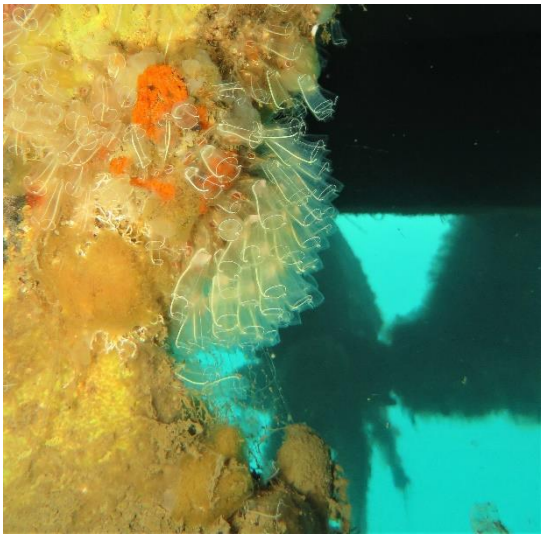
Long-term indicators for non-indigenous species (NIS) in marine systems

Updated 2018

Prepared for Ministry for the Environment

October 2018



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NIWA CLIENT REPORT No: 2018310CH
Report date: October 2018
NIWA Project: MFE19501

Quality Assurance Statement		
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Cover Image: The lightbulb ascidian *Clavelina lepadiformis* as hull biofouling. [Chris Woods, NIWA]

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Executive summary

Marine non-indigenous species (NIS) are classified as a 'National Indicator' of the condition of New Zealand's marine environments. The 2016 assessment of New Zealand's marine domain – "Our Marine Environment 2016" – reported on three indicators of the status on NIS in NZ's waters:

- Time series information on the presence/absence of NIS in New Zealand waters, and by region.
- Range expansion/decrease for the key selected species.
- Information on the abundance/prevalence and change in abundance/prevalence for key selected species.

To meet the requirements of the upcoming "Our Marine Environment 2019" report, the Ministry for the Environment (MFE) requires an update on these indicators that includes data on NIS compiled since 2016.

As of March 2018, there were 377 NIS that had been recorded in New Zealand marine waters; 213 of these were found in natural habitats or on permanent artificial substratum and are considered to have established self-sustaining populations. Between 2016 and March 2018, 14 species that are considered new-to-New Zealand were detected and identified. Only three of these species are considered to have established naturalised populations. The additional 11 species were recorded from vessels and other structures that are not permanently located in New Zealand.

We calculated changes in the distribution and relative abundance of nine 'key species'. The nine species were:

- Asian bag mussel, *Arcuatula senhousia;*
- Asian paddle crab, *Charybdis (Charybdis) japonica;*
- Australian droplet tunicate, *Eudistoma elongatum;*
- Greentail or 'greasy-back' prawn, *Metapenaeus bennettae;*
- Mediterranean fanworm, *Sabella spallanzanii;*
- Clubbed tunicate, *Styela clava;*
- Fragile clam, *Theora lubrica;*
- The Asian kelp, *Undaria pinnatifida;*
- Indo-Pacific ascidian, *Symplegma brakenhielmi*.

The colonial ascidian, *S. brakenhielmi* was added to the 'key species' reporting list in 2018. It was first identified in New Zealand in 2015 and subsequently expanded its distribution rapidly over a short time frame, fulfilling the 'Invasive' criteria as described in McGeoch et al. (2012).

The Mediterranean fan worm, *S. spallanzanii,* continued to expand its distribution over the reporting period. Between 2015 and 2017, the cumulative area occupied by *S. spallanzanii* in Waitematā Harbour (measured as cumulative occupancy of 100 x 100 m grid cells) increased by 23 %. This corresponded with a 12 % increase in the number of grid cells searched, calculated using the

cumulative grid cell occupancy in the ports and harbours of the Marine High Risk Site Surveillance (MHRSS) programme between 2015 and 2017. Search effort remained consistent through time.

Three species expanded their latitudinal range since 2016 (Inglis & Seaward 2016). *M. bennettae* was recorded for the first time in the Bay of Islands in August 2017. *C. (Charybdis) japonica* was recorded for the first time in Tauranga Harbour in January 2018 and *S. brakenhielmi* was discovered in Whāngārei Harbour and then spread extensively throughout Waitematā Harbour in a short period of time.

1 Introduction

The *Environmental Reporting Act 2015* established a framework for reporting on the condition of New Zealand's environments. The framework requires regular reports on five environmental domains: air, atmosphere and climate, fresh water, land, and marine. Information is required to address three general topics for each domain:

- human activities and natural factors that influence the condition of the environment ('pressures');
- the biophysical condition of the environment (its 'state'); and
- how changes in the condition of the environment affect New Zealand society and natural resources ('impact').

Information on the state of indigenous biodiversity and ecosystems is provided for the land, freshwater and marine domains.

Statistical measures are used to report on specific aspects of each environmental domain and to track trends over time. Marine non-indigenous species, have been classified as a national indicator for New Zealand's marine domain and indigenous marine biodiversity.

Inglis and Seaward (2016) developed a set of indicators to report on non-indigenous species in marine systems for the Ministry for the Environment (MfE). The indicators contributed to the 2016 national assessment of the overall condition of New Zealand's marine domain, as reported in the "Our Marine Environment 2016" report (Ministry for the Environment & Statistics New Zealand 2016). The Ministry is now seeking to update information on the indicators for non-indigenous species (NIS) using data current to 2018. The updates include data on NIS compiled for the years 2016, 2017 and records collected up until 1 March 2018. As in the previous series (Inglis & Seaward 2016), summaries of the data will report on:

- time series information on the presence and establishment of non-indigenous species (NIS) in New Zealand waters, and by region;
- range expansion/decrease for the key selected species;
- information on the abundance/prevalence and change in abundance/prevalence for key selected species.

This report also describes the:

- methodology used to obtain and analyse the data;
- findings, including summary statistics and trends;
- uncertainty surrounding the data;
- gaps in our knowledge of the presence/absence/prevalence of the key species;
- recommendations for further work to fill those gaps.

1.1 National data holdings and monitoring for non-indigenous marine species in New Zealand

Since 2001, the New Zealand Government has invested in a variety of activities that were designed to increase the information and knowledge surrounding existing and potential threats posed by NIS in the New Zealand marine environment. These included a range of baseline surveys in major shipping ports and marinas of first entry (Port Biological Baseline Surveys), a programme of surveillance for high risk marine pests (Marine High Risk Site Surveillance programme) and a taxonomic clearing house service (Marine Invasives Taxonomic Service, MITS) to support the Ministry for Primary Industries (MPI) – Biosecurity New Zealand's marine biosecurity operations.

As a provider of many of these services and, through its own biosystematics and biosecurity research, NIWA assumed a de facto curatorial role for much of the national data and collections on NIS within New Zealand. Since 2010, NIWA and Biosecurity New Zealand have worked to consolidate the data sources into a single point of reference: the Marine Biosecurity Porthole (www.marinebiosecurity.org.nz). The porthole is, however, not the only source of information on NIS in New Zealand. Research undertaken by universities and other institutions, and monitoring implemented by regional councils, other government agencies, industry and the public also collects observations on marine NIS. At present, this information is not consolidated nationally and is difficult to capture on an on-going basis. Seaward et al. (2015) and Inglis and Seaward (2016) provide information on these national programmes; their aims, target species lists, survey locations and how these data are collated for the purpose of this report (Figure 1-1 and Figure 1-2).

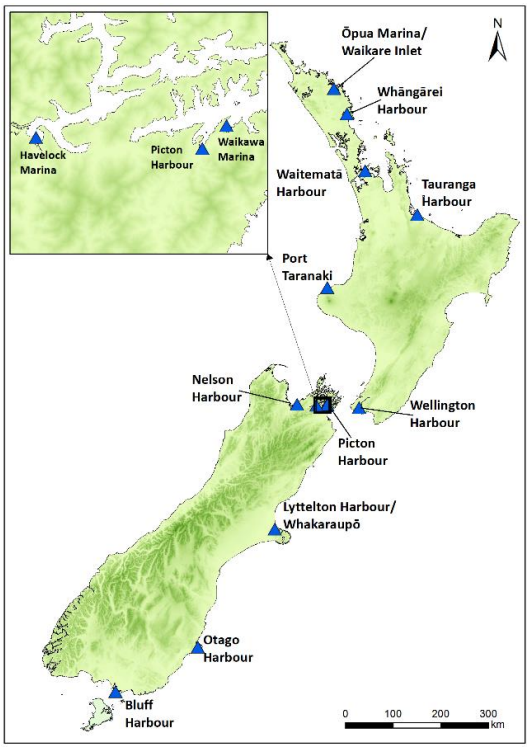

Figure 1-1: Locations of the 11 high-risk sites covered by the Marine High Risk Site Surveillance (MHRSS) programme.

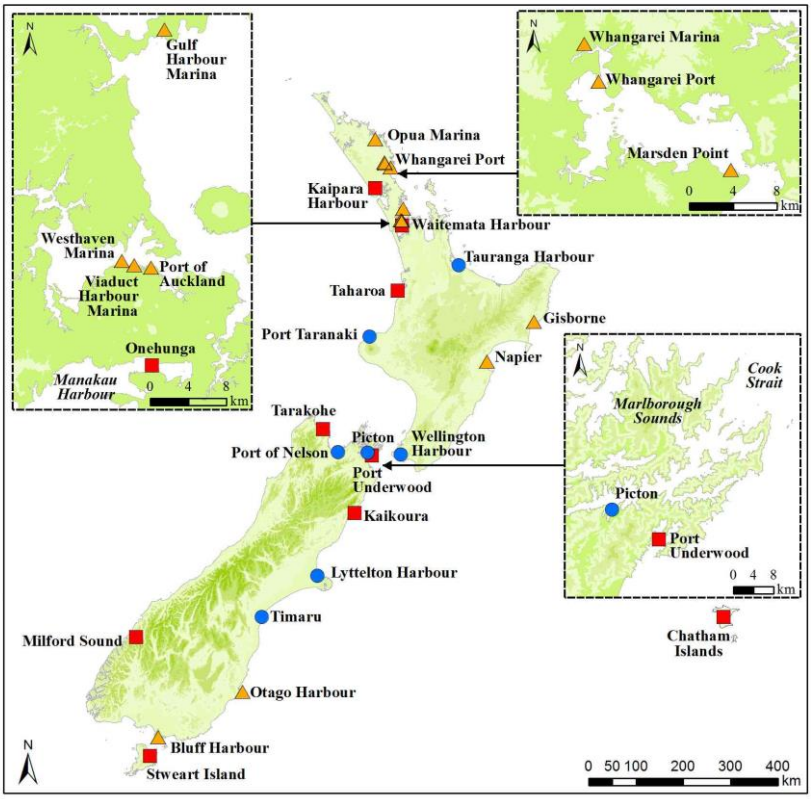

Figure 1-2: Commercial shipping ports and marinas where the Port Biological Baseline Surveys were undertaken. Blue circles = locations surveyed in 2001–2002 and re-surveyed in 2004–2005. Orange triangles = locations surveyed in 2002–2003 and resurveyed in 2005–2006. Red squares = locations surveyed only once between 2006–2007. Wellington harbour was also resurveyed for a third time in 2016.

1.2 Key Species

The '*Marine non-indigenous species'* indicator which this project contributes to, is used to measure the '*Pests, diseases and exotic species'* topic within New Zealand's Environmental Reporting Series. It aligns with the national '*Land pests'* indicator (Ministry for the Environment & Statistics New Zealand 2015). Eight marine species were nominated as 'Key Species' in 2016 to encompass a range of life habits, taxonomic and trophic groups that occur in a variety of different environments. The eight species also represent a broad time scale of introductions to New Zealand, from relatively recent incursions (e.g., *Sabella spallanzanii* (Gmelin, 1791) and *Metapenaeus bennettae,* Racek and Dall, 1965) to species that have been present in New Zealand for more than 40 years (e.g., *Theora lubrica* Gould, 1861). Each has been chosen because it fits at least one of the three criteria proffered by McGeoch et al. (2012) to classify a NIS as 'Invasive' (Invasive Alien Species, IAS):

- Criterion 1) Alien species that had a demonstrated impact on indigenous biodiversity in the country in question.
- Criterion 2) Alien species that had an extensive distribution range, are very abundant, or had a high population growth rate in the country.

- Criterion 3) Invasive elsewhere, i.e., the established alien species was invasive anywhere else (other than the country in question in the introduced range of the species based on criterion one or two).

Inglis and Seaward (2016) nominated eight key marine species that were intended to measure threats from NIS to New Zealand's cultural and natural heritage, and to economic activities such as commercial and recreational fishing, shellfish harvesting, and aquaculture (Ministry for the Environment & Statistics New Zealand 2015). These were:

- Asian bag mussel, *Arcuatula senhousia* Benson, 1842;
- Asian paddle crab, *Charybdis (Charybdis) japonica* (A. Milne-Edwards, 1861);
- Australian droplet tunicate, *Eudistoma elongatum* (Herdman, 1886);
- Greentail or 'greasy-back' prawn, *Metapenaeus bennettae* Racek and Dall, 1965;
- Mediterranean fanworm, *Sabella spallanzanii* (Gmelin, 1791);
- Clubbed tunicate, *Styela clava* Herdman, 1881;
- Fragile clam, *Theora lubrica* Gould, 1861;
- Undaria, *Undaria pinnatifida* (Harvey) Suringar, 1873.

A new colonial ascidian, *Symplegma brakenhielmi* (Michaelsen, 1904), first described in New Zealand in early 2015, is recommended as an addition to the list of key species for 2018. *S. brakenhielmi* is a colourful, very distinctive, encrusting ascidian that grows to approximately 100 mm in diameter (Page 2015). It has an extensive pan-tropical distribution that includes: Bermuda, USA, Puerto Rico, Australia, Ghana, Hawaii, New Caledonia and Israel. *S. brakenhielmi* was first detected from Marsden Cove marina in Whāngārei Harbour in February 2015. In 2017, it was recorded in Waitematā Harbour. *S. brakenhielmi* was not recorded at any survey locations in Waitematā Harbour during the winter 2016 MHRSS survey, but during the 2017 surveys was found extensively throughout the harbour (Figure 1-3). It appears to have a fast rate of growth and spread, but with marked seasonality.

A summary of invasive criteria, trophic functional group, habit and type of organism for the selected 'key species' are provided in Table 1-1 from Inglis and Seaward (2016), with the addition of the new species, *S. brakenhielmi.*

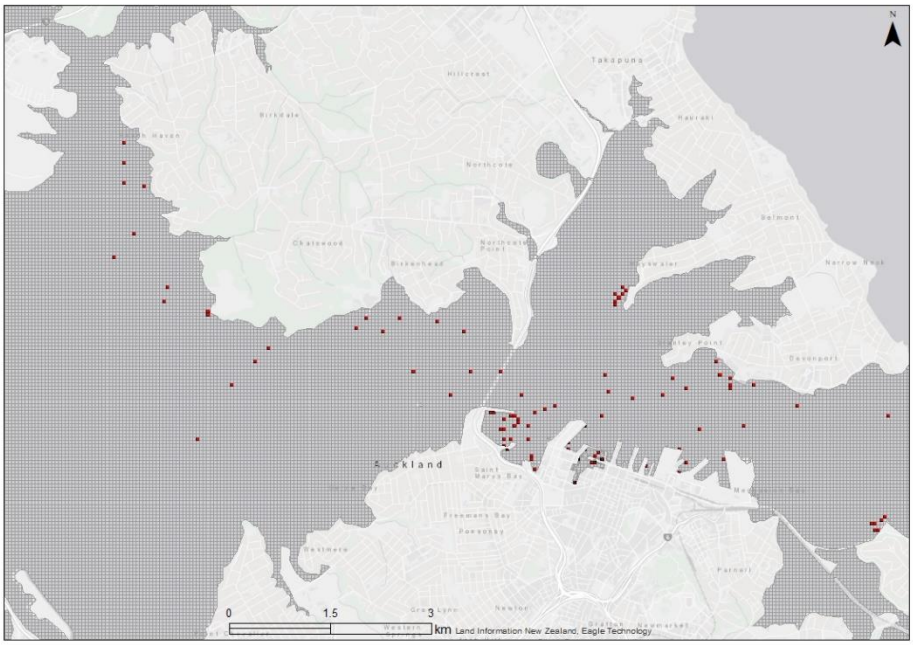

Figure 1-3: Grid cell occupancy of the presence of *Symplegma brakenhielmi* in Waitematā Harbour in 2017.

Table 1-1: Summaries of the nine key marine non-indigenous species proposed for indicators of trends in geographic range and abundance.

Common name	Species	Type of organism	Trophic functional group	Habit	Date of discovery in New Zealand	†Meets criteria for an IAS?
Asian bag mussel	*Arcuatula senhousia*	Bivalve mollusc	Macro-planktivore	Sedentary in intertidal and subtidal sediments	1978	1, 2, 3
Asian paddle crab	*Charybdis (Charybdis) japonica*	Swimming crab	Predator / omnivorous consumer	Mobile in subtidal estuarine environments (rocky reefs and soft sediments)	2000	1, 3
Australian droplet tunicate	*Eudistoma elongatum*	Colonial ascidian	Macro-planktivore	Sedentary attached to rocks, seagrass, mangroves and artificial substrata	2005	1, 3
Green tail or 'Greasy-back' prawn	*Metapenaeus bennettae*	Decapod prawn	Deposit feeder	Mobile in subtidal estuarine sediments	2009	3
Mediterranean fanworm	*Sabella spallanzanii*	Polychaete worm	Macro-planktivore	Sedentary attached to artificial substrata and shells or rocks in soft sediments	2008	1, 2, 3
Clubbed tunicate	*Styela clava*	Solitary ascidian	Macro-planktivore	Sedentary attached to rocks, shells or artificial substrata	2004	1, 2, 3
Fragile clam	*Theora lubrica*	Bivalve mollusc	Deposit feeder	Mobile within muddy subtidal sediments	1971	2, 3
Wakame / Undaria	*Undaria pinnatifida*	Brown alga (kelp)	Primary producer	Sedentary on rocky reefs and hard shorelines	1987	1, 2, 3
Indo-Pacific ascidian	*Symplegma brakenhielmi*	Colonial ascidian	Macro-planktivore	Sedentary attached to rocks, seagrass, mangroves and artificial substrata	2015	2, 3

† Criteria proposed by McGeoch et al. (2012)

2 Methodology

2.1 Time series

Data on the date of first record of NIS in New Zealand waters were compiled using queries from the central database that underpins the Marine Biosecurity Porthole (https://marinebiosecurity.org.nz/). Only NIS that are thought to have established populations in New Zealand marine environments were included in the summaries. Cryptogenic species or those whose biosecurity status in New Zealand is ambiguous are not included in the summaries. Species are classed as cryptogenic if it is not possible to determine their original native distribution and whether that included New Zealand. Similarly, species that are new to science and whose global distribution has not been adequately described are also considered cryptogenic (sensu Carlton 1996).

Whether or not a NIS has established in New Zealand waters is determined from sample location, the substratum on which it occurred, metadata and expert taxonomist personal communications. For example, species that have been collected only from vessels and which have not been found in natural habitats or on permanent artificial substratum are considered not to have established self-sustaining populations, pending further evidence. Information on the status of the species is updated when new specimens are identified on permanent substratum in the marine environment. For time series analysis, the number of species per year or decade were plotted against the year or decade in which they were first recorded in New Zealand. As discussed by Inglis and Seaward (2016), this representation does not account for variation in observation effort over time (i.e., sample bias).

2.2 Prevalence

Changes in the prevalence of key species were examined by analysis of the cumulative occupancy of 100 m x 100 m grid-cells in a grid created for the 11 MHRSS locations (Inglis and Seaward 2016). For each year of sampling, the number of grid cells that a species occupied during the MHRSS programme, was tabulated using ArcGIS. Data were then exported for summaries on grid cell occupancy rates and range expansion.

Geographic records for NIS were summarised by local government regions. Summaries were calculated spatially using ArcGIS. Shapefiles of New Zealand regional jurisdictions were used to allocate sampling locations to the correct area and mapped using equal interval symbology. These were calculated using all four sources of data for all NIS records until 1 March 2018.

2.3 Geographic range

Changes in the geographic extent of distribution of each key species within New Zealand were measured as changes in the maximum cumulative latitudinal range. This was calculated using the nationwide distribution of each species by year and retrieving the records from the northern- and southern-most latitudes to compare with previous years. This analysis was performed on all four sources of data and includes all NIS records up to 1 March 2018.

3 Trends and Summary Statistics

3.1 Time series

As at 1 March 2018, 377 NIS were identified in New Zealand marine waters, of which 213 had become established (Figure 3-1).

Changes to the taxonomic classifications of some species since the previous report has affected the total numbers of NIS known from New Zealand (Inglis & Seaward 2016). Inglis and Seaward (2016) reported that 318 NIS were known to be present in New Zealand in 2009. Re-examination of some species by specialist taxonomists has since caused the number of NIS to be revised upward. It is now thought that there were 328 NIS in New Zealand in 2009. A description of these taxonomic revisions is provided in Table 3-1. The revisions have also affected the numbers of NIS that were actually present in New Zealand in 2016. Three hundred and fifty one NIS were reported to have been present in 2016 by Inglis and Seaward (2016) but this number has also been revised upwards to 364 (Table 3-1). These changes are mostly due to revisions of the biosecurity status of species that were not previously considered to be non-indigenous or by re-identification of specimens made by taxonomists. As new samples are submitted for identification through MITS, new material can lead to re-evaluation of older preserved specimens. In some cases, analysis of DNA phylogeny can reveal cryptic or mis-identified species. This can result in changes to classifications and biosecurity status and, therefore, affect totals for analysis and statistical comparisons between reporting years.

For example, the colonial ascidian, *Botrylloides giganteum* (Pérès, 1949), was first recorded from specimens collected from Marsden Cove marina, Whāngārei Harbour, in 2014. DNA barcoding of the specimens led to a review of other specimens from the genus *Botrylloides* that had been collected earlier, in 2006. Although these older samples were initially thought to be the cryptogenic species, *B. leachii* (Savigny, 1816), re-examination confirmed that they were *B. giganteum*, so the date of first record was revised to 2006 (Page 2014 revised).

Between 2009 (328 species) and 2017 (377 species), the cumulative number of marine NIS in New Zealand waters increased by 15%. Using the revised number of NIS for 2016, a further 14 NIS that had not previously been recorded in New Zealand have been detected (to 1 March 2018) (Inglis & Seaward 2016). Only three of these species were recorded from natural marine habitats or permanent artificial substratum and are considered (Table 3-2) established.

An individual of the caprellid amphipod, *Caprella penantis* Leach, 1814, was detected in 2016 in Tauranga Harbour (Table 3-2) (Woods 2016). In 2017, several species of tropical fish were collected from a sailing cruise ship that was in dry dock in Auckland after having arrived from Tahiti. The fish were removed alive from the vessel's sea chest, but because they were not observed in natural marine environments, are not considered to have established self-sustaining populations in New Zealand (Figure 3-1,Table 3-2).

Two species of caprellid, and one tube-dwelling amphipod have established self-sustaining populations in New Zealand in the last two years. *Caprella scauroides* Mayer, 1903 and *Jassa* cf. *marmorata* Holmes, 1905 were both recorded from Waitematā Harbour at The Landing, Okahu Bay, Orakei (Peart & Woods 2017). Over 100 individuals of *C. scauroides* were collected from a recreational swing mooring over two separate sampling periods. Both *C. scauroides* and *J.* cf. *marmorata*, are part of larger complex of species that are morphologically difficult to identify. Further DNA analysis is being used to examine these records and those previously identified in New

Zealand as *Caprella californica*, Stimpson, 1856, which are part of the larger species complex, often confused with *C. scauroides* (Peart & Woods 2017).

Table 3-1: Revisions to the NIS present in New Zealand.

Class	Taxon Name	Year of discovery	Reason for correction
Actinopterygii	*Chironemus maculosus*	1989	Not previously recorded in database
Actinopterygii	*Gobiopterus semivestitus*	2004	Not previously recorded in database
Actinopterygii	*Parioglossus marginalis*	2000	Not previously recorded in database
Ascidiacea	*Botrylloides giganteum*	2006	Identification revised
Ascidiacea	*Diplosoma listerianum*	1994	Previously recorded as cryptogenic
Ascidiacea	*Polyandrocarpa*	2016	Previously recorded as indeterminate
Ascidiacea	*Polyandrocarpa zorritensis*	2015	Identification revised
Gymnolaemata	*Amathia chimonidesi*	2011	Identification revised
Gymnolaemata	*Schizoporella cf. errata*	Pre-1960	Identification revised
Hydrozoa	*Plumularia setacea*	Pre-1896	Previously recorded as cryptogenic
Hydrozoa	*Obelia geniculata*	1898	Previously recorded as cryptogenic
Malacostraca	*Ligia (Megaligia) exotica*	2012	Not previously recorded in database
Scyphozoa	*Phyllorhiza punctata*	2011	Not previously recorded in database
Ulvophyceae	*Chaetomorpha linum*	1874	Not previously recorded in database

The Auckland region had the largest number of NIS in New Zealand with a total of 279 (74%) species recorded from the area (Figure 3-2). The Northland region had the second largest number of NIS with 168 records. These numbers include those species not known to be established yet in New Zealand waters. The Auckland and Northland regions also have the highest total search effort through the MHRSS in New Zealand (Figure 3-2). This larger search effort reflects the importance of Auckland as a node for vessel traffic and NIS. For the Northland region, there are two high risk surveillance sites present; Whāngārei and the Bay of Islands, which raises the search effort in the far north, whereas all other regions only have one high-risk harbour that is surveyed as part of the national surveillance programme.

Table 3-2: The location, source of record and recorded substratum of NIS recorded in New Zealand since the 2016 report (Inglis and Seaward 2016).

Other source	Taxon name	Author	Year	Revised location	Established	Revised substratum
Auckland Museum	*Acanthurus xanthopterus*	Valenciennes, 1835	2017	Waitematā Harbour	no	Vessel hull
MHRSS	*Caprella scauroides*	Mayer, 1903	2017	Waitematā Harbour	yes	Artificial (wharf piles etc.)
Auckland Museum	*Chaetodon trichrous*	Gunther, 1874	2017	Waitematā Harbour	no	Vessel hull
Auckland Museum	*Heniochus acuminatus*	(Linnaeus, 1758)	2017	Waitematā Harbour	no	Vessel hull
Auckland Museum	*Heniochus monoceros*	Cuvier, 1831	2017	Waitematā Harbour	no	Vessel hull
MHRSS	*Jassa* cf. *marmorata*		2017	Waitematā Harbour	yes	Artificial (wharf piles etc.)
MITS	*Mimachlamys gloriosa*	(Reeve, 1853)	2016	Muriwai Beach	no	Vessel hull
Auckland Museum	*Myripristis amaena*	(Castelnau, 1873)	2017	Waitematā Harbour	no	Vessel hull
Auckland Museum	*Myripristis berndti*	Jordan and Evermann, 1903	2017	Waitematā Harbour	no	Vessel hull
Auckland Museum	*Myripristis murdjan*	(Forsskål, 1775)	2017	Waitematā Harbour	no	Vessel hull
Auckland Museum	*Sargocentron*	Fowler, 1904	2017	Waitematā Harbour	no	Vessel hull
Auckland Museum	*Sargocentron diadema*	(Lacepede, 1802)	2017	Waitematā Harbour	no	Vessel hull
Auckland Museum	*Sargocentron punctatissimum*	(Cuvier, 1829)	2017	Waitematā Harbour	no	Vessel hull
MHRSS	*Caprella penantis*	Leach, 1814	2016	Tauranga Harbour	yes	Artificial (wharf piles etc.)

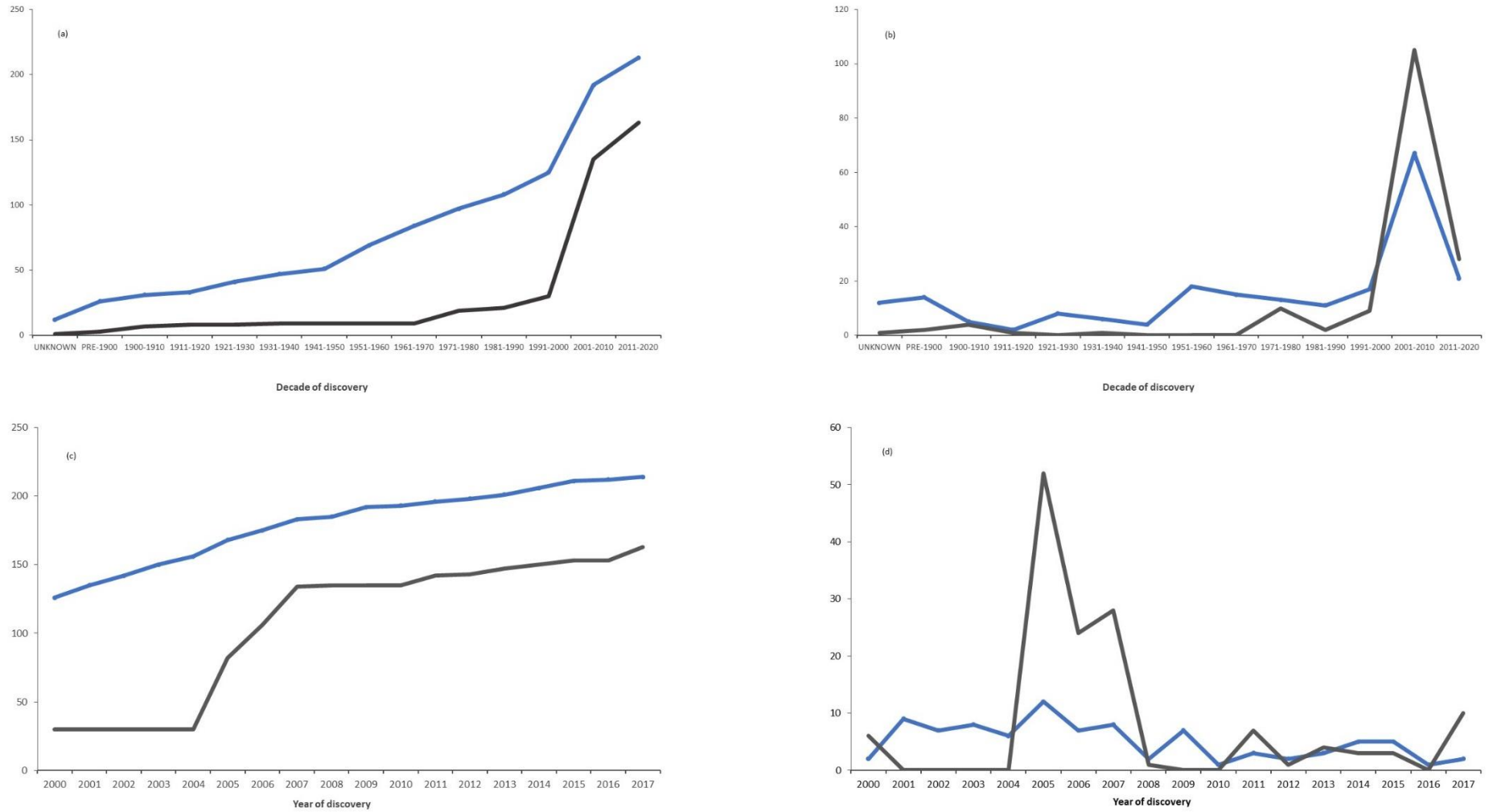

Figure 3-1: Time series of the discovery record of non-indigenous marine species in New Zealand. Blue lines = species established in New Zealand, black lines = species not known to be established in New Zealand. (a) Cumulative number of species binned by decade (1900–2017), (b) Number of new-to-New Zealand species binned by decade (1900–2017), (c) Cumulative number of species binned by year (2000–2017), (d) Number of new species binned by year (2000–2017).

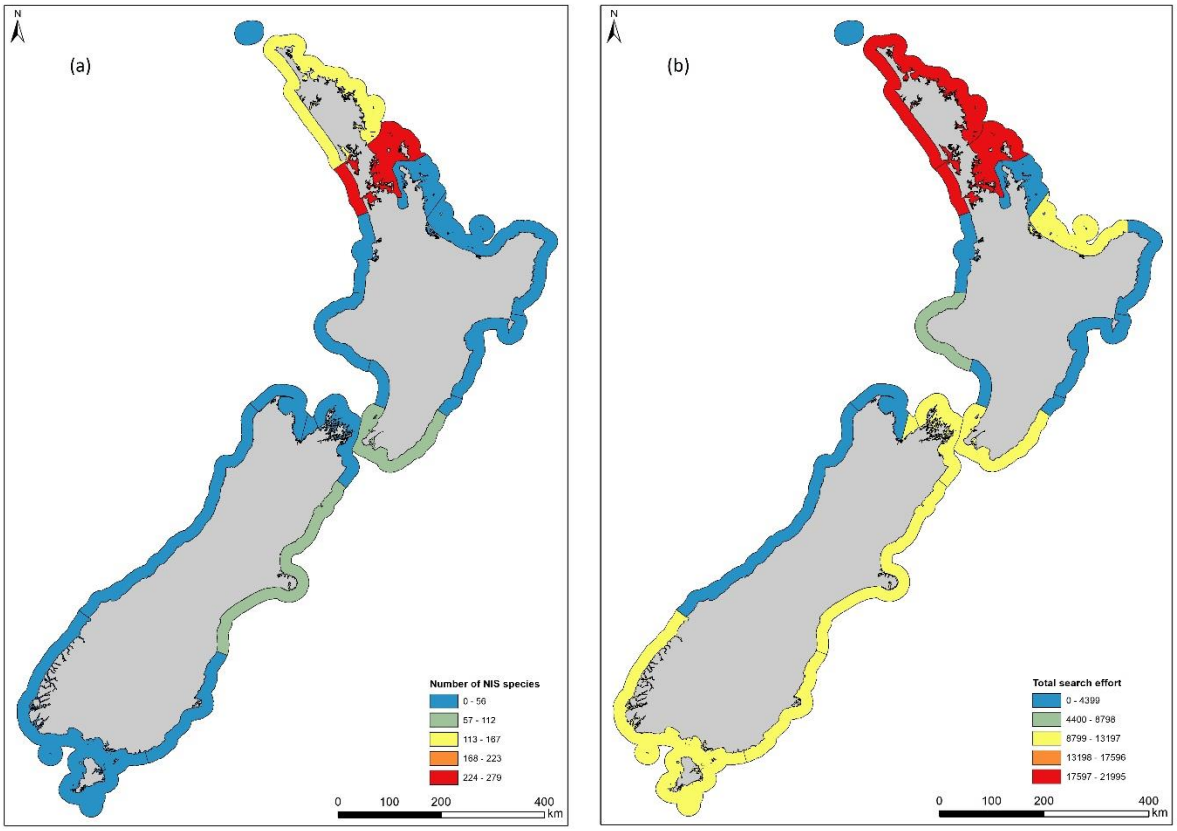

Figure 3-2: (a) Numbers of non-indigenous marine species (NIS) summarised by regional council coastal area. (b) Total search effort in each coastal area.

3.2 Prevalence

As an example of the prevalence/abundance indicator, Table 3-3 summarises changes in the (a) annual and (b) cumulative grid occupancy by the Mediterranean fanworm, *S. spallanzanii*, across the 11 MHRSS ports and harbours between 2009 and 2017. The number of cells occupied annually are calculated using data only collected during the MHRSS as this reflects a real change in occupancy of a species as the annual survey effort in each location has remained constant over that time period. The total geographic area a species occupies can give a measure of localised range expansion to complement range extent information from maximum latitudinal distance data on prevalence for other key species can be found in Appendix C.

The MHRSS programme detected *S. spallanzanii* in fewer ports in 2017 than in 2016 (Table 3-3 (a)). *S. spallanzanii* has been detected in seven of the 11 MHRSS locations (Table 3-3 (b)). *S. spallanzanii* has also been recorded at other locations via sources other than the MHRSS including Whangaroa, Gisborne, Tarakohe, Whangaparaoa, Keri Keri, Coromandel and Golden Bay (Marine Invasives Taxonomic Service 2018). However, no specimens were found in Lyttelton, Wellington and Tauranga in 2017. It is likely that *S. spallanzanii* is still present in low abundance at these three locations. *S. spallanzanii* was first detected in Lyttelton in 2008 – the first New Zealand record – and was the subject of a concerted local elimination programme between 2008–2010 (Inglis et al. 2009). Several hundred worms were removed during the programme, and numbers detected since have been consistently very small.

Measures of the cumulative occupancy of grid cells by *S. spallanzanii* indicate that it has expanded its distribution within each port that it is present in since 2014. Figure 3-3 shows the cumulative grid cell occupancy of presence records of *S. spallanzanii* in Waitematā Harbour from its initial discovery in 2009–March 2018.

There was a 12 % increase in the cumulative number of 100 m x 100 m grid cells surveyed throughout New Zealand between 2016 and 2017 (Table 3-4). The MHRSS has a stratified sampling design with survey locations allocated based on available habitat and relative risk of target species arriving in those areas. The total number of grid cells searched per year has varied between 3068 and 3692 since 2009, but search effort has remained consistent. Sometimes more than one sample point is allocated within an individual grid cell, however, every year over 3000 individual grid cells are sampled. When comparing these numbers with the cumulative total of grid cells being surveyed through time there is a significant overlap where 'high-risk' areas are being sampled more intensively and will, therefore, contain grid cells that have been sampled repeatedly.

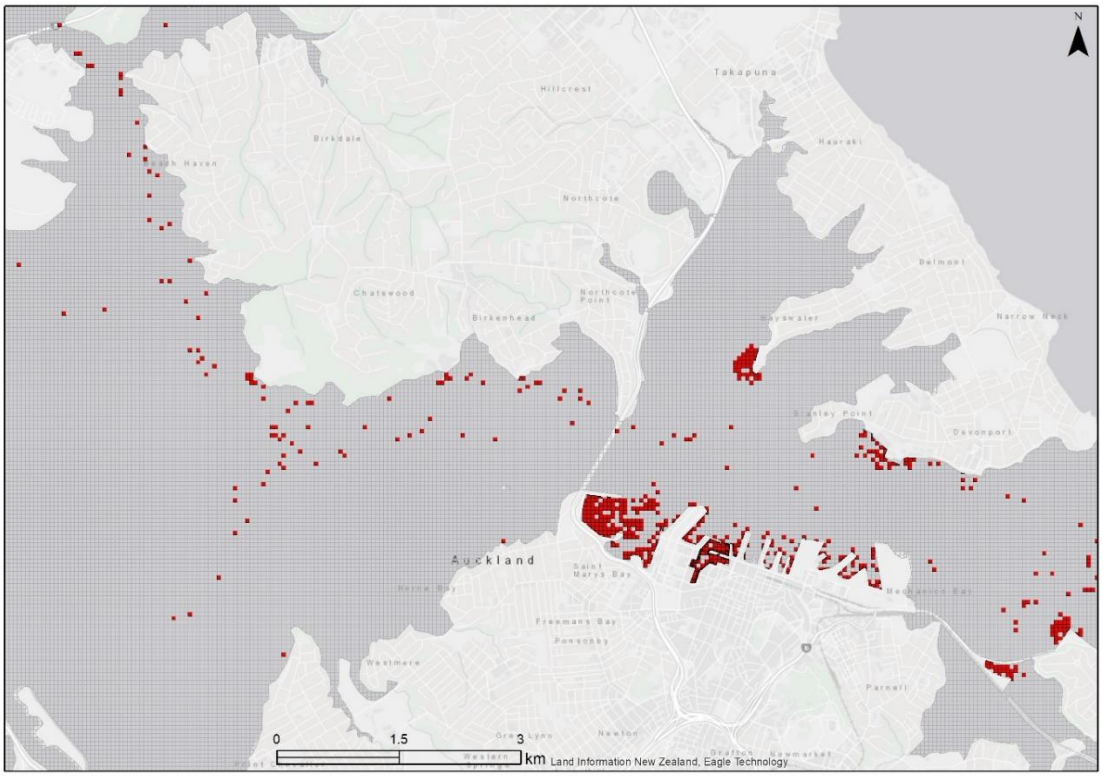

Figure 3-3: Cumulative grid cell occupancy by *Sabella spallanzanii* in Waitematā Harbour (2009 to March 2018).

The range extension of *Symplegma brakenhielmi* was first discovered in Waitematā Harbour in February 2016 as part of an MPI funded programme examining the use of settlements plates to monitor NIS associated with vessel biofouling in Westhaven Marina (Tait et al. 2018). As that project was not part of the MHRSS these records have not been included in the prevalence calculations for *S. brakenhielmi.* However, after its spread into Waitematā Harbour it was detected in 96 grid cells in the harbour after one year, and had occupied a total of 193 100 m x 100 m grid cells in Whāngārei and Waitematā by March 2018 (Figure 3-4, Table 3-5). Records from Whāngārei Harbour for 2016 and 2017, however, suggest that *S. brakenhielmi* may exhibit substantial interannual variability in prevalence (Table 3-5).

Table 3-3: Changes in the occupancy of the Mediterranean fanworm, *Sabella spallanzanii* in the Marine High Risk Surveillance Sites (MHRSS) (2009–2017). (a) The number of 100 m x 100 m grid cells in which the fanworm was detected per annum, (b) the cumulative number of unique grid cells in which the fanworm was detected.

	(a) No. 100 m x 100 m grid cells per year									(b) Cumulative no. 100 m x 100 m grid cells								
MHRSS Site	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Ōpua	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Whāngārei	0	0	0	14	12	26	0	16	24	0	0	0	14	24	38	38	46	55
Waitematā	1	37	123	206	94	180	83	54	199	1	38	153	311	370	465	497	531	603
Tauranga	0	0	0	0	3	5	2	3	0	0	0	0	0	3	6	7	10	10
Taranaki	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wellington	0	0	0	0	0	3	2	0	0	0	0	0	0	0	3	4	4	4
Picton	0	0	0	0	0	2	0	1	1	0	0	0	0	0	2	2	2	3
Nelson	0	0	0	0	3	1	1	1	2	0	0	0	0	3	4	4	5	7
Lyttelton	1	5	2	1	4	0	0	1	0	1	6	8	9	13	13	13	14	14
Otago	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bluff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
No. infested MHRSS	**2**	**2**	**2**	**3**	**5**	**6**	**4**	**6**	**4**	**2**	**2**	**2**	**3**	**5**	**7**	**7**	**7**	**7**
National total no. infested grid cells	**2**	**42**	**125**	**221**	**116**	**217**	**88**	**75**	**226**	**2**	**44**	**161**	**333**	**411**	**529**	**565**	**612**	**696**

Table 3-4: Annual survey effort in each of the Marine High Risk Surveillance Sites (MHRSS). (a) Number of 100 m x 100 m grid cells sampled per annum, (b) cumulative number of unique 100 m x 100 m grid cells sampled per annum.

	(a) No. 100 m x 100 m grid cells per year									(b) Cumulative no. 100 m x 100 m grid cells								
MHRSS Site	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Ōpua	147	232	281	298	300	181	293	301	369	147	307	423	532	654	690	748	803	850
Whāngārei	464	340	186	333	335	445	182	318	442	464	684	782	855	1003	1179	1241	1347	1495
Waitematā	723	765	758	1027	428	757	1005	375	738	723	1277	1702	1872	2045	2316	2582	2694	2932
Tauranga	321	324	343	350	462	213	335	449	186	321	538	691	704	871	924	995	1088	1118
Taranaki	101	128	186	116	432	158	118	128	114	101	159	220	176	201	234	243	253	257
Wellington	333	319	310	191	328	400	291	181	384	333	525	651	600	731	862	905	936	1025
Picton	206	170	120	188	161	122	146	160	162	206	265	280	304	320	324	330	336	352
Nelson	284	276	173	354	263	174	271	279	259	284	418	464	539	585	605	645	665	689
Lyttelton	180	314	419	202	328	397	290	319	188	180	430	677	528	681	870	930	1051	1116
Otago	359	379	496	219	378	331	419	317	331	359	645	930	756	936	1066	1165	1256	1343
Bluff	194	321	291	414	188	280	241	241	240	194	431	583	625	665	734	734	806	840
National total no. grid cells surveyed	**3312**	**3568**	**3563**	**3692**	**3303**	**3458**	**3591**	**3068**	**3413**	**3312**	**5679**	**7403**	**7491**	**8692**	**9804**	**10553**	**11235**	**12017**

Table 3-5: Changes in the occupancy of the Indo-Pacific ascidian, *Symplegma brakenhielmi* in the Marine High Risk Surveillance Sites (MHRSS) (2017–March 2018). (a) The number of 100 m x100 m grid cells in which the ascidian was detected per annum, (b) the cumulative number of unique grid cells in which the ascidian was detected.

	(a) No. 100 m x 100 m grid cells per year		(b) Cumulative no. 100 m x 100 m grid cells	
MHRSS Site	2017	2018	2017	2018
Whāngārei	35	0	35	35
Waitematā	96	62	96	158
National total no. infested grid cells	131	62	131	193

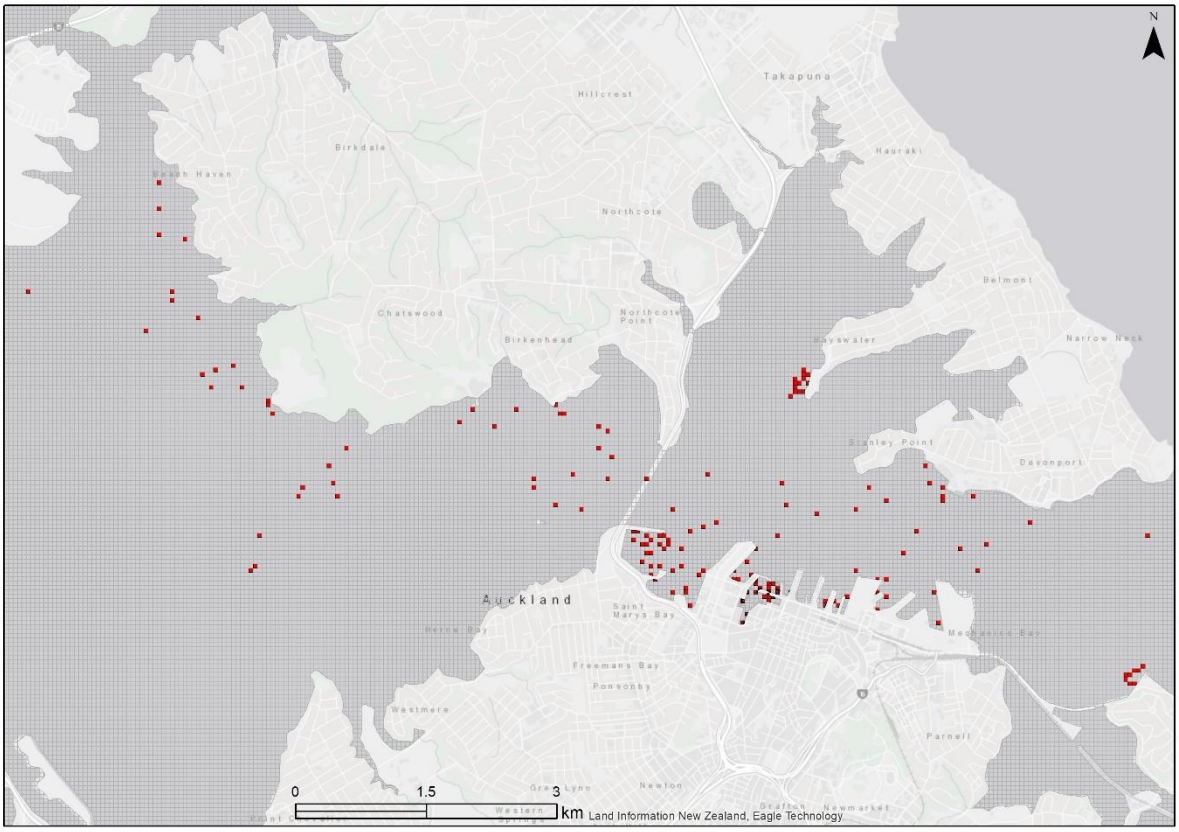

Figure 3-4: Cumulative grid cell occupancy by *Symplegma brakenhielmi* in Waitematā Harbour (2017 to March 2018).

3.3 Latitudinal extent

The maximum latitudinal extents of most of the 'key species' have remained consistent since the previous report in 2016. Two species, *Undaria pinnatifida* and *Theora lubrica*, were already recorded from both northern and southern extremes of the New Zealand mainland (Inglis & Seaward 2016).

Two individuals of the Asian paddle crab, *Charybdis* (*Charybdis*) *japonica* were detected in Tauranga Harbour in February 2018. This represents an expansion in the southern range of this species (Figure 3-5).

The colonial ascidian, *S. brakenhielmi*, was discovered in 2015 and has subsequently been detected throughout Waitematā Harbour. The latitudinal range of *S. brakenhielmi* since 2015 is displayed in Figure 3-3.

Sabella spallanzanii has also had an unchanged latitudinal extent, however, specimens submitted to the MITS since 2016 indicate that *S. spallanzanii* has been recorded from Gisborne and Tarakohe for the first times (Inglis & Seaward 2016). Although there has been no change to its latitudinal range in New Zealand, it has been found in new locations that it had not been found in before (Figure 3-5).

Theora lubrica was recorded as a single specimen from Bluff in 2008, but since this first report no other specimens of this species have been recorded. It is regularly recorded as far south as Lyttleton Harbour/Whakaraupō but so far it has not been recorded as far south as Otago Harbour or again in Bluff Harbour.

A record for the colonial ascidian, *Eudistoma elongatum*, from Nelson contained in the 2016 report has subsequently been determined to be inaccurate. The latitudinal extent for this species is limited to the far north from Ōpua to Waitematā Harbour. The species has, however, recently been noted to have a range expansion longitudinally as it has been recorded from Kaipara Harbour on the west coast of the North Island for the first time (Marine Invasives Taxonomic Service 2018).

The greasy-back prawn, *Metapennaeus bennettae*, was recorded in Ōpua (Bay of Islands) for the first time in 2017. This represents a northern range expansion of this species (Figure 3-5). *M. bennettae* was first recorded in New Zealand in 2009, as a single record from Waitematā Harbour It was subsequently recorded in Whāngārei in 2012 and has been recorded regularly from both locations since 2012.

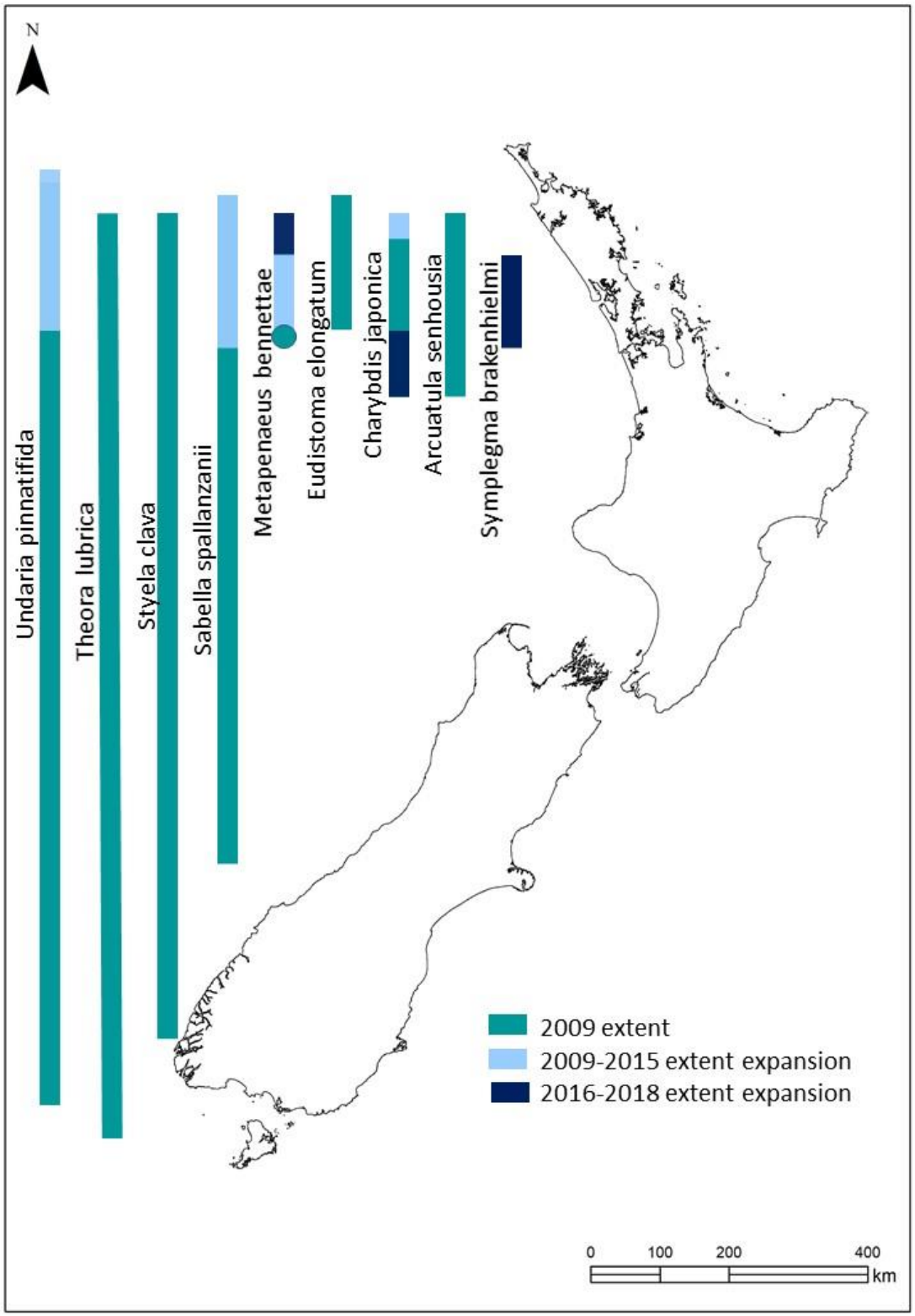

Figure 3-5: Maximum north to south extent of selected non-indigenous species in New Zealand from 2009–March 2018. The bars connect the maximum recorded northern and southern latitudes at which the species have been found in New Zealand. They are not intended to represent the species' density or pattern of occurrence throughout that range. Data are based on records submitted to the Marine Invasives Taxonomic Service and from systematic surveys undertaken through various MPI-funded programmes.

4 Recommendations

Data summarised in this report for the 'Marine pests' indicator are sourced from the Marine Biosecurity Porthole and, as such reflect the large amount of survey effort that has been devoted to the major shipping ports in New Zealand. Survey effort and observations outside these areas are sporadic. There are, therefore, gaps in our knowledge of the presence and prevalence of NIS in areas of New Zealand that have had little or no survey effort. In some parts of New Zealand, there are few baseline data on native biodiversity and marine NIS. These include large areas of the west coast of the South Island and portions of the east coast of the North Island. Several smaller ports such as Napier, Timaru and Oamaru have not been surveyed in the last 10 years, and the large harbours of Kaipara and Manukau have also not been sampled in over 10 years. Records in these areas are largely provided as a result of passive surveillance by members of the public or through other scientists working on projects in the area. These irregularly surveyed or un-surveyed locations provide a large gap in knowledge of NIS presence in New Zealand.

The Marine Biosecurity Porthole (https://marinebiosecurity.org.nz/) centralises several sources of data that have been used for this report, but is not a complete record of all observations of NIS in New Zealand. Other, unconsolidated data holdings are likely to exist within universities, technological institutes, regional councils, and other research organisations. Integrating and verifying these other sources of data would increase our datasets and knowledge of NIS in New Zealand. This task would be time consuming and having protocols in place to verify records would need to be established before integrating new sources of data, but the information would be extremely valuable in recording and reporting range extensions of current NIS in New Zealand.

5 Acknowledgements

Thanks to Chris Woods for reviewing this report. Data described above were sourced predominantly from marine biosecurity programmes funded by the MPI—Biosecurity New Zealand (and its predecessors). Important contributions to their collection and curation have been made by Chris O'Brien (MFish), Chad Hewitt (MAF Biosecurity New Zealand), Brendan Gould, Abraham Growcott, Tim Riding, Justin McDonald and Simon McDonald (Ministry for Primary Industries), Serena Cox, Done Morrisey, Chris Woods, Shane Ahyong, Oli Floerl, Nick Gust (NIWA) and the biosystematics group at NIWA.

6 Glossary of abbreviations and terms

CBD	International Convention on Biological Diversity
Cryptogenic	Species that are not demonstrably indigenous or non-indigenous within a biogeographic region
Established	A non-indigenous species that has formed a self-sustaining population(s). Synonymous with ‘naturalised’
IAS	Invasive Alien Species
Indigenous	Species that occurred within a biogeographic region historically and were not introduced by human activities. Synonymous with ‘native'
MHRSS	Marine High Risk Site Surveillance
MITS	Marine Invasives Taxonomic Service
MPI	Ministry for Primary Industries
New-to-New Zealand	Species that have not previously been recorded from New Zealand waters
Non-indigenous species (NIS)	Species that are known or suspected to have been introduced as a result of human activities. Synonymous with ‘alien’, ‘adventive’, ‘exotic’, ‘introduced’ and ‘non-native’
Not-established	A non-indigenous species that has been reported only from a vessel or other transient structure or which was introduced but failed to form self-sustaining populations

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Appendix A Time series data on NIS in New Zealand

(Provided as Excel spreadsheet with associated metadata).

Appendix B Cumulative latitudinal extents of NIS in New Zealand from 2009–March 2018.

(Provided as Excel spreadsheet with associated metadata).

Appendix C Grid cell occupancy of 'key species' by year for all MHRSS ports and harbours.

(Provided as Excel spreadsheet with associated metadata).