewater. All such discharges will meet the requirements of MARPOL and associated New Zealand regulations. Any discharges are considered to be neutral, near-source confined (within the vicinity of the mining vessel), short-term and reversible. Therefore, the potential consequence is minor and, with a likelihood of possible, the environmental risk is low.

8.10 Marine Biosecurity

As described in Sections 4.7.5 and 4.7.6, biosecurity issues associated with CRP's proposed mining vessel are managed in accordance with the Biosecurity Act (with the statutory authority for biosecurity lying with MPI) and the import health standards (to be replaced by the craft risk management standards). There are two key aspects of marine biosecurity that will be managed at the start of CRP's proposed mining project when the mining vessel arrives in New Zealand.

First, ballast water loaded to the vessel at another international location cannot be discharged within the waters of the EEZ without prior approval. The vessel will complete a ballast water declaration to show that it complies with New Zealand's maritime biosecurity requirements. The ballast water requirements will be met by either re-ballasting en-route or by demonstrating that the ballast water is adequately treated.

Second, it is a requirement to ensure that the vessel's hull is clean of any visible biofouling when it arrives in a New Zealand port from international waters. Prior to the arrival of the mining vessel in New Zealand, contact will be made with Border Standards, MPI. Inspection and possible cleaning requirements will be confirmed following the identification of the mining vessels' route to New Zealand for the first time. The hull will be inspected to ensure that it is free of visible biofouling prior to arrival in New Zealand.

Following the arrival of the mining vessel in New Zealand, biosecurity issues will be managed as a component of CRP's overall EMMP for the project (a draft EMMP is contained in Appendix 35(i)). Following the confirmation of the vessel's operating port (for unloading phosphorite, bunkering and maintenance), the biosecurity management section of the EMMP will be updated to reflect New Zealand specific concerns in relation to unwanted marine organisms. Should a port be developed at the Chatham Islands, the EMMP will address specific biosecurity issues that apply to the Chatham Islands.

Once the vessel arrives in New Zealand, the day to day biosecurity risks are considered no higher than any vessel working in coastal waters in this part of New Zealand (e.g., fishing vessels, coastal traders or vessels servicing the Chatham Islands). On this basis, given that CRP will comply with the requirements of the Biosecurity Act, it is considered that there is no biosecurity risk associated with CRP's mining vessel.

8.11 Project Operational Management and Risks

8.11.1 Introduction

This section provides a summary of the risks associated with the operation of the mining vessel on the Chatham Rise. Commercial vessels operating in New Zealand waters are required to comply with New Zealand's environmental regulations and generally accepted international environmental practices. The New Zealand regulations (referred to in Sections 8.9 and 8.10) have been implemented to ensure that the New Zealand marine environment is managed sustainably and that the risks to the environment from vessels operating in New Zealand waters are minimised.

When on the Rise, the mining vessel will be working within a limited area (over a 5 by 2 km mining block) within the proposed marine consent area.

8.11.2 Vessels on the Chatham Rise

Although CRP's Chatham Rise mining location is well away from mainland New Zealand and coastal shipping movements, the mining vessel operations will have to consider fishing vessels from New Zealand ports, vessels going to and from the Chatham Islands, marine research vessels and some international shipping traffic.

Figure 146 provides a snapshot of vessel traffic in the Chatham Rise region. The data in Figure 146 are obtained from the National Centre for Ecological Analysis and Synthesis website[33] (refer Halpern et al. 2008). The data are derived from a 12 month period beginning October 2004. The data were collected as a part of the World Meteorological Organization Voluntary Observing Ships Scheme[34] as this year was considered to be representative of global vessel positions (Halpern et al. 2008). The information is one of the few compiled snapshots of global vessel traffic. The data reflects the number of vessel tracks in 1 km^2 cells, with a global range of 0 to 1,158 ship tracks in any cell.

Figure 146 shows the most intense area of vessel movement is off the Kaikoura coast, and corresponds to 463 to 695 tracks, or 1 to 2 tracks a day, in each cell. The main coastal traffic passing down the east coast of the North and South island indicates 0.6 to 1.2 tracks per day in each cell.

The National Aquatic Biodiversity Information System[35] (NABIS) provides information on commercial fishing effort. Fishing areas 401 to 404 and 407 to 410 (areas used for statistical analysis) cover the area between Mernoo Bank and the Chatham Islands. The number of fishing days for vessels of any size reported in these fishing areas in the 2012/13 period ranged from 1 to 520. In any fishing statistical area, the annual daily average is up to two vessels. However, vessels operate seasonally and therefore there will be periods when more than two vessels are operating in the area.

The mining vessel will be working in an area of low vessel traffic. Much of the Chatham Rise area has no vessel traffic at all. The main traffic within and close to the mining area is expected to be working and transiting fishing vessels. Therefore it is unlikely, provided the requirements of international law and the MT Act are complied with, that CRP's mining operations will have any impact on vessels in the area.

[33] http://www.nceas.ucsb.edu/globalmarine/impacts

[34] http://www.vos.noaa.gov/vos_scheme.shtml

[35] http://www2.nabis.govt.nz

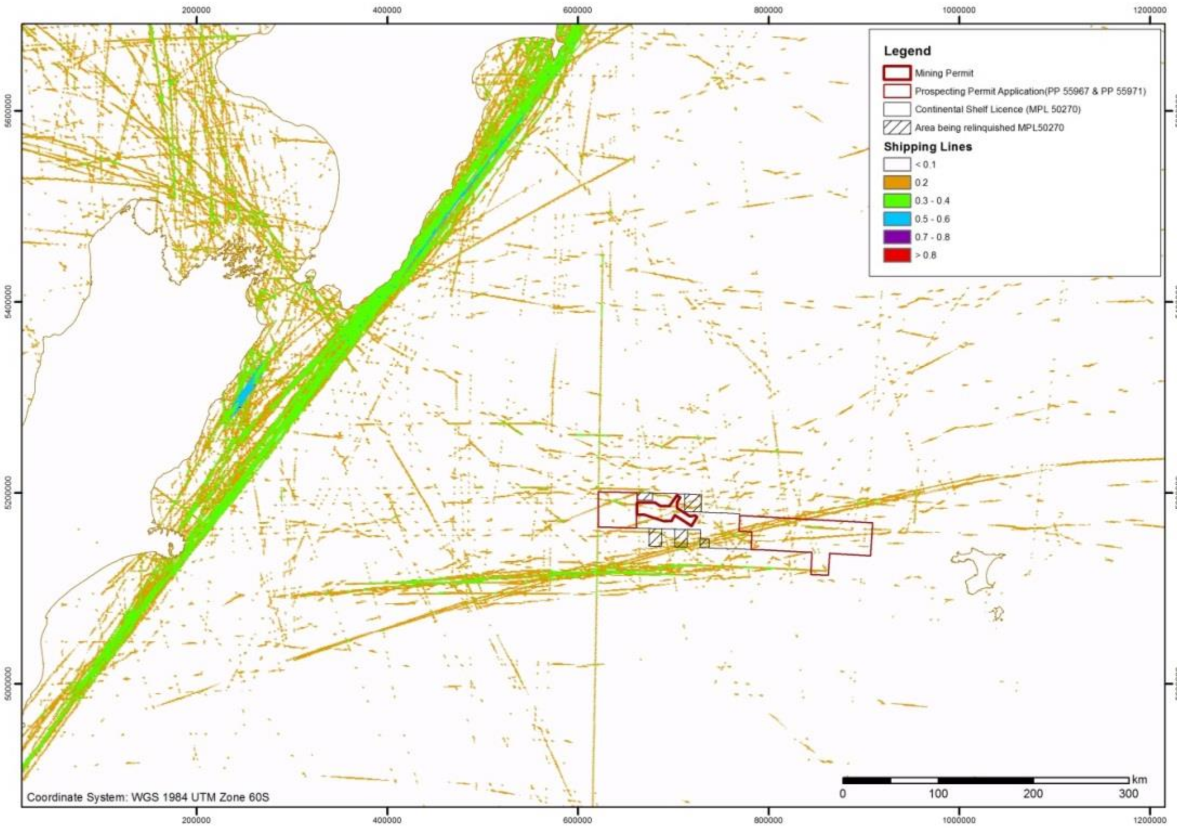

Figure 146: Vessel traffic in the vicinity of the Chatham Rise. Data are from the National Centre for Ecological Analysis and Synthesis website for the period October 2004 – September 2005 (refer Halpern et al. 2008).

8.11.3 Working in bad weather

The mining vessel will work within specified weather limits to ensure vessel safety.

These will be defined following the completion of all aspects of vessel design.

While working on the Chatham Rise, the vessel Master has the responsibility to decide whether it is safe for the vessel to continue working. If not, the vessel could travel to port to unload, wait out the weather/sea conditions on site or transit to another area for shelter, possibly the Chatham Islands.

8.11.4 Fuel and oil

There are two possible sources of fuel and oil which could be spilt in an unexpected event. They are the fuel and hydraulic oils carried on board the vessel and the oil contained in the underwater pumps.

In the highly unlikely event of a shipwreck or collision, all of the fuel and oil on board of the vessel could be spilt, although this would be dependent upon the nature of the incident, the location and security of the bunker tanks and whether or not they were ruptured. The amount of oil and fuel spilt would be dependent on the volumes carried at the time, ranging from fully laden immediately following bunkering through to far lesser volumes upon returning to port, but would be significantly less than an oil tanker. The spilt oil and fuel would have adverse impacts on marine life and in particular any sea birds[36] and potentially other impacts on the foreshore and existing interests, depending on where the ship wreck occurred.

[36] The impacts on sea birds are assessed in Section 8.6.6.3.

Maritime NZ is responsible, under the MT Act, for managing New Zealand's oil spill response system and for the enforcement of fuel and oil management in respect of ships within New Zealand waters. Given these responsibilities, Maritime NZ maintains a New Zealand Marine Oil Spill Response Strategy and National Plan (known as the National Marine Oil Spill Contingency Plan, last updated in December 2013) in conjunction with Regional Marine Oil Spill Contingency Plans.

The Strategy sets out how New Zealand will minimise the impact of oil pollution on the marine environment. The Strategy also requires a national spill response capability, and sets out the details of this system. The oil spill response system in New Zealand is tiered (Tiers 1 to 3) to allow appropriate levels of response to different sized spills and different environments[37]. Tier 3, which requires a national response led by Maritime NZ, is a spill that exceeds the specific response capacity of a regional authority, or is located in an area beyond the Territorial Sea.

In accordance with the MT Act, and its associated rules and regulations all commercial ships (including the mining vessel) are required to have an IOPPC and for ships greater than 400 gross tonnes a SOPEP is also required. A SOPEP must include the following information: identification of all activities using fuel and oil, how they are stored and managed to prevent spills; spill risk identification, assessment and prevention requirements; the equipment, procedures and systems to be used in the event of a spill, spill notification procedures; and, personnel training requirements. The mining vessel will require an IOPPC and SOPEP which will be inspected by Maritime NZ before the ship can operate in New Zealand waters.

The probability of a shipwreck or a collision that would rupture bunker tanks is very low. However, should a major incident occur with resultant significant loss of oil, the environmental impacts could potentially be serious (depending on location). CRP's risk assessment, which included consideration of appropriate preventive measures and the robust oil spill response systems available, is that the risk of an oil spill from a shipwreck is a low environmental risk.

To further minimise any risk associated with the operation of the mining vessel, it will only carry fuel oil sufficient for the vessel's purpose. All refuelling, or bunkering, will be carried out at port in accordance with both the port's and Boskalis risk assessment and management requirements.

As well as fuel, as described in Section 4, the mining vessel will have electrically driven underwater pumps whose drives will contain oil. The vessel will have lifting equipment (cranes, hose reels etc.) that will also contain hydraulic fluids. All on-board equipment containing hydraulic fluid will have regular maintenance and observation checks and appropriate equipment will be kept on the mining vessel to immediately manage losses from equipment if necessary. The on-board hydraulic fluid management strategy will ensure no that overboard losses occur.

The additional oil spill risk from CRP's activities, beyond that of shipwreck of a vessel of equivalent size and function, is the risk of oil spill from the underwater pumps on the drag-head. The in-water pumps are sealed and will contain pressure sensors to identify and monitor the status of seals. Should indicators show changes in pressure that are out of specification, equipment will brought to the surface and checked and maintenance carried out as required. The hydraulic fluid in the in-water pumps is expected to be Mobil EAL hydraulic oil (or similar). The total volume of oil in any oil spill would be in the order of 10 to 30 L. These oils fall into a category of green oils and are the most suitable for operations on the Chatham Rise. The additional oil spill risk from the oil contained in the underwater pumps is therefore assessed to be a low environmental risk because the impacts would be minor and probability of a spill occurring is low.

In 2010 Maritime NZ carried out an oil spill risk assessment and this will be reviewed by 2016. The assessment identifies the level of risk of pollution of the sea, coastline and posts of New Zealand. The risk profile has been assessed based on information available on oil and vessel movements, as well as both national and international incident data. Risk classifications range from very low, low,

[37] http://www.maritimenz.govt.nz/Environmental/

moderate, high and very high. Taranaki, due to the presence to the oil industry and significant vessel movements, is classified as high risk as is Whangarei because of the oil refinery traffic. Napier, Lyttleton, Oamaru and Bluff are also classified as areas of high risk. The risk profile of the rest of the east coast of New Zealand is generally moderate to low risk, with the Chatham Islands being classified as having a very low risk. The oil spill risk assessment also identifies the total risk profile is driven by smaller sized spills (< 100 t).

Boskalis, who will be operating the mining vessel, operate a separate risk assessment for oil spill system on all its vessels. This system identifies all aspects of its operations that have a potential risk. Boskalis' risk assessment system requires it to identify the hazards and consequences associated with specific activities (e.g., fuel supply, bunkering and storage), identifies the standard control and reduction measures and if the risk profile is still assessed as being too high after the application of these standard measures, then the system requires additional control and reduction measures to be applied. The effectiveness of this system is evident from its fuel and oil incident history. Boskalis operate approximately 30 trailing suction hopper dredgers around the world, most of which operate 120 hours a week and 45 weeks a year. A review of Boskalis' environmental incident database from 2010 onwards has identified only one small spill to the marine environment from a broken hydraulic hose (December 2013 in Sweden). If such an incident were to occur on the mining vessel then spill will be no more than 30 L and such a spill would dissipate quickly.

8.11.5 Fire on vessel

The mining vessel will comply with all international requirements for fire prevention, fire safety, firefighting and training and other related requirements, in particular Maritime NZ's Safety Guidelines for Passenger and Non-Passenger Vessels (2009).

8.11.6 Collision risk

Maritime Rules Part 22 (April 2011) deals with collision prevention in New Zealand waters. The Part incorporates the requirement of the Convention on the International Regulations for Preventing Collisions at Sea, 1972 and includes:

- Conduct of vessels under any visibility condition.
- Conduct of vessels in sight (e.g., a fishing vessel).
- Installation and performance and use of lights for collision avoidance.

Part 22.27 in particular includes matters relating to any vessel that has restricted ability to manoeuvre (e.g., such as the mining vessel).

The vessel will comply will all the requirements in Part 22.

The potential for collisions with marine mammals (i.e., ship strike) is discussed in Section 8.6.6.2.

8.11.7 Loss of phosphorite nodules

Loss of phosphorite nodules from the mining vessel could occur through two mechanisms: an incident resulting in return of nodules in the riser to the seabed, and the loss of nodules through vessel stranding or sinking.

The loss of nodules as a result of spillage from the riser would have minimal if any environmental impact. The total volume loss under such a scenario, given the size of the riser, the volume of the material in the riser and the back-up systems that will be in place so the whole volume of the riser is not lost, will ensure that the loss of material (refer to Section 8.4.4.4) is small (<20 m^3 of nodules and sediment). The impacts of a small unintended loss of sediment from an incident are described in Section 8.4.5. The downstream plume from such an event is predicted to be small and potential impacts are minor compared to sediment releases from the returns disposal. These incidents will be infrequent, but at this point there are no operational data to gauge their possible frequency.

Loss of large volumes of nodules to the seabed would require the vessel to capsize or sink, an extremely unlikely event. If the vessel were to capsize or sink, then the environmental consequences related to the loss of the nodules are unlikely to be significant as the nodules have resided on the Chatham Rise seabed for millions of years, they are in equilibrium with seawater, and they are unlikely to affect the seabed or water chemistry through processes such as dissolution.

Loss of large volumes of nodules to the seabed is therefore both unlikely, and unlikely to constitute a significant environmental hazard.

8.11.8 Hazardous substances

There will be no chemicals or hazardous substances used in the mining operation.

Any substances deemed hazardous by the HaSNO regime will be managed in accordance with the requirements of that regime, administered by Maritime NZ.

8.11.9 Vessel routing

New Zealand has a voluntary code for vessel routing along some stretches of coast. This code was put in place to minimise the risk to particular locations within the EEZ from vessels carrying bulk oil and chemicals. Areas included are the Three Kings and Poor Knights Islands off Northland (refer Part 190 of the Marine Protection Rules). The transport of phosphorite nodules by the vessel or possible loss of nodules from the vessel from the Chatham Rise to port for unloading is not considered an environmental risk. However, vessel routing will be considered (to ensure vessel safety) when the port for nodule unloading is selected.

8.11.10 Summary

In summary, the mining vessel will operate in New Zealand waters in full compliance with all applicable Maritime NZ rules and requirements, and relevant international regulations. These requirements will be embodied within the mining vessel's standard operating procedures, the EMMP (Appendix 35(i)) and Mining Plan. These management measures will ensure that the vessel is able to deal with contingencies in a manner that has regard for vessel, vessel crew and environmental safety.

8.12 Cumulative Impacts

8.12.1 Introduction

The environment of the Chatham Rise has been subject to a number of human induced impacts over time. Apart from vessels sailing to and from New Zealand that pass across or near the Chatham Rise, the earliest direct impacts on the Rise came from whaling.

In this section, the assessed cumulative impacts of the proposal to mine on the Chatham Rise are discussed. The assessment commences by describing the known historic and current impacts:

- The impacts of historic whaling activity.
- The impacts of historic and current fishery activity on seabirds and marine mammals.
- The impacts of historic and current fishery activity on the benthic environment through the direct contact of fishing gear with the seabed.
- The impacts of historic and current fishery activity on non-benthic by-catch.

The extent of these known historic and current impacts on the Chatham Rise's marine environment is then used to assess the cumulative impacts of CRP's proposed mining operations on the Chatham Rise.

The direct impacts of fishing (on fish populations) for economic gain and population sustainability (i.e., providing food) have not been assessed as a cumulative impact.

8.12.2 Whaling

Whaling was a significant activity during the 18th and 19th century in parts of New Zealand. Torres et al. (2011) identified that an estimated 40,000 southern right whales were killed in the waters around New Zealand and east Australia and 220,000 sperm whales in the South Pacific.

Torres et al. (2011) showed through analysis of observation and catch records that southern right whales were caught in significant numbers and sperm whales were caught in high numbers on the southern flank of the Chatham Rise. Figure 147 illustrates the importance of the area south of the Chatham rise to whalers in the 1800s.

Whaling effort dropped markedly after 1850 with small numbers of whales encountered until the late 1880s. The distribution of encounters in Figure 147 reflects distribution based on where whaling vessels travelled at that time. Modern observations of whales, along with their habitat and distribution, are discussed in Section 6.8.

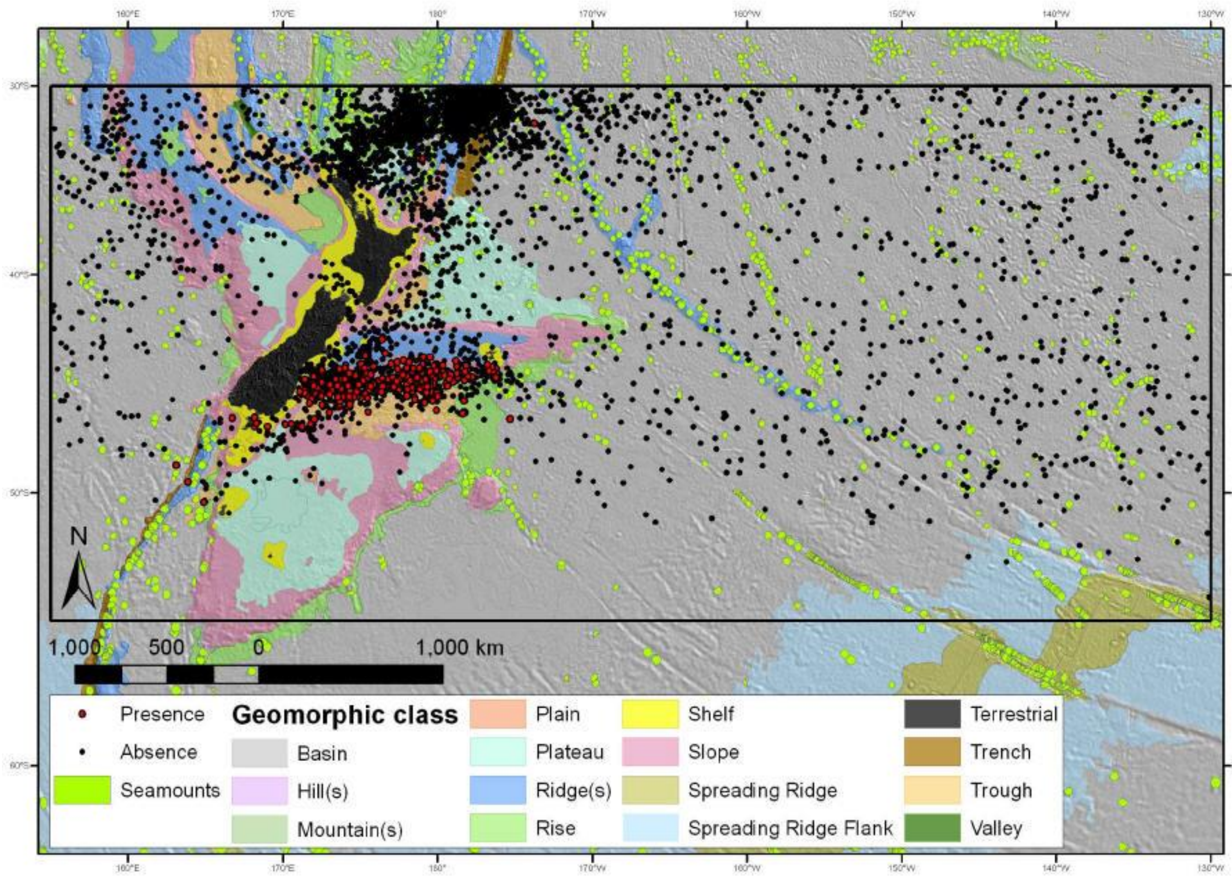

Figure 147: Distribution of southern right whales during summer based on 19th century whaling records (from Torres et al. 2011).

8.12.3 Marine mammals and seabirds by-catch

Abraham & Thompson (2011) describes New Zealand fur seal captures from trawling and long-lining within the EEZ. MPI (2012a) provides a summary of observed captures over the period 2001 through 2011.

Observed fur seal captures during trawling have occurred predominantly at the western end of the Chatham Rise, between the Mernoo Bank and Canterbury. This area is relatively close to the South Island and distance from land is a factor in seal distribution. Fur seals have also been occasionally captured east of Mernoo Bank. The main fishery areas that contribute to the estimated annual catch of New Zealand fur seals within the EEZ are: middle depths and deep water trawl fisheries associated with Cook Strait hoki, west coast of the South Island middle depths fisheries (mainly hoki), western Chatham Rise hoki fishery, and the Bounty Islands southern blue whiting fishery (Baird & Smith 2007, Thompson & Abraham 2010). MPI (2012a) summarise that catches have declined for both trawl and surface long-line fisheries, with a reduction in observed captures of 65 % for trawl fisheries and 62 % for surface long-line fisheries between 1998/99 and 2008/09. Thompson et al. (2013) identify that there were 376 estimated captures by the trawl fishery in 2010/11, 69 within the EEZ.

Thompson et al. (2013) also identified that there have been dolphin captures in the mackerel fishery off the west coast of the North Island over the period from 1995 through 2011. However, there are no known dolphin captures in the Chatham Rise fisheries.

In the 2010/11 fishing year, there were an estimated 4,931 seabird captures across all trawl and long-line fisheries in the EEZ. About 57 % of the captures were in trawl fisheries, 15 % in surface long-line fisheries, and 28 % in bottom long-line fisheries. Thompson (2013) (Appendix 21) reports that 4 to 10 % of all seabird by-catch within the EEZ comes from FMA3, which includes the Chatham Rise.

Seabirds are captured during deep water fishing (refer Section 6 and Thompson 2013 - Appendix 21). MPI (2012a) provides information regarding seabird interaction with fisheries. Abraham & Thompson (2011) provide modelled data on captures in the New Zealand trawl and long-line fishery. Whitecapped, Salvin's, and southern Buller's have been the most frequently observed captured albatrosses, and sooty shearwater and white chinned petrel have been the other species most frequently observed as by-catch. About 42 % of observed seabird captures were albatrosses.

Seabird captures have been reported for the ling fishery on the Chatham Rise, and the number of birds caught reflects the distribution of fishing effort. Salvin’s and Chatham have been the most frequently observed captured albatrosses, and white chinned petrel, grey petrel, sooty shearwater, and black petrels have been the other species most frequently observed as by-catch. Only about 14 % of observed captures were albatrosses.

The fishing industry has taken several initiatives to reduce seabird captures as described by MPI (2012a).

8.12.4 Benthic fisheries and by-catch

MPI (2012a) provides a summary of research undertaken in New Zealand at regular intervals since 1998 on by-catch and discard levels of non-protected species from fishing vessels in selected New Zealand fisheries. The key categories of by-catch/discards examined were: all QMS species combined, all non-QMS species combined, all invertebrate species combined, javelinfish, and all other rattail species combined.

Of the fishery activity on the Chatham Rise, the fishery that has the highest proportion of by-catch is the scampi fishery which is focussed at the western end of the Chatham Rise (refer Section 6). MPI (2012a) indicates that in the scampi fishery as a whole, scampi fishing accounts for about 17 % of the total estimated catch from all observed trawls. The main by-catch species, or species groups, were javelinfish (16 %), rattails (13 %), sea perch (*Helicolenus* spp., 8.4 %), ling (7.5 %), and hoki (6.1 %). MPI (2012a) notes that of the by-catch, the first three of these groups were mostly discarded.

8.12.5 Benthic environments

Benthic impacts arising from the interaction of fishing gear with the seabed include the generation of suspended sediment, altering sediment and water chemistry, altering seabed physical features, and removing and damaging habitat and sessile benthic biota.

MPI (2012a) provides a summary of studies undertaken on the impacts of bottom trawling and dredging in several fisheries within the EEZ. These include observations on the impacts of trawling on the Graveyard complex seamounts, about 50 km north of the proposed marine consent area, by Clark et al. (2010) and Williams et al. (2010).

MPI (2012a) summarise that the Benthic Optimised Marine Environment Classification[38] (BOMEC) Class H environment covering 138,550 km^2 of the crest of the Chatham Rise (including the proposed marine consent area), has a minimum and maximum annual trawl footprint of 9,583 to 20,344 km^2. It was estimated that over the 16 year period used for the analysis there was a 45 % overlap of trawl footprints.

Mormede & Dunn (2013) used information on the amount of seabed swept by fishing gear from 1990 to 2005 in two representative areas on the flanks of the Chatham Rise (within BOMEC Class K - mid depth seabed – refer to Figure 148). In the high impact area (block within area '401' at the western end of the Chatham Rise), the area swept rose from about 1,000 km^2/year to over 2,000 km^2/year in 2000 and then declined to about 1,000 km^2/year in 2005. In the eastern part of the Chatham Rise (block within area '404'), the annual amount of seabed swept by fishing gear has risen from a negligible area in 1990 to 100 to 200 km^2 from 2001 to 2005.

The impacts of individual trawls on benthic environments are likely to be variable as they are dependent on the type of gear and how it is used. In a modelling exercise undertaken by Mormede & Dunn (2013) the impact of bottom gear on one species of benthic biota (a coral) from a single trawling event was predicted to cause the mortality of 50 or 80 % of biota in the path of the trawl (Figure 148).

The impact of seabed disturbance is dependent on the nature of the benthic community disturbed, in particular whether the species are short- or long-lived. Most benthic communities include a spectrum of short- and long-lived species. Mormede & Dunn (2013) modelled the recovery of benthic communities, and their modelling identified that the communities eventually rebuilt following the cessation of fishing, with the assumption that there is a remnant of the population present in the area.

Studies on seamounts off Australia and New Zealand (as examples of biologically sensitive environments where trawling has occurred) have demonstrated differences in the structural complexity of benthic habitats, species numbers and abundance, and the composition and structure of assemblages between fished and unfished seamounts. Large sessile taxa (e.g., sponges, echinoids, cold water corals) are particularly susceptible to damage, showing dramatic reductions in coverage after only a few trawls (Althaus et al. 2009, Clark et al. 2010).

[38] For information purposes only, the marine consent area covers approximately of the EEZ's 12.7 % of BOMEC class, and 0.4 % of the total BOMEC.

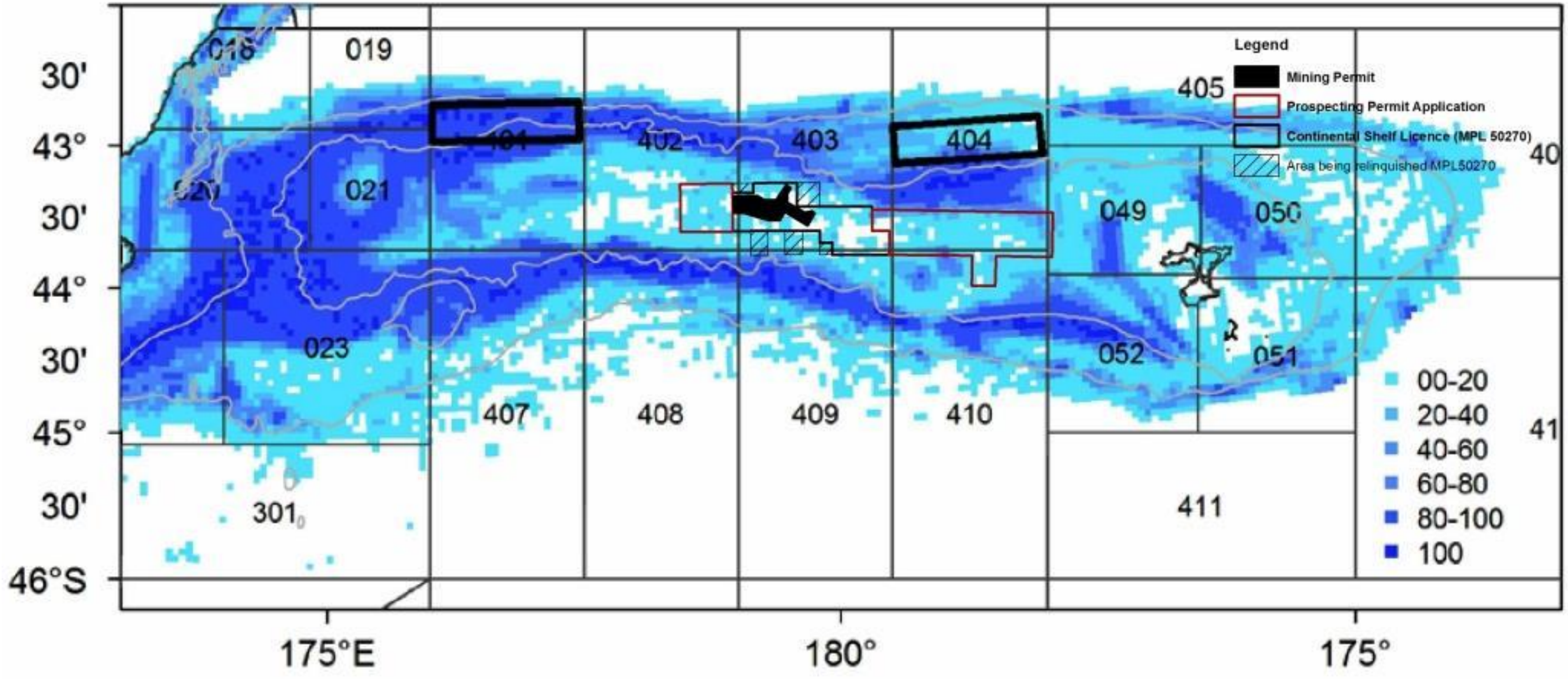

Figure 148: The fisheries footprint on the Chatham Rise expressed as the percentage of seabed trawled, calculated in 25 km² areas. The 500 and 1,000 m depth contours are shown in grey. (from Mormede & Dunn 2013).

8.12.6 Summary

Existing activities on the Chatham Rise (fishing and shipping) have no known impact on whales. There is some impact on other marine mammals from fishing on the Chatham Rise, but this is predominantly in the west and on the flanks of the Rise. The proposed mining activities on the crest of the Chatham Rise, given the nature of the activity and the mitigation measures proposed (refer to Sections 8.6 and 9.7) will not add to these impacts.

There is some impact on seabirds from fishing on the Chatham Rise, but this is predominantly in the major fishing grounds on the flanks of the Rise. The proposed mining activities on the crest of the Chatham Rise will not add to these impacts as potential impacts will be avoided and / or managed as assessed in Sections 8.6.6.3 and 8.7.

Fishing has a significant impact on the environment of the Chatham Rise. The total areas of seabed swept by trawling on the Chatham Rise above the 1,000 m contour (about 188,000 km^2) is estimated to be 92,346 km^2 for the period 1989/90 to 2010/11, and 17,768 km^2 for the 2010/11 fishing year. At water depths of 350 to 450 m, 35,477 km^2 was swept by trawling in the 1989/90 to 2010/11 fishing period. Phosphorite mining will result in the direct loss of about 30 km^2 of seabed each year and a total of about 450 km^2 over the initial 15 year mining period. These areas are considered small compared to the area affected by bottom trawling.

Common fishing practices often result in repeated impacts on the seabed. In contrast, CRP's mining method will impact each area of the seabed only once, although minor impacts from the dispersal of the returns will occur throughout the mining period.

8.13 Summary

The potential impacts on the marine environment associated with CRP's proposed mining operations are:

- The immediate impacts of seabed disturbance from drag-head operations.
- Physical impacts of the disposal of the returns.
- The impacts of sediment disposal on water and sediment quality.
- The impacts of mining and sedimentation on ecological and conservation values (including loss of benthic habitat and fauna, sedimentation impacts on benthic fauna, impacts on ecological resources with conservation value, impacts on the Chatham Rise ecosystem and other fisheries).
- Impacts associated with vessel and mining related noise.
- Vessel lighting impacts.
- Potential impacts associated with vessel waste discharges, marine biosecurity and project operational management and risks.
- Cumulative impacts.

In assessing these impacts an environmental risk matrix approach has been utilised to assist in ranking the significance of potential impacts. The risk matrix approach assigns a direction (positive, neutral or adverse), extent, duration and reversibility of the impact. If an impact has been assessed as adverse, based on potential consequence and likelihood of the impact, the level of potential environmental risk (ranging from low to serious) is then identified.

The level of environmental risk is usually determined after the application of avoidance, remediation and mitigation measures. The mitigation measures have generally been proposed for potential impacts which have been assessed as having high or serious environmental risk. In addition, mitigation measures have also been proposed in circumstances where they reflect responsible corporate environmental behaviour and industry best practice. Section 10 summarises the mitigation measures that have evolved out of the impact assessment carried out within this section of the EIA, along with CRP's commitment to an environmental compensation package as mitigation for the loss of benthic habitat and fauna within the mining blocks and sedimentation of benthic habitats adjacent to the mining blocks.

This assessment concludes that the physical impacts from mining activities, water and sediment quality impacts, impacts on commercial fisheries (including on the Chatham Rise and at the Chatham Islands), impacts on conservation values, noise impacts, vessel waste discharges, biosecurity issues and project operations risks are minor and also of low to medium environmental risk, including after the proposed application of industry best practice approaches. Potential impacts on seabirds from vessel lighting provided the proposed mitigation measures (i.e., as outlined in the draft LMP) are implemented, were assessed as having a potential environmental risk of medium or low.

Mining will result in cumulative impacts on benthic resources on the crest of the Chatham Rise but this loss is proportionally very small compared with the area that has been affected by fishing activities.

The remaining potential impacts (the loss of benthic habitat and fauna within the mining blocks, the potential impacts of suspended solids near the seabed and sedimentation impacts on benthic habitat adjacent to the mining blocks) remain a high or serious environmental risk, within the mining area, even after the adoption of proposed mitigation measures. For this reason, a programme to monitor the actual impacts, including the nature and timing of recolonisation of mined areas, is proposed prior to and during the initial stage of mining (refer to Section 11) to improve understanding of the actual significance of these impacts.

A summary of the impact and environmental risk assessment, in relation to the potential impacts associated with CRP's proposed mining operations, is in Table 27.

Table 27: Potential impacts and environmental risk after the application of avoidance, remediation and mitigation measures.

Potential impact	Assessment of impact	Potential consequence	Potential likelihood	Environmental Risk
Immediate impacts of seabed disturbance from drag-head operations	**Neutral** to adverse, near-source confined, short-term and reversible	Minor	Possible	Low
Impacts of sediment disposal on sediment quality	**Neutral,** near-source confined, short-term and reversible	-	-	-
Impacts of sediment disposal on water quality	**Neutral**, near-source confined, short-term and reversible	-	-	-

Potential impact	Assessment of impact	Potential consequence	Potential likelihood	Environmental Risk
Benthic habitat and fauna loss within the mining blocks	Adverse, near-source confined, medium to long-term but ultimately reversible	Serious	Almost certain	Serious
Sedimentation impacts on benthic habitats	Adverse, near-source confined, medium-term and ultimately reversible	Medium	Almost certain	High
Impacts on conservation values, namely marine mammals and seabirds	Neutral to adverse, near-source confined (i.e., where and when mining is occurring), short-term and reversible	Minor	Unlikely	Low
Impacts on seabirds from oil spills	Adverse, near-source confined (given controls in place, medium-term and reversible.	Serious	Rare	Low to Medium
Impacts on conservation values, namely cold water corals (i.e., separate from the loss of benthic habitat, including corals, within the mining permit area)	**Neutral** given distribution throughout the Chatham Rise and EEZ. Locally adverse (i.e., within the mining area) as assessed in relation to benthic habitat and fauna loss.	-	-	-
Impacts on fisheries resources	Adverse, near-source confined (i.e., within the mining areas), short-term and reversible	Medium	Unlikely	Low
Impacts associated with vessel and mining related noise	**Neutral,** near-source confined, short-term and reversible	Minor	Possible	Low
Vessel lighting impacts	Adverse, near-source confined, long-term (i.e., as long as the mining occurs) and reversible	Minor to Serious (depending on bird species)	Unlikely	Low to Medium
Impacts associated with vessel waste discharges	**Neutral** given compliance with MARPOL and associated regulations	-	-	-
Marine biosecurity	**Neutral** given compliance with the Biosecurity Act.	-	-	-

Potential impact	**Assessment of impact**	**Potential consequence**	**Potential likelihood**	**Environmental Risk**
Project operational management and risks	**Neutral** given compliance with relevant rules and national and international regulations	-	-	-

9. Social, Cultural and Economic Impact Assessment

KEY ELEMENTS

- CRP's proposed mining operations have the potential to impact on Chatham Islanders, existing interests which include commercial fishers and other vessels traversing the area, Iwi / Imi, as well as New Zealanders generally.
- Social impacts on the Chatham Islands are considered positive given that potential impacts on the Chatham Island's fisheries have a very low environmental risk. CRP is also considering a range of opportunities that will provide for a range of direct social benefits for the Islands.
- Potential impacts on existing interests (in particular quota and ACE holders), namely impacts on fishery resources and potential vessel movement and occupation conflicts, are considered to be of low environmental risk.
- Ngati Mutunga and Moriori, who claim the Chatham Islands in their rohe, have identified a range of potential issues, revolving around mining approach, potential impacts on the marine environment including fisheries, rangatiratanga and economic development opportunities, that they consider are associated with the proposal. Other Iwi raised similar issues, with Ngai Tahu also identifying potential impacts on marine mammals (taonga species). CRP will continue to engage with Iwi and Imi to address these issues if Iwi and Imi consider they do impact on cultural values, and in order to develop a relationship.
- Economic impacts are positive. Potential adverse environmental impacts are less than minor while the positive economic impacts are high. It is estimated that New Zealand's economy will benefit form an additional NZ$900 million over the initial 15 years of mining if the mining were to commence today.
- CRP's proposal also has a range of other positive impacts including reduced phosphate run-off and thus nutrient enrichment of waterways and reduced cadmium build up in soils if the Chatham Rise phosphorite is used in New Zealand agriculture, improved knowledge and understanding of the area's marine environment and increased employment opportunities.

9.1 Introduction

The Chatham Rise is a unique geographical area which forms a large underwater plateau extending from east of mainland New Zealand to beyond the Chatham Islands. The Chatham Islands are the only parts of the Chatham Rise that are above sea level, and the Chatham Islands community has strong links to the Chatham Rise area. In addition, New Zealanders generally are also aware of and thus have connection with the Chatham Rise area.

Although people do not live on the Chatham Rise, there is still a range of social (including existing interests), cultural and economic values associated with the area. The social and existing interest values associated with the area and the potential impacts of CRP's proposed mining are outlined in Section 9.2 below, with a focus on the Chatham Islands' community and existing interests (as defined by the EEZ Act). Section 9.3 overviews CRP's consultation and engagement with Iwi and Imi, the cultural values (as different from their commercial fishing interests) that they associate with the area and, where Iwi and Imi comment on the potential impacts of CRP's proposed mining operations on cultural values, then these have also outlined. The potential economic impacts are assessed in

Section 9.4, in accordance with the requirements of section 59 of the EEZ Act. Other positive impacts of CRP's proposed mining operation, not already assessed in relation to social and economic considerations, are outlined in Section 9.5.

The assessment of potential social (including existing interests), cultural and economic impacts has been carried out in accordance with the impact assessment approach outlined in Section 8.2. That is, where applicable, the direction (positive, neutral or adverse), extent, duration and reversibility of the potential impact is discussed, and then placed in the context by considering the consequence, likelihood and then environmental risk associated with the potential impact (if relevant).

9.2 Social Setting and Impact Assessment

9.2.1 Chatham Islands and Islanders

Officially part of New Zealand since 1842, the Chatham Islands group consists of 10 islands. Only two islands are populated, Chatham and Pitt Islands. The main settlements are at Waitangi, Kaingaroa, Te One, Port Hutt and Owenga on Chatham Island. As at the 2013 census, the usually resident population of the Chatham Islands was 600 people. The Chatham Islands economy is largely based on primary production activities, namely fishing and farming.

As outlined in Section 7, the Chatham Islands community has shown a strong interest in this project, and for this reason CRP continues to consult and engage with the Chatham Islanders. From this consultation and engagement process, CRP has identified a number of opportunities that could benefit the Chatham Islanders. These are summarised in Table 17 in Section 7.5. These opportunities include employment opportunities, provision of cheaper rock phosphate for Chatham Island farmers, provision of medi-vac facilities and other support for the project on the Chatham Islands, and sourcing of environmental monitoring, bunkering and provisioning services from the Chatham Islands. In addition, other initiatives proposed by CRP that may be of direct benefit to the local community include scholarships for Chatham Islanders and CRP support of Chatham Island-based ecological improvement and sustainability projects as part of the project's environmental compensation package. Sections 8 and 10 describe the proposed environmental compensation approach and its role as a mitigation measure for CRP's proposed mining operations on the Chatham Rise.

The other potential social impact arising from CRP's proposal relates to the Chatham Islands' fishing industry (including the rock lobster and paua fisheries). These potential impacts are assessed separately from an environmental perspective in Section 8.6 and therefore are not reiterated within this section of the EIA. However, these assessments conclude that given the environmental management approaches (including avoidance, remediation and mitigation measures) that will be incorporated into the proposed mining operations and the distance off-shore of the proposed mining area there is a very low environmental risk of an adverse impact on the Chatham Islands' inshore fishing industry as a result of CRP's activities.

Therefore, any potential social impacts of CRP's proposed mining operations on the Chatham Rise are on the whole considered to be neutral to positive, widespread (i.e., on the Chatham Islands) and long-term (during the period of mining).

In addition, there are likely to be broader social benefits to New Zealanders arising from the economic benefits of this proposal (refer to Section 9.4 below).

9.2.2 Existing Interests

9.2.2.1 Existing interests associated with the proposed mining operations

The EEZ Act requires applications for marine consents to assess the potential impacts on existing interests. CRP has therefore identified existing interests as defined by the EEZ Act (as provided in Table 28) in order to carry out the impact assessments required by section 39 and assist the decision maker in addressing the mandatory considerations in sections 59 and 60.

Table 28: Existing interests associated with CRP's proposed mining operations.

Existing interest definition	Comment
(a) any lawfully established existing activity, whether or not authorised by or under any Act or regulations, including rights of access, navigation and fishing:	This applies to all persons who have lawfully established activities in and immediately adjacent to the proposed marine consent area, such vessels lawfully navigating through the area and holders of fishing quota. It also potentially includes those exercising customary fishing rights and impacts on the ability to exercise those rights. This EIA has both identified and assessed the impacts of CRP's activity on those interests.
(b) any activity that may be undertaken under the authority of an existing marine consent granted under section 62:	This does not apply, as there are no relevant activities authorised by an existing marine consent granted under this EEZ Act, nor any proposed activities that might be affected that may seek a marine consent in the future.
(c) any activity that may be undertaken under the authority of an existing resource consent granted under the Resource Management Act 1991:	This does not apply, as CRP's proposed activity is a considerable distance from the outer limit of the RMA's jurisdiction and there is no impact on activities that might be authorised by resource consents.
(d) the settlement of a historical claim under the Treaty of Waitangi Act 1975:	This is not relevant and does not apply. With the exception of the fisheries claim settlements (covered by part (e) – see below), there are no historical Treaty claims settlements, that CRP is aware of, that extend to the Chatham Rise. The potentially relevant settlements that CRP is aware of do not extend beyond the territorial sea.
(e) the settlement of a contemporary claim under the Treaty of Waitangi as provided for in an Act, including the Treaty of Waitangi (Fisheries Claims) Settlement Act 1992:	This applies as Iwi were provided with fishing quota under the Treaty of Waitangi (Fisheries Claims) Settlement Act 1992 in full and final settlement of all commercial fishing claims. Therefore, as with part (a) of this definition, these quota holders are also considered to be existing interests.
(f) a protected customary right or customary marine title recognised under the Marine and Coastal Area (Takutai Moana) Act 2011.	If the definition is read as written, this does not appear to be relevant and would not apply. While it is understood that there are a number of applications which have been made[39], the definition of existing interests appears to apply only to customary rights or customary marine title that have in fact been recognised under the Marine and Coastal Area (Takutai Moana) Act. In addition, current applications are geographically considerably remote from any area or resource that might be impacted by CRP's proposal.

[39] CRP has reviewed the current applications on the Ministry of Justice's website at http://www.justice.govt.nz/treaty-settlements/office-of-treaty-settlements/marine-and-coastal-area-takutai-moana/current-marine-and-coastal-applications

Existing interest definition	Comment
	Therefore, as at the time of lodgement, there are no protected customary rights (whether applied for or recognised) that CRP is aware of that extend to the Chatham Rise or that would otherwise be impacted by its project, which is in any event well beyond the marine and coastal area as defined in the Marine and Coastal Area (Takutai Moana) Act 2011, and hence the scope of interests that might be covered by it.

It is noted that the definition is not drafted inclusively. Therefore to be an 'existing interest' for the purposes of the EEZ Act, a person must fall within one of the categories in paragraphs (a) to (f) of the definition as outlined in Table 28.

Based on the analysis contained in Table 28, the main existing interests associated with CRP's proposed mining area are commercial fishers, including Iwi fishing companies (as per parts (a) and (e) above). In addition, vessels traversing the area could also be considered existing interests in terms of (a) above.

9.2.2.2 Iwi customary fisheries and fishing interests

To the extent that there are Iwi customary fisheries and fishing interests that might be affected (for example, Ngati Mutunga in a draft CIA, as discussed in Section 9.3, have expressed concerns regarding eel migration impacts), these may fall within the scope of (a) above and have in any event been assessed in this EIA at Section 8.6.7.3 CRP accepts that Moriori and Ngati Mutunga, and Ngai Tahu, have stated that they have an interest in the Chatham Rise in a number of respects. However, this does not inevitably mean that those cultural interests are existing interests as defined by the EEZ Act. However, those cultural interests and the potential impacts on them have been assessed in this EIA (as outlined in Section 9.3).

Except to the extent that fishing and fisheries are likely to fall within the scope of existing interests and have been assessed, CRP has concluded that matters (d) and (e) of the definition are not relevant. In doing so, it has reviewed Waitangi Tribunal reports and databases to identify existing settlements (and which do not involve commercial fisheries) that might be impacted by its proposal. For example, the Tribunal's 2001 report and recommendations in *"Rekohu: A Report on Moriori and Ngati Mutunga Claims in the Chatham Islands"* has been considered. There is no resource or interest apparent in that report that would be directly adversely impacted by CRP's proposal. While the report urges additional allocation of fishing quota as redress, that issue has been assessed in this EIA in terms of impacts on fishing and fisheries. In addition, as discussed in Section 9.3, in relation to Ngai Tahu, Te Tau Ihu Iwi, Ngati Kahungunu, Rangitane ki Wairarapa and others, from consultation and a review of Treaty of Waitangi claims and / or settlements, CRP also considers (with the exception of the commercial fishing interests that have already been acknowledged) that while these Iwi have an identified cultural interest in CRP's proposal, this interest does not qualify as an existing interest as defined by the EEZ Act.

In summary, whilst Iwi and Imi have cultural interests in CRP's mining proposal as outlined and assessed in Section 9.3, these interests do not equate to existing interests under the EEZ Act. CRP acknowledges that as a subset of these cultural interests, as a result of the Treaty of Waitangi (Fisheries Claims) Settlement Act 1992, Iwi and Imi commercial fishing operations are an existing interest. The potential impacts on these existing interests have therefore been assessed separately (within this section of the EIA), from the broader cultural interests of Iwi and Imi and indeed all other broader interests associated with the mining consent area and the Chatham Rise environment.

Contemporaneous claims for non-commercial fishing rights may continue to be made in terms of paragraph (e) of the definition of existing interests. However, CRP is not aware of any such contemporaneous claims nor can it reasonably speculate on how its proposal might affect the settlement of any such claims. As far as it has been able to determine through its research, and subject to the reservation regarding commercial fishing interests and quota, CRP is not aware of any existing settled claims or unsettled historical or contemporary claims that relate to the Chatham Rise or would otherwise be directly affected by its proposal.

9.2.2.3 Commercial fishing interests

In terms of commercial fishing interests, FishServe[40] has provided a list of the commercial fishers with quota and / or annual catch entitlements (ACE) within Quota Management Areas (QMA) 3 and 4 (the areas are associated with the broader Chatham Rise, not just CRP's marine consent area - Figure 107 in Section 6.7.4.14 shows the extent of QMA 3 and the western part of QMA 4). There are 128 individuals and companies that hold quota in QMAs 3 and 4, and 164 individuals and companies with ACE on these same areas. There is a significant cross over between both lists. Appendix 34 contains a list of the individual and companies with quota and ACE within QMA 3 and 4.

Given the large number of existing interests, as outlined in Section 7.3, CRP has consulted with the deep-water fishing industry via the Deep Water Group Ltd (an amalgamation of EEZ Fisheries' quota owners) along with other industry representatives. CRP has also consulted with some specific commercial fishing companies, including Iwi fishing companies. This consultation is on-going. In addition, CRP has advised that they will consult with any interested party, including the fishing existing interests, to discuss the project and environmental issues.

In relation to the potential impacts on these existing interests, issues raised through consultation with these parties included potential impacts on: the Chatham Island's rock lobster fishery, fishing grounds and thus the fishing industry (including impacts associated with the release of uranium), and spawning areas associated with species that are commercially fished (refer to Table 17).

The key potential impacts identified as arising from project activities are associated with the localised (in relation to the proposed marine consent area and the Chatham Rise) impacts of suspended sediments and sedimentation on benthic fauna. Potential impacts on sediment and water quality, including impacts associated with uranium release, are discussed and assessed in Section 8.3 where it is concluded that the potential environmental risk is low and therefore the potential impacts on existing fishing interests are low. There is also the potential impact on the ling fishery east of the mining permit area (the initial area for mining), but within the eastern prospecting area (PP 55967). The potential impacts of CRP's proposal on the fisheries in the broader area are discussed and assessed in Section 8.6. All of the information about the distribution, sensitivity of fish, food web and the predicted size and extent of mining effects indicates that impacts on fishery resources are of a low environmental risk. The principle reasons for this conclusion are: the water quality changes are localised, short-lived and not significant and will not affect the primary food production in the mid or upper water column, the sedimentation impacts are close to the mining areas, the mining plan is designed to maximise the chances for recolonisation, and, the mining footprint in any year is relatively small.

These issues are of interest to the commercial fishing industry because adverse impacts on the fisheries could have an economic impact on the industry. It is possible that localised changes in benthic fauna could have flow on effects on fishery resources. However, to have a significant flow on impact the fishery would have to be very dependent on the seabed ecosystems within the mining block or its immediate environs. None of the information about the fisheries, including the trophic modelling of the Chatham Rise ecosystems (Pinkerton 2013 - Appendix 22) suggests such a link exists.

[40] FishServe (www.fishserve.co.nz) provides information about and for New Zealand's commercial fishing industry.

It is acknowledged that reduced catches have the potential to reduce the economic viability of the fishing operations of some individuals or companies, abut this is considered to be highly unlikely as a consequence of CRP's proposal. Additionally, the Economic Assessment (Appendix 6) considered the potential impacts on the fishery and concluded that, *"Impacts on current use values such as fishing will be small, and unless future monitoring of operations reveals new information of features that are scarce or susceptible to unrecoverable change, the impacts on future use and non-use values of continued existence of the environment and its functions are also likely to be small"*[41]. On this basis, given the analysis contained in Sections 6 and 8 of this assessment, any potential impacts on fishing operations will be less than minor from an economic perspective.

The fishing industry has also raised the issue of potential adverse market reaction to mining occurring within the BPA. The Economic Assessment (Appendix 6) also considered this matter and concluded that there was little likelihood of a significant impact on the international value of the fishery to New Zealand. In addition, CRP has undertaken to use its best endeavours (refer to Section 11.4) to facilitate a more holistic planning approach to identify and establish marine reserves or protected areas than that which was used to establish the BPA.

The fishing industry has also raised the potential for an adverse market reaction due to impacts associated with the release of uranium. As the environmental risk of uranium release is low, the potential for an adverse market reaction is also assessed as being low.

The eastern prospecting permit area (PP 55967) is one of the areas where ling are caught by long-lining. As outlined in Section 6.7.2, there is no significant long-lining effort in the area covered by MPL 50270. CRP's proposed mining operations do not require exclusive occupation of the proposed marine consent area or permanent structures. Initially, CRP's proposed mining operations are restricted to the mining permit area and the impacts are not predicted to affect the long-lining fishery. If CRP seeks to extend mining to part of the eastern prospecting permit area in the future, then it will be subject to the adaptive management condition in Section 11.4. This includes confirming plume modelling behaviour for the area and therefore that mining impacts are localised and unlikely to affect the fishery. In addition, CRP will develop a mining plan, in consultation with the proposed ERG, which recognises any special requirements associated with the area and minimises any impacts on it, including on the ling fishery if this is shown to be necessary. Operationally, provided that CRP's mining vessel and fishing vessels both operate in accordance with international law and the Maritime Transport Act 1994 there should be no conflicts between these two activities.

Together, the proposed mining operations and the marine consent conditions, make it highly unlikely that existing interests will be precluded or curtailed in any material sense by CRP's activities.

9.2.2.4 Vessels traversing the mining area

Provided the requirements of international law and the Maritime Transport Act are complied with, there will be no potential impacts on the existing interests whom operate vessels that traverse the area. There will be ample opportunity for safe navigational passage to be achieved and CRP's activities will not cause any measurable impact.

[41] p.40, in Section 6.2, of the Economic Assessment (Appendix 6).

9.2.2.5 Summary

Considering section 60 of the EEZ Act matters that must be considered when deciding the impacts of an activity on existing interests:

- **The area that the activity would have in common with the existing interest** (section 60(a)). There is an overlap between the area for which a marine consent is sought and the areas where people have rights to access fishing quota (subject to other legal constraints). However, given the relatively small areas of the seabed that are proposed to be mined at any one time, and the relatively confined level of potential impacts, the proposed mining activities can be carried out in common with those undertaken by existing interests without any significant conflicts occurring. In particular, given that bottom trawling is not permitted in the area where the proposed initial mining activity is proposed, the use of the seabed by CRP will not conflict with existing interests and occupation of the water column by the mining equipment will be minor and transitory.
- **The degree to which both the activity and the existing interest must be carried out to the exclusion of other activities** (section 60(b)). CRP does not seek to nor does it require exclusive occupation of the proposed marine consent area and is unlikely to have any material impact on the rights of existing interests. It is quite possible for CRP's activities and those of existing interests to co-exist and there need not be any exclusion of one by the other. There are no permanent structures, except for the proposed monitoring landers, associated with either CRP’s operations or those of existing interests. CRP's activities, from a safety and operational perspective, will require some clearance from other activities during mining, but this can be effectively dealt with through existing navigational law.
- **Whether the existing interest can be exercised only in the area to which the application relates** (section 60(c)). The proposed marine consent area is considerably smaller than the areas of QMA 3 and 4 and there are substantial parts of those QMA outside of the marine consent area. It is not proposed to limit existing interest holders' activities within the marine consent area, and there is ample opportunity for those interests to be given effect to beyond the marine consent area.
- **Any other relevant matter** (section 60(d)). No other matters are considered relevant for the purposes of section 60 of the EEZ Act.

Therefore, any potential impacts of CRP’s proposed mining operations on existing interests (predominantly commercial fishers, including Iwi commercial fishers) are considered to be neutral to adverse, near-source confined (i.e., within the mining area), short-term and reversible. The potential consequence is medium and the likelihood is unlikely and therefore the potential impact is of low environment risk.

It is noted that the marine consent being sought by CRP includes activities associated with its environmental surveying and monitoring programme. It is unlikely that the environmental surveying and monitoring programme will have an adverse impact on existing interests due to the very small scale of those activities and their associated environmental impacts. If, contrary to this assessment, the environmental surveying and monitoring programme has an adverse impact on existing interests, those effects would be negligible in comparison to impacts associated with mining activity itself.

9.3 Cultural Setting and Impact Assessment

CRP recognises the important spiritual and cultural connection that Maori and Moriori have with their physical environment, and their role as Kaitiaki (Guardians). For this reason, in the early stages of this project, with the guidance and assistance of Tuia, CRP initiated a process for Iwi (Maori) and Imi (Moriori) engagement (refer to Section 7).

From CRP's perspective, the purpose of this engagement was:

- To establish a basis for a long-term relationship between CRP and Iwi and Imi.
- To establish a process for identifying the potential impacts of CRP's proposed mining operations on Iwi and Imi cultural values and practices as tangata whenua and tangata moana, and to identify potential mitigation measures.
- To develop a basis for a long-term partnership between Iwi, Imi and CRP going forward.

To establish durable and constructive relationships, consideration has been given to the cultural impacts of the project in a wider sense. This is principally because productive relationships are unlikely to form if the focus on impacts is limited to the aspects of the mining operations for which the marine consent is being sought (i.e., the activities on the Chatham Rise). CRP is committed to continuing to engage with Iwi and Imi with the goal of building long-term relationships.

Given the above, CRP has consulted with Iwi and Imi (and will continue to do so) in relation to cultural values and the associated potential interest from a cultural perspective in CRP's proposed mining operations on the Chatham Rise. The Iwi and Imi consulted include Ngati Mutunga and Moriori who claim the Chatham Islands in their rohe rangatiratanga and kaitiakitanga over the Chatham Rise, and also include Ngai Tahu whose rohe include the inshore coastal waters of the South Island and who indicated as interest in 'taonga species' that may be present on the Chatham Rise (refer below). In addition, as outlined in Section 7.3.3, Ngati Kahungunu, Rangitane o Wairarapa (and related Hapu), Rangitane o Wairau, Ngati Toa Rangatira and Taranaki Whanui ki Te Upoko o Te Ika a Maui, were identified as Iwi who may have an interest at a broader cultural level and were also consulted.

For the purposes of clarity, the cultural issues outlined within this section of the EIA, with the exception of the commercial fishing operations of the Iwi and Imi, are not considered to be existing interests as defined by the EEZ Act. Existing interests, and the potential impacts on existing interests which includes Iwi fishing interests, are assessed in Section 9.2.2 above.

CRP and Tuia held a series of hui with Ngati Mutunga and Moriori on the Chatham Islands in November 2012 and April and October 2013, as well as meeting with Iwi and Imi representatives in New Zealand on other occasions. Hui have been held (variously) with tribal leaders/trustees, kaumatua and interested Iwi/Imi members. Interest and turn-out at these hui, particularly on the Island, was high.

Ngati Mutunga and Moriori, following the engagement that has been carried out by CRP to date, have outlined the potential issues that they consider are associated with the mining proposal. These potential issues are outlined in a draft CIA prepared by Ngati Mutunga and a letter from Moriori (contained in Appendix 33).

In its draft CIA (Appendix 33), prepared in June 2013, Ngati Mutunga outlines who they are, including the fact that in 1835 Ngati Mutunga migrated to the Chatham Islands from Taranaki via Petone, and established a permanent tribal base. Given Ngati Mutunga's role of Kaitiaki for current and future generations, and thus its desire to ensure ventures within its rohe are sustainable, its concerns in relation to CRP's proposal are outlined below. Also, where relevant, comment is provided about where these issues raised are assessed within this EIA:

- **Disruption to seabed and sea life**. Specific concerns described include potential impacts on seabirds, rock lobsters (in terms of risks) and impacts on migrating eels. An assessment of these potential impacts is provided in Sections 8.6 and 8.8 where it is concluded, that the environmental risk of an adverse impact is low. In relation to the issue of a lack of research into eel migration, CRP has initiated discussions about financially supporting some larval eel research as part of its environmental compensation package (refer to Section 10.5).

- **Interference with cultural heritage and Whakapapa** and **Fisheries Risk**. Ngati Mutunga are renowned for its koura, ika and me paua (crayfish, fish and paua). Fishing is a mainstay of the Ngati Mutunga economy. Any impacts on these fisheries will affect Ngati Mutunga's identity and will also have significant economic impacts. An overview of the nature of the plume from the mining activity is provided in Section 8.4, while an assessment of the impacts on the fishery is contained in Section 8.6. This technical assessment concludes that potential impacts on the fishery are of a low environmental risk.

- **Impact on Cultural Values relating to Moana.** Ngati Mutunga, given its Kaitiaki status, aims to protect Moana (the sea) and the bounty of Tangaroa. As already stated, the potential impacts of CRP's mining operations on the marine environment are assessed in Section 8.

- **Tino Rangatiratanga**. Ngati Mutunga have rangatiratanga over sea and its resources, including the coastal waters of the Chatham Islands. Accordingly, the proposed mining area is with its rohe. This area was a migration pathway.

- **Economic Development**. Ngati Mutunga requests that should the project proceed that potential economic prospects for the Chatham Islands are seriously considered. As outlined in Section 9.2.1 above, CRP has committed to trying to provide such opportunities.

- **Sinkholes & Aquifers** and **Chemicals**. Table 17, in Section 7.5, responds to these issues. However, to reiterate one matter, there are no chemicals used in CRP's mining system. All mining operations rely on mechanical, not chemical, processes.

The letter (dated June 2013) from Moriori advises that they are still formulating their views. In order to do so, they first want the opportunity to review this EIA and related technical assessments. The letter also outlines that Moriori are the tangata whenua of Rekohu (the Chatham Islands) and tangata moana of the Chatham Rise. The potential issues that Moriori consider are associated with CRP's mining proposal, as identified in their letter, are:

- *"Interference with cultural heritage and hokopapa through physical disruption of the Chatham Rise;*

- *Impacts on other cultural values relating to the moana (sea) and other general water rights;*

- *Sovereignty/rangatiratanga issues relating to the management and control of sea and its resources, including the coastal waters of the Chatham Islands, and the return of royalties from mining to the Rekohu/Chatham Islands;*

- *The extent to which the project will contribute to economic development for Moriori and the Rekohu/Chatham Islands;*

- *Seabed and sea life disruption (in terms of ecology, also particularly impacts on the migratory paths of crayfish, eels, and other species);*
- *Risks relating to fisheries; in respect of both mahinga kai (customary food gathering practices) and commercial fisheries;*
- *Interference with sink holes and underwater aquifers; and*
- *Use of chemicals and other potentially harmful agents in the mining process."*

The potential issues identified by Moriori are similar to those raised by Ngati Mutunga. The responses, where relevant to the draft CIA prepared by Ngati Mutunga, therefore also apply to the issues raised by Moriori.

Finally, both Ngati Mutunga and Moriori have advised that they wish to continue to engage and discuss issues with CRP as the project progresses (or with EPA as part of the marine consent process). This includes, but is not limited to, receiving information as it becomes available. CRP has undertaken to do so, and will provide a copy of this revised application as soon as it is appropriate to do so.

In relation to the other Iwi, based on the consultation that has been carried out (in relation to Ngai Tahu) and a review of Treaty of Waitangi claims and / or settlements, with the exception of the commercial fishing existing interests that has already been acknowledged, the following cultural issues and values have also been identified:

- **Ngai Tahu**. Ngai Tahu settled its claim with the Crown in 1998. The Ngai Tahu Claims Settlement Act 1998 (NTCS Act), amongst its provisions, outlines a range of values and interests associated with its rohe including a number of Statutory Acknowledgement Areas. The Statutory Acknowledgement for Te Tai o Marokura (Kaikoura coastal marine area) and the Statutory Acknowledgement for Te Tai o Mahaanui (Selwyn – Banks Peninsula coastal marine area) outline Ngai Tahu's cultural values and interest with these inshore coastal waters (i.e., within the Territorial Sea). These Statutory Acknowledgements outline: the historic association that Ngai Tahu have with these coastal areas and the adjoining land; that this coastal area is important for mahinga kai; and, that these coastal waters acted as an inshore transportation highway. The two specific issues identified by Ngai Tahu during consultation related to potential impacts on its fisheries settlement assets and impacts on taonga species, marine mammals, identified in Schedule 97 of the NTCS Act. The marine mammal taonga species, as listed in Schedule 97 of the NTCS Act, are southern elephant seals, New Zealand fur seals, humpback whales, sperm whale, New Zealand sea lion / Hooker's sea lion, southern right whale. Ngai Tahu has commissioned a CIA (currently being prepared), which, it is understood, considers potential impacts on marine mammal taonga species. Impacts on marine mammals, from a technical perspective, are assessed in Sections 8.6.6.2 and 8.7.
- **Te Tau Ihu**. *"Te Tau Ihu o te Waka a Maui: Report on Northern South Island Claims"* (Waitangi Tribunal 2008) outlines the Waitangi Tribunal's recommendations for the eight Iwi and Hapu of Te Tau Ihu. The report describes the customary occupation and rights associated with the area while also acknowledging that the natural resources of significance to Iwi, including kaimoana resources associated with the area's inshore coastal area and Cook Strait. Based on this review, CRP considers that there is no resource or interest identified in this report that could be classified as an existing interest under the EEZ Act, and nor will they be directly or indirectly impacted by CRP's proposal. In making this statement, it is acknowledged that any fisheries settlement assets of the Iwi and Hapu are considered to be a potential existing interest.

- **Ngati Kahungunu, Rangitane Hapu and Other Claimant Groups.** "*The Wairarapa ki Tauarua Report*" (Waitangi Tribunal 2010) outlines the Waitangi Tribunal's recommendations in terms of the Treaty of Waitangi claims from Wairarapa Iwi. The report identifies that in terms of cultural values and interests, the Wairarapa coastal areas were used as a transport route, and for its coastal resources and fisheries. The importance of the coastal resources adjoining the Wairarapa influenced Māori occupation and settlement. Some Hapu also identify that their rohe includes the foreshore and seabed, not just the land. This report also identifies that, given the fisheries settlement under the Treaty of Waitangi (Fisheries Claims) Settlement Act 1992, any future commercial or customary fishing claim is effectively ruled out. Therefore, CRP considers that the identified resources or areas of cultural interest identified in this report will not be directly or indirectly impacted by CRP's proposal.

9.4 Economic Setting and Impact Assessment

An assessment of the economy-wide costs and benefits of the CRP's mining proposal is contained in a report prepared by NZIER titled 'Economic Assessment of Chatham Rock Phosphate' (2014) (Appendix 6). An overview of the key components of the Economic Assessment is provided below.

The Economic Assessment assesses the predicted economic impacts of CRP's proposed Chatham Rise mining proposal, taking into account both impacts on the New Zealand economy and the economic implications of potential environmental impacts.

The Economic Assessment has taken into account the legislative requirements of the EEZ Act, in particular the purpose of the EEZ Act (as outlined in Section 2 of this EIA), and section 59, which states that consideration of an application must take into account:

- The economic benefit to New Zealand of allowing the application (section 59(2)(f)).
- The efficient use and development of natural resources (section 59(2)(g)).

As outlined in Section 3.6, demand for rock phosphate, including as a manufactured product, has increased significantly since World War II. It is anticipated that increased demand will continue into the future, as it will be driven by growing affluence and demand for protein rich foods in emergent developing countries.

NZIER (2014) categorise the economic impact into direct impacts and flow-on (indirect) impacts. The direct impacts include an increase in New Zealand's exports of rock phosphate (from a baseline of no such exports), and a decrease in their import. Flow-on impacts include effects on downstream agricultural industries which use fertiliser, effects on competing exporting industries and effects on household expenditure. These national level flow-on economic impacts are summarised in Table 5 of the Economic Assessment (Appendix 6). The Economic Assessment identifies that downstream agricultural industries will be barely affected (as phosphate prices are determined by the international market and are unlikely to be reduced), competing exporting industries are impacted (between -0.01 % to -0.07 %) due to increased demand for New Zealand dollars caused by increased rock phosphate exports while household expenditure industries will have positive flow-on impacts as a result of increased spending from higher capital and labour returns and increased export earnings.

Overall, NZIER (2014) identifies that the New Zealand economy benefits as a result of utilising a previously unused resource. Exports rise, resulting in an increase in wealth, which generates increased consumption spending. This impact is assessed as being positive, widespread, and long-term (i.e., for the initial 15 year life of the project).

Environmental impacts are also considered in Section 4 of the Economic Assessment (NZIER 2014) where the economic costs of potential environmental impacts are assessed. These impacts, from a scientific (not economic) perspective are discussed in detail in Section 8. The Economic Assessment examines this material for the likelihood of any economic consequences of biophysical impacts significant enough to affect the interpretation of the economy-wide modelling. It acknowledges that there will be potential on-site and off-site impacts associated with CRP's mining proposal. Potential on-site impacts include impacts on the seabed (benthic habitat loss) and surrounding environment (from the return of the non-phosphatic material and other activities use of the water space, particularly commercial fishing). Off-site impacts include reduced phosphate run-off and reduced cadmium build-up in soils in New Zealand as a result of substituting rock phosphate for superphosphate manufactured from imported supplies[42]. The change in international transport emissions as a result of reduced imports and increased exports is also considered as part of NZIER's Economic Assessment.

NZIER (2014) discusses the net economic impacts, including those linked to the project's proposed environmental impacts, in Section 6 of the Economic Assessment (Appendix 6).

The Economic Assessment identifies that the economic impacts associated with the proposal will generate around NZ$265 million of export revenue per year, and reduce reliance on imported phosphorite by NZ$85 million per year. The predicted change in exports arising from CRP's mining proposal is NZ$230 million per year. The revenue and additional spending this stimulates is predicted to result in an overall increase in imports by NZ$190 million per year. These gains in trade would boost gross domestic product (GDP) by NZ$280 million for each year that CRP undertakes mining on the Chatham Rise. Domestic consumption would increase and the predicted welfare gain is NZ$130 million per year. For the proposed initial 15 years of the project, the Economic Assessment concludes that implementing the mining project over this term is equivalent to the country's economy being enhanced by an additional $900 million in today's dollars, with around NZ$380 million accruing to New Zealand entities other than CRP.

In relation to potential environmental impacts on the seabed and water spaces, the economic assessment refers to the ecosystem services approach to identifying how the environment supports economic and social well-being. The economic consequence of the potential impacts on provisioning services (fishery catch), one aspect of regulatory services (biodiversity regulation) and some aspects of cultural services (biodiversity as well as amenity and non-use values) are assessed as either adverse or neutral, with the consequence being minor. Other areas of potential impacts on the seabed and water space associated with supporting, regulatory and cultural services, namely detoxification and nutrient cycling, air quality and navigation, have been assessed as being neutral, with the consequence also being minor.

The economic consequence of potential impacts on the land mass of New Zealand was also assessed, as well as the potential impacts beyond New Zealand as a result of international transport emissions. In relation to reduced phosphate leaching and reduced cadmium build-up in soil the impacts are assessed as positive and potentially widespread in that they could have a positive impact throughout New Zealand in areas wherever locally sourced phosphorite is substituted for imported phosphorite and phosphate leaching and cadmium accumulation are approaching critical levels. The economic impacts of changes in transport emissions are considered to be positive to the extent that substitution of distant-sourced imports reduces remissions and negative to the extent that rock phosphate is exported. The overall value of any change depends on the balance of transport distances to import sources and export destinations and is indeterminate at this time.

The Economic Assessment concludes that the economic costs of the potential impacts on the natural environment are unlikely to be significant, and *"from an economic perspective, the operation is likely to be consistent with economic efficiency and sustainable management of the environmental*

[42] Morocco has the world's largest reserves estimated at around 50,000 Mt (or approximately 2000 years of supply. Other countries with long-term supplies include Algeria (1,100 Mt), Syria (643 Mt), Jordan (250 Mt), South Africa (652 Mt), Senegal (277 Mt) and Russia (130 Mt). The reserves of other major producers (i.e., currently producing half of the world's supplies), including China and the USA, are expected to run out this century. (Cooper et al. 2011).

resources, while extracting value from the mineral resource to the benefit of New Zealander's well-being"[43].

Therefore, based on the NZIER's Economic Assessment (Appendix 6), CRP's proposed phosphorite mining is likely to be of considerable benefit to the New Zealand economy. The potential negative economic impacts associated with potential adverse environmental impacts are assessed as less than minor from an economic perspective, and overall, the economic impacts of the proposal are considered to be positive.

9.5 Positive Impacts

In addition to the potential adverse impacts assessed within this EIA, CRP's proposal to mine phosphorite nodules from the crest of the Chatham Rise will result in a range of positive impacts or benefits. A number of these have already identified within previous sections of this EIA, but for the purposes of completeness they are reiterated below.

The economic benefits associated with the project, as outlined in Section 9.4 above, include:

- NZ$265 million of export revenue per year will be generated and at the same time the amount of phosphorite imported will be reduced by NZ$85 million per year.
- GDP will be boosted by NZ$280 million for each year that mining occurs.
- Domestically consumption would increase with a predicted welfare gain of NZ$130 million per year.
- New Zealand's economy, over an initial 15 year mining period, will be enhanced by as much as NZ$900 million in today's dollars.

In relation to the use of the Chatham Rise rock phosphorite, there is a body of research[44] that suggests that it may be more effective to use direct application of ground rock phosphate (at least in part) for pasture growth rather than superphosphate. Direct application of rock phosphate is not as soluble as superphosphate. This means that direct application of rock phosphate has less potential to run-off into waterways, thus reducing the potential for eutrophication and algal blooms within freshwater systems. As phosphate accumulation has been identified as a potential water quality issue in New Zealand, with associated regulation and control on farming activities already being considered, the direct application of the Chatham Rock phosphate to land is a potentially positive impact, or benefit, associated with the proposal. Section 4.2.4 of the Economic Assessment (Appendix 6) assesses this further.

In addition, as discussed in the Economic Assessment (Appendix 6) the Chatham Rise phosphorite has a lower cadmium content than other rock phosphate sources currently imported into the New Zealand. Cadmium is a heavy metal that when applied to the soil in trace quantities in fertiliser persists and accumulates in the soil. The cadmium can then be taken up by plants and then animals that eat the plants where it accumulates in their liver and kidneys. Given the risks associated with cadmium in animals, food safety regulations in New Zealand prohibit the sale, as food, of these organs from old animals. A portion of New Zealand's farmland may already exceed the identified 1 mg/kg concentration limit that is considered safe for agricultural and residential land uses. It is anticipated that under current land management practises it is unlikely that the situation will improve. Utilising Chatham Rise phosphorite has the potential benefit of reducing the cadmium build-up in New Zealand soils.

[43] p.40, in Section 6.2, of the Economic Assessment (Appendix 6).

[44] More information on the reduced run-off characteristics of ground phosphate rock is provided on CRP's website - http://rockphosphate.co.nz

CRP has also committed to ensuring that the Chatham Islands community benefits from the proposal. Beneficial actions that are being evaluated by CRP include providing subsidised fertilisers to Chatham Island farmers, establishment of a medi-vac facility on the Chatham Islands, providing employment opportunities, scholarships, utilising Chatham Island resources to assist with environmental monitoring as well as bunkering and provision support services, and providing for opportunities to enhance conservation values in and around the Chatham Islands from the proposed environmental compensation package.

Another positive impact for the Chatham Rise area is increased knowledge and understanding of the Chatham Rise marine environment as a result of the research and monitoring carried out to support CRP's mining project.

A local port will also be used to handle and store the phosphorite prior to transporting it to international and national destinations. Use of a local port is likely to have positive impacts for that area, particularly in relation to increased employment opportunities and elevated regional economic activity. The economic benefits associated with this activity were not directly assessed as part of the Economic Assessment (Appendix 6).

9.6 Summary

CRP's proposed mining operations on the Chatham Rise are likely to have a number of positive impacts, including social and economic impacts for both the local community and New Zealand as a whole. There are opportunities for the Chatham Island's community, which CRP has committed to, should the proposal proceed, that have the potential to specifically benefit Chatham Island's residents.

Potential impacts on commercial fishers, including Iwi commercial fishers, are directly connected to potential impacts to the fishery itself which are considered to be of low environmental risk. Provided international and national laws are complied with conflict between CRP's mining vessel and other vessels, including long-liners or other vessels in transit, will not occur.

In addition to social impacts, potential impacts on cultural values in the form of issues have been outlined by Ngati Mutunga in their draft CIA and Moriori in a letter to CRP. The issues of significance to Iwi and Imi largely revolve around mining approach, potential impacts on the marine environment including fisheries, rangatiratanga and economic development opportunities, and for Ngai Tahu potential impacts on marine mammals (taonga species). Ngati Mutunga and Moriori also advise that they wish to receive more technical information in relation to these potential impacts and they wish to continue to develop a relationship with CRP. CRP has committed to doing so.

There will be benefits to New Zealanders as a result of positive impacts on the New Zealand economy. The positive economic impacts are likely to be widespread, generating increased wealth for New Zealand as a result of increased imports and exports and increased spending. GDP will be boosted by NZ$280 million each year while New Zealand's economy will be enhanced by as much as NZ$900 million, in today's dollars, over the initial 15 years of the project.

Other potential positive impacts include reduced nutrient runoff if Chatham Rise phosphorite is applied directly to land, reduced cadmium build-up in soils as a result of using locally sourced phosphorite, improved knowledge and understanding of the marine environment, and increased employment opportunities at the port used for the unloading, storage and subsequent dispatch of the phosphorite nodules.

10. Environmental Mitigation

KEY ELEMENTS

- Avoidance, remediation and mitigation measures in conjunction with best practice policies and procedures have been adopted as part of the project to minimise potential impacts.
- The loss of benthic habitat as a result of mining and sedimentation cannot be fully avoided, remedied or mitigated. CRP has therefore committed to an environmental compensation package.
- CRP proposes to establish a trust to achieve its environmental compensation approach.

10.1 Introduction

This section of the EIA describes the avoidance, remediation and mitigation measures that are proposed as a means of addressing the potential adverse impacts associated with CRP's mining operations on the Chatham Rise. Collectively these measures are referred to as the mitigation hierarchy. Sections 8 and 9 discuss the potential impacts identified through the impact assessment process or through consultation with interested parties, and how these have been assessed.

In assessing the impacts of CRP's mining proposal, it is important to consider the significance of the potential impacts without the application of environmental controls or the mitigation hierarchy, and then to reassess their significance following the application of controls. For this reason, this section of the EIA provides a summary of all of the avoidance, remediation and mitigation measures proposed, but it does not reiterate the reasoning behind their development. It also discusses options for what is broadly known as biodiversity offsetting. However in this case it is more appropriately termed environmental compensation and avoided risk.

CRP's environmental mitigation actions during the operational phase of mining will adhere to the conditions attached to the marine consent (proposed conditions are in Section 11.4), management plans, other regulatory requirements and the Marine Mining Code. This will be achieved by following the quality management approach advocated through the ISO 14001 EMS framework and the Marine Mining Code (i.e., planning, implementation and operation, checking and review).

Additional details on how the mitigation measures and the monitoring required to detect the effectiveness of those measures are to be undertaken is outlined in CRP's Environmental Management and Monitoring Plan (EMMP) (Appendix 35(i)).

10.2 Mitigation Approach

10.2.1 Application of the mitigation hierarchy

CRP will apply the mitigation hierarchy to all aspects of the operational phase of its mining project. This means that avoidance measures will be implemented through operational controls such as the design of the mining process, the mining plan, and the adoption of the proposed mining exclusion areas. If impacts cannot be avoided or remedied in full or in part, then other relevant mitigation actions will be used to minimise the overall impact.

The need for mitigation has been assessed on the basis of the risk of potential impacts carried out as part of the impact assessment process, as outlined in Sections 8.1 and 8.2. The impact assessment process, which assists in ranking the significance of potential impacts, considered the direction of the impact, its extent, duration and reversibility. An environmental risk assessment matrix (ranging from low to serious) was then applied based on the consequence of the potential impact (ranging from minor to catastrophic) and likelihood of the potential impact (ranging from rare to almost certain). Using this approach, if the environmental risk is assessed as 'high' or 'serious' then specific avoidance, remediation and mitigation measures are proposed, where practicable, as outlined in Sections 8 and 9. These are summarised in Section 10.3.

If the outcome of the impact assessment process was 'low' or 'medium', general good practice mechanisms may still be applicable even if avoidance, remediation and mitigation measures may not be required. Such mechanisms are also summarised in Section 10.4.

10.2.2 Environmental compensation

As outlined in Section 8, CRP recognises that it is not possible to apply direct avoidance or remediation measures to all of the potential impacts categorised as 'high' or 'serious' environmental risks. This is particularly the case in relation to the loss of benthic habitat immediately within the mining areas. Given this, CRP is committed to establishing an environmental compensation package.

Environmental compensation is not what is known as biodiversity offsetting. Offsetting is most effective where it provides environmental compensation in a form that is similar to the biodiversity affected, the 'like-for-like' methodology, and is as closely related to the impacts of the project as possible.

Section 10.5 outlines CRP's proposed process for implementation of an environmental compensation package that will support research, ecological sustainability and / or environmental enhancement on the Chatham Rise and at or around the Chatham Islands.

10.3 Proposed Mitigation of Identified Potential Adverse Impacts

As assessed in Section 8, several proposed avoidance and remediation measures have been identified for potential impacts identified as being of high or serious risk, prior to mitigation. These potential impacts, the mitigation measures proposed, and the environmental risk following the application of the mitigation are summarised in Table 29. Potential impacts identified as low or medium environmental risk have not been included in Table 29, unless a proposed control measure reflects good practice. These controls have also been included in Table 29.

Following the grant of the marine consent and before mining commences the draft EMMP (Appendix 35(i)) will be updated to ensure that all mitigation strategies are accommodated within the EMMP by way of procedures, checklists or specific management plans.

Mitigation measures have not been proposed for potential social (including existing interests), cultural and economic impacts as these potential impacts are considered to range from neutral to positive. Potential impacts on existing interests were considered to be of low environmental risk.

During consultation with Chatham Islanders, including Iwi and Imi, CRP committed to benefits that it will endeavour to provide to the Islands' community. These include potential employment opportunities, subsidised fertiliser for farmers, sourcing local personnel for provision of medi-vac facilities for the project, sourcing of environmental monitoring from the Chatham Islands, bunkering and provision services sourced from the Chatham Islands, education scholarships and the provision of environmental compensation through support of Chatham Island ecological improvement projects (refer to Section 10.5).

While mitigation measures are not proposed for social, cultural and economic considerations, CRP's environmental management processes outlined in the EMMP (once fully developed), includes: the requirement to consult regularly with interested parties and the Chatham Islands community, to keep records of and respond to any complaints or issues, and, to ensure that the monitoring of social, economic and cultural concerns continues. CRP has also committed to establish an ERG with membership including representatives from the Chatham Islands community, the deep-water fishing industry and Iwi / Imi. The EMMP's management approach is discussed in more detail in Section 11.

10.4 Proposed Management of Vessel Related Potential Risks

This section of the EIA provides an overview of the proposed mitigation measures that have been developed in response to the potential impacts associated with operating the mining vessel.

These mitigation measures focus on ensuring that environmental responsibility and good practice are adopted and that operational procedures ensure that the risk of environmental harm is minimised. Operational procedures (or SOPs) outline the methods to be followed to avoid adverse impacts, and how to remedy and mitigate adverse effects should they occur. For example, operational procedures addressing biosecurity controls, waste management, wastewater and oily waste are identified in the draft EMMP in Appendix 35(i). An overview of the mitigation measures to be incorporated into these procedures, once the EMMP is fully developed (prior to mining commencing), are in Table 30.

10.5 Proposed Environmental Compensation

The impact assessment in Section 8 identifies that the removal of benthic habitat from the mining area cannot be fully avoided, remedied or mitigated. In addition, as the actual (versus predicted) scale of environmental impacts associated with the proposed mining activity may not be fully known until after mining has commenced and monitoring results are analysed, the effectiveness of the proposed mitigation measures discussed in Sections 10.3 and 10.4 may not be known for some time.

CRP has therefore committed to minimising the environmental impact of its activities, and to providing sustainable and appropriate environmental compensation for the impacts associated with its operations that cannot be fully avoided, remedied or mitigated. This is mitigation or environmental compensation enacted outside of the mining impact zone to address residual impacts of the mining activity through positive benefits to the environment. A proposed marine consent condition reflecting CRP's commitment to an environmental compensation package in the form of a trust is provided in Section 11.4 (Conditions 41 to 43).

To this end, CRP has committed to forming a project-wide initiative, by establishing a trust for its environmental compensation package.

CRP proposes to establish a trust, once the marine consent has been granted and prior to mining operations commencing, with initial funding of $200,000 and subsequent annual funding of the same amount, inflation adjusted. CRP will continue to contribute to the trust for the duration of the marine consent or until mining operations authorised by the marine consent cease.

Table 29: Avoidance, remediation and mitigation measures for potential adverse impacts.

Potential impact	Assessed in	Avoidance, remediation and mitigation measures	Resultant environmental risk category
Impacts on hard substrate benthic fauna	Outlined in Section 4.3	Mining will generally not occur in large rock outcrops areas (if such areas are identified during mining) as it is generally not feasible to do so. These mining exclusion areas avoid direct adverse impacts on areas of hard substrate benthic fauna.	-
Impacts on areas of scientific or conservation value	Sections 4.4.1, and 8.6.6.4	CRP proposes establishing mining exclusion areas within the marine consent area. These areas, which will not be mined, have been identified through a marine spatial planning exercise which considered areas of particular sensitivity or value within a broader area of the crest of the Chatham Rise. The identified mining exclusion areas include some areas of cold water corals. In addition, CRP has committed to using its best endeavours to ensure that the areas identified through the marine spatial planning exercise can be protected through an appropriate legal mechanism from all future seabed disturbance activities. This proposal reflects the adoption of environmental responsibility and good practice.	Loss of cold water corals within mining blocks - Serious
Localised sedimentation impacts from drag-head operations (rather than the disposal of the returns)	Section 8.3	A variety of measures has been incorporated into the mining method to minimise the potential for the mining activity to create localised sedimentation impacts. These include: controlling excavation and suction rates, optimisation of the drag-head to reduce the potential for spillage and leakage, maximising the width of the drag-head, use of lower pressure jets to fluidise the material to be mined and disposing of the processed non-phosphatic materials close to the seabed. These reflect the adoption of environmental responsibility and industry best practice.	Low
Sedimentation impacts on benthic habitat in close proximity to the mining blocks	Section 8.6.3	During first five years of mining, mining blocks are to be sufficiently separated such that sedimentation impacts between the mining blocks are minimised. This also has the potential to facilitate recolonisation of the mined area. Monitoring to ascertain the nature of sedimentation impacts will then be undertaken to provide data to compare to predictions and to assist optimising future mining operations from an environmental impact perspective.	High

Potential impact	Assessed in	Avoidance, remediation and mitigation measures	Resultant environmental risk category
Loss of benthic habitat (recolonisation potential)	Sections 8.6.2 to 8.6.4	Hard substrate habitat creation options, as a mitigation strategy for enhancing recolonisation, will be evaluated as part of the monitoring programme. If the proposed trials are considered viable, then CRP will proceed with the establishment of hard substrate recolonisation areas, in consultation with the ERG.	Serious
Noise impacts on marine mammals	Section 8.7	A 200 m mitigation zone (radius from the mining vessel) will be checked prior to mining start up. If marine mammals are observed within this zone, then mining will not commence. Mining will only commence once no marine mammals have been observed in the 200 m mitigation zone for a period of 30 minutes or more. This reflects the adoption of environmental responsibility and industry best practice as the environmental risk was considered low prior to any mitigation measures being applied.	Low
Vessel lighting impacts on seabirds	Section 8.8	Avoidance, remediation and mitigation measures include, subject to ensuring the all vessel health and safety requirements are complied with: white light sources are replaced with green light sources where possible, lighting is shielded or faces downwards and lighting that is not needed at night is switched off, to minimise bird strike incidents, and deck equipment is designed to minimise the use of vertical wires and objects. A Draft LMP reflecting these mitigation strategies is in Appendix 35(iii). The LMP, once fully developed prior to mining commencing, specifies the need to adopt lighting policies on the vessel and the development of a range of procedures to achieve these requirements, and actions to be followed should bird resting or strike occur.	Low to medium

Table 30: Vessel related operational management and risks - avoidance, remediation and mitigation measures.

Project risk/operational management	Assessed in	Avoidance, remediation and mitigation measures
Waste and emission management	Sections 4.7.4 and 8.9	CRP will comply with the requirements of the Marine Pollution Rules and Marine Pollution Regulations which give effect to Annexes I to VI of MARPOL, and Annex VI of MARPOL which relates to air pollution from vessels. Specifically: • CRP will ensure the mining vessel holds an IOPPC for the management of its oily waste • The proposed mining vessel's wastewater treatment facility will meet the requirements of Schedule 6 of the Marine Pollution Regulations and the vessel will hold an International Sewage Pollution Prevention Certificate • All waste management activities on the vessel will be undertaken in accordance with a WMP. A Draft WMP is contained in Appendix 35(iii) • Material Safety Datasheets will be held for the chemicals held on the vessel, the majority of which are household products or typical of those used on vessels in New Zealand. Procedures will be contained in the EMMP (once fully developed) specifying handling and storage requirements, spill contingency plans and incident reporting procedures • The mining vessel will utilise fuels available at New Zealand ports. These fuels meet the 3 % sulphide dioxide requirement of Annex VI of MARPOL.
Biosecurity risks	Sections 4.7.5, 4.7.6 and 8.10	CRP will comply with the requirements of the Biosecurity Act as follows: • The mining vessel will re-ballast enroute to New Zealand (e.g., Tasman Sea if that is the route followed) and before entering New Zealand waters, or otherwise treat ballast water to the requisite standard • CRP will ensure that the hull is clean upon arrival in New Zealand. If the vessel visits ports in New Zealand that have different biosecurity risk issues, then CRP will ensure that additional hull cleaning occurs as required.
Oil spill risks	Section 8.11.4	CRP will hold a SOPEP for the mining vessel and will comply with all of Maritime NZ's requirements CRP will ensure that it has systems in place that minimise the potential for any spills occurring. Relevant procedures will be contained in the EMMP (once fully developed) specifying handling and storage requirements, spill contingency plans and incident reporting procedures.

Project risk/operational management	Assessed in	Avoidance, remediation and mitigation measures
General vessel operational risk management approaches	Section 8.11	CRP will comply with all relevant requirements, including: • Having in place appropriate plans for bad weather • Comply with Maritime NZ’s Safety Guidelines for Passenger and Non Passenger Vessels in case of fire on the vessel • Comply with Maritime Rules Part 22 that relates to vessel collision prevention • Once a decision on the port is made, develop a vessel route that complies with New Zealand’s voluntary code for vessel routing as well as any local routing codes

Trustees will be independent of CRP, although CRP proposes to have one representative on the trust. It is proposed that other trustees will be drawn from DOC, the marine science community, Iwi / Imi and an environmental non-government organisation.

The trust will administer this fund, in accordance with related trust objectives, for expenditure in the areas of:

- Scientific research of the Chatham Rise, in particular areas and communities of relevance to CRP's mining activities. Examples of such research include rare and/or endemic coral communities, recolonisation research, impacts on the water column and its ecology including fish, research into aspects of the impacts of the mining project on marine mammals and/or seabirds.
- Biodiversity and environmental related initiatives on the Chatham Islands. Examples of such initiatives include the Taiko Trust's proposal to establish a second breeding colony for the Chatham Island albatross, as discussed further below, and research into the Chatham Islands long finned eel population and fishery.
- Research into, and development of technological improvements in, seabed mining methods which reduce or mitigate adverse impacts on the marine environment. Examples of such research include returning hard substrate to the seabed for colonisation by corals and other benthic species and investigation into better mining methods that further minimise environmental impacts.
- Other environmental and / or biodiversity initiatives related to the adverse impacts of CRP's mining activities that cannot be avoided, remedied or mitigated.

CRP has to date commenced discussions with the Taiko Trust (discussed below), NIWA, and the EDS with regard to this proposal to establish a trust. CRP, through its trust, could contribute funds to the research and work being carried done by the coastal trust managed by EDS.

An example of a project-specific trust is the Chatham Islands Taiko Trust. The Chatham Islands albatross is endemic to the Chatham Islands and its only breeding ground is on The Pyramid in the Chatham Islands. Threats to these birds are considered to include fisheries by-catch, illegal chick harvest, habitat degradation due to severe storms, contaminants, disease out-breaks, and global climate change. These threats are magnified by reliance on the single breeding population on The Pyramid. To reduce the risks associated with a single breeding colony, the Chatham Islands Taiko Trust has commenced work to establish a second colony of the Chatham Islands albatross at Blyth's Point on Chatham Island. On-going work to ensure the success of initial translocation and fledging of chicks requires longer term funding, and CRP is in discussions with the Taiko Trust about this.

10.6 Summary

CRP has applied a mitigation hierarchy to the design and management of its proposed mining operations at the Chatham Rise that includes avoidance, remediation and mitigation measures.

These include, but are not limited to: establishment of mining exclusion areas to protect areas of particular sensitivity or value, sufficient separation between the mining blocks to avoid sedimentation impacts on other blocks during the first five years of mining, environmental monitoring, a 200 m marine mammal mitigation zone prior to mining start up, and vessel lighting mitigation strategies.

CRP has also committed to use its best endeavours to ensure that the mining exclusion areas identified through the marine spatial planning exercise can be protected through an appropriate legal mechanism from all seabed disturbance activities.

In addition, best practice approaches have been adopted, in some instances even with the potential environmental risk has been assessed as being low.

The loss of benthic habitat as a result of mining and sedimentation cannot be fully avoided, remedied or mitigated. CRP has therefore committed to establishing an environmental compensation package consisting of a trust charged with carrying out research, relevant to CRP mining operations, or support for ecological sustainability and / or environmental enhancement on the Chatham Rise or at or around the Chatham Islands.

11. Environmental Management, Monitoring and Proposed Marine Consent Conditions

KEY ELEMENTS

- The development and implementation of sound environmental management procedures will ensure that CRP minimises the impacts associated with its mining operations. These procedures will also ensure that marine consent conditions and any other requirements arising from other legislation are met.
- An Environmental Monitoring and Management Plan (EMMP) containing such procedures, along with associated specific management plans, will be finalised prior to mining commencing. A draft EMMP providing an outline of possible procedures has been appended to this EIA. Together, these will be CRP's environmental management system.
- Environmental monitoring will measure baseline levels of physical properties of the Chatham Rise, water quality impacts and seabed ecological communities, and measure the nature and scale of impacts from mining operations for comparison with the predicted impacts. Additional research, particularly within CRP's prospecting areas, will support the assessment of monitoring data by providing further resource and ecological information on the Chatham Rise environment.
- EMMP procedures will ensure that a feedback loop between the investigation and review of monitoring results, as well as CRP's operational activities and research within its prospecting areas, is established. This reflects an adaptive management approach and aims to ensure that appropriate measures, where achievable, can be implemented should unexpected adverse impacts occur.
- The environmental management approaches identified within this EIA have been incorporated into proposed marine consent conditions. This includes an adaptive management approach whereby mining will initially be restricted to the current mining permit area, and mining will only be able to move into CRP's prospecting areas once specific requirements have been met, based on monitoring results, additional resource and environmental investigations and the granting of mining permits.

11.1 Introduction

Sound procedures for environmental management are of key importance for CRP's mining proposal to avoid, remedy or mitigate potential environmental impacts, to implement marine consent conditions (and any requirements arising from other legislation), and to operate in accordance with the requirements of the Marine Mining Code.

This section outlines the environmental management and monitoring framework CRP proposes for its mining operations on the Chatham Rise. The framework reflects the marine consent conditions proposed by CRP (as outlined below), including management and operational controls and a monitoring programme which will be fully integrated into CRP's Environmental Monitoring and Management Plan (EMMP) prior to mining commencing. The draft EMMP (Appendix 35(i)) provides the basis for the final EMMP that will be developed after the issue of the marine consent and before the start of mining.

On-going environmental research and environmental monitoring is an important component of CRP's proposed mining operations. CRP's proposed monitoring will measure baseline levels of physical properties of the Chatham Rise and of benthic communities, and the nature and scale of impacts from mining operations for comparison with the predicted impacts. These monitoring activities will ensure timely implementation of mitigation measures and optimise mining strategies should unexpected adverse impacts occur (adverse impacts, following the application of avoidance, remediation and mitigation measures, beyond those identified within this EIA).

Additional research is planned by CRP as part of its prospecting licence and permit obligations, and the results will provide further information on the Chatham Rise environment and mineral prospectivity. The results of this research will lead into and support the proposed monitoring programme.

11.2 Environmental Management Framework

11.2.1 Overview

CRP's environmental management objective is to minimise impacts from its mining operations as far as practicable. CRP also needs to fully comply with consent conditions, management plans, other regulatory requirements and the Marine Mining Code. This will be achieved through following the quality management approach as advocated through the ISO 14001 EMS framework and the Marine Mining Code.

The environmental framework which CRP will apply is represented diagrammatically in Figure 149.

Figure 149: Environmental management framework for CRP's proposed mining operations on the Chatham Rise.

The framework requires development of an environmental management system (EMS) that will provide the direction for environmental management.

An EMS provides a clearly defined and structured approach to managing environmental performance. It specifies all procedures, practices, people, equipment and technology needed for environmental management of an activity. An EMS typically follows a 'plan-do-check-act' continuous improvement process. Although many models and structures are used for an EMS, they all essentially address:

- Identifying applicable legal requirements (e.g., complying with marine consent conditions), impacts, and risks.
- Implementing controls to manage those requirements, impacts, and risks (controls are broadly defined to include procedures, training, inspections, equipment, etc.).
- Monitoring the implementation of the controls and the resulting performance over time.
- Setting goals and taking action to ensure the objectives of the environmental programme are achieved and performance improved where possible.

CRP's EMS will comprise an environmental programme designed to identify, minimise and monitor the impacts of mining. Where necessary and possible, the EMS process will initiate modification to mining operations and measures to avoid, remedy or mitigate impacts where this is achievable. The EMS will comply with consent conditions (as outlined in Section 11.4) and other requirements and will specify roles and responsibilities for all aspects of CRP's environmental management. The EMS will focus on minimising adverse impacts on the environment and the risk of their occurrence, and delivering reliable regulatory compliance. It will be implemented through management and operational procedures specified in the EMMP.

11.2.2 Environmental Management and Monitoring Plan

11.2.2.1 Introduction

The EMMP (Appendix 35(i)) will provide the management and operational procedures needed to identify, avoid, remedy or mitigate or compensate adverse impacts, and the framework for monitoring and responding to monitoring results if necessary.

Management procedures will include an environmental management and monitoring programme that will provide the capability to identify and assess the actual environmental impacts associated with CRP's mining operations, to receive and respond to concerns of the broader interested community, and to track social, cultural and economic impacts. The proposed Mine Plan, WMP, and LMP are examples of operational procedures.

A summary of management procedures, standard and mining operational procedures, and an outline of their associated content is in Sections 11.2.2.2 to 11.2.2.4.

11.2.2.2 Management Procedures

CRP's proposed EMMP management procedures are outlined in Table 31 below.

Table 31: Proposed management procedures.

Procedure	Content
Environmental aspects identification	To review potential environmental impacts from planned and new developments and new or modified activities. The EIA will be utilised as a starting point for this procedure.

Procedure	Content
Legal requirements	Monitor changes to legislation and plans that could impact on operations, as well as any potential change to consent conditions that have impacts on what needs to be managed and monitored.
Environmental programme: objectives, targets and responsibilities	Documents the environmental management objectives and regular review of attainment of targets. Develops environmental programme to enact objectives and targets and assign responsibilities for it.
Environmental and operational training	Identifies environmental information and training requirements for all mining vessel personnel and contractors.
Communication	Processes for internal and external communication, communication with regulatory agencies and interested parties, the press, Iwi / Imi, handling complaints (i.e., who can do what and how).
Documentation and document control	To comply with ISO 14001 document control requirements.
Environmental incident reporting, including emergency preparedness and response plan	Specific procedure covering all potential environmental incidents, including who to contact, who is responsible, and the nature and level of response.
Annual review and audit process	Review of monitoring results, operational practices, incidents, changes to process and impacts at least annually. In instances where an incident occurs or where an unexpected adverse impact is identified, then a review process will also be initiated.

11.2.2.3 Standard Operational Procedures

Operational procedures provide instructions on how to implement those operational aspects of CRP's mining operations with a risk of adverse environmental impacts.

On the basis of known areas of potentially serious risks, the marine consent conditions and the Marine Mining Code, operational procedures will be developed to give instruction to those responsible for carrying out specific aspects of the mining operations. Standard operational procedures cover operations related to but ancillary to mining itself. An outline of standard operational procedures is in Table 32.

Table 32: Standard operational procedures.

Activity	Content
Preparation for mining	Notify authorities, signals/navigational safety, prepare sighting programme for baseline data (seabirds and marine mammals), and implement other baseline conditions in marine consent. Define mining exclusion areas.
Hull cleaning and ballast water management	To cover requirements under the Biosecurity Act.
Mining activity interaction with wildlife	For example, operating near marine mammals.

Activity	Content
Waste management	Ensuring that CRP complies with the requirements of Annexures I, IV and VI of MARPOL and the specific New Zealand Regulations and Rules.
Vessel lighting	Special attention to specific measures to reduce the attraction of birds to the vessel. Minimising the potential for seabird strike will be undertaken via a Vessel Lighting Management Plan.
Vessel noise	Controls to minimise potential impacts on marine mammals and other marine life. Noise reduction techniques, operating times, frequency limits etc.
Equipment loss at sea	Describe how any equipment lost at sea may be salvaged.
Port operations (e.g., vessel to shore transfer of material, bunkering etc.)	To be determined when port confirmed and port controls and management requirements known.
Hazardous substances	Operational procedure for handling and storage of all materials that are managed under the New Zealand HSNO Regulations including holding the MSDSs and having in place a SOPEP.

11.2.2.4 Mining Operational Procedures

The principal procedure for managing mining operations will be through implementation of the Mine Plan. Aspects of the Mine Plan that have a potential environmental impact will have associated operational procedures that outline how, where, when and at what rate and scale the mining operation will be undertaken.

Table 33 provides an outline of mining operational procedures similar to those referred to in the draft EMMP.

Table 33: Mining operational procedures.

Activity	Content
Seabed mining	The Mine Plan including : • Seabed pick-up system. • Positioning and movement of the dredging drag-head to accurately follow the mining plan.
Minimising environmental impacts	Operational procedures that implement the avoidance, remediation and mitigation measures stated in Section 8, and any conditions attached to the marine consent also developed for this purpose. A range of procedures and associated controls will need to be developed.
Return of the processed non-phosphatic material	Will include controls for the range of conditions under which the returns must be discharged, including location, water depth etc.

11.2.3 Environmental management responsibilities and structure

A crucial part of any EMS is the allocation of environmental responsibilities to individuals. CRP will allocate responsibilities for the implementation of the EMS and all management and operational procedures. This is likely to be achieved through a roles and responsibilities table which will specify the training required for individual personnel given their assigned responsibilities.

Responsibilities will also be designated for general environmental management performance such as internal and external communication on environmental matters, management of incidents and complaints, record keeping, document control, and monitoring and reporting.

11.2.4 Audit and review

CRP will review monitoring results and the EMMP annually, and whenever monitoring results show something unexpected or when an environmental incident occurs and the response undertaken does not achieve expected outcomes.

A report detailing the results of these reviews will be provided to the parties outlined in the proposed marine consent conditions. If required, the EMMP and associated processes will also be amended.

11.3 Research and Environmental Monitoring

11.3.1 Introduction

Integration of all the environmental data collected by the prospecting surveys, resource definition surveys and environmental monitoring programme will result in knowledge of the environment throughout the marine consent area that is similar to or exceeds that in the existing mining permit area. If commercially viable deposits of phosphorite are discovered in the marine consent area then decisions about if and how they are mined will be based on a level of knowledge comparable to that in the existing mining permit area.

Many of the environmental factors that are relevant for considering the impacts of mining on the Chatham Rise are broad scale (e.g., oceanographic fronts, fish distributions) and there is sufficient information about them to predict their spatial importance. Other factors vary on such small scales that it is impossible in practice to know them in detail, but the habitat and community modelling carried out for this project (refer Section 6.3) shows that these can be included in analyses of the impacts of mining if they are sampled appropriately. The sampling and observations throughout the central Chatham Rise region used in this EIA are sufficient to support a spatial planning analysis of the biodiversity and economic values that can guide development decisions for the region.

11.3.2 Further environmental research

CRP will continue to collect data on the nature of the seabed and ecology of areas of the Chatham Rise relevant to its activities. The focus of this research will be on the areas both inside and outside of the mining permit area. These surveys will be undertaken as part of the environmental monitoring plan and will be part of the on-going assessment of the resource distribution and seabed characteristics to inform mine planning decisions, and of the exploration effort in the prospecting areas adjacent to the mining permit.

The proposed environmental monitoring plan associated with the mining operations is described in Section 11.3.3 below. The research and surveys associated with mine planning decisions are described below.

One of the areas of research associated with mine planning decisions includes systematic surveys before and after mining to assess the efficiency of the mining process. The results of these surveys will be used to refine future mining operations to improve productivity and to reduce environmental impacts, if possible.

Prior to mining commencing in any location, pre-mining surveys will be carried out to refine the detailed understanding of the resource distribution and the nature of the seabed, to identify rich and barren areas and areas unsuitable for mining (e.g., conservation values, unsuitable for drag-head operations etc.). These surveys will collect a broad spectrum of data, including photographs and samples of the seabed. The data will be used to document seabed habitats, oceanographic conditions and the distribution of the phosphorite resource. Similar surveys will be carried out after mining to assess the drag-head performance. These surveys will provide the baseline for subsequent surveys that observe recolonisation of the mining blocks.

As a condition of the prospecting licence and proposed prospecting permits, CRP is required to undertake surveys and associated research similar to those undertaken to support the application for MP 55549. They will collect samples of the seabed to determine the distribution of the phosphorite resource, the physical properties of the sediments and the nature of the benthic communities. In addition, a broad spectrum of baseline seabed and oceanographic data will also be collected to identify spatial changes in benthic habitats and the marine environment as well as measurements relevant for mine planning purposes and regulation of mining activities.

In addition to the CRP-led research outlined above, CRP proposes to support research led by other parties through its environmental compensation package (refer to Section 10.5). Examples identified, include research of cold-water coral distribution and recolonisation on the Chatham Rise and how larval long-finned eels return to New Zealand.

Many aspects of this research will support the considerations associated with the adaptive management approach, as outlined in the proposed marine consent conditions. Under the proposed adaptive management approach, mining cannot occur in areas outside of the current mining permit until the identified requirements are met. These requirements will be based on the outcome of monitoring results, additional resource and environmental investigations and the granting of mining permits (as outlined in the proposed conditions in Section 11.4).

All of these surveys and research will increase the broader understanding of the nature of the Chatham Rise ecosystem, including its sensitivity to disturbance and mechanisms for recovery from activities such as mining.

11.3.3 Environmental monitoring

11.3.2.1 Purpose

Monitoring environmental impacts is essential when undertaking any activity for which there may be adverse environmental impacts. Monitoring tests whether the actual impacts are similar to the impacts predicted in the EIA. It is also important to monitor the areas that have been assessed as having potentially high or serious environmental risks.

Environmental monitoring will be carried out by CRP to provide information on:

- Baseline oceanographic information, including currents, temperature and salinity.
- Water turbidity (suspended solids) prior to, during and after mining.
- Benthic ecology. This monitoring will observe the actual impacts of mining (i.e., habitat removal and sedimentation) and the nature and rate of recolonisation in mined areas.

Data collected as part of the environmental monitoring programme will be collected by moorings, surveys by autonomous underwater vehicles (AUVs), or similar equipment, and seabed samples.

11.3.2.2 Monitoring programme framework

The proposed monitoring programme is designed to meet the objectives outlined below. This framework has been incorporated into the draft EMMP (Appendix 35(i)) as well as the proposed marine consent conditions.

The monitoring programme framework for the initial phases of the proposed mining operations consists of:

- **Water quality and baseline oceanographic information monitoring**.

  The monitoring objectives are: to continuously measure near seabed turbidity and other physical and chemical properties of the marine environment at selected sites in the marine consent area, and to measure turbidity and other physical and chemical properties of the marine environment during mining operations to enable comparison with predicted values.

  The purpose of this monitoring is to determine baseline values for turbidity and other physical and chemical properties of the marine environment, and to assist with optimising mining operations and system design to minimise the environmental impacts of the project.

  The monitoring includes:

  - ***Baseline and regional turbidity data collection***. Data will be collected at four monitoring sites within the marine consent area. These sites may move over time to accommodate both control and impact sites. A mooring will be deployed at each monitoring site with instruments to monitor turbidity, current speed and direction, temperature, conductivity, and pressure. The instruments will be chosen and deployed to provide detailed information about the lower part of the water column (within about 50 m above the seabed) and less detailed information about the remainder of the water column. The instruments will be deployed before mining begins to gather baseline information and they will be maintained throughout the life of the project. It is expected that the moorings and instruments will be serviced every 6 months.
  - ***Water column turbidity associated with mining.*** An AUV, or similar equipment, will be used to track and map the turbidity in the water column during mining operations as fixed moorings are unable to adequately monitor the unpredictable path of the suspended material. The AUV, or similar equipment, will be equipped with sensors capable of measuring turbidity and fluorescence, current speed and direction, temperature, conductivity, pressure, and particle size distribution. The AUV, or similar equipment, will be deployed during mining operations and programmed to systematically survey the water column, adapting its course to follow the areas of greatest turbidity. These surveys will take place every four months for the initial 12 months of the mining operation, and once a year thereafter.

- **Monitoring of ecological impacts outside the mining area.**

  The monitoring objective is to provide long term information on the seabed ecology at locations outside the mining blocks but which may be affected by mining activity.

  The monitoring will include surveys of the control sites established for the water quality monitoring as well as systematic surveys of the areas adjacent to the mining operations to a distance where it is possible to be confident that the significant mining sedimentation impacts have been observed. These surveys will use an AUV, or similar equipment, to take photographs and/or videos of the seabed and appropriate equipment to collect seabed samples. The data will be used to quantitatively assess changes in the structure of epifaunal and infaunal communities (number of replicates to be determined). These surveys will take place every four months for the initial 12 months of the mining operation, and once a year thereafter.

- **Recolonisation monitoring.**

  The monitoring objectives are: to assess natural recolonisation following completion of mining in the first mining block, and to assess the viability and value of installing material to provide added hard substrate habitat, thereby possibly enhancing biodiversity within and adjacent to mined areas on the Chatham Rise.

  The monitoring method includes:

  - ***Recolonisation after mining***. This entails monitoring the nature of the ecological community developing within the first mining block at defined distances from the edge of the mining activity. This will be undertaken using an AUV, or similar equipment, to take photographs and/or videos of the seabed to identify visual changes in epifaunal communities. Seabed samples will also be collected using appropriate sampling equipment, for example a box-corer. The purpose of this monitoring will be to observe changes in epifaunal and infaunal communities (number of replicates to be determined). Information collected at each site will include sediment physical properties and ecology (epibenthos via video/photographs, infauna from seabed samples). These surveys will be completed every year for the first 5 years of the mining project, and every other year for the next 10 years of the project.

  - ***Hard substrate trials.*** Four test sites will be established to assess the viability and value of adding hard substrate habitat to enhance biodiversity within and adjacent to the mined areas. A variety of hard substrate types will be placed on the seabed to determine the practicality of larger scale deployments. Each trial of hard substrate type will deposit no more than 10 m^3 of material. The trial sites will be regularly monitored to determine variations in the development of benthic and pelagic communities. The sites will be monitored every year for the first 5 years of the mining project, and every other year for the next 10 years of the project. If adding hard substrate is determined to be viable and valuable then it is proposed that, following protocols developed in conjunction with the proposed ERG, hard substrate recolonisation areas will be established on the crest of the Chatham Rise by CRP.

11.4 Proposed Marine Consent Conditions

11.4.1 Introduction

Section 63 of the EEZ Act enables the EPA to grant a marine consent subject *"to any condition that it considers appropriate to deal with adverse effects*".

CRP has developed marine consent conditions to identify compliance controls for potential adverse impacts associated with CRP's proposed mining operations on the Chatham Rise. These conditions reflect the identified avoidance, remediation and mitigation measures, the management plans, the environmental monitoring and the adaptive management process to identify and respond to unexpected impacts and to reduce those impacts, where possible, as mining progresses.

To avoid impacts (as outlined in Sections 4.4.1 and 8.6.6.4), CRP volunteers a condition to exclude mining activities from parts of the marine consent area identified through a marine spatial planning exercise as being of particularly environmental sensitivity or value. Such a condition can only bind CRP and cannot be binding on third parties who may wish to carry out other activities in the marine consent area in the future. Nevertheless, based on the research and monitoring that have been completed and that will be continued by CRP, i appropriate ‘reserves’ within the marine consent area, as well as the broader area associated with the spatial planning exercise carried out (refer to Appendix 32), can be identified. CRP also volunteers a best endeavours condition that it will provide support and advocate for the creation of statutory protection or permanent protection through other mechanisms for the mining exclusion areas, as well as other areas considered as part of the spatial planning exercise but which are located outside of the marine consent area. This might, for example, be through the creation of marine reserve status, or through new or updated legislation which affords protected status to areas of New Zealand's EEZ.

11.4.2 CRP’s proposed adaptive management approach

Section 64 of the EEZ Act identifies that an adaptive management approach may be included in marine consent conditions. Section 64(2) defines adaptive management as including:

(a) *“allowing an activity to commence on a small scale or for a short period so that its effects on the environment and existing interests can be monitored:*

(b) *any other approach that allows an activity to be undertaken so that its effects can be assessed, or continued with or without amendment, on the basis of those effects.”*

Further explanation is then provided. Section 64(3) identifies that the application of an adaptive management approach may mean imposing marine consent conditions whereby an activity is undertaken in stages, with monitoring and associated reporting required before the next stage, or the next period, of the activity may commence. To provide further clarification, section 64(4) then states that *“a stage may relate to the duration of the consent, the area over which the consent is granted, the scale or intensity of the activity, or the nature of the activity”.*

The nature of the mining activity is directly connected to the nature of the mining vessel and associated mining equipment, specifically the trailing suction drag-head and returns diffuser. The construction of the mining vessel and associated equipment is anticipated to take about two years and cost up to half a billion dollars. This reflects a significant upfront investment for CRP. Given the capital investment needed for this equipment to start the proposed mining, it is not possible to commence mining on a significantly smaller scale than proposed in this application.

Any prolonged period of reduced production or a significant break in production in response to a requirement to adapt or modify the mining system, could threaten the financial viability of the project.

As outlined in Section 12, the design of the mining vessel and mining plant reflects the most viable mining approach, based on decades of experience and extensive engineering and environmental modelling. The specifications for the drag-head and the diffuser include features designed to avoid and minimise the potential for significant adverse effects. The proposed dredging technology, albeit modified for the conditions, is not new and is utilised widely throughout the world. On this basis, the likely impacts are in a general sense well understood.

If unexpected impacts are identified through the mechanisms which form the proposed EMMP, including the consideration of monitoring information, then where possible CRP will amend the relevant aspects of its operations to avoid, remedy or mitigate the impact. It is anticipated that adaptive management methodologies will most likely be associated with the mitigation actions identified in this EIA. A proposed adaptive management condition reflecting this is in Section 11.4.4.

While recognising the potential limitations associated with applying adaptive management to the proposed mining operations within the mining permit area, adaptive management can also be utilised as the basis for expanding future mining operations beyond the mining permit area. Accordingly, proposed marine consent conditions reflecting this approach are outlined in Section 11.4.4. The proposed adaptive management approach is in accordance with that described in section 64(3) of the EEZ Act as CRP's proposed mining operations will be staged, with CRP only being able to move onto other stages (i.e., other areas) based on the outcomes of the monitoring and research that have been undertaken and reported to the EPA.

11.4.3 Mining activities to be authorised by the marine consent

As CRP's proposed mining operations on the Chatham Rise are not permitted activities under the EEZ Act Regulations, CRP is seeking a marine consent to mine phosphorite at the Chatham Rise. The mining activities that trigger the need to seek a marine consent, in accordance with sections 20, 20A and 20C of the EEZ Act, are identified in Table 34.

Table 34: Mining activities (sections 20, 20A[1] and 20C[1] of the EEZ Act).

Component of the mining activity	Description	Section of the EEZ Act
Monitoring equipment placement on the seabed	As part of the proposed monitoring programme, up to four structures (mooring landers) will be placed, moved and ultimately removed from the seabed.	section 20(2)(a)
Mining of phosphorite nodules from the seabed	Mining, using a trailing suction drag-head, will result in the phosphorite nodules (a non-living natural material) being removed from the seabed and subsoil.	section 20(2)(d)
Seabed disturbance associated with mining operations	Within the mining blocks, given the proposed use of the trailing suction drag-head, the seabed and subsoil will be removed, and thus disturbed.	section 20(2)(e)
Collection of seabed samples during environmental surveying and monitoring	Collection of seabed samples, as described in Section 4.4.7, will disturb the seabed and subsoil and also result in the removal of non-living natural material (sediments) from the seabed and subsoil.	sections 20(2)(d) and 20(2)(e)
Return of the non-phosphatic material to the seabed	Following the processing of the mined material on the mining vessel, the unwanted material will be deposited, or discharged (i.e., a mining discharge from a ship) to the seabed via a flexible sinker hose and diffuser.	sections 20(2)(f), 20A(2) and 20C
Proposed recolonisation trials, and possible subsequent habitat creation	Deposition of relatively small amounts of hard substrate onto the seabed for recolonisation trials, and if successful then possibly subsequent habitat creation through the deposition of larger amounts of hard substrate on the seabed.	section 20(2)(f)
Seabed disturbance and damage associated with mining operations, and environmental surveying and monitoring, which adversely affects marine species and habitat	As outlined above in relation to section 20(2)(e) of the EEZ Act, within the mining blocks the seabed (and subsoil) and the marine species living in and on the seabed will be removed (i.e., both disturbed and damaged). The collection of seabed samples will also disturb the seabed and subsoil and associated marine species and habitats, although the impacts of this activity are minor.	section 20(2)(g)

Component of the mining activity	Description	Section of the EEZ Act
Generation of noise, and possibly vibrations, associated with the operation of mining equipment in the water column and on the seabed.	The operation of the mining equipment, namely the drag-head, return and associated riser and sinker, may generate noise that may adversely impact on marine life.	section 20(4)(b)

Note: (1) Sections 20A and 20C are not in force at the time this application was lodged. Irrespective of this, the considerations and assessments required by these sections have been addressed within this EIA.

11.4.4 Proposed conditions

It is proposed that CRP's marine consent authorising the mining of phosphorite from the Chatham Rise seabed, for a term of 35 years, be subject to conditions outlined below.

Definitions

Chief Executive	The Chief Executive of the Environmental Protection Authority (or his or her designate appointed in writing).
EEZ Act	Exclusive Economic Zone and Continental Shelf (Environmental Effects Act 2012
EMMP	Environmental Management and Monitoring Plan.
EPA	Environmental Protection Authority, the consent authority for this marine consent under the EEZ Act.
ERG	Environmental Reference Group. A group established in accordance with the conditions of this consent.
mining block	the areas, generally 5 by 2 km in dimension, that have been or are to be mined.
unexpected adverse impact	an adverse impact, after the application of avoidance, remediation and mitigation measures, which are beyond the scope of those outlined in the marine consent application and associated EIA.

Mining Operations in Accordance with Application and Consent

1. The Consent Holder shall undertake all activities in general accordance with the marine consent application, consisting of Volumes One and Two, and titled "Chatham Rock Phosphate Limited – Proposed Mining Operation – Marine Consent Application and Environmental Impact Assessment" submitted to EPA in May 2014.

   Where there is inconsistency or ambiguity between the marine consent application (including the associated EIA) and the conditions of this consent, these conditions shall prevail.

2. The Consent Holder shall ensure that all personnel and contractors undertaking work and tasks authorised by this consent are made aware of the conditions of this consent and that all personnel and contractors comply with those conditions.

3. At all times, a copy of all plans and management plans required in accordance with the conditions of this consent, including a copy of this marine consent, shall be readily available at the Consent Holder's offices and on the vessel/s undertaking the mining operations and related activities.

Notice of Mining Commencement

4. At least six calendar months prior to mining activities commencing in accordance with this consent, the Consent Holder shall advise the Chief Executive, in writing, of the proposed mining commencement date.

Mining Operations

5. During the first 5 years of mining operations carried out in accordance with this consent, mining shall only occur in a 820 km^2 area, located on the crest of the Chatham Rise, within the Consent Holder's mining permit (MP) 55549.

   After the first 5 years of mining and provided the adaptive management requirements of Condition 13 have been met, the Consent Holder may also undertake mining operations in the following areas on the crest of the Chatham Rise, but only if the Consent Holder has obtained the relevant mining permits pursuant to the Crown Minerals Act 1991:

   (a) that area of 2,886 km^2 associated with the minerals prospecting licence (MPL) 50270, which excludes the 1,019 km^2 relinquished by the Consent Holder and the 820 km^2 associated with MP 55549 located in the western end of MPL 50270;

   (b) that area of 1,501 km^2 associated with the Consent Holder's application for a prospecting permit (PP) 55971 adjoining and located to the west of MPL 50270; and

   (c) that area of 4,985 km^2 associated with the Consent Holder's application for a prospecting permit (PP) 55967 adjoining and located to the east of MPL 50270.

   The locations of these areas are shown in the figure in Attachment A to this consent. (Note: Figure to be provided, although it will be similar to Figure 4 contained in Section 1.4).

6. During the first 5 years of mining operations carried out in accordance with this consent, the Consent Holder shall ensure that the mining blocks are sufficiently separated such that sedimentation impacts between the mining blocks are minimised in any given year.

7. At all times, the Consent Holder shall only operate one mining vessel in order to carry out its mining operations in accordance with this consent.

8. The Consent Holder shall ensure that the non-phosphatic material returned to the seabed is deposited no more than 10 m, on average, above the seabed and within or alongside the mining block that is being mined by the mining vessel at the time. A diffuser or similar technology, which reduces the velocity at which the material is deposited on the seabed is to be used at all times.

9. The Consent Holder shall ensure that mining does not occur in the following areas:

   (a) the mining exclusion areas identified in the figure in Attachment B to this consent. (Note: Figure to be provided, although it will be similar to Figure 18 contained in Section 4.4.1);

   (b) any additional mining exclusion areas identified by the Consent Holder as a result of research undertaken as part of further prospecting activities. Any additional mining exclusion areas that are identified are to be advised in writing to the Chief Executive; and

(c) rock outcrop areas greater than 2 km^2.

Advice Note: Condition 44 provides a best endeavours approach for the Consent Holder to advocate and support for striving to ensure protection mechanisms from a range of activities, not just mining, for the exclusion areas identified under parts (a) and (b) of this condition.

Environmental Management

10. On every occasion that the mining vessel returns to the mining location from port, prior to mining recommencing, the Consent Holder shall ensure that an area extending 200 m from the mining vessel in all directions is visually checked. If marine mammals are observed within this zone, then mining operations shall not commence. The Consent Holder shall only commence mining operations once no marine mammals have been observed within this defined zone for a period of at least 30 minutes.

11. Subject to ensuring that all vessel health and safety requirements are complied with, the Consent Holder shall ensure that, at a minimum, the following seabird impact avoidance measures are implemented on the mining vessel:

    (a) where possible, the utilisation of green light sources is maximised;

    (b) lighting is shielded or faces downwards;

    (c) lighting that is not needed at night is turned off; and

    (d) the use of vertical wires and objects on the deck is minimised as far as it practicable.

    Advice Note: It is understood that the Consent Holder intends to comply with this condition, and the related intent of minimising potential lighting impacts on seabirds, through the development and implementation of a Lighting Management Plan. Such a plan is a subsidiary management plan to the overarching EMMP required by Condition 29.

12. The sewage and greywater treatment system on the mining vessel shall comply with the Grade A standard for wastewater treatment as defined in Schedule 6 of the Resource Management (Marine Pollution Regulations) 1998.

Adaptive Management Approach

13. After the first five years of mining operations, the Consent Holder may undertake mining activity within areas outside of mining permit 55549 specified in Condition 5, provided the Consent Holder meets the following requirements:

    (a) that the adaptive management approach relating to concentrations of total suspended solids, as described in Condition 14, has not been triggered.

    (b) in relation to a proposed additional area to be mined, the following prospecting activities have been completed:

        (i) bathymetry has been confirmed;

        (ii) sampling of the physical characteristics of the seabed, including the presence of phosphorite nodules has been carried out; and

        (iii) sampling (defined as epibenthic photography and infaunal sampling) of the benthic ecology has been carried out.

    (c) in addition to (a) and (b) above, the Consent Holder has confirmed the plume modelling results for the proposed additional mining area based on current data collected for the area. This includes confirming that the limits described in in Condition 14 will continue to be complied with.

(d) the Consent Holder has:

(i) from the information gathered in accordance with part (b) of this condition, identified additional areas that cannot be mined in accordance with Condition 9;

(ii) in accordance with Condition 16, provided the Environmental Reference Group (ERG) with the opportunity to evaluate the information gathered in accordance with this condition; and

(iii) been granted a mining permit in accordance with the provisions of the Crown Minerals Act 1991.

(e) Provided a report to the Chief Executive on the location and nature of the additional mining area as well as compliance with the requirements of this condition.

(f) Within three months of the receipt of the report provided in accordance with part (e), the Chief Executive must advise the Consent Holder, in writing, as to whether or not the this condition has been complied with. Upon receipt of approval in writing from the Chief Executive that this condition has been complied with, the Consent Holder may commence mining in the additional mining area.

(g) The mining of additional mining areas by the Consent Holder shall be subject to compliance with all relevant conditions of this consent.

14. If the results of total suspended solids monitoring carried out in accordance with Condition 32 while mining is occurring exceeds 50 mg/L above background levels, at a point 5 km or greater away from the mining operations or at a point 50 m or greater above the seabed at any location, on any monitoring undertaken in accordance with Condition 32(ii), then the Consent Holder shall:

(a) undertake the following additional monitoring:

(i) within no more than 48 hours of monitoring exceeding the 50 mg/L limit in accordance with the criteria described above, the Consent Holder shall carry out an additional round of monitoring while mining operations are occurring; and

(ii) if the second round of monitoring also exceeds the 50 mg/L limit in accordance with the criteria described above, the Consent Holder shall carry out two further rounds of monitoring, also no more than 48 hours apart, when mining operations next occur on the Chatham Rise (that is, once the mining vessel returns to site and commences mining).

(b) if the 50 mg/L limit is exceeded, in accordance with the criteria described in this consent, on all the additional monitoring rounds carried out in accordance with part (a), then the Consent Holder shall as soon as practicable and no later than 5 working days of receiving the final monitoring advise the Chief Executive in writing;

(c) in conjunction with the assessment to be carried out in accordance with part (d) of this condition, gather sufficient information during the targeted monitoring events to identify suspended solids concentrations in the near seabed water column at progressive distances away from the mining block. The purpose of the data is to identify at what point total suspended solids reaches 50 mg/L and at what point they reach 'background' levels;

(d) within 3 months of advising the Chief Executive, complete an assessment of adaptive management responses, if any, that can be implemented that will avoid, remedy or minimise total suspended solids levels associated with mining operations. If a solution is identified, the assessment shall identify the timeframe for implementation. This assessment shall be provided to the Chief Executive; and

(e) the Consent Holder shall ensure that if an adaptive management approach is to be implemented, it shall be implemented in accordance with the timeframe identified in the assessment required by part (d) of this condition.

Advice Note: *If the proposed adaptive management approach entails modifications to any of the key elements of the mining vessel or associated components, such as the drag-head, separation plant or the non-phosphatic material return, then it is acknowledged that it may take some time to implement the proposed management approach.*

15. In circumstances where an unexpected adverse impact is identified by the Consent Holder and / or another party as a result of activities authorised by this consent, the Consent Holder shall:

(a) as soon as practicable and no later than 5 working days of becoming aware of the unexpected adverse impact, advise the Chief Executive in writing;

(b) within 3 month of advising the Chief Executive, complete an assessment of adaptive management approaches, if any, that can be implemented that will avoid, remedy or minimise the unexpected adverse effect associated with the Consent Holder's mining operations. If a solution is identified, the assessment shall identify the timeframe for implementation. This assessment shall be provided to the Chief Executive; and

(c) the Consent Holder shall ensure that if an adaptive management approach is to be implemented, it shall be implemented in accordance with the timeframe identified in the assessment required by part (b) of this condition.

Advice Note: *If the proposed adaptive management approach entails modifications to any of the key elements of the mining vessel or associated components, such as the drag-head, separation plant or the non-phosphatic material return, then it is acknowledged that it may take some time to implement the proposed management approach.*

Environmental Reference Group

16. At least three calendar months prior to mining activities commencing in accordance with this consent, the Consent Holder shall establish an ERG. The brief for the ERG shall include, but not be limited to:

(a) receive data and reports from the environmental monitoring undertaken in accordance with this consent, as well as other relevant research that is to be considered as part of the adaptive management approach described within the conditions of this consent;

(b) consider the impacts on the Chatham Rise marine environment of the Consent Holder's mining activities;

(c) identify and discuss appropriate measures, or management actions, to address issues identified or to remedy or mitigate unexpected adverse impacts for the Consent Holder to consider; and

(d) other matters relevant to the environmental management and performance of the Consent Holder's mining activities.

The ERG shall consider these matters at regular meetings, as required by the Condition 19 of this consent.

17. In establishing the ERG in accordance with Condition 16, the Consent Holder shall invite representatives from the following organisations and experts with appropriate qualifications or experience or both to join the ERG. The organisations and experts include, but are not limited to:

    (a) one representative from CRP, as the Consent Holder;

    (b) a suitably qualified technical specialist in the field of deep-water marine ecology;

    (c) a suitably qualified specialist in the field of marine sedimentology;

    (d) a representative from the Department of Conservation;

    (e) a representative nominated by the deep-water fishing industry;

    (f) a representative from the Chatham Islands' community;

    (g) a representative from an environmental non-government organisation with an interest in the marine ecosystems of the EEZ; and

    (h) an Iwi / Imi representative from the collective of Ngati Mutunga o Wharekauri, Moriori, and Te Runanga o Ngai Tahu.

    Additional members may also be co-opted onto the ERG, either temporarily or permanently, to ensure that the ERG has the requisite skills to deliver on the brief described in Condition 4.

    <u>Advice Note:</u> *To provide for an ERG that is both effective and efficient, it is acknowledged that the Consent Holder shall generally seek to restrict the ERG membership to no more than 12 individuals.*

18. The Consent Holder shall provide reasonable administrative, logistical and financial support to facilitate the function of the ERG, including the provision of an independent facilitator to chair ERG meetings.

19. The Consent Holder shall use reasonable endeavours to ensure that meetings of the ERG occur at the following frequency:

    (a) at least twice a year during the first two years of mining operations authorised by this consent; and

    (b) after the first two years of mining, at least annually.

20. The Consent Holder shall ensure that all ERG members are advised of meeting dates and location in a timely manner, and no later than one calendar month in advance of the meeting.

21. The Consent Holder shall ensure that all information, including data and reports, which are to be discussed at ERG meetings are provided in a timely manner, and no later than 10 working days in advance of the meeting.

22. The Consent Holder shall ensure that a record of the ERG meetings is forwarded to the Chief Executive in accordance with the reporting requirements outlined in the conditions this consent.

Mine Plan

23. At least three calendar months prior to mining activities commencing in accordance with this consent, the Consent Holder shall prepare and forward to the Chief Executive a Mine Plan which provides, at least, the following information:

    (a) a description of the mining method to be utilised, including but not limited to, the seabed mining method, the separation method and the method used to return the non-phosphatic material to the seabed;

    (b) management and maintenance requirements for key components of the mining operations;

    (c) the location of the areas that are not to be mined in accordance with Condition 9 of this consent;

    (d) the location of the mining blocks to be mined over the next 12 months;

    (e) identification of the predicted extent of sediment deposition associated with the return to the seabed of the non-phosphatic material;

    (f) restrictions, if any, that will apply to navigation while mining is occurring;

    (g) identification of the proposed vessel route to and from port that complies with New Zealand's voluntary code for vessel routing and relevant local routing codes;

    (h) contingency procedures to prevent and deal with unusual events, including but not limited to, extreme weather events and equipment failure; and

    (i) other actions necessary to comply with the conditions of this consent and any other relevant regulatory or legislative requirements.

24. No later than 31 October of each year while mining operations in accordance with this consent continue to occur, the Consent Holder shall update the Mine Plan and forward the updated Mine Plan to the Chief Executive. The updated Mine Plan is to provide the information identified in Condition 23 above for the following calendar year, and at least the following additional information:

    (a) confirmation of the areas mined in the previous 12 month period;

    (b) the volume of material removed from the seabed, retained and transferred to port, and returned to the seabed in the previous 12 month period; and

    (c) any changes to the mining method utilised.

25. The Chief Executive shall review the Mine Plan and within one month of receiving the Plan from the Consent Holder in accordance with Conditions 23 or 24, the Chief Executive must either approve the Mine Plan, or advise the Consent Holder that amendments are required. If the Chief Executive specifies that amendments are required in accordance with this condition, the Chief Executive must advise the Consent Holder within 10 working days of receipt of the revised Mine Plan whether it is approved or not. If the Chief Executive does not advise the Consent Holder within the timeframes specified within this condition, the Mine Plan is deemed to be approved by the Chief Executive.

26. The Consent Holder shall ensure that mining operations are undertaken at all times in accordance with the Mine Plan.

Environmental Management and Monitoring Plan

27. At least three calendar months prior to mining activities commencing in accordance with this consent, the consent holder shall prepare and forward to the Chief Executive an EMMP. The purpose of the EMMP is to provide a management and operational framework which continually guides and informs measures and management approaches, in accordance with an avoid, remedy or mitigate hierarchy, any adverse impacts associated with the Consent Holder's mining operations. The EMMP shall include, but not be limited to, the following:

    (a) the Consent Holder's environmental policy;

    (b) the purpose of and objectives for the EMMP;

    (c) a list of key personnel and points of contact;

    (d) management procedures including, but not limited to, continued identification of potential environmental impacts, assessment of legal requirements, development of an environmental programme for the management of environmental impacts, identification of roles and responsibilities, environmental and operations training requirements, internal and external communication, documentation and document control, environmental incidents, audit and review;

    (e) standard operational procedures and mining operational procedures, as they relate to potential environmental impacts. These procedures shall include, but not be limited to, ballasting, hull cleaning, potential interaction with wildlife, waste management, vessel lighting, vessel noise, equipment loss at sea, hazardous substances management, mining operations and minimising potential environmental impacts associated with mining;

    (f) monitoring procedures required to implement the monitoring programme, including the monitoring required by Condition 32 of this consent. Monitoring procedures shall include, but not limited to, the monitoring objectives, monitoring requirements and associated roles and responsibilities, calibration and repair requirements for the equipment, processes for monitoring compliance reviews and audits, non-conformance and corrective actions and control of monitoring records; and

    (g) other procedures or actions necessary to comply with the conditions of this consent and any other relevant regulatory or legislative requirements.

    The Consent Holder may prepare separate, but subsidiary to the EMMP, management plans to comply with this condition.

    <u>Advice Note:</u> *Within the marine consent application, the Consent Holder identified at least 2 separate but subsidiary management plans. These are the draft Lighting Management Plan and the draft Solid Waste Management Plan.*

28. The Consent Holder must audit and review the EMMP as follows:

    (a) at a minimum, no later than 31 October of each year while mining operations in accordance with this consent continue;

    (b) if an unexpected adverse impact is identified as described as part of the adaptive management approach outlined in Conditions 14 and 15; and

    (c) if an environmental incident has occurred, or a complaint has been received, that has triggered the need to advise the Chief Executive in accordance with Condition 36 of this consent.

29. The Consent Holder shall provide the Chief Executive with a copy of the EMMP within one month of it being reviewed and updated in accordance with Condition 28.

30. The Chief Executive shall review the EMMP and within 1 month of receiving the Plan from the Consent Holder in accordance with Conditions 27 or 28, the Chief Executive must either approve the Mine Plan, or advise the Consent Holder that amendments are required. If the Chief Executive specifies that amendments are required in accordance with this condition, the Chief Executive must advise the Consent Holder within 10 working days of receipt of the revised EMMP whether it is approved or not. If the Chief Executive does not advise the Consent Holder within the timeframes specified within this condition, the EMMP is deemed to be approved by the Chief Executive.

31. At all times, the Consent Holder shall ensure that all operations are undertaken in accordance with the requirements of the EMMP.

Monitoring

32. The Consent Holder shall implement an environmental monitoring programme designed to ascertain and confirm the actual impacts on water quality, benthic ecology and the nature of recolonisation following mining operations. The monitoring programme shall include, but not be limited to, the following:

    (a) monitoring of water quality, including turbidity and physical and chemical properties of the ocean, which shall consist of:

        (i) turbidity, current speed and direction, temperature, conductivity and pressure monitoring, from at least four fixed moorings at locations within the marine consent area. The location of these moorings will be able to be moved throughout the term of this consent, although the mooring must be positioned in a manner that will enable the impacts from mining to be confirmed. Data is to be retrieved at least every six months while mining operations are occurring; and

        (ii) at least once every four months during the first 12 months of mining operations, and every year thereafter, an AUV (or similar equipment) is to be used to track and map the turbidity in the water column during mining operations.

    (b) long- term monitoring of ecological impacts shall consist of:

        (i) establishment of at least two control sites, and at least four impacts sites;

        (ii) surveys, consisting of seabed photographs and / or videos and seabed samples, which provide sufficient data to quantitatively assess changes in the structure of epifaunal and infaunal communities; and

        (iii) these surveys shall take place at least every four months during the first 12 months of mining operations and every year thereafter while mining operations are occurring.

    (c) recolonisaton monitoring:

        (i) after completion of the first mining block, the biodiversity of the benthic communities will be assessed annually for five years and thereafter every second year for the next 10 years. Sample locations shall extend out from the edge of the mining block up to a point at least 2 km away. Surveys shall consist of seabed photographs and / or videos and seabed samples, which shall provide sufficient data to quantitatively assess changes in the structure of epifaunal and infaunal communities.

(d) if determined by the Consent Holder, in consultation with appropriately qualified environmental scientists and the Chief Executive, that it is viable and of value to create new hard substrate to enhance biodiversity within the area covered by this consent, the Consent Holder shall:

(i) establish four test sites, in appropriate locations. These sites shall be surveyed annually for five years after they are established and thereafter every second year for the next 10 years. Surveys shall consist of seabed photographs and / or videos.

Reporting

33. No later than 30 April and 31 October during the first two years of mining operations, and thereafter no later than 31 October of each year, the Consent Holder shall forward a report to the Chief Executive.

34. The report in relation to the period it covers shall include, but not necessarily be limited to, the following:

(a) assess compliance with the conditions of this consent and provide detailed explanations of any non-compliance and measures taken accordingly to remedy these;

(b) provide an appropriate record of the ERG meetings;

(c) analyse and summarise the results of monitoring undertaken in accordance with the conditions of this consent, and, if appropriate, make recommendations in relation to monitoring programme changes;

(d) summarise and analyse incidents or complaints receiving during the reporting period;

(e) provide an overview of the funds held by the Trust established in accordance with Condition 41, the activities funded by the Trust and the outcomes or results arising from this funding;

(f) provide an overview of other deliverables prepared and provided to the Chief Executive in accordance with the conditions of this consent. This includes whether any adaptive management approaches have been or are to be implemented, the Mine Plan, the EMMP and any other subordinate management plans; and

(g) detail any other issues considered important and relevant by the Consent Holder.

Incidents and Complaints

35. The Consent Holder shall establish and publicise a telephone number so that there is a known point of contact for any matters that may arise from the Consent Holder's mining operations. This number shall also be advised, in writing, to the Chief Executive and the ERG. At a minimum, the Consent Holder shall ensure that during standard working hours an appropriate contact person can be reached on the phone.

36. The Consent Holder shall maintain and keep a register of any environmental incidents or complaints that are associated with activities authorised by this consent. Upon becoming aware of any environmental incident or complaint, the Consent Holder shall:

(a) record the date, time and duration of the event or incident;

(b) if a complaint is received, the time at which it was received, and if the complainant is willing to provide the information, the complainant's name, contact details and their location and the time of the event or incident;

(c) the cause or likely cause of the event or incident and any factors that influenced its severity;

(d) the nature and timing of any measures implemented by the Consent Holder to avoid, remedy or mitigate any adverse effects, if any, associated with the event or incident;

(e) the steps to be taken in future to prevent the recurrence of similar events or incidents; and

(f) any other relevant information.

All of the above actions are to be recorded on the register.

37. In circumstances where an event or incident is likely to result in a non-compliance with the conditions of this consent, then the Consent Holder shall advise the Chief Executive, as soon as practicable and no later 24 hours after the event or incident occurring.

Other Conventions and Legislation

38. The Consent Holder shall ensure that it complies with the requirements of relevant international Conventions.

39. The Consent Holder shall ensure that it complies with the requirements of other relevant statutes and regulation. This includes, but is not limited to, the Biosecurity Act 1993, the Marine Mammals Protection Act 1978, the Maritime Transport Act 1994 and associated Regulations and Rules, and the Wildlife Act 1953.

40. Within one month of finalising specific documentation required under other international obligations, statutes or regulations, the Consent Holder shall provide a copy to the Chief Executive of the following:

(a) an International Oil Pollution Prevention Certificate;

(b) A Shipboard Oil Pollution Emergency Plan

(c) A Ballast Water Declaration in accordance with the provisions of the Biosecurity Act 1993; and

(d) The permit to take coral in accordance with the provisions of the Wildlife Act 1953.

Environmental Compensation

41. The Consent Holder, through the establishment of a Trust, shall provide environmental compensation for those areas of its environmental impacts that cannot be avoided, remedied or mitigated. The Trust is to be established at least 12 calendar months prior to the commencement of any activities authorised by this consent. Trustees shall include, but not be limited to:

(a) a representative from CRP, as the Consent Holder;

(b) a representative from the Department of Conservation;

(c) a suitably qualified deep-water marine scientist;

(d) a representative from Iwi / Imi; and

(e) a representative from an environmental non-government organisation with an interest in the marine ecosystems of the EEZ.

42. The purpose of the Trust is to administer annual funding, to be settled on the Trust by the Consent Holder, of $200,000 per annum (annually adjusted for inflation), for the duration of this consent or at the cessation of mining operations, whichever is earlier.

43. The objectives of the Trust are:

(a) to advance environmental and biodiversity enhancement in the marine environment of the Chatham Rise, and on or around the Chatham Islands;

(b) to support scientific research of the Chatham Rise, in particular geographic areas and biological communities relevant to the Consent Holder's mining operations; and

(c) to support research into and technological improvements in seabed mining methods which reduce or mitigate adverse effects on the marine environment.

Protection of Mining Exclusion Areas

44. Prior to undertaking mining operations under this consent, the Consent Holder shall:

(a) In consultation with the Ministry of Business, Innovation and Employment – NZ Petroleum & Minerals, the Department of Conservation and other interested parties, use best endeavours to establish a legal mechanism to protect the areas referred to in Condition 9(a) and (b), and other areas outside of the marine consent area but identified from the marine spatial planning exercise undertaken by the Consent Holder, from future mining operations and any other activities that would disturb the seabed ; and

(b) Upon either:

(i) the legal mechanism being established; or

(ii) best endeavours being exhausted,

the Consent Holder shall provide evidence to the Chief Executive, for the purposes of approval, of a satisfactory legal mechanism being established or best endeavours discussions being exhausted.

Advice Note: *This condition is a proffered condition intended to further protect the mining exclusion areas. It is in addition to the legal protection that is to be sought under Condition 9(a) and (b).*

Non-lapsing and Non-cancellation of Marine Consent

45. During the first 10 years following the grant of this consent, this consent shall not be liable to lapsing pursuant to section 85 of the EEZ Act or cancellation pursuant to section 86 of the EEZ Act.

Marine Consent Review

46. The EPA may, within two months of the second anniversary of the grant of this marine consent, and every five years thereafter, serve notice to the Consent Holder, in accordance with sections 76 and 77 of the EEZ Act, of its intention to review either the duration and / or the conditions of this marine consent for the purposes described in section 76(1) of the EEZ Act.

47. At any time, if an adaptive management approach, in accordance with Conditions 14 and 15, has not been considered to be achievable by the Consent Holder following completion of an

assessment carried out in accordance with these conditions, the EPA may serve notice to the Consent Holder, in accordance sections 76 and 77 of the EEZ Act, of its intention to review either the duration and / or the conditions of this marine consent.

11.5 Summary

Sound environmental management processes to avoid, remedy and mitigate potential and actual adverse environmental impacts will be incorporated into CRP's proposed EMS, including an EMMP and supporting procedures and management plans.

Most importantly, a process which provides a feedback loop between the investigation and review of monitoring results and CRP's operational activities has been identified and will be implemented when mining operations commence on the Chatham Rise. This process will ensure that if unexpected impacts occur then they will be minimised by the adoption of appropriate mitigation measures, where achievable. This reflects an adaptive management approach.

These environmental management activities are the key controls for the proposed mining operations and have been incorporated into proposed marine consent conditions. An adaptive management approach whereby mining will be restricted to the mining permit area and mining will only be able to move into CRP's prospecting areas once specific requirements have been met has also been incorporated into these conditions.

12. Alternatives Assessment

KEY ELEMENTS

- The 'do nothing' alternative (i.e., not to mine) is not a desirable alternative given the presence of the phosphorite resource, the fact that it can now be mined and mining of the resource will have economic benefits for New Zealand.
- The proposed marine consent area, particularly the area associated with the mining permit, contains the greatest known concentrations of the phosphorite resource.
- A trailing suction drag-head is the most appropriate mining method (rather than use of a ROV or mechanical excavation).
- On-board processing of the seabed material (rather than separation at the seabed or onshore) is the best option from an economic and environmental perspective.
- Return of the processed non-phosphatic material close to the seabed (at the seabed or 10 m above, rather than at the sea surface or at intermediate water depths) is the best option because it minimises environmental impacts, particularly the extent of sedimentation and the plume.
- The selected mining pattern minimises the potential to cover unmined areas with processed non-phosphatic material while maximising the amount of the time the vessel is mining.
- Factors affecting these decisions included technological feasibility and risks, economic viability and the potential impacts on the environment.

12.1 Introduction

Best practice requires the consideration of alternatives, including alternatives to the project, the location of the project, and the methods to be utilised to avoid or minimise potential adverse environmental impacts associated with the project. In addition, section 39(1)(g) of the EEZ Act requires that any impact assessment seeking a marine consent for an activity needs to *"specify any possible alternative locations for, or methods for undertaking, the activity that may avoid, remedy, or mitigate any adverse effects".*

Although sections 20A and 20C of the EEZ Act are not yet in force, CRP has nevertheless addressed relevant considerations in relation to mining discharges (i.e., the return of the non-phosphatic material to the seabed), including those in section 87D (also not yet in force).

This section of the EIA outlines CRP's consideration of alternatives that had, or have, implications for the nature and extent of potential impacts associated with the proposed mining operations on the Chatham Rise. CRP's consideration of these alternatives has assisted them in refining the proposal to achieve an environmentally responsible mining project. However, as assessed in Sections 8 and 9, this does not mean that all potential impacts of CRP's proposed mining operations have been avoided and no impacts will occur.

The alternatives discussed below include whether to mine or not (the 'do nothing' alternative), alternative locations for the mining proposal, and alternative mining methods.

12.2 Do Nothing

The first alternative is whether to retain the status quo and do nothing. That is, whether or not to mine the phosphorite nodules on the Chatham Rise at all.

This option would ensure that potential impacts arising from the mining proposal would not occur, but it would mean that a potential resource, namely phosphorite, would remain on the Chatham Rise. As described in the Economic Assessment (Appendix 6), this means that the economic value of the phosphorite resource would remain untapped and the potential benefits to New Zealand's fertiliser industry, the increased productivity of New Zealand farming and the economic benefits from increased export income could not be realised.

A decision not to mine the phosphorite would potentially delay, rather than remove, the realisation of these benefits as the resource would remain on the Chatham Rise for use by future generations should they so wish.

As outlined in Section 1.1, the Chatham Rise phosphorite deposit is the most significant known deposit within New Zealand. Currently the phosphorite used for fertiliser manufacture in New Zealand is imported, predominantly from Morocco. Studies show that Chatham Rock phosphorite may be more effective for pasture growth than the currently used superphosphate, with less environmental impact. In addition, it contains significantly lower concentrations of cadmium, reducing the long-term risk of cadmium contamination of soil, pasture and livestock.

Recognising these facts, and given that CRP and its technical partner Boskalis have identified that mining is now feasible and can be undertaken economically, CRP consider that mining the Chatham Rise phosphorite can successfully complete, economically and environmentally, with importing phosphorite from Morocco.

Therefore, given the technological and economic viability of the proposal which incorporates responsible environmental management, CRP considers that the 'do nothing' option is not a desirable option.

Mining of Chatham Rise phosphorite has a number of benefits for New Zealand. These matters are discussed in more detail in the Economic Assessment contained in Appendix 6.

12.3 Location

The Chatham Rise phosphorite deposit is the most significant known phosphorite deposit within New Zealand's EEZ, and this area is the best and only economically viable location for phosphorite mining close to New Zealand. Therefore CRP has focussed its research and exploration on the Chatham Rise deposit.

As outlined in Section 3, research carried out between 1952 and the early 1980s identified the areas on the Chatham Rise with the highest volumes of potentially mineable phosphorite nodules. CRP's minerals prospecting licence (MPL 50270) covered the area which, based on estimates of phosphorite nodules concentrations, has the most potential for an economically viable mining operation. MPL 50270, including the area which CRP has offered to relinquish, covers an area of about 4,726 km^2, approximately 2.5 % of the area of the Chatham Rise shallower than 1,000 m[45].

Further exploration and analysis carried out by CRP since the granting of MPL 50270 has refined the estimate of the extent of the most valuable phosphorite resource. As a result, CRP now proposes to

[45] Depending on how much of the 'flanks' of the Chatham Rise are included in the estimate, the area is approximately 95,000 to 410,000 km^2. However, throughout this EIA, 188,000 km^2 has been utilised as the figure representing the area of the Chatham Rise (i.e., the area above the 1,000 m water depth contour).

focus initial mining activity on 820 km^2 at the western end of MPL 50270. Although on-going exploration activities may result in requests for expansions of the mining areas within CRP's proposed prospecting licence and permit areas (total area of 10,199 m^2), exploration activities to date have identified this mining area as containing the greatest concentration of the resource, making it the most economic area to start mining in.

CRP's decision to proceed with its proposed mining operations initially within the areas of greatest known concentration of phosphorite nodules has included consideration of environmental control measures on the mining approach. These measures include the refinement of the mining methods to minimise potential impacts, proposed environmental mitigation, and the management and monitoring measures outlined in Sections 10 and 11.

12.4 Mining Approach

12.4.1 Overview

Section 4 describes the proposed mining operations, including the conditions that have influenced the choice of mining method, such as the metocean and seabed conditions and the environmental constraints. Metocean and seabed conditions (the slope of the seabed and areas of rock outcrops) influence operational considerations, rather than environmental outcomes per se, and therefore these matters are not considered further within this section of the EIA.

The mining approach revolve is designed to minimise the potential impacts associated with the release of fine material during mining, release and dispersion of fine material during the return of processed sediment to the seabed, the total volume of water to be handled on the vessel, and the area of seabed disturbed during and after mining.

Given these considerations, the options considered in relation to the mining approach are:

- Mining method.
- Separation of mined seabed material.
- Return of the processed non-phosphatic material.
- Mining pattern.

12.4.2 Mining method

During the mine feasibility assessment phase of the project, Boskalis considered which mining operations were technically feasible and that also followed the principles of best practice for the protection of the environment[46].

The mining options available, albeit modified to meet the requirements of the site (i.e., depth to the resource and harsh sea conditions), are:

- **Remotely Operated Vehicles (ROV) or crawlers.** ROV or crawlers are seabed based vehicles connected to a vessel by an umbilical. Mechanical or hydraulic excavation methods (see below) could be utilised on an ROV. An ROV could be 'driven' on the seabed and could move in different directions as required across the resource, or mining, area. The major disadvantages associated with ROV operations in relation to CRP's proposed mining activities, are the uncertainty associated with traction on the seabed (i.e., it may be stuck or topple), and the amount of complex equipment at the seabed. Also, manoeuvrability, one of the key benefits of ROV operations, is not required for CRP's proposed mining system.

[46] Boskalis utilised PIANC 100, entitled "Dredging Management Practices for the Environment -A structured selection approach", for guidance during this option assessment process. PIANC is the "Permanent International Association of Navigation Congresses".

- **Mechanical excavation methods**. Traditional mechanical excavation and lift methods such as bucket line, grab and backhoe, are not practicable at the water depths within the proposed marine consent area. Drilling methods were not considered as not only is this method ineffective in terms of the rate of recovery of material, the phosphorite is located within the upper layers of the seabed. Seabed mechanical systems that could potentially be used in conjunction with a hydraulic lift system include mechanical screw or cutterheads.
- **Hydraulic excavation methods**. Hydraulic excavation methods loosen the seabed material by suction and / or by water jets, and then raise it from the seabed through a pipe or riser system. Traditional hydraulic excavation methods which rely on a stationary vessel, platoon or barge are not applicable to CRP's proposed mining operation as it would be necessary to lift the equipment, move the mining vessel, then lower the equipment so that mining could be resumed until it was necessary to move once again. However, a trailing suction drag-head system, as proposed for this project, has the advantages of the mining vessel itself providing the main means of forward movement for the drag-head while minimising the need to lift the equipment from the seabed (and thus cease mining). A comparison of the trailing suction drag-head with the other mining method options is discussed below.

The reasons for choosing conventional trailing suction drag-head technology included:

- The mining tool needs to be simple, robust, versatile and flexible. The mining tool needs to be able to mine at a rate of about 1 m/s to be economically viable in areas of low nodule concentration. It needs to be able to cope with variable nodule concentrations and seabed characteristics, the thin and variable thickness of the resource, the remoteness of the mining site and the challenging sea conditions. A trailing suction drag-head with water jets (possibly assisted by cutting teeth incorporated into the drag-head) to loosen the seabed to be mined meets these requirements better than any other mining tool.
- A trailing suction drag-head, in conjunction with its support components, can be lifted and placed as desired. It can also be easily modified, repaired, deployed, recovered and exchanged.
- The trailing suction drag-head system is suspended from the surface vessel, thus avoiding drawbacks associated with systems such as crawlers that rely on the seabed to provide friction for traction and that can topple over or sink into the seabed.
- The trailing suction drag-head is relatively small (approximately 6 m wide) and of a moderate weight in the context of off-shore facilities. The drag-head will be designed to have reduced 'on-bottom traction' thus limiting its penetrating capacity and trail force. The pressure jets (with possible assistance from cutting teeth) used to loosen the phosphorite containing sediments will be adjusted to minimise cutting into the underlying ooze.
- The mining operation needs to minimise the potential to collect the chalk layer underlying the sediment containing the phosphorite nodules. Using mechanical excavation, like cutters, as the principal mining tool could loosen and collect more of the unwanted ooze than hydraulic excavation. This would have potential economic and environmental consequences if large amounts of unwanted ooze is collected or suspended within the water column.

12.4.3 Material separation

An initial option assessed by Boskalis was whether to bring all of the material back to port and carry out material separation on land rather than on the mining vessel. The advantages of this option were that operations at the Chatham Rise would be less complex and there would be no environmental impacts from disposal of the returns to the sea.

The disadvantages associated with this option included limitations on port space and/or permissions for material treatment. Also, 85 % of the material transported back to the port would be unwanted material that required storage and disposal (possibly on land or back into coastal waters). Processing of the material would include water handling, and water treatment (to remove suspended solids) and the disposal of both the water and unwanted material could be challenging. It would be uneconomic to use the mining vessel to convey the unprocessed material to port. Using a second vessel would be expensive and transfer of material at sea would be technologically challenging. Given these economic and environmental challenges, it was decided that 'on-site' separation at the Chatham Rise was preferable.

Having decided to separate the mined material on-site, two main options were then considered for materials separation. This was whether to carry out all material separation on-board the mining vessel or close to the seabed. Boskalis considered that on-board separation was the most practicable option and this is the option described in Section 4. The principal reason for this decision was the desire to minimise the amount of equipment on the seabed and in the water column and limit the potential risks and sensitivities associated with operating such equipment. Other challenges associated with separation equipment at the seabed include placing the returns away from the mining track, providing additional power, the hoisting equipment needed to accommodate the additional weight associated of the separation equipment, and developing the complex technology needed for efficient seabed separation.

Having decided to separate the mined material on-board the vessel, Boskalis then carried out an assessment of separation treatment options. The separation technology options considered included settling tanks for screening (relies on the fact that larger particles settle faster than smaller particles), sieves (trommel and flatbed), jetting equipment (to skim and suspend clay material), polishing and liquefaction equipment (e.g., log washer or pebble washer), hydro-cyclones for the separation of misplaced nodules and particles (< 1 mm), dewatering of separated fine material (< 1 mm) and crushing.

The phosphate nodules are concentrated in particles larger than 1 mm and therefore the initial design of the separation system focussed on retrieving phosphorite greater than 1 mm. Given the amount of material to be processed (i.e., approximately 10,000 m^3/hr), a one-stage separation plant (using any of the technology options identified above) for all material in excess of 1 mm is not a viable option and therefore was discarded. This option would require an extremely large screening area and it would not be able to handle the volume of clay and ooze also retrieved from the seabed.

Boskalis proposed an optimised separation system with components arranged in several streams to separate the phosphorite greater than 2 mm (i.e., retrieves a significant portion of the mined phosphorite, is efficient at 'cleaning' the retained nodules stored on the vessel and fits within the area available). The cut-off of 2 mm was accepted after analysis of laboratory data showed that this would not result in a significant loss of the resource, and engineering analysis showed that it would be much simpler to build and operate. This revised cut-off provides for the highest overall efficiency of the proposed mining operations. As a result, all sand sized material and smaller will be returned to the seabed via the return system (refer to Section 12.4.4 below).

The system is described in Section 4 and consists of a stage separation system with parallel processing steams for the small particles (i.e., between 2 to 8 mm) and the larger particles.

12.4.4 Return of processed non-phosphatic material

12.4.4.1 Introduction

Boskalis, as part of its initial investigations into the engineering viability of CRP's proposed mining operations, assessed the available options for the return of the mined material following separation and removal of the phosphorite resource to the seabed. The options considered were:

- Whether the returns should be treated, or modified, prior to disposal but following on-board processing
- Locations for disposal
- Water depths for the return of the processed material

12.4.4.2 Returns modification prior to disposal

Boskalis considered treatment of the returns with flocculants to 'thicken' them prior to discharge. The advantage of this treatment method is that the returns should settle to the seabed more quickly. Disadvantages associated with the use of flocculants are the formation of a 'fluffy layer' after the material settles on the seabed. This layer takes more time to consolidate than for non-treated returns, increasing the potential for re-mobilisation of sediment and increased turbidity, and the flocculants add to the cost of the resource processing. In addition, regardless of the nature of the flocculants, adding chemicals to the marine environment is perceived to be undesirable.

Boskalis decided that a well-designed mechanical disposal method (diffuser) rather than flocculants would give more effective control of the behaviour of the returns and a more manageable result.

For the purposes of section 87D(2)(a) of the EEZ Act, the return of non-phosphatic material to the seabed will not have any impacts on human health.

12.4.4.3 Locations for disposal

Disposing of the returns within the area being mined was considered the most appropriate option, principally because the material would be discharged within the disturbed (mined) area rather an area undisturbed by mining activities.

Three conceptual options were considered for disposal of the processed non-phosphatic material. The first two are effectively off-site options (i.e., away from the area being mined) and the third was to return the processed material to the area being mined. The off-site options were:

- **Separate disposal site using a second vessel.** This option involved loading the returns into a second vessel and then disposing of the material at a separate disposal site, possibly off the Chatham Rise. Although this option had the potential benefit of avoiding depositing returns over areas to be mined, it relies on being able to find a suitable location for disposal. It was considered that it was more appropriate from an environmental perspective to return the processed material to the area disturbed by the mining rather than disposing of the material elsewhere and disturbing two areas by the mining activities. In addition, the operational complication of transferring to a second vessel on the Chatham Rise, given the rough sea conditions at times, and the need to ensure that any disposal location was located close enough to be economical meant that this option was discarded.

- **Separate disposal site using a transfer pipeline.** This theoretical option would be similar to the above option except it relies on the use of a transfer pipeline (transferring the processed material to a location in deep water off the flank of the Chatham Rise, possibly up to 100 km away) rather than a second vessel. However, this option is considered to be feasible only for a stationary mining vessel, which is not the case for CRP's proposed mining operations and / or where the disposal location is no more than 5 km away (the maximum extent of any transfer pipeline). Therefore, this option was not viable.

12.4.4.4 Water depths for the return of the processed non-phosphatic material

As outlined in Section 4, returns disposal at or near the seabed is the preferred and is the concept incorporated into CRP's proposed mining operations at the Chatham Rise.

Having made the decision to return the processed material to the area being mined (i.e., directly beside the mining vessel), Boskalis considered a range of water depths for disposal:

- **Disposal of the returns at or near the sea surface**. This option involved disposing of the material at or near the surface and thus within the photic zone (where photosynthesis occurs). The key disadvantage associated with this option is the returns could potentially restrict light penetration within the photic zone and thus reduce productivity. Also, waves, as well as ship propellers, could exacerbate upward mixing of the sediment into the surface water thus leading to an extended, and possibly visible, sediment plume. For these reasons, this option was discarded.

- **Disposal of the returns at intermediate water depth**. This option involved disposing of the processed non-phosphatic material in the water column below the photic zone. Although a cost effective option from an engineering perspective, initial modelling work carried out by NIWA and Deltares (summarised in Section 8.4) indicated that the extent of the plume generated as a result of this discharge location was large compared with the option of discharging the returns at or near the seabed (as discussed below). Compared to the near or at seabed option, this option also did not maximise the potential for the majority of the material to settle within the areas already disturbed by the mining operations (i.e., the returns would be spread over a wider area). For these reasons, this option was discarded.

- **Disposal of the returns at or near the seabed.** Modelling carried out by Deltares has identified that releasing the processed material at or near the seabed (up to 10 m above the seabed) will result in a smaller sediment plume than other options, with most of the sand component of the returns settling within the mining areas (thus reducing the extent of sedimentation impacts on benthic habitats). It was therefore considered that discharge options where disposal occurred close to the seabed were worthy of further investigation.

  As outlined in Section 8.4, disposal at the seabed results in a smaller 'disposal area' than if the returns are discharged at 5 or 10 m above the seabed. However, Boskalis considers that it may not be technically feasible to discharge at the seabed because the engineering challenges may not be solvable with current technology (it is known that 10 m above the seabed, on average, is feasible from an engineering perspective). The engineering issues arise from the stresses on cables and equipment associated with ensuring the diffuser head sits on the seabed during all weather, and ensuring that the diffuser does not become tangled with the drag-head unit. Boskalis will continue technical studies to investigate how to overcome these challenges.

12.4.5 Mining pattern

The 'spiralling out' option (outlined in Section 4) is the mining pattern that CRP proposes to utilise on the Chatham Rise. This mining pattern was developed by Boskalis following evaluation of operational and environmental factors. The strategic aim of the mining pattern is to minimise re-handling of material (i.e., mining the processed material returned to the seabed) while ensuring that the mining blocks themselves are 'touched only once'.

Given this aim, the key parameters for the proposed mining pattern are the area of seabed that will be covered with returns and the operational performance of the vessel and mining system (the vessel's turning time and turning radius).

Four mining pattern concepts were assessed (refer Figure 150):

- **Option A** ('up-down'). This option required the diffuser to be manoeuvred to either side of the mining head so that the vessel can turn on the spot (i.e., because the drag-head is also lifted clear of seabed). Under this option, within the mining area only one strip would be left covered by returns but left un-mined, while another strip would be mined but uncovered by the processed material returned to the seabed. Irrespective of the strips left un-mined, given the practical and engineering challenges associated with being able to move the diffuser and given the proposal to locate the diffuser on the opposite side of the vessel (or separated by half a vessel width) to the drag-head, this option was discarded.
- **Option B** ('moving rectangular'). This option also required the diffuser head to be able to move to either side of the vessel. It was considered because it was expected to save manoeuvring time. However, after investigation it was found that for a conventionally propelled vessel it could save manoeuvring time, but for a vessel with azimuth propellers as proposed for CRP's mining vessel, it will not. Overall there is no saving in time compared to Option A, with more area left un-mined. Hence, Option B was discarded.
- **Option C** ('spiralling-in'). The diffuser head will be on one side of the mining vessel which means that the return system, from an engineering perspective, is simpler. Starting with a wide rectangle minimises the un-mined area but increases the traversing time. Under this option, the next rectangle can return the processed non-phosphatic material on the same strip as the previous rectangle (i.e., the mined strip is eventually covered by approximately two times the original layer thickness, refer to green area in Figure 150).
- **Option D** ('spiralling-out'). This option can use the same return system as Option C. A central strip will be covered by two layers of returns, leaving two mined strips uncovered by processed non-phosphatic material. Traversing time is equal to Option C. In the central strip, returns are disposed directly adjacent to a strip yet to be mined (no vessel's width in between), which increases the amount of returns in parts still to be mined and/or reduces the operational flexibility. Option D offers no efficiency advantages compared to Option C except that this option does not result in an un-mined area becoming covered in two layers of processed non-phosphatic material.

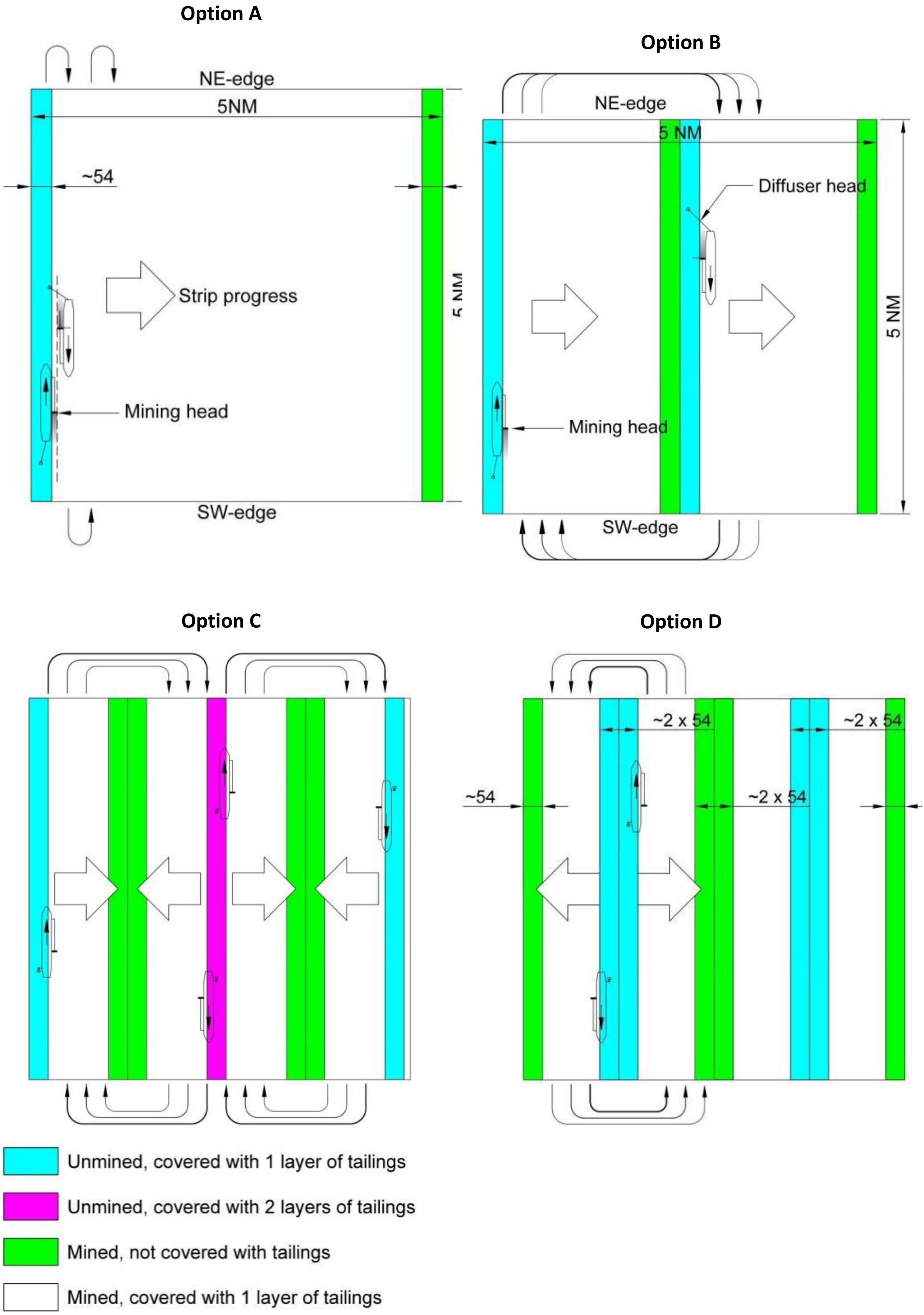

Figure 150: Mining pattern options.

12.5 Summary

From the assessments that have been undertaken by CRP and Boskalis, CRP consider that the mining of phosphorite from the Chatham Rise is technologically and economically viable. The resource is available and the proposed operation has a number of benefits for New Zealand. On this basis, the 'do nothing' alternative is not considered to be a desirable alternative.

The choice of location of the mining activity (the proposed marine consent area) is based on previous research and CRP's recent voyages and data analysis. The mining area, particularly the mining permit area, is estimated to contain the greatest known concentrations of the phosphorite resource and therefore represents the best location for the proposed mining activity.

In developing the mining approach, alternative options were considered for the seabed mining method, material separation, handling of the return of the processed non-phosphatic material and the mining pattern. The assessment of these alternatives considered technological feasibility, economic viability and the potential environmental impacts. Minimising potential environmental impacts was a key factor in the final decisions for each of these mining elements.

These decisions have resulted in the proposed mining approach which uses a trailing suction drag-head (rather than use of a ROV or mechanical excavation), on-board processing of the seabed material (rather than seabed separation or off-site processing) and return of the processed material from the mining vessel close to the seabed (rather than at the sea surface, at intermediate water depths or at a site remote from the mining activity). The chosen mining pattern was selected to minimise covering unmined areas with returns and to maximise the mining efficiency.

13. Conclusions

In the 1970s and 1980s exploration and field trials identified that phosphorite nodules from the Chatham Rise could meet New Zealand's fertiliser needs for at least 25 years. For a variety of reasons commercial mining of this resource was not considered feasible at that time.

However, given recent increases in the market value of phosphorite, driven largely by demand for protein rich food in emergent developing countries, and advances in offshore mining methods, CRP considers that it is now economically feasible to mine the Chatham Rise phosphorite resource. Mining this phosphorite resource will improve New Zealand's security of supply for a resource which is of significant importance to the country's agricultural sector. The economic benefits of the project are also considered to be significant.

CRP proposes to initially mine phosphorite from an 820 km^2 area on the crest of the Chatham Rise. This initial area is associated with CRP's mining permit. Mining operations may in future extend into other parts of the proposed marine consent area (10,192 km^2), subject to the outcomes of resource assessments, meeting the requirements of the adaptive management process incorporated into the suggested marine consent conditions, and the granting of mining permits for these areas. The production target, mining system and mining operations will not change significantly if mining extends beyond the current mining permit area.

Mining will be carried out from a specially designed mining vessel. The phosphorite bearing material will be retrieved from the seabed via a trailing suction drag-head. This material will be lifted to the vessel where the phosphorite nodules will be separated from other seabed material. The phosphorite will be stored in the vessel's holds for transport to a port and the remaining material will be returned to the seabed. CRP proposes to mine about three 10 km^2 mining blocks per annum to meets its annual minimum production target of 1.5 Mt of phosphorite.

This EIA has assessed the potential impacts of the project on the marine environment as well as social, cultural and economic considerations, utilising an environmental risk matrix approach, in accordance with the requirements of the EEZ Act and the Marine Mining Code.

The assessment of the potential impacts on the marine environment considers that the physical impacts from drag-head operations, water and sediment quality impacts, impacts on conservation values, impacts on commercial fisheries (including on the Chatham Rise and at the Chatham Islands), noise impacts, vessel waste discharges, marine biosecurity and project operations risks are minor and also of low to medium environmental risk, including after the proposed application of industry best practice approaches avoidance and mitigation measures. Potential impacts on seabirds from vessel lighting prior to the application of mitigation measures (as outlined in the draft LMP) were originally assessed as a medium to high environment risk, but following the application of proposed avoidance, remediation and mitigation measures the potential environmental risk reduced to medium or low. Mining will also result in cumulative impacts on benthic resources on the crest of the Chatham Rise but this loss is proportionally small when compared with the area that has been affected by fishing activities.

The other potential impacts (the loss of benthic habitat and fauna within the mining blocks and sedimentation impacts on benthic habitat adjacent to the mining blocks) remain a high or serious environmental risk, within the mining area, even after the adoption of proposed mitigation measures. For this reason, a programme to monitor the actual impacts, including the nature and timing of recolonisation of mined areas, to improve understanding of the actual significance of these impacts has been developed. CRP has committed to adopting an environmental compensation package for these potential impacts.

In relation to potential social impacts, CRP recognises that the Chatham Islanders and existing interests have a direct relationship with the Chatham Rise and for this reason CRP has consulted with them to understand their interest in the mining proposal. As a result of consultation with the Chatham Islands community, as part of the project CRP has committed to a range of potential benefits specifically focussed to benefit Chatham Islanders. Potential impacts on existing interests (i.e., commercial fishers, including Iwi commercial fishers, and vessels using or transiting through the area) have been assessed as having a low environmental risk. The potential social impacts are considered to be positive.

In relation to the economic benefits of the project, an extra NZ$265 million per year of export revenue will be generated, and phosphorite imports will be reduced by NZ$85 per year. Domestic consumption will increase with a predicted welfare gain of NZ$130 million per year of mining, and implementing the project over a 15 year period will be equivalent to New Zealand becoming NZ$900 million richer today. GDP will be boosted by NZ$280 million per annum.

Potential impacts on cultural values are continuing to be discussed with Moriori, Ngati Mutunga, and other Iwi who may have a cultural interest in the project, including Ngai Tahu.

Other potential positive impacts associated with CRP's proposed mining operations include reduced nutrient run-off if Chatham Rise phosphorite is applied directly to land, reduced cadmium build up in New Zealand soils, an improved knowledge and understanding of New Zealand's marine environment and increased employment opportunities as a result of supporting activities, such as at the port used by CRP.

Based on the assessment contained within this EIA, including the proposed mitigation strategies, environmental management process (including adaptive management measures) and environmental compensation package, it is considered that CRP's proposed mining operations will achieve the purpose of the EEZ Act (section 10). Any impacts beyond the mining area will effectively be avoided, remedied and mitigated and therefore the life-supporting capacity of the wider Chatham Rise environment will be safeguarded (irrespective of the loss of benthic habitat within the mining blocks). Within the mining blocks, the benthic environment will be adversely affected and the recolonisation of the seabed, especially for slow growing species such as corals, will take some time. Proposed avoidance, remediation and mitigation measures include mining exclusion areas identified through the marine spatial planning exercise to avoid impacts on areas of particular sensitivity or value. These measures will not fully off-set the loss of habitat within areas being mined and therefore a package of environmental compensation is also proposed.

In conclusion, the natural resources (excluding the parts of the phosphorite resource that will be mined[47]) of the Chatham Rise will be sustained for future generations. The mining also provides for sustainable economic management as there are significant positive economic impacts associated with the project, not just for CRP but for New Zealand as a whole.

[47] Section 10(2)(a) of the EEZ Act identifies that mineral resources do not need to be sustainably managed. This recognises that once a mineral, in this case the phosphorite nodules, is removed it no longer available for future generations.

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