Marine non-indigenous species in the Pacific islands: a desktop review

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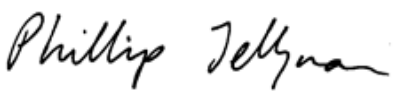	Approved for release by:	Phillip Jellyman

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Executive summary

The introduction and spread of non-indigenous marine species to Pacific Island countries and territories is a threat to biodiversity, commerce, and socio-cultural values. Yet, little is known about what marine non-indigenous species (NIS) are present throughout the Pacific Island region or what their impacts are. We define here an invasive species as an NIS if (i) the species has demonstrated impact anywhere outside its indigenous range, (ii) the species is widespread, abundant, fast-spreading or has a high population growth rate anywhere outside its indigenous range, or (iii) the species is widespread, abundant, fast spreading or has a high population growth rate in the reporting country (McGeoch et al. 2012). Not all NIS are considered harmful or "invasive".

The importance of the marine environment to communities inhabiting Pacific islands highlights the importance of ongoing action to address marine invasive species in the Pacific Islands region. The Global Environment Facility 6 (GEF6) Regional Invasive Project aims to reduce the threats from NIS to marine biodiversity in the Pacific by developing and implementing comprehensive national and regional management frameworks. To achieve this, the Secretariat of the Pacific Regional Environment Programme (SPREP) will develop a Pacific Marine Biosecurity Toolkit containing a series of guidance documents intended to be used to address marine biosecurity issues.

The first step in developing the Toolkit is to review and collate information on marine NIS present in Pacific islands and identify those which are invasive or on the verge of becoming invasive. We reviewed and compiled records of marine NIS in Pacific islands from the primary literature, public databases, and personal communication for the following countries and territories: American Samoa, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Guam, Kiribati, the Republic of the Marshall Islands, Nauru, New Caledonia, Niue, Northern Mariana Islands, Palau, Papua New Guinea, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu, and Wallis and Futuna. We reviewed species with documented intentional introductions, usually for the purpose of aquaculture, and those without documented introductions and likely to have been introduced unintentionally. We collected data on the taxa, known geographic range within the country or territory (if available), and likely pathway of introduction.

From our review of peer-reviewed literature, public databases, and personal communication with Pacific Island experts we reported 169 different NIS across 21 Pacific Island countries and territories, with the majority having been introduced unintentionally (*N*=121). Two island groups, Nauru and Wallis and Futuna, have no known records of marine NIS. Guam (*N*=80), American Samoa (*N*=35), French Polynesia (*N*=43), Palau (*N*=40) and Samoa (*N*=23) make up over 70% of all marine NIS reports across the Pacific region. Nearly all unintentionally introduced species have sessile lifestyles, i.e. species that are permanently attached at the base and not freely moving and were reported from harbours with some level of commercial activity, suggesting shipping vessels as an important vector for NIS introductions into the Pacific. Notably Guam, American Samoa, Samoa, and Palau identified many unintentionally introduced marine NIS through a biological survey and the higher number of NIS recorded from these Pacific Island countries and territories could reflect survey effort and not necessarily marine biosecurity hot spots representing a greatest source of risk. Similar surveys will be needed to identify the status of NIS in the jurisdictions of other Pacific islands.

Information on vectors and pathways is limited outside of those NIS introduced for aquaculture (e.g. Pacific oyster *Magallana gigas*, green mussel *Perna viridis*, red alga *Kappaphycus alvarezii*) or wild population enhancement (e.g. trochus *Rochia nilotica*, green snail *Turbo marmoratus*). It is likely, however, that shipping is an important vector for translocating NIS into the Pacific islands, on the

basis that many of them have sessile adult lifestyles and are reported from either permanent infrastructure in the harbours and ports, e.g. wharves or directly from vessel hulls. There is a large number of vessels moving within the Pacific region and entering the Pacific islands from countries on the Pacific Rim each year. These vessels include international cruise liners, cargo vessels, foreign fishing fleets and domestic cargo and fishing fleets. There are also a large number of recreational vessels entering and operating within the Pacific Islands region. Floating marine debris and plastic pollution could be an important pathway for marine NIS in the Pacific that is yet to be quantified.

There were few data available on the impacts of marine NIS reported from Pacific islands. Most of the reports are single records of the occurrence (presence) of a species; whether a species has established and is invasive in the Pacific Islands region is frequently unknown. Species reported here, such as the algae *Codium arenciola* and the hydroid *Pennaria disticha*, are invasive in other geographic regions and are established in some Pacific islands but without much documented impact. The green mussel *P. viridis* is a well-known invasive species that has failed to establish in the Pacific Islands region despite numerous intentional introductions. Other fouling organisms such as the barnacles *Amphibalanus amphritrite* and *Chthamalus proteus* are cosmopolitan NIS present throughout Pacific islands. Although they are nuisance species, little information is available regarding their impacts.

The *State of Environment and Conservation in the Pacific Islands: 2020 Regional Report* classified the success indicator status of monitoring marine invasive species as poor. There are currently 16 priority marine invasive management programmes in the Pacific region. Implementing monitoring programmes across the Pacific region, especially in high-risk biosecurity areas such as ports and harbours, will help identify NIS and ascertain those marine species that are invasive or will become invasive.

1 Introduction

A healthy marine environment is critical to the environmental, economic, and socio-cultural values of the Pacific Islands region. Pacific island countries and territories maintain resource rights and management over approximately 27 million square kilometres of ocean (SPREP 2021), totalling 20% of the global exclusive economic zones (EEZ). The Pacific island marine and coastal ecosystems of estuaries and mangroves, coral atolls and coral reefs, lagoons, and open oceans, are home to hundreds of plants and animals that are not found anywhere else on earth. The Pacific region marine environment supports subsistence and high-value commercial fisheries, tourism, and traditional cultural practices. As such, the introduction, spread and establishment of marine non-indigenous species (NIS) to the Pacific region is a serious threat to Pacific flora and fauna and the communities that depend on them. NIS have been introduced to Pacific islands across terrestrial, freshwater, and marine systems, threatening endemic island biodiversity with extinction. There is a lack of information on marine NIS in the Pacific and about their impacts on native ecosystems and economies compared with terrestrial and freshwater ecosystems (Russell and Kueffer 2019). An invasive species is an NIS if (i) the species has demonstrated impact anywhere outside its indigenous range, (ii) the species is widespread, abundant, fast-spreading or has a high population growth rate anywhere outside its indigenous range, or (iii) the species is widespread, abundant, fast-spreading or has a high population growth rate in the reporting country (McGeoch et al. 2012). Not all NIS are harmful or "invasive".

Historically, knowledge of marine NIS in Pacific islands has been based on literature reviews summarizing introductions of organisms primarily for aquaculture or fisheries purposes (Eldredge 1994). Eldredge (1994) reviewed commercial species that were introduced intentionally into the Pacific, which comprised a range of bivalves, gastropods, decapods, fishes, and algae. Intentional species introductions have generally been unsuccessful, with many species failing to become established and the ventures supporting their introduction terminated (Eldredge 1994). Investigations into farming Pacific oysters *Magallana gigas* were terminated following a series of unsuccessful attempts after the species was introduced into Fiji, French Polynesia, Guam, New Caledonia, Palau, Tonga, Vanuatu, and Samoa from Japan, North America, and Australia (Angell 1986). The green mussel *Perna viridis* is a global high-priority pest species because of its ability to foul surfaces in high population densities (Rajagopal et al. 2006). It was introduced unsuccessfully from the Philippines to a number of Pacific islands for the purpose of establishing aquaculture (Eldredge 1994). The introduction and establishment of the penaeid shrimp *Penaeus merguiensis* to Fiji is an example of an intentionally introduced species that has established in the wild, where it now occurs naturally in the Ba area (Choy 1983; Andrews 1985). The impacts of the established introduced *P. merguiensis* population is unknown. Farming of the red alga *Kappaphycus alvarazii* was investigated for many parts of the Pacific. The expected outcomes of seaweed farming were not realised for many areas; instead, in some places, particularly in Hawai'i, these species have become threats to marine ecosystems, smothering coral reefs and outcompeting native species (Eldredge and Smith 2001).

Greater site-specific information has become available with biological baseline surveys in harbours detecting unintentionally introduced marine NIS in Guam (Paulay et al. 2002), American Samoa (Coles et al. 2003), Samoa (Skelton et al. 2008), Palau (Colin 2009; Campbell et al. 2016) and the remote Palmyra Atoll (Knapp et al. 2011). There is also much information available on the status of NIS in Hawai'i. Nearly a quarter of the total flora and fauna reported from several harbours in Hawai'i during biological surveys were either NIS or cryptogenic (Coles et al. 1999a; Coles et al. 1999b).

Biological baseline surveys are useful to gather information on marine biodiversity within an area, highlighting what NIS are present and providing a benchmark for future monitoring programmes (Campbell et al. 2016). Coles et al. (2003) reported 17 NIS at the main berth in Pago Pago Harbour, American Samoa, composing 10% of the total biota identified at that site. The high number of sessile organisms (species that are permanently attached at the base and not freely moving), in particular fouling species such as bryozoans, ascidians, and hydroids found in the harbours in Palau and Guam, strongly suggests their introduction was supported by vessel movement. Notably, only 14% of sessile species detected on international vessel hulls were not detected in the port environs, which is strongly suggestive of the role of vessels in translocating NIS in the Pacific (Campbell et al. 2016).

The Pacific Ocean is 98% water and 2% land, consequently, Pacific island countries and territories are heavily dependent on shipping for commerce. Maritime vessel movement is recognised as the most important pathway for the unintentional introduction and spread of marine NIS (Hewitt and Campbell 2010). Vessels can translocate species across biogeographic boundaries through biofouling – the growth and accumulation of organisms on immersed ship surfaces or structures (IMO 2011) – or via ballast water exchange (Carlton et al. 1995). For this reason, ports of entry are often at greater risk of species introduction (Godwin 2003), and ports account for the largest numbers of unintentionally introduced NIS reported from the Pacific region (Coles et al. 2003; Skelton et al. 2008; Campbell et al. 2016). Shipping in the Pacific region can be categorised into the broad categories: (1) transit shipping that will pass through the region without stopping; (2) international shipping, including cargo or cruise ships, that originate from outside of the Pacific that call into major Pacific ports; (3) regional and domestic shipping, including cargo and passenger ships moving between and within Pacific island countries and territories; (4) domestic fishing fleet; and (5) miscellaneous which include all others that do not fit into the above, such as navy vessels, research vessels and recreational craft. Cargo vessels service the Pacific through five main regional transport hubs in Fiji, French Polynesia, New Caledonia, Papua New Guinea (PNG) and Samoa; Port Moresby, PNG, receives almost double the number of vessels than Suva, Fiji, and almost eight-times more than Apia, Samoa (SPREP 2015). Such hubs are points of interest from a marine biosecurity perspective, as any introductions at the hubs could soon spread throughout the Pacific via regional and domestic shipping. The potential for NIS introductions via vessels into the Pacific islands has been present for some time because the Pacific was seen as having strategic military locations during World War Two (WWII), receiving a high number of vessels and visitors that could have similarly facilitated NIS transfer (Knapp et al. 2011).

Marine plastic pollution has emerged as a serious environmental issue in the Pacific that may also act as an important pathway for spread of NIS (Miller et al. 2018). The Pacific islands are susceptible to plastic pollutants originating from the Pacific region via their direct loss from landfills into the ocean via wind or water (SPREP 2021) and are common recipients of plastic waste originating from overseas via ocean currents (Lachmann et al. 2017). The presence of marine plastic pollution can provide settlement substrate for marine plants and animals to disperse to non-indigenous areas. As of 2017, over 600 biofouled debris items with over 300 living species landed in the northeast Pacific following the 2011 Japanese earthquake (Miller et al. 2018); notably, the invasive mussel *Mytilus galloprovincialis* was on over 50% of the debris items (Miller et al. 2018). Despite regional guidelines on regulating plastics in the Pacific and new laws addressing single-use plastics (SPREP 2021), the Pacific will continue to receive plastic waste mainly from overseas sources for many years via ocean currents that could provide a potential pathway for NIS into the Pacific.

The Global Environment Facility 6 (GEF6) Regional Invasive Project aims to reduce the threats from NIS to marine biodiversity in the Pacific by developing and implementing comprehensive national and regional management frameworks. The Pacific region rely heavily on the marine environment for food, commerce, and/or social well-being. Marine tourism, subsistence and commercial fisheries, and aquaculture contribute over 10% of the Gross National Income for some Pacific island countries and territories (Campbell et al. 2016), highlighting the threat NIS could have on livelihoods throughout the Pacific if there were to become established and become invasive.

A first step to providing guidance documents for addressing marine biosecurity in the Pacific Islands region is the production of inventories of species introduced into the Pacific region. By reviewing primary publications, databases, and other sources, including personal communications, we provide here an inventory of species that have been recorded as introduced intentionally and unintentionally into the Pacific. The scope of this review was marine species but does include euryhaline species that can tolerate brackish or low-salinity water. We did not include native species that have become invasive such as the crown of thorns starfish *Acanthaster planci* or the algae *Sargassum* sp.

2 Methods

2.1 Desktop review process

We carried out a desktop review (May–June 2021) of NIS identified in 21 Pacific islands (Figure 1). We used records from the English-language primary literature, databases, and personal communications. The primary literature was reviewed by querying the Web of Science Database[i] for each Pacific Island country or territory. We used the following search terms: TS=((non-indigenous OR nonindigenous OR non-native OR introduce* OR invasi* OR alien) AND ([country or territory])). Publicly available data on Pacific invasive species were recovered from the National Estuarine and Marine Exotic Species Information System (NEMESIS; https://invasions.si.edu/nemesis/), the National Introduced Marine Pest Information System (NIMPIS; https://nimpis.marinepests.gov.au/), and the Global Biodiversity Information Facility (GBIF; gbif.org) following the instructions in the Battler Series publication (SPREP 2018). Further, the Global Register of Introduced and Invasive Species (GRIIS; gbif.org/griis) was queried for each Pacific Island country and territory. The GRIIS data were downloaded and imported into Microsoft Excel. After filtering the GRIIS data for 'marine', all species records were transferred to a separate Microsoft Excel sheet and tabulated for each country and territory. We did an additional general query using the general Google search engine for 'marine invasive' and 'NIS' for each Pacific Island country and territory and recorded all relevant results.

All records were tabulated by country or territory in a spreadsheet in Microsoft Excel. The following data were recorded: taxonomy, reference, known range within the country or territory and any notes on the vector or pathway. A specific note was made on whether the NIS were introduced intentionally or unintentionally. The taxonomy and authority was confirmed for each species in the World Register of Marine Species (WoRMS; marinespecies.org) to ensure the most up-to-date taxonomy was recorded. Cryptogenic species — a species of unknown origin, that is not demonstrably native or introduced — were also recorded. Records of NIS recovered from databases were cross-referenced for assurance of the validation of the report. Species which we could not cross-reference were not included in the tables presented in Section 3. All graphs and summary statistics were produced using Microsoft Excel.

Existing lists of NIS for Hawai'i and tropical Australia were downloaded (Salimi et al. 2021). Records from tropical Australia were selected because of the similar environment to the Pacific islands. Tropical Australia included north of Queensland on the east coast, the northern coastline and north of Perth on the west coast (see Salimi et al. 2021). A list of the most up-to-date records of introduced species in New Zealand was extracted from the New Zealand Marine Biosecurity Porthole (https://www.marinebiosecurity.org.nz/). Records from all three regions were tabulated in Excel and compared with the NIS inventories from the Pacific to identify those species present in the Pacific island countries and territories and the aforementioned areas and to identify known invasive species present in Hawai'i, tropical Australia and New Zealand that are not present in the Pacific Region and that could present a risk.

Information on commercial freight shipping routes, individual vessels, ports of call and frequency of travel were obtained from each vessel company that services the Pacific Islands region via their current online shipping schedules as of June 2021. Results were downloaded and collated in Microsoft Excel. Information on routes of fishing vessels, recreational craft, research vessels and other miscellaneous vessels were not collected because of they do not have fixed itineraries.

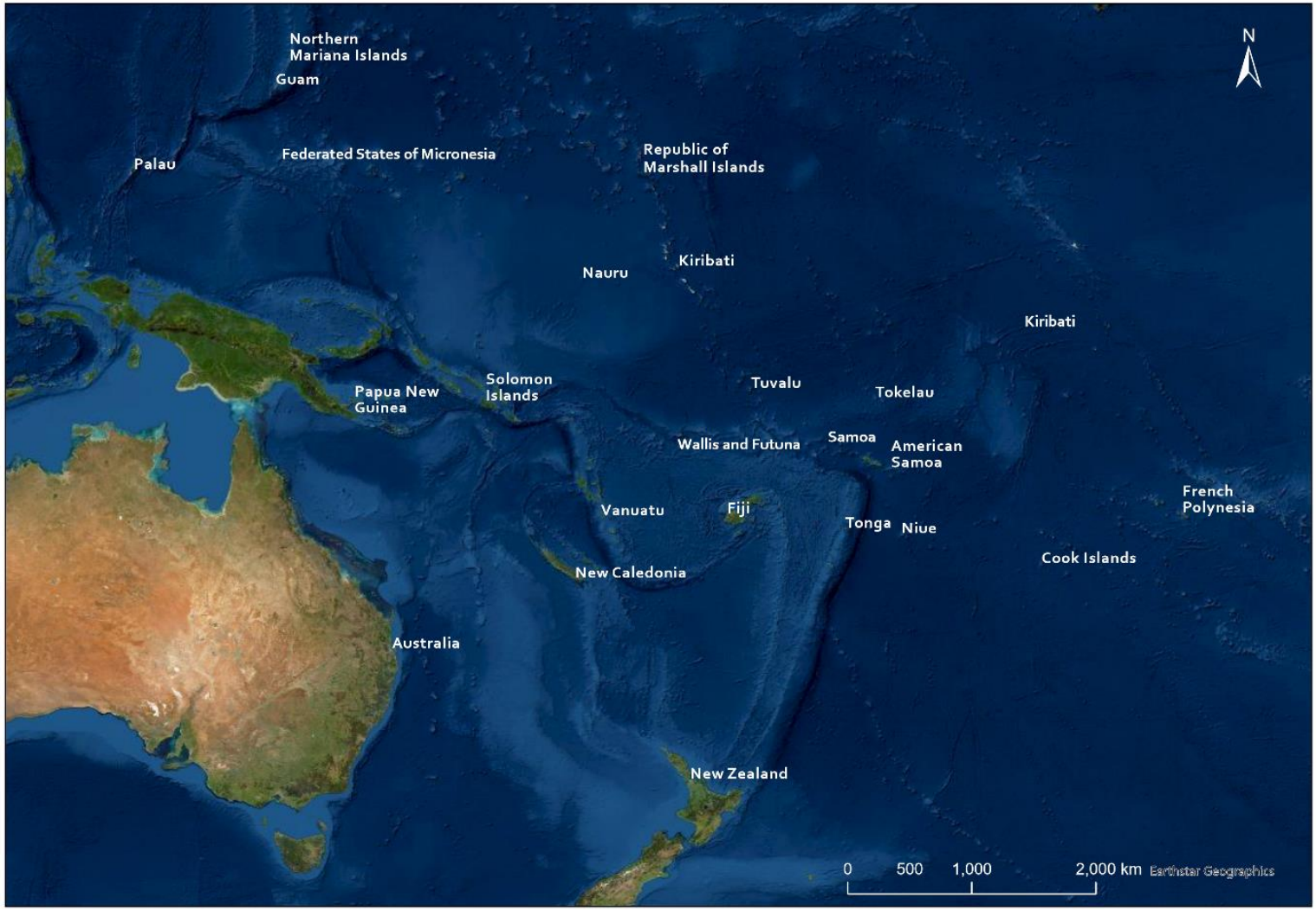

Figure 1: Map of Pacific Island countries and territories addressed in this study, and Australia and New Zealand. Credit: Kimberley Seaward/NIWA

3 Results

3.1 Presence of marine non-indigenous species in the Pacific Islands region

We identified 168 different marine species that have been introduced into Pacific island countries and territories: 47 species introduced intentionally, for the purposes of either aquaculture or fisheries, and 121 species introduced unintentionally. The countries and territories with the largest number of recorded species introductions, including cryptogenic species, were American Samoa, French Polynesia, Guam, Palau, and Samoa (Table 1; Figure 2). These five countries and territories made up over 70% of the total number of records made across 21 countries and territories (Table 1). NIS introduced to each SPREP member country and territories are presented in Tables 2–20. We did not find any records of introduced marine species for Nauru and Wallis and Futuna so there are no tables for these countries.

Pathways for introduction for each species are listed in Tables 2–20. Data on pathways without any documented introduction—i.e. unintentionally introduced species—are limited; those included here are presumptive pathways based on the species life-history and known pathways into other jurisdictions.

Species introduced intentionally into the Pacific Islands region represented six taxa: algae, cnidarians, molluscs, decapods, teleost fishes and chordates, specifically reptiles (Figure 3). Molluscs were the most commonly introduced taxa, composing nearly 50% of all species introduced. They included commonly farmed bivalves such as the Pacific oyster *Magallana gigas* and the invasive green mussel *Perna veridis.* The marine gastropod *Rochia nilotica* (trochus) was the most frequently introduced, having been introduced deliberately to at least 12 Pacific islands. Many species introduced intentionally for aquaculture failed to establish and are now believed to be extirpated (see Eldredge 1994; Tables 2–20). The only cnidarian was the flame jellyfish *Rhopilema esculentum* intentionally introduced into Samoa in 2019–2019.

A more diverse range of taxa was reported without documented introductions and are, therefore, likely to have been introduced unintentionally. Sessile taxa such as ascidians (24%), cnidarians (specifically hydroids and anthozoans, 17%) and bryozoans (10%) contributed over 50% of all species without a documented record of introduction (Figure 3). Ascidians are common fouling organisms, but the high number of ascidians reported have probably also benefited from surveys carried out by taxonomic experts (Lambert 2002; Paulay 2003). Paulay (2003) clearly demonstrates an increase in fish species richness following the arrival of the first fish taxonomist on Guam in the 1960's (see Figure 1 of Paulay 2003)).

Virtually all records were from harbours or embayments (Table 2–20). There were few documented vectors or pathways; however, vessels are a likely vector of many of the species introduced unintentionally considering the predominantly sessile lifestyle of the species and that most records were made inside of harbours.

Marine NIS present in the Pacific region that are also NIS in Hawai'i, tropical Australia and New Zealand are presented in Table 2–20. Most of the marine NIS shared among these countries are common fouling sessile organisms such as hydroids and ascidians, except for a few instances of species introduced for aquaculture, including red algae *Eucheuma denticulatum and Kappaphycus alvarezii*, the Pacific oyster *M. gigas* and penaeid prawns.

Shipping records show there is frequent movement between Pacific islands and to Pacific island countries and territories originating from other Pacific Rim countries (Figure 5; Table 21). There is frequent movement of vessels in the South Pacific, particularly originating in New Zealand travelling to Fiji, Cook Islands and New Caledonia. Fiji, Papua New Guinea, New Caledonia, and both American Samoa and Samoa are common ports of entry, receiving numerous vessels as well as being sites of origin for vessels that subsequently move to other Pacific island ports. Seven Pacific countries, Cook Islands, Fiji, PNG, RMI, Samoa, Tonga, and Tuvalu have a specific National Ballast Water Management Strategy in accordance to the Ballast Water Management Convention.

Table 1: Summary table of marine NIS and cryptogenic species reported from Pacific island countries and territories. Cryptogenic species have unknown origins; therefore, the total number here represents the largest known number of species that may have been introduced and reported.

Pacific island country or territory	NIS (*N*)	Cryptogenic species (*N*)	Total
American Samoa[a]	24	11	35
Cook Islands	7	0	7
Federated States of Micronesia	5	0	5
Fiji	16	1	17
French Polynesia	36	7	43
Guam[a]	45	35	80
Kiribati	10	0	10
Republic of the Marshall Islands	6	0	6
Nauru	0	0	0
New Caledonia	12	0	12
Niue	1	0	1
Northern Mariana Islands	2	0	2
Palau[a]	39[b]	1	40
Papua New Guinea	2	1	3
Samoa[a]	19	4	23
Solomon Islands	2	0	2
Tokelau	1	0	1
Tonga	14	0	14
Tuvalu	2	0	2
Vanuatu	8	0	8
Wallis and Futuna	0	0	0

[a] Represents countries and territories that have performed baseline biological surveys.

[b] Colin (2009) recorded at least 15 ascidians as 'possible introductions', and therefore may not be NIS. We have recorded them as NIS here until new data becomes available.

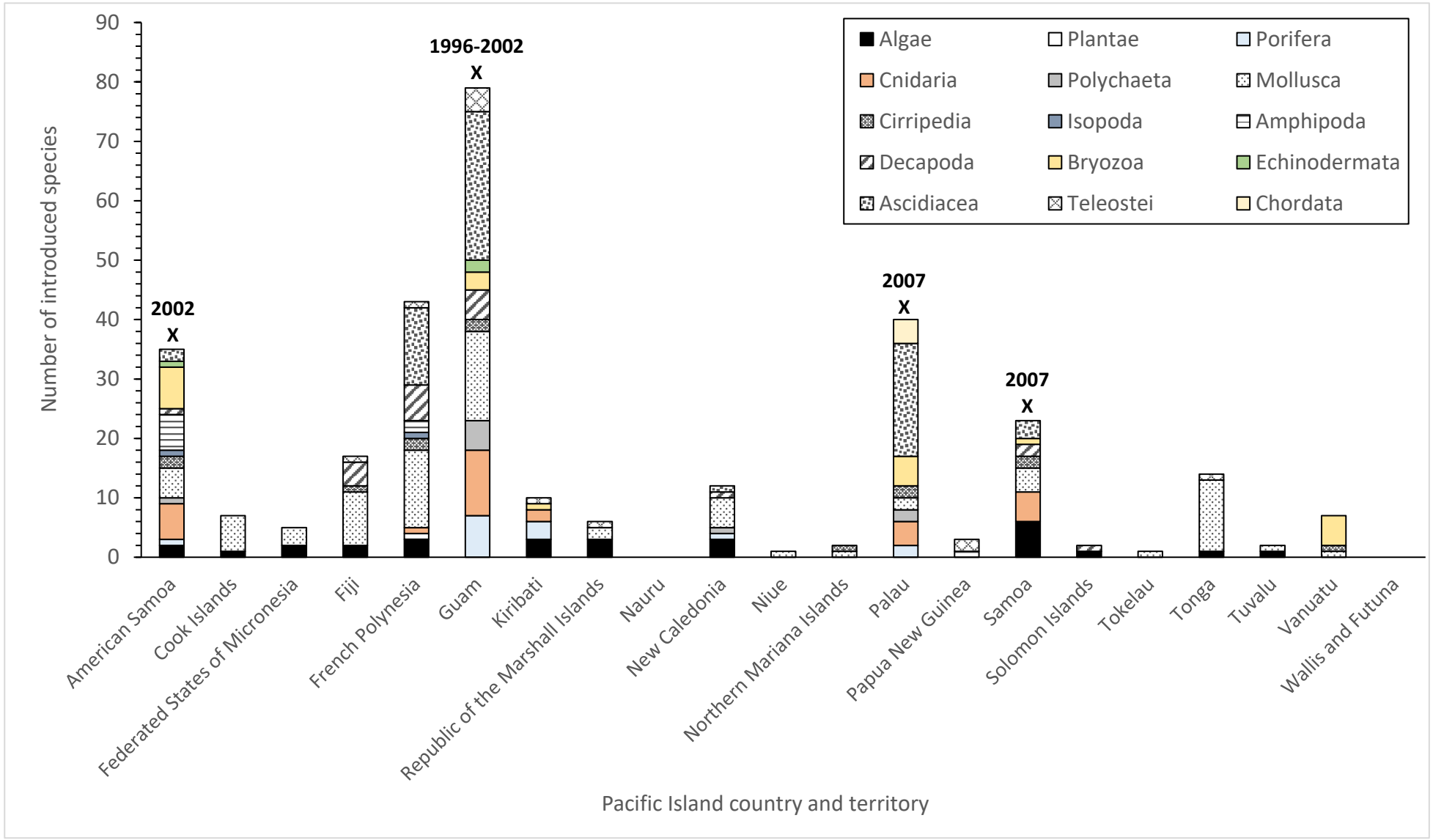

Figure 2: Number of marine species recorded as introduced into Pacific island countries and territories by taxa. X denotes countries and territories where a biological baseline survey and the year(s) it was carried out.

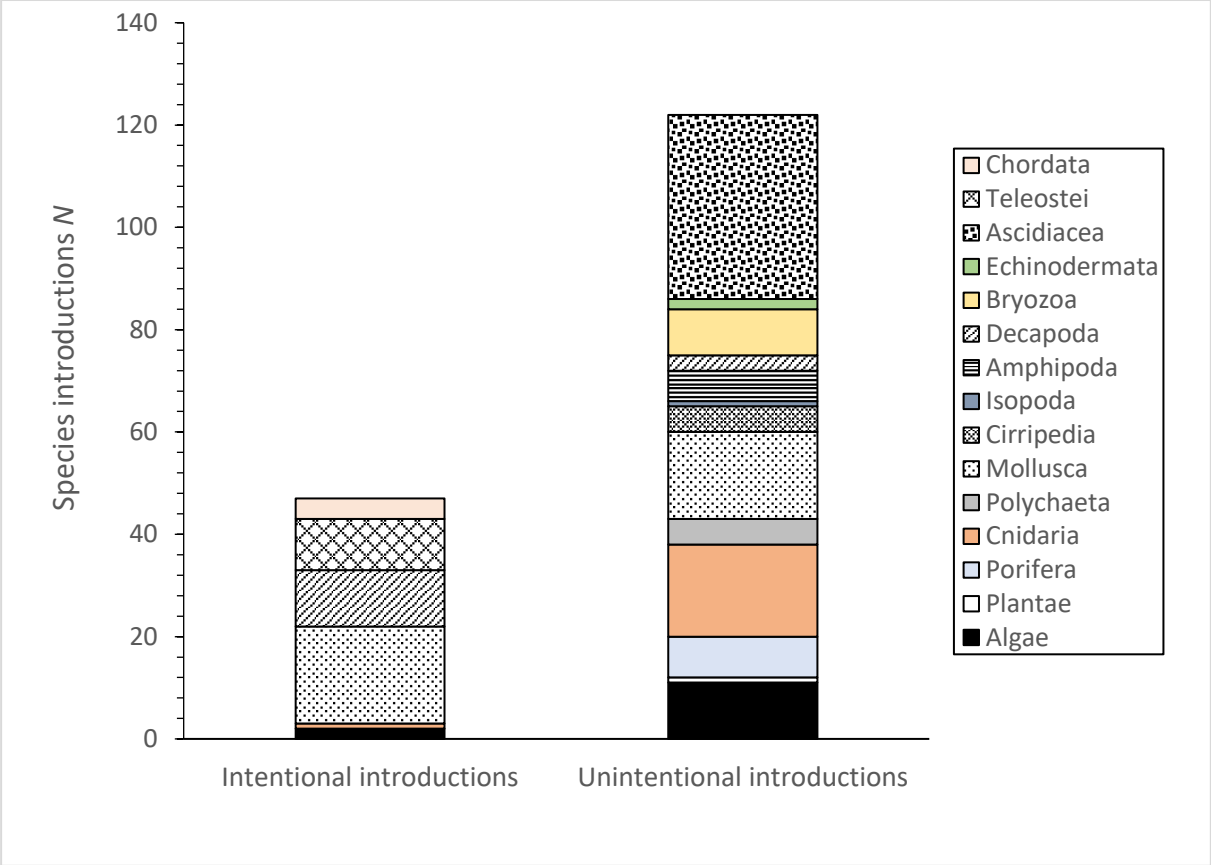

Figure 3: Total number of intentional marine species introduced into the Pacific Island countries and territories by taxa. Note the number of unintentionally introduced species is likely to be an underestimate of the real number of species introductions.

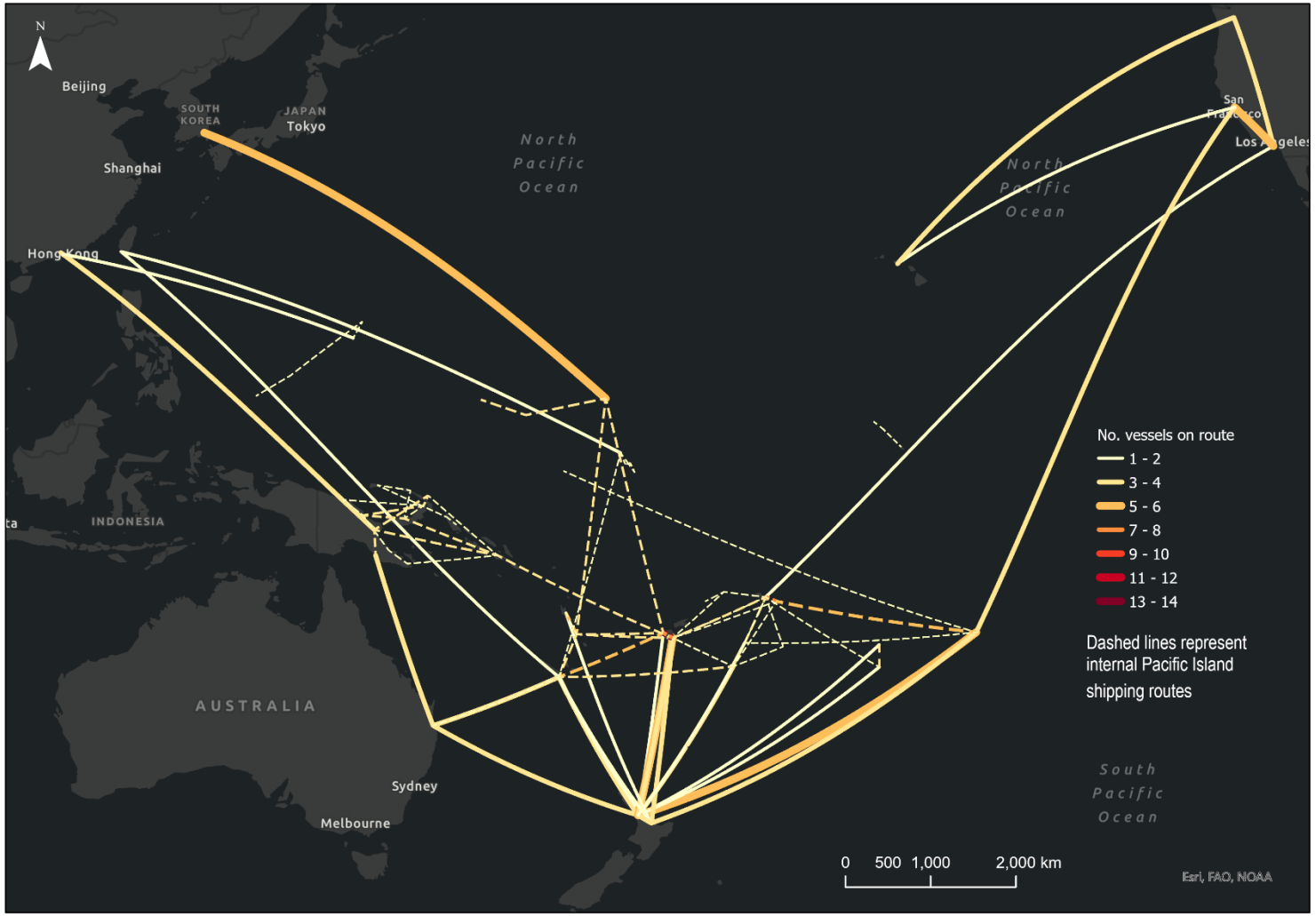

Figure 4: Number of cargo vessels on routes into the Pacific region and between Pacific island countries and territories. Note the colour and thickness of the line represents the number of vessels on that route. For example, thick red line represents 13-14 vessels on that route whereas thin pale-yellow line represents 1-2 vessels. The dashed lines represent intra-Pacific trips between countries and territories i.e. not originating from outside of the Pacific islands. Credit: Kimberley Seaward/NIWA.

Table 2: Marine species identified as introduced to American Samoa. The double underline denotes species recorded as cryptogenic.

Taxon name	Authority	Family	Known range within American Samoa	Pathway	Reference
Algae					
Caulerpa serrulata	(Forsskål) J.Agardh, 1837	Caulerpaceae	Fagatele Bay, Pago Pago Harbour, Fagasa Bay	Shipping (ballast, biofouling)	(Coles et al. 2003)
Halymenia durvillei	Bory de Saint-Vincent, 1828	Halymeniaceae	Fagatele Bay, Pago Pago Harbour, Vatia Bay	Shipping (ballast, biofouling)	(Coles et al. 2003)
Porifera	Grant, 1836				
Mycale	Gray, 1867	Mycalidae	Pago Pago Harbour	Shipping (ballast, biofouling)	(Coles et al. 2003)
Cnidaria	Hatschek, 1888				
Dynamena crisioides	Lamouroux, 1824	Sertulariidae	Pago Pago Harbour	Shipping (ballast, biofouling)	(Coles et al. 2003)
Pennaria disticha[a]	Goldfuss, 1820	Pennariidae	Pago Pago Harbour	Shipping (ballast, biofouling)	(Coles et al. 2003)
Plumularia strictocarpa	Pictet, 1893	Plumulariidae	Fagatele Bay, Pago Pago Harbour	Shipping (ballast, biofouling)	(Coles et al. 2003)
Sertularella diaphana	(Allman, 1885)	Sertulariidae	Fagasa Bay	Shipping (ballast, biofouling)	(Coles et al. 2003)
Thyroscyphus fruticosus	(Esper, 1797)	Thyroscyphidae	Pago Pago Harbour	Shipping (ballast, biofouling)	(Coles et al. 2003)
Turritopsis nutricula	McCrady, 1857	Oceaniidae	Pago Pago Harbour	Shipping (ballast, biofouling)	(Coles et al. 2003)
Polychaeta	Grube, 1850				
Salmacina dysteri	(Huxley, 1855)	Serpulidae	Fagatele Bay, Pago Pago Harbour	Shipping (ballast, biofouling)	(Coles et al. 2003)
Mollusca					
Chama pacifica	Broderip, 1835	Chamidae	Pago Pago Harbour	Shipping (ballast, biofouling)	(Coles et al. 2003)
Monia nobilis	(Reeve, 1859)	Anomiidae	Pago Pago Harbour	Shipping (ballast, biofouling)	(Coles et al. 2003)
Rochia nilotica	(Linnaeus, 1767)	Trochidae	Pago Pago Harbour	Intentionally introduced for fisheries	(Eldredge 1994)

Taxon name	Authority	Family	Known range within American Samoa	Pathway	Reference
Tridacna derasa	(Röding, 1798)	Cardiiae	Unknown locations	Intentionally introduced to restock wild population	(Itano and Buckley 1988; Togia et al. 2021)
Tridacna gigas	(Linnaeus, 1758)	Cardiiae	Unknown locations	Intentionally introduced to restock wild population	(Itano and Buckley 1988; Togia et al. 2021)
Cirripedia	Burmeister, 1834				
Amphibalanus amphitrit[a b c]	(Darwin, 1854)	Balanidae	Pago Pago Harbour	Shipping (ballast, biofouling)	(Coles et al. 2003)
Amphibalanus reticulatus[a c]	(Utinomi, 1967	Balanidae	Pago Pago Harbour	Shipping (ballast, biofouling)	(Coles et al. 2003)
Isopoda	Latreille, 1817				
Ligia (Megaligia) exotica	Roux, 1828	Ligiidae	Pago Pago Harbour	Shipping (ballast, biofouling)	(Coles et al. 2003)
Amphipoda	Latreille, 1816				
Bemlos virgus	Myers, 1985	Aoridae	Vatia Bay	Shipping (ballast, biofouling)	(Coles et al. 2003)
Ericthonius brasiliensis	(Dana, 1853)	Ischyroceridae	Pago Pago Harbour	Shipping (ballast, biofouling)	(Coles et al. 2003)
Monocorophium insidiosum	(Crawford, 1937)	Corophiidae	Pago Pago Harbour	Shipping (ballast, biofouling)	(Coles et al. 2003)
Leucothoe micronesiae	J.L. Barnard, 1965	Ischyroceridae	Pago Pago Harbour	Shipping (ballast, biofouling)	(Coles et al. 2003)
Stenothoe gallensis	Walker, 1904	Stenothoidae	Unknown	Shipping (ballast, biofouling)	(Togia et al. 2021)
Stenothoe valida	Dana, 1852	Stenothoidae	Pago Pago Harbour	Shipping (ballast, biofouling)	(Coles et al. 2003)
Decapoda	Latreille, 1802				
Acantholobulus pacificus[a]	(Edmondson, 1931)	Panopeidae	Pago Pago Harbour	Shipping (ballast)	(Coles et al. 2003)
Bryozoa					(Coles et al. 2003)
Virididentula dentata	(Lamouroux, 1816)	Bugulidae	Pago Pago Harbour	Shipping (ballast, biofouling)	(Coles et al. 2003)
Bugula neritina[a b c]	(Linnaeus, 1758)	Bugulidae	Pago Pago Harbour	Shipping (ballast, biofouling)	(Coles et al. 2003)
Poricella robusta	(Hincks, 1884)	Arachnopusiidae	Pago Pago Harbour	Shipping (ballast, biofouling)	(Coles et al. 2003)
Savignyella lafontii	(Audouin, 1826)	Savignyellidae	Fagatele Bay, Pago Pago Harbour	Shipping (ballast, biofouling)	(Coles et al. 2003)

Taxon name	Authority	Family	Known range within American Samoa	Pathway	Reference
Schizoporella errata[a c]	(Waters, 1878)	Schizoporellidae	Pago Pago Harbour	Shipping (ballast, biofouling)	(Coles et al. 2003)
Virididentula dentata[c]	(Lamouroux, 1816)	Bugulidae	Unknown	Shipping (ballast, biofouling)	(Togia et al. 2021)
Watersipora subtorquata[b c]	(d'Orbigny, 1852)	Watersiporidae	Pago Pago Harbour	Shipping (ballast, biofouling)	(Coles et al. 2003)
Echinodermata	Bruguière, 1791 [ex Klein, 1734]				
Ophiactis savignyi[a]	(Müller & Troschel, 1842)	Ophiactidae	Pago Pago Harbour, Vatia Bay, Fagasa Bay	Shipping (ballast)	(Coles et al. 2003)
Ascidiacea	Blainville, 1824				(Coles et al. 2003)
Phallusia nigra	Savigny, 1816	Ascidiidae	Pago Pago Harbour	Shipping (ballast, biofouling)	(Coles et al. 2003)
Styela canopus[a c]	(Savigny, 1816)	Styelidae	Pago Pago Harbour	Shipping (ballast, biofouling)	(Coles et al. 2003)

[a] recorded from New Zealand, [b] recorded from tropical Australia, [c] recorded from Hawai'i

Table 3: Marine species identified as introduced to Cook Islands.

Taxon name	Authority	Family	Known range within Cook Islands	Pathway	References
Algae					
Kappaphycus alvarezii[c]	(Doty) Doty ex P.C.Silva, 1996	Solieriaceae	Unsuccessfully introduced to Aitutaki, Pukapuka and Penrhyn	Intentionally introduced for aquaculture	(Eldredge 1994) (Hayashi et al. 2017)
Mollusca					
Hippopus hippopus	(Linnaeus, 1758)	Cardiidae	Aitutaki	Intentionally introduced to restock wild population	(Eldredge 1994)
Perna viridis	(Linnaeus, 1758)	Mytilidae	Unsuccessfully introduced	Intentionally introduced for aquaculture	(Eldredge 1994)
Pinctada maxima	(Jameson, 1901)	Margaritidae	Suwarrow	Intentionally introduced for aquaculture	(Eldredge 1994)
Rochia nilotica	(Linnaeus, 1767)	Trochidae	Aitutaki Island, Rakahanga, Manihiki, Palmerston Island, Suwarrow	Intentionally introduced for fisheries	(Eldredge 1994)
Tridacna derasa	(Röding, 1798)	Cardiidae	Aitutaki	Intentionally introduced to restock wild population	(Itano and Buckley 1988; Eldredge 1994)
Turbo marmoratus	Linnaeus, 1758	Turbinidae	Unsuccessfully introduced to Aitutaki, Rarotonga	Intentionally introduced for aquaculture and fisheries	(Eldredge 1994)

[c] recorded from Hawai'i

Table 4: Marine species identified as introduced to the Federated States of Micronesia.

Taxon name	Authority	Family	Known range within Federated States of Micronesia	Pathway	References
Algae					
Eucheuma denticulatum[c]	(N.L.Burman) Collins & Hervey, 1917	Solieriaceae	Pohnpei, Kosrae	Intentionally introduced for aquaculture	(Gamel 1987) (Eldredge 1994)
Kappaphycus alvarezii[c]	(Doty) Doty ex P.C.Silva, 1996	Solieriaceae	Pohnpei, Kosrae	Intentionally introduced for aquaculture	(Eldredge 1994) (Hayashi et al. 2017)
Mollusca					
Rochia nilotica	(Linnaeus, 1767)	Trochidae	Chuuk, Puluwat, Pohnepu, Satawal, Kosrae, Woleai, Faraulep, Ifalik, Eaurpik, Elato, Lamotrak, West Fayu, Nukuoro, Kapingamarangi, Pingelap, Farchaulap	Intentionally introduced for fisheries	(Gamel 1987) (Eldredge 1994)
Tridacna derasa	(Röding, 1798)	Cardiidae	Unknown locations	Intentionally introduced to restock wild population	(Gamel 1987)
Turbo marmoratus	Linnaeus, 1758	Turbinidae	Kosrae	Intentional for aquaculture, fisheries	(Edward 2002)

[c] recorded from Hawai'i

Table 5: Marine species identified as introduced to Fiji. The double underline denotes species recorded as cryptogenic.

Taxon name	Authority	Family	Known range within Fiji	Pathway	References
Algae					
Kappaphycus alvarezii[c]	(Doty) Doty ex P.C.Silva, 1996	Solieriaceae	Suva, Mana Island, Telau Islands, Bau, Rairaki	Intentionally introduced for aquaculture	(Booth et al. 1983; Prakash 1990; Eldredge 1994)
Codium arenicola	M.E.Chacana & P.C.Silva, 2014	Codiaeceae	Suva Harbour	Shipping (ballast, biofouling), aquaculture (co-transfer)	(Coles et al. 2003)
Mollusca					
Crassotrea virginica	(Eldredge 1994)	Ostreidae	Introduced from Hawaii to Bilo Bay	Intentionally introduced for aquaculture	(Eldredge 1994)
Magallana bilineata	(Röding, 1798)	Ostreidae	Two introductions (1976 & 1976) from Philippines to an undisclosed location	Intentionally introduced for aquaculture	(Eldredge 1994)
Magallana gigas	(Thunberg, 1793)	Ostreidae	Several introductions from Australia, California, Japan, Philippines to Bay of Islands near Lami and Namari Bay	Intentionally introduced for aquaculture	(Glude 1984) (Eldredge 1994)
Mytilopsis sallei	(Récluz, 1849)	Dreissenidae	Cryptogenic, likely to be *M. adamsi*	N/A if native *M. adamsi*, but shipping (ballast, biofouling) if *M. sallei*	(Hertlein and Hanna 1949); (Marelli 2020)
Ostrea edulis	Linnaeus, 1758	Ostreidae	Introduced from Japan to an undisclosed location	Intentionally introduced for aquaculture	(Andrews 1985)
Perna viridis	(Linnaeus, 1758)	Mytilidae	Introduced from Philippines to Namarai Bay, Laucala Bay, Rewa Delta	Intentionally introduced for aquaculture	(Eldredge 1994)
Ruditapes philippinarum	(A. Adams & Reeve, 1850)	Veneridae	Introduced from California to Cave Island, Bay of Islands	Intentionally introduced for aquaculture	(Glude 1972)

Taxon name	Authority	Family	Known range within Fiji	Pathway	References
Saccostrea echinata	(Quoy & Gaimard, 1835)	Ostreidae	Introduced from Australia and Tahiti to Mago Island, Laucala and Namarai Bays	Intentionally introduced for aquaculture	(Glude 1972) (Vereivalu 1989)
Saccostrea glomerata	(Gould, 1850)	Ostreidae	Introduced from Australia and California to Savusavu, Bilo Bay, Tavenui, Labasa	Intentionally introduced for aquaculture	(Edward 2002)
Cirripedia	Burmeister, 1834				
Amphibalanus amphitrite[a b c]	(Darwin, 1854)	Balanidae	Laucala Bay	Shipping (ballast, biofouling)	(Foster 1974)
Decapoda	Latreille, 1802				
Penaeus indicus	H. Milne Edwards, 1837	Penaeidae	Introduced from Tahiti to Raviravi	Intentionally introduced for aquaculture	(Eldredge 1994)
Penaeus merguiensis	de Man, 1888 [in de Man, 1887-1888]	Penaeidae	Introduced from Tahiti to Raviravi and now established in the Ba area	Intentionally introduced for aquaculture	(Choy 1983; Andrews 1985)
Penaeus monodon	Fabricius, 1798	Penaeidae	Navua	Intentionally introduced for aquaculture	(Eldredge 1994)
Penaeus vannamei	Boone, 1931	Penaeidae	Introduced from Hawaii to an undisclosed area	Intentionally introduced for aquaculture	(Briggs et al. 2004)
Teleostei					
Salmo trutta	Linnaeus, 1758	Salmonidae	Unknown; information may be unreliable (Eldredge 1994)	Intentionally introduced for aquaculture	(Andrews 1985)

[a] recorded from New Zealand, [b] recorded from tropical Australia, [c] recorded from Hawai'i

Table 6: Marine species identified as introduced to French Polynesia. The double underline represents species recorded as cryptogenic.

Taxon name	Authority	Family	Known range within French Polynesia	Pathway	References
Algae					
Avrainvillea amadelpha	(Montagne) A.Gepp & E.S.Gepp, 1908	Dichotomosiphonaceae	Unknown	Shipping (ballast, biofouling), natural dispersal	(UICN Comité français 2019)
Eucheuma	J.Agardh, 1847	Solieriaceae	Unknown		(UICN Comité français 2019)
Ostreopsis ovata	Fukuyo, 1981	Ostreopsidaceae	Unknown	Shipping (ballast)	(UICN Comité français 2019)
Plantae					
Rhizophora stylosa	Griff.	Rhizophoraceae	Introduced from New Caledonia in 1937 to Vaianahe that has now spread through most of Moorea	Intentionally introduced by humans; reason unknown	(Langer and Lipps 2006)
Cnidaria					
Exaiptasia diaphana	(Rapp, 1829)	Aiptasiidae	Unknown	Intentionally introduced for aquaculture	(UICN Comité français 2019)
Mollusca					
Acar plicata	(Dillwyn, 1817)	Arcidae	Unknown	Shipping (ballast, biofouling)	(UICN Comité français 2019)
Dendostrea frons	(Linnaeus, 1758)	Ostreidae	Vessel hull in Pape'ete Port	Shipping (ballast, biofouling)	(Garcia-Vazquez et al. 2020)
Drupa albolabris	(Blainville, 1832)	Muricidae	Dock in Vai'are and Pape'ete	Shipping (ballast, biofouling)	(Garcia-Vazquez et al. 2020)
Littoraria coccinea glabrata	(Philippi, 1846)	Littorinidae	Dock in Vai'are and Pape'ete	Shipping (ballast, biofouling)	(Garcia-Vazquez et al. 2020)
Magallana gigas[a]	(Thunberg, 1793)	Ostreidae	Introduced from California to Tahiti, Taiatea, Tahaa	Intentionally introduced for aquaculture	(Eldredge 1994)
Nerita tessellata	Gmelin, 1791	Neritidae	Dock in Vai'are	Shipping (ballast, biofouling)	(Garcia-Vazquez et al. 2020)

Taxon name	Authority	Family	Known range within French Polynesia	Pathway	References
Perna viridis	(Linnaeus, 1758)	Mytilidae	Introduced from New Caledonia to Taututu Bay and Uturoto Bay	Intentionally introduced for aquaculture	(AQUACOP 1979; Eldredge 1994)
Rochia nilotica	(Linnaeus, 1767)	Trochidae	Introduced from New Caledonia and Vanuatu	Intentionally introduced for aquaculture, fisheries	(Van Pel 1957) (Yen 1985)
Ruditapes philippinarum	(A. Adams & Reeve, 1850)	Veneridae	Introduced to an undisclosed location	Intentionally introduced for aquaculture	(Davy and Graham 1982)
Saccostrea cucullata	(Born, 1778)	Ostreidae	Dock in Pao-Pao	Intentionally introduced for aquaculture	(Garcia-Vazquez et al. 2020)
Saccostrea echinata	(Quoy & Gaimard, 1835)	Ostreidae	Introduced from New Caledonia to an undisclosed location	Intentionally introduced for aquaculture	(Coeroli et al. 1984; Eldredge 1994)
Semiricinula tissoti	(Petit de la Saussaye, 1852)	Muricidae	Dock in Pao-Pao	Shipping (ballast, biofouling)	(Garcia-Vazquez et al. 2020)
Turbo marmoratus	Linnaeus, 1758	Turbinidae	Introduced from Vanuatu to Tautira then transplanted throughout French Polynesia	Intentionally introduced for restocking	(Yen 1991; Eldredge 1994)
Cirripedia					
Amphibalanus amphitrite[a b c]	(Darwin, 1854)	Balanidae	Vessel hull Vai'are	Shipping (ballast, biofouling)	(Ardura et al. 2016)
Chthamalus proteus[c]	Dando & Southward, 1980	Chthamalidae	Dock in Vai'are	Shipping (ballast, biofouling)	(Zardus and Hadfield 2005)
Isopoda					
Ligia (Megaligia) exotica[a]	Roux, 1828	Ligiidae	Society Islands, Raiatea & Tuamotu Archipelago, Rangiora Islands, Mohican Reef	Shipping (ballast, biofouling)	2002–2021 Invertebrate Zoology Collections Database
Amphipoda					
Stenothoe gallensis	Walker, 1904	Stenothoidae	Mangareva Island, Gambier Islands, Tuamotu Archipelago	Shipping (ballast, biofouling)	(Krapp-Schickel 2015)

Taxon name	Authority	Family	Known range within French Polynesia	Pathway	References
Stenothoe valida	Dana, 1852	Stenothoidae	North side of ferry channel Society Islands, Moorea	Shipping (ballast, biofouling)	(Ruiz and Gellar 2018)
Decapoda					
Penaeus stylirostris	Stimpson, 1871	Salmonidae	Introduced from Latin America to Tahiti	Intentionally introduced for aquaculture	(Cuzon et al. 2004)
Metapenaeus ensis	(De Haan, 1844 [in De Haan, 1833-1850])	Penaeidae	Introduced from New Caledonia to Tahiti	Intentionally introduced for aquaculture	(AQUACOP 1975)
Penaeus aztecus	Ives, 1891	Penaeidae	Introduced from Texas to Tahiti	Intentionally introduced for aquaculture	(AQUACOP 1975; Eldredge 1994)
Penaeus japonicus[c]	Spence Bate, 1888	Penaeidae	Introduced from Japan to Tahiti	Intentionally introduced for aquaculture	(AQUACOP 1975; Eldredge 1994)
Penaeus merguiensis	de Man, 1888 [in de Man, 1887-1888]	Penaeidae	Introduced from New Caledonia to Tahiti	Intentionally introduced for aquaculture	(AQUACOP 1975; Eldredge 1994)
Penaeus semisulcatus	De Haan, 1844 [in De Haan, 1833-1850]	Penaeidae	Introduced from New Caledonia to Tahiti	Intentionally introduced for aquaculture	(AQUACOP 1975; Eldredge 1994)
Ascidiacea					
Ascidia sydneiensis[c]	Stimpson, 1855	Ascidiidae	Unknown location	Shipping (biofouling)	(UICN Comité français 2019)
Botrylloides niger	Herdman, 1886	Styelidae	Unknown location	Shipping (ballast, biofouling), aquaculture, and natural dispersal	(UICN Comité français 2019)
Didemnum perlucidum[b c]	Monniot F., 1983	Didemnidae	Undisclosed location	Shipping (ballast, biofouling)	(Monniot et al. 1985)
Diplosoma listerianum[a]	(Milne Edwards, 1841)	Didemnidae	Unknown location	Shipping (ballast, biofouling)	(UICN Comité français 2019)
Herdmania momus[c]	(Savigny, 1816)	Pyuridae	Unknown location	Shipping (ballast, biofouling)	(UICN Comité français 2019)
Lissoclinum fragile[c]	(Van Name, 1902)	Didemnidae	Unknown location	Shipping (ballast, biofouling)	(UICN Comité français 2019)
Microcosmus exasperatus[c]	Heller, 1878	Pyuridae	Unknown location	Shipping (ballast, biofouling)	(UICN Comité français 2019)
Perophora viridis	Verril, 1871	Perophoridae	Unknown location	Shipping (ballast, biofouling)	(UICN Comité français 2019)

Taxon name	Authority	Family	Known range within French Polynesia	Pathway	References
Polycarpa maculata	Hartmeyer, 1906	Styelidae	Unknown location	Shipping (ballast, biofouling)	(UICN Comité français 2019)
Polyclinum constellatum[c]	Savigny, 1816	Polyclinidae	Unknown location	Shipping (ballast, biofouling)	(UICN Comité français 2019)
Pyura sacciformis	(Drasche, 1884)	Pyuridae	Unknown location	Shipping (ballast, biofouling)	(UICN Comité français 2019)
Styela canopus[a c]	(Savigny, 1816)	Styelidae	First recorded from the outer reef at Hao	Shipping (ballast, biofouling)	(Monniot et al. 1985)
Symplegma brakenhielmi[a c]	(Michaelsen, 1904)	Styelidae	Unknown location	Shipping (biofouling)	(UICN Comité français 2019)
Teleostei					
Lates calcarifer	(Bloch, 1790)	Latidae	Undisclosed location	Intentionally introduced for aquaculture	(Thouard et al. 1994)

[a] recorded from New Zealand, [b] recorded from tropical Australia, [c] recorded from Hawai'i

Table 7: Marine species identified as introduced to Guam. The double underline represents species recorded as cryptogenic.

Taxon name	Authority	Family	Known range within Guam	Pathway	References
Porifera					
Callyspongia (Cladochalina) fibrosa	(Ridley & Dendy, 1886)	Callyspongiidae	Apra Harbour	Shipping (ballast, biofouling)	(Kelly et al. 2003, Paulay et al. 2002)
Gelloidea wilsoni	Carballo, Aquilar-Camacho, Knapp & Bell, 2013	Niphatidae	Unknown	Shipping (ballast, biofouling)	(Carballo et al. 2013)
Lanthella basta	(Pallas, 1766)	Ianthellidae	Apra Harbour	Shipping (ballast, biofouling)	(Kelly et al. 2003, Paulay et al. 2002)
Mycale	Gray, 1867	Mycalidae	Apra Harbour	Shipping (ballast, biofouling)	(Kelly et al. 2003, Paulay et al. 2002)
Niphates	Duchassaing & Michelotti, 1864	Niphatidae	Apra Harbour	Shipping (ballast, biofouling)	(Kelly et al. 2003, Paulay et al. 2002)
Tedania (Tedania) ignis[c]	(Duchassaing & Michelotti, 1864)	Tedaniidae	Apra Harbour	Shipping (ballast, biofouling)	(Kelly et al. 2003, Paulay et al. 2002)
Cnidaria					
Actiniaria	Hertwig, 1882		Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002)
Clytia noliformis	(McCrady, 1859) sensu Calder, 1991	Campanulariidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002)
Clytia hemisphaerica	(Linnaeus, 1767)	Campanulariidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002)
Clytia thornelyi	(Nutting, 1927)	Campanulariidae	Inside Apra Harbour and occurs outside of Apra Harbour in natural habitat	Shipping (ballast, biofouling)	(Paulay et al. 2002)
Clytia linearis	(Thorneley, 1900)	Campanulariidae	Inside Apra Harbour and occurs outside of Apra Harbour in natural habitat	Shipping (ballast, biofouling)	(Paulay et al. 2002)
Corydendrium parasiticum	(Linnaeus, 1767)	Oceaniidae	Inside Apra Harbour and occurs outside of Apra Harbour in natural habitat	Shipping (ballast, biofouling)	(Paulay et al. 2002; Kirkendale and Calder 2003)
Ectopleura viridis	(Pictet, 1893)	Tubulariidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002; Kirkendale and Calder 2003)
Obelia dichotoma	(Linnaeus, 1758)	Campanulariidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002)

Taxon name	Authority	Family	Known range within Guam	Pathway	References
Pennaria disticha[a]	Goldfuss, 1820	Pennariidae	Inside Apra Harbour and occurs outside of Apra Harbour in natural habitat	Shipping (ballast, biofouling)	(Paulay et al. 2002)
Thyroscyphus fruticosus	(Esper, 1797)	Throscyphidae	Inside Apra Harbour and occurs outside of Apra Harbour in natural habitat	Shipping (ballast, biofouling)	(Paulay et al. 2002)
Turritopsis nutricula	McCrady, 1857	Oceaniidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002)
Polychaeta					
Oenone fulgida	(Lamarck, 1818)	Oenonidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002)
Sabellastarte spectabilis[a]	(Grube, 1878)	Sabellidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002)
Salmacina dysteri	(Huxley, 1855)	Serpulidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002)
Thelepus setosus	(Quatrefages, 1866)	Terebellidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002)
Timarete caribous	(Grube, 1859)	Cirratulidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002)
Mollusca					
Bostrycapulus aculeatus	(Gmelin, 1791)	Calyptraeidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002)
Cellana mazatlandica	(G. B. Sowerby I, 1839)	Nacellidae	Introduced from China and Japan, extirpated	Intentionally introduced	(Paulay et al. 2002)
Chama asperella	Lamarck, 1819	Chamidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002)
Chama macerophylla	Gmelin, 1791	Chamidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002)
Crucibulum spinosum	(G. B. Sowerby I, 1824)	Calyptraeidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002)
Isognomon ephippium	(Linnaeus, 1758)	Isognomonidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002)
Magallana gigas[a]	(Thunberg, 1793)	Ostreidae	Introduced from Taiwan, extirpated	Intentionally introduced for aquaculture	(Paulay et al. 2002)
Monia nobilis	(Reeve, 1859)	Anomiidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002)
Neotrapezium sublaevigatum[a]	(Lamarck, 1819)	Trapezidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002)
Rochia nilotica	(Linnaeus, 1767)	Trochidae	Inside Apra Harbour and occurs outside of Apra Harbour in natural habitat	Intentionally introduced for aquaculture, fisheries	(see Eldredge 1994; Paulay et al. 2002)
Saccostrea cucullata	(Born, 1778)	Ostreidae	Introduced from Solomon Islands to Sasa Bay, Apra Harbour	Intentionally introduced for aquaculture	(Eldredge 1994)
Saccostrea echinata	(Quoy & Gaimard, 1835)	Ostreidae	Introduced from Palau Sasa Bay, Apra Harbour	Intentionally introduced for aquaculture	(Eldredge 1994)
Tathrella iredalei	Laseron, 1959	Pyramidellidae	Apra Harbour, extirpated	Shipping (ballast, biofouling)	(Paulay et al. 2002)

Taxon name	Authority	Family	Known range within Guam	Pathway	References
Tridacna derasa	(Röding, 1798)	Cardiidae	Apra Harbour	Intentionally introduced to re-stock wild population	(Paulay et al. 2002)
Tridacna gigas	(Linnaeus, 1758)	Cardiidae	Apra Harbour, extirpated	Intentionally introduced to re-stock wild population	(Paulay et al. 2002)
Cirripedia					
Amphibalanus eburneus[a c]	(Gould, 1841)	Balanidae	Outside of Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002)
Chthamalus proteus	Dando & Southward, 1980	Chthamalidae	Likely introduced from Hawaii to Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002)
Decapoda					
Charybdis (Charybdis) hellerii[a]	(A. Milne-Edwards, 1867)	Portunidae	Apra Harbour	Shipping (ballast)	(Paulay et al. 2002)
Metopograpsus oceanicus	(Hombron & Jacquinot, 1846 [in Hombron & Jacquinot, 1842-1854])	Grapsidae	Apra Harbour	Shipping (ballast)	(Paulay 2007)
Penaeus monodon[c]	Fabricius, 1798	Penaeidae	Introduced from Taiwan, extirpated	Intentionally introduced for aquaculture	(Eldredge 1994)
Penaeus stylirostris[c]	Stimpson, 1871	Penaeidae	Introduced from Hawaii	Intentionally introduced for aquaculture	(see Eldredge 1994; Paulay et al. 2002)
Penaeus vannamei[c]	Boone, 1931	Penaeidae	Probably introduced from New Caledonia	Intentionally introduced for aquaculture	(see Eldredge 1994; Paulay et al. 2002)
Bryozoa					
Amathia distans[a b c]	Busk, 1886	Vesiculariidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002)
Amathia verticillata[a b c]	(delle Chiaje, 1822)	Vesiculariidae	Unknown	Shipping (ballast, biofouling)	NEMISIS
Schizoporella serialis	(Heller, 1867)	Schizoporellidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002)
Echinodermata					
Amphiura (Amphiura) luetkeni	Duncan, 1879	Amphiuridae	Apra Harbour, recorded from northern Australia and may represent an introduction from there	Shipping (ballast)	(Starmer 2003)
Ophiactis savignyi[a]	(Müller & Troschel, 1842)	Ophiactidae	Inside Apra Harbour and occurs outside of Apra Harbour in natural habitat	Shipping (ballast)	(Paulay et al. 2002)

Taxon name	Authority	Family	Known range within Guam	Pathway	References
Ascidiacea					
Ascidia sydneiensis[c]	Stimpson, 1855	Ascidiidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)
Botrylloides niger	Herdman, 1886	Styelidae	Inside Apra Harbour and occurs outside of Apra Harbour in natural habitat	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)
Botrylloides simodensis[c]	Saito & Watanabe, 1981	Styelidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)
Cnemidocarpa irene[c]	(Hartmeyer, 1906)	Styelidae	Inside Apra Harbour and occurs outside of Apra Harbour in natural habitat	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)
Didemnum perlucidum[b c]	Monniot F., 1983	Didemnidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)
Didemnum psammatodes	(Sluiter, 1895)	Didemnidae	Outside of Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)
Diplosoma listerianum[a]	(Milne Edwards, 1841)	Didemnidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)
Herdmania mauritiana	(Drasche, 1884)	Pyuridae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)
Herdmania pallida[c]	(Heller, 1878)	Pyuridae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)
Lissoclinum fragile[c]	(Van Name, 1902)	Didemnidae	Inside Apra Harbour and occurs outside of Apra Harbour in natural habitat	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)
Microcosmus exasperatus[c]	Heller, 1878	Pyuridae	Inside Apra Harbour and occurs outside of Apra Harbour in natural habitat	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)
Microcosmus helleri	Herdman, 1881	Pyuridae	Inside Apra Harbour and occurs outside of Apra Harbour in natural habitat	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)
Microcosmus pupa	(Savigny, 1816)	Pyuridae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)
Perophora multiclathrata	(Sluiter, 1904)	Perophoridae	Inside Apra Harbour and occurs outside of Apra Harbour in natural habitat	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)

Taxon name	Authority	Family	Known range within Guam	Pathway	References
Perophora sagamiensis	Tokioka, 1953	Perophoridae	Inside Apra Harbour and occurs outside of Apra Harbour in natural habitat	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)
Phallusia nigra	Savigny, 1816	Ascidiidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)
Polyandrocarpa anguinea	(Sluiter, 1898)	Styelidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)
Polycarpa aurita[c]	(Sluiter, 1890)	Styelidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)
Polyclinum constellatum[c]	Savigny, 1816	Polyclinidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)
Pyura confragosa	Kott, 1985	Pyuridae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)
Pyura curvigona	Tokioka, 1950	Pyuridae	Inside Apra Harbour and occurs outside of Apra Harbour in natural habitat	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)
Pyura honu	Monniot C. & Monniot F., 1987	Pyuridae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)
Pyura robusta	Hartmeyer, 1922	Pyuridae	Inside Apra Harbour and occurs outside of Apra Harbour in natural habitat	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)
Styela canopus[c]	(Savigny, 1816)	Styelidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)
Symplegma brakenhielmi[a c]	(Michaelsen, 1904)	Styelidae	Apra Harbour	Shipping (ballast, biofouling)	(Paulay et al. 2002; Lambert 2003)
Teleostei					
Mugil cephalus	Linnaeus, 1758	Mugilidae	Introduced from Hawaii and Taiwan	Intentionally introduced for aquaculture	(Paulay et al. 2002)
Neopomacentrus violascens	(Bleeker, 1848)	Pomacentridae	Apra Harbour, possibly introduced from Philippines	Potentially through ballast considering its detection in the harbour	(Paulay et al. 2002)
Omobranchus elongatus	(Peters, 1855)	Blenniinae	Apra Harbour, possibly introduced from Philippines	Shipping as it was reported from a dry-docked ship	(Paulay et al. 2002)

Taxon name	Authority	Family	Known range within Guam	Pathway	References
Parioglossus philippinus	(Herre, 1945)	Microdesmidae	Apra Harbour, possibly introduced from Philippines	Shipping as it was reported from a dry-docked ship	(Paulay et al. 2002)

[a] recorded from New Zealand, [b] recorded from tropical Australia, [c] recorded from Hawai'i

Table 8: Marine species identified as introduced to Kiribati.

Taxon name	Authority	Family	Known range within Kiribati	Pathway	References
Algae					
Acanthophora spicifera[c]	(M.Vahl) Børgesen, 1910	Rhodomelaceae	Introduced from Hawaii to the Line Islands	Co-transfer with *E. denticulatum* and *K. alvarezii*	(Knapp et al. 2011)
Eucheuma denticulatum[c]	(N.L.Burman) Collins & Hervey, 1917	Solieriaceae	Introduced from Hawaii to Fanning Atoll and Kiritimati	Intentionally introduced for aquaculture	(Russell 1982; Eldredge 1994)
Kappaphycus alvarezii[c]	(Doty) Doty ex P.C.Silva, 1996	Solieriaceae	Introduced from Hawaii to Fanning Atoll and Kiritimati	Intentionally introduced for aquaculture	(Russell 1982; Eldredge 1994)
Porifera					
Gelliodes fibrosa[c]	Dendy, 1905	Niphatidae	Palmyra Atoll	Shipping (ballast, biofouling)	(Knapp et al. 2011)
Gelliodes wilsoni	Carballo, Aquilar-Camacho, Knapp & Bell, 2013	Niphatidae	Palmyra Atoll	Shipping (ballast, biofouling)	(Carballo et al. 2013)
Haliclona (Soestella) caerulea[c]	(Hechtel, 1965)	Chalinidae	Palmyra Atoll	Shipping (ballast, biofouling)	(Knapp et al. 2011)
Cnidaria					
Pennaria disticha[a]	Goldfuss, 1820	Pennariidae	Palmyra Atoll	Shipping (ballast, biofouling)	(Knapp et al. 2011)
Rhodactis howesii	Saville-Kent, 1893	Discosomidae	Palmyra Atoll	Shipping (ballast, biofouling)	(Work et al. 2008; Carter et al. 2019)
Bryozoa					
Amathia verticillata[a b c]	(delle Chiaje, 1822)	Vesiculariidae	Palmyra Atoll, Line Islands	Shipping (ballast, biofouling)	(Knapp et al. 2011)
Teleostei					
Omobranchus obliquus	(Garman, 1903)	Blenniidae	Palmyra Atoll	Likely shipping	(Springer and Gomon 1975; Mundy et al. 2010)

[a] recorded from New Zealand, [b] recorded from tropical Australia, [c] recorded from Hawai'i

Table 9: Marine species identified as introduced the Republic of the Marshall Islands.

Taxon name	Authority	Family	Known range within Republic of the Marshall Islands	Pathway	References
Algae					
Acanthophora spicifera[c]	(M.Vahl) Børgesen, 1910	Rhodomelaceae	Unknown locations	Shipping (ballast, biofouling), intentionally introduced	(Tsuda et al. 2008)
Eucheuma denticulatum[c]	(N.L.Burman) Collins & Hervey, 1917	Solieriaceae	Introduced from Pohnpei (FSM) to Majuro lagoon then to Mili and Likiep	Intentionally introduced for aquaculture	(Eldredge 1994)
Kappaphycus alvarezii[c]	(Doty) Doty ex P.C.Silva, 1996	Solieriaceae	Introduced from Pohnpei (FSM) to Majuro lagoon then to Mili and Likiep	Intentionally introduced for aquaculture	(Eldredge 1994)
Mollusca					
Pinctada imbricata[a]	Röding, 1798	Margaritidae	1935-36 introduced from Japan to Ebon, operations abandoned 1942	Intentionally introduced for aquaculture	(Eldredge 1994)
Rochia nilotica	(Linnaeus, 1767)	Trochidae	1939 introduced from Palau to Jaluit then Ebon, Aur, and Maloelap	Intentionally introduced for aquaculture	(Eldredge 1994)
Teleostei					
Siganus spinus	(Linnaeus, 1758)	Siganidae	Unknown locations	Intentionally introduced	(Pagad et al. 2020)

[a] recorded from New Zealand, [c] recorded from Hawai'i

Table 10: Marine species identified as introduced to New Caledonia.

Taxon name	Authority	Family	Known range within New Caledonia	Pathway	References
Algae					
Codium taylori	P.C.Silva, 1960	Codiaceae	Unknown location	Shipping (biofouling)	(UICN Comité français 2019)
Ulva ohnoi	M.Hiraoka & S.Shimada, 2004	Ulvaceae	Unknown location	Shipping (biofouling)	(UICN Comité français 2019)
Ostreopsis ovata	Fukuyo, 1981	Ostreopsidaceae	Unknown location	Shipping (ballast)	(UICN Comité français 2019)
Porifera					
Mycale (Zygomycale) parishii	(Bowerbank, 1875)	Mycalidae	Unknown location	Shipping (biofouling)	(UICN Comité français 2019)
Polychaeta					
Sabellastarte spectabilis[a]	(Grube, 1878)	Sabellidae	Unknown location	Shipping (biofouling)	(UICN Comité français 2019)
Mollusca					
Godiva quadricolor	(Barnard, 1927)	Myrrhinidae	Unknown location	Likely shipping	(UICN Comité français 2019)
Magallana gigas[a]	(Thunberg, 1793)	Ostreidae	Multiple introductions from Australia, China and Japan to undisclosed locations	Intentionally introduced for aquaculture	(Eldredge 1994)
Perna viridis	(Linnaeus, 1758)	Mytilidae	Introduced from Philippines to Baie de St Vincent	Intentionally introduced for aquaculture	(Eldredge 1994)
Saccostrea echinata	(Quoy & Gaimard, 1835)	Ostreidae	Introduced from Tahiti	Intentionally introduced for aquaculture	(Eldredge 1994)
Saccostrea glomerata	(Gould, 1850)	Ostreidae	Introduced from Australia to Ouenghi area of Saie St Vincent	Intentionally introduced for aquaculture	(Eldredge 1994)
Decapoda					
Penaeus stylirostris	Stimpson, 1871	Penaeidae	Imported from Mexico	Intentionally introduced for aquaculture	(Galinié 1989)
Ascidiacea					
Didemnum perlucidum[b c]	Monniot F., 1983	Didemnidae	Unknown	Shipping (ballast, biofouling)	(Monniot 1996)

[a] recorded from New Zealand, [b] recorded from tropical Australia, [c] recorded from Hawai'i

Table 11: Marine species identified as introduced to Niue.

Taxon name	Authority	Family	Known range within Niue	Pathway	References
Mollusca					
Rochia nilotica	(Linnaeus, 1767)	Trochidae	Introduced from Fiji to numerous locations in Niue: Uani, Matalave, Makatutuaha, Patuoto	Intentionally introduced for restocking	(Gillet 1992)

Table 12: Marine species identified as introduced to Northern Mariana Islands.

Taxon name	Authority	Family	Known range within Northern Mariana Islands	Pathway	References
Mollusca					
Rochia nilotica	(Linnaeus, 1767)	Trochidae	Introduced from Palau and Yap to Saipan	Intentionally introduced for restocking	(Gillet 1992)
Cirripedia					
Chthamalus proteus[c]	Dando & Southward, 1980	Chthamalidae	Unknown location	Shipping (ballast, biofouling)	(Zardus and Hadfield 2005)

[c] recorded from Hawai'i

Table 13: Marine species identified as introduced to Palau. The double underline denotes species recorded as cryptogenic.

Taxon name	Authority	Family	Known range within Palau	Pathway	References
Porifera					
Haliclona (Soestella) caerulea[c]	(Hechtel, 1965)	Chalinidae	Malakal Harbour on wharves, moorings and areas without commercial activity. There is dispute on whether this is a native species	Shipping (ballast, biofouling)	(Campbell et al. 2016; L. Colin and M. Kelly pers. comm.)
Mycale	Gray, 1867	Mycalidae	Malakal Harbour on wharves and areas without commercial activity. There is dispute on whether this is a native species	Shipping (ballast, biofouling)	(Campbell et al. 2016; L. Colin and M. Kelly pers. comm.)
Cnidaria					
Exaiptasia diaphana	(Rapp, 1829)	Aiptasiidae	Ongeim'l Tketau (Jellyfish lake)	Human mediated via lagoon	(Marino et al. 2008) (Patris et al. 2019)
Eudendrium carneum	Clarke, 1882	Eudendriidae	Koror–Babeldaob Channel and other high current areas, likely introduced from China in 1990s	Shipping (ballast, biofouling)	(Colin, 2009)
Obelia sp.		Campanulariidae	Malakal Harbour on wharves, vessels and moorings	Shipping (ballast, biofouling)	(Campbell et al. 2016)
Thyroscyphus fruticosus	(Esper, 1797)	Throscyphidae	Koror–Babeldaob Channel	Shipping (biofouling)	(Colin 2009)
Polychaeta					
Sabellastarte	Krøyer, 1856	Sabellidae	Malakal Harbour on wharves	Shipping (ballast, biofouling)	(Campbell et al. 2016)
		Serpulididae	Malakal Harbour on wharves and vessels	Shipping (ballast, biofouling)	(Campbell et al. 2016)
Mollusca					
Magallana gigas[a]	(Thunberg, 1793)	Ostreidae	Introduced from west coast USA to Ngatpang Bay	Intentionally introduced for aquaculture	(Eldredge 1994)
Pinctada imbricata[a]	Röding, 1798	Margaritidae	Introduced from Japan	Intentionally introduced for aquaculture	(Smith 1947; Eldredge 1994)
Cirripedia					
Amphibalanus eburneus[a c]	(Gould, 1841)	Balanidae	Malakal Harbour on wharves and vessels	Shipping (ballast, biofouling)	(Campbell et al. 2016)

Taxon name	Authority	Family	Known range within Palau	Pathway	References
Chthamalus proteus[c]	Dando & Southward, 1980	Chthamalidae	Malakal Harbour on moorings and areas without commercial activity	Shipping (ballast, biofouling)	(Campbell et al. 2016)
Bryozoa					
Amathia distans[a b c]	Busk, 1886	Vesiculariidae	Malakal Harbour on wharves and vessels	Shipping (ballast, biofouling)	(Campbell et al. 2016)
Bugula neritina[a b c]	(Linnaeus, 1758)	Bugulidae	Malakal Harbour on wharves and vessels	Shipping (ballast, biofouling)	(Campbell et al. 2016)
Tricellaria occidentalis/inopinata[a b]	(Trask, 1857)/d'Hondt & Occhipinti Ambrogi, 1985	Candidae	Malakal Harbour on wharves and moorings	Shipping (ballast, biofouling)	(Campbell et al. 2016)
Virididentula dentata[c]	(Lamouroux, 1816)	Bugulidae	Malakal Harbour on wharves	Shipping (ballast, biofouling)	(Campbell et al. 2016)
Watersipora subtorquata[b c]	(d'Orbigny, 1852)	Watersiporidae	Malakal Harbour on vessels	Shipping (ballast, biofouling)	(Campbell et al. 2016)
Ascidiacea					
Ascidia archaia	Sluiter, 1890	Ascidiidae	Reported from vessel biofouling, distribution currently unknown, and uncertain if nonindigenous	Shipping (ballast, biofouling)	(Colin 2009)
Ascidia sydneiensis[c]	Stimpson, 1855	Ascidiidae	Malakal Harbour on wharves	Shipping (ballast, biofouling)	(Campbell et al. 2016)
Botrylloides tyreus	Herdman, 1886	Stelidae	Reported from vessel biofouling, distribution currently unknown, and uncertain if nonindigenous	Shipping (ballast, biofouling)	(Colin 2009)
Botryllus	Gaertner, 1774	Styelidae	Malakal Harbour on wharves and moorings	Shipping (ballast, biofouling)	(Campbell et al. 2016)
Didemnum perlucidum[b c]	Monniot F., 1983	Didemnidae	Malakal Harbour on moorings and vessels, potentially not established.	Shipping (ballast, biofouling)	(Campbell et al. 2016)
Diplosoma listerianum[a]	(Milne Edwards, 1841)	Didemnidae	Malakal Harbour on wharves	Shipping (ballast, biofouling)	(Campbell et al. 2016)
Ecteinascidia diaphanis	Sluiter, 1886	Perophoridae	Reported from vessel biofouling, distribution currently unknown, and uncertain if nonindigenous	Shipping (ballast, biofouling)	(Colin 2009)

Taxon name	Authority	Family	Known range within Palau	Pathway	References
Eusynstyela hartmeyeri[c]	Michaelsen, 1904	Styelidae	Reported from vessel biofouling, distribution currently unknown, and uncertain if nonindigenous	Shipping (ballast, biofouling)	(Colin 2009)
Herdmania mauritiana	(Drasche, 1884)	Pyuridae	Reported from vessel biofouling, distribution currently unknown, and uncertain if nonindigenous	Shipping (ballast, biofouling)	(Colin 2009)
Herdmania momus[c]	(Savigny, 1816)	Pyuridae	Reported from vessel biofouling, distribution currently unknown, and uncertain if nonindigenous	Shipping (ballast, biofouling)	(Colin 2009)
Lissoclinum fragile[c]	(Van Name, 1902)	Didemnidae	Reported from vessel biofouling, distribution currently unknown, and uncertain if nonindigenous	Shipping (ballast, biofouling)	(Colin 2009)
Microcosmus helleri	Herdman, 1881	Pyuridae	Reported from vessel biofouling, distribution currently unknown, and uncertain if nonindigenous	Shipping (ballast, biofouling)	(Colin 2009)
Microcosmus pupa	(Savigny, 1816)	Pyuridae	Reported from vessel biofouling, distribution currently unknown, and uncertain if nonindigenous	Shipping (ballast, biofouling)	(Colin 2009)
Perophora multiclathrata	(Sluiter, 1904)	Perophoridae	Reported from vessel biofouling, distribution currently unknown, and uncertain if nonindigenous	Shipping (ballast, biofouling)	(Colin 2009)
Phallusia nigra	Savigny, 1816	Ascidiidae	Malakal Harbour on wharves	Shipping (ballast, biofouling)	(Campbell et al. 2016)
Phallusia philippinensis[c]	Millar, 1975	Ascidiidae	Reported from vessel biofouling, distribution currently unknown, and uncertain if nonindigenous	Shipping (ballast, biofouling)	(Colin 2009)
Polyclinum nudum	Kott, 1992	Polyclinidae	Reported from vessel biofouling, distribution currently unknown, and uncertain if nonindigenous	Shipping (ballast, biofouling)	(Colin 2009)
Pyura curvigona	Tokioka, 1950	Pyuridae	Reported from vessel biofouling, distribution currently unknown, and uncertain if nonindigenous	Shipping (ballast, biofouling)	(Colin 2009)
Pyura honu	Monniot C. & Monniot F., 1987	Pyuridae	Reported from vessel biofouling, distribution currently unknown, and uncertain if nonindigenous	Shipping (ballast, biofouling)	(Colin 2009)

Taxon name	Authority	Family	Known range within Palau	Pathway	References
Pyura vittata	(Stimpson, 1852)	Pyuridae	Reported from vessel biofouling, distribution currently unknown, and uncertain if nonindigenous	Shipping (ballast, biofouling)	(Colin 2009)
Chordata					
Alligator mississippiensis	(Daudin, 1802)	Alligatoridae	Introduced from Philippines pre-WWII, extirpated	Intentionally introduced	(Brazaitis et al. 2009)
Crocodylus mindorensis	Schmidt, 1935	Crocodylidae	Introduced from Philippines pre-WWII, extirpated	Intentionally introduced	(Brazaitis et al. 2009)
Crocodylus novaeguineae	Schmidt, 1928	Crocodylidae	Introduced from Philippines pre-WWII, extirpated	Intentionally introduced	(Brazaitis et al. 2009)
Crocodylus porosus	Schneider, 1801	Crocodylidae	Same species as the native Palau crocodile, however, introduced from Philippines pre-WWII, extirpated	Intentionally introduced	(Brazaitis et al. 2009)

[a] recorded from New Zealand, [b] recorded from tropical Australia, [c] recorded from Hawai'i

Table 14: Marine species identified as introduced to Papua New Guinea. The double underline denotes species recorded as cryptogenic.

Taxon name	Authority	Family	Known range within Papua New Guinea	Pathway	References
Amphipoda					
Stenothoe valida	Dana, 1852	Stenothoidae	Padoz Tinan reef, Madang Lagoon	Shipping (ballast, biofouling)	NEMISIS
Teleostei					
Petroscirtes breviceps	(Valenciennes, 1836)	Blenniidae	Introduced from Australia into Port Moresby	Shipping (ballast, biofouling)	(Springer and Gomon 1975)
Salmo trutta	Linnaeus, 1758	Salmonidae	Unknown	Intentionally introduced for aquaculture	(Glucksman et al. 1976)

Table 15: Marine species identified as introduced to Samoa. The double underline denotes species recorded as cryptogenic.

Taxon name	Authority	Family	Known range within Samoa	Pathway	References
Algae					
Anadyomene stellata	(Wulfen) C.Agardh, 1823	Anadyomenaceae	Apia Harbour, possible introduction	Shipping (ballast, biofouling)	(Skelton et al. 2008)
Codium arenicola	M.E.Chacana & P.C.Silva, 2014	Codiaeceae	Peripheral areas of Apia Harbour, particularly the reef slope of Vaiala and the blue-holes at Matutu	Shipping (ballast, biofouling), aquaculture (co-transfer)	(Skelton et al. 2008)
Codium ovale	Zanardini, 1878	Codiaeceae	Apia Harbour	Shipping (ballast, biofouling), aquaculture (co-transfer)	(Skelton et al. 2008)
Gracilaria ephemera	Skelton, G.R.South & A.J.K.Millar, 2004	Graciliariaceae	Matagialalua pond, Apia, probably extirpated	Vessels	(Skelton et al. 2008)
Renouxia antillana	Fredericq & J.N.Norris, 1995	Rhodogorgonaceae	Apia Harbour	All observations in or near harbour suggesting vessels	(Skelton et al. 2008)
Spatoglossum macrodontum	J.Agardh, 1882	Dictyotaceae	Apia Harbour, Mulinuu	Native to Australia, possible vessels	(Skelton et al. 2008)
Cnidaria					
Carijoa riisei[c]	(Duchassaing & Michelotti, 1860)	Clavulariidae	Apia Harbour	Shipping (ballast, biofouling)	(Skelton and South 2009)
Condylactis	Duchassaing de Fombressin & Michelotti, 1864	Actiniidae	Mulinu'u blue hole	Shipping (ballast, biofouling)	(Skelton et al. 2008)
Gymnangium	Hincks, 1874	Agalopheniidae	Apia Harbour	Shipping (ballast, biofouling)	(Skelton et al. 2008)
Pennaria disticha[a]	Goldfuss, 1820	Pennariidae	Wharf, Apia Harbour	Shipping (ballast, biofouling)	(Skelton et al. 2008)
Rhopilema esculentum	Kishinouye, 1891	Rhizostomatidae	Unknown location, introduced in 2019–2019	Intentionally introduced for release into the wild	(U. Roebek pers. comm.)
Mollusca					
Magallana gigas[a]	(Thunberg, 1793)	Ostreidae	Introduced from Pacific northwest USA to an undisclosed location	Intentionally introduced for aquaculture	(Chew 1990; Eldredge 1994)

Taxon name	Authority	Family	Known range within Samoa	Pathway	References
Perna viridis	(Linnaeus, 1758)	Mytilidae	Introduced from Tahiti to Upolu and Savai'i	Intentionally introduced for aquaculture	(Bell and Albert 1983; Eldredge 1994)
Rochia nilotica	(Linnaeus, 1767)	Trochidae	Introduced from Fiji to Fakaofo, Namu'a Island	Intentionally introduced for aquaculture	(Eldredge 1994)
Tridacna derasa	(Röding, 1798)	Cardiidae	Introduced from FSM and Fiji in 1988 and 1992–1993, respectively. Samoa Fisheries have an established brood stock of both species, which they use for spawning activities as part of their restocking program.	Intentionally introduced for wild population restocking	(U. Roebek pers. comm.)
Tridacna gigas	(Linnaeus, 1758)	Cardiidae	Savaia Lefaga and Salē Saipipi Savaii	Intentionally introduced	(U. Roebek pers. comm.)
Turbo marmoratus	Linnaeus, 1758	Turbinidae	Undisclosed location	Intentionally introduced for aquaculture	(see Andréfouët et al. 2014)
Cirripedia					
Amphibalanus amphitrite[a b c]	(Darwin, 1854)	Balanidae	Apia Harbour	Shipping (biofouling)	(Skelton et al. 2008)
Tetraclita japonica[a]	(Pilsbry, 1916)	Tetracliitidae	Attached to buoys, Apia Harbour	Shipping (ballast, biofouling)	(Skelton et al. 2008)
Decapoda	Latreille, 1802				
Penaeus monodon[c]	Fabricius, 1798	Penaeidae	Introduced from Tahiti	Intentionally introduced for aquaculture	(Popper 1982)
Percnon guinotae	Crosnier, 1965	Percnidae	Attached to buoys, Apia Harbour	Shipping (ballast, biofouling)	(Skelton et al. 2008)
Bryozoa					
Bugula neritina	(Linnaeus, 1758)	Bugulidae	Attached to buoys, Apia Harbour	Shipping (biofouling)	(Skelton et al. 2008)
Ascidiacea					
Didemnum perlucidum[b c]	Monniot F., 1983	Didemnidae	Growing on reef and wharf pylons, Apia Harbour	Shipping (ballast, biofouling)	(Skelton et al. 2008)

Taxon name	Authority	Family	Known range within Samoa	Pathway	References
Didemnum spongioides	Sluiter, 1909	Didemnidae	Attached to buoys and other artificial substratum, Apia Harbour	Shipping (ballast, biofouling)	(Skelton et al. 2008)
Polycarpa nigricans	Heller, 1878	Styelidae	Attached to buoys and other artificial substratum, Apia Harbour	Shipping (ballast, biofouling)	(Skelton et al. 2008)

[a] recorded from New Zealand, [b] recorded from tropical Australia, [c] recorded from Hawai'i

Table 16: Marine species identified as introduced to Solomon Islands.

Taxon name	Authority	Family	Known range within Solomon Islands	Pathway	References
Algae					
Kappaphycus alvarezii [c]	(Doty) Doty ex P.C.Silva, 1996	Solieriaceae	Imported from Fiji and transplanted to Vonavona, Munda, Gizo, Ontong Java, extirpataed	Intentionally introduced for aquaculture	(Eldredge 1994)
Decapoda					
Penaeus monodon[c]	Fabricius, 1798	Penaeidae	Imported from Australia	Intentionally introduced for aquaculture	(Munro 1993)

[c] recorded from Hawai'i

Table 17: Marine species identified as introduced to Tokelau.

Taxon name	Authority	Family	Known range within Tokelau	Pathway	References
Mollusca					
Rochia nilotica	(Linnaeus, 1767)	Trochidae	Introduced from Fiji and Aitutaki (Cook Islands) to Tokelau to Fakaofo	Intentionally introduced for re-stocking	(Gillett 1988; Eldredge 1994)

Table 18: Marine species identified as introduced to Tonga.

Taxon name	Authority	Family	Known range within Tonga	Pathway	References
Algae					
Kappaphycus alvarezii[c]	(Doty) Doty ex P.C.Silva, 1996	Solieriaceae	Introduced from Fiji	Intentionally introduced for aquaculture	(Eldredge 1994)
Mollusca					
Magallana belcheri	(G. B. Sowerby II, 1871)	Ostreidae	Introduced from Sabah to Nukunukumotu Channel and Tongatapu	Intentionally introduced for aquaculture	(Eldredge 1994)
Crassostrea virginica	(Gmelin, 1791)	Ostreidae	Introduced from California through Fiji	Intentionally introduced for aquaculture	(Eldredge 1994)
Magallana bilineata	(Röding, 1798)	Ostreidae	Unknown location	Intentionally introduced for aquaculture	(Eldredge 1994)
Magallana gigas[a]	(Thunberg, 1793)	Ostreidae	Introduced from Japan and Tasmania (Australia)	Intentionally introduced for aquaculture	(Eldredge 1994)
Ostrea edulis[a]	Linnaeus, 1758	Ostreidae	Introduced from Japan and California	Intentionally introduced for aquaculture	(Eldredge 1994)
Perna viridis	(Linnaeus, 1758)	Mytilidae	Introduced from Philippines, Singapore, Sabah to lagoons at Tongatapu, Pangaimotu, Vava'u, Fanga'uta Lagoon	Intentionally introduced for aquaculture	(Eldredge 1994)
Pinctada imbricata[a]	Röding, 1798	Margaritidae	Introduced from Japan to Vava'u	Intentionally introduced for aquaculture	(Tanaka 1990)
Pinctada maxima	(Jameson, 1901)	Margaritidae	Introduced from Japan to Vava'u	Intentionally introduced for aquaculture	(Tanaka 1990; Eldredge 1994)
Pinctada margaritifera	(Linnaeus, 1758)	Margaritidae	Introduced from Japan to Vava'u	Intentionally introduced for aquaculture	(Tanaka 1990; Eldredge 1994)
Rochia nilotica	(Linnaeus, 1767)	Trochidae	Introduced from Fiji	Intentionally introduced for aquaculture	(Gillett 1992)
Saccostrea glomerata	(Gould, 1850)	Ostreidae	Introduced from New Zealand and California to Fanga'uta Lagoon	Intentionally introduced for aquaculture	(Eldredge 1994)
Turbo marmoratus	Linnaeus, 1758	Turbinidae	Introduced to Euaiki Island, Fukave Island	Intentionally introduced for aquaculture	(Fa'anunu et al. 2001)

Taxon name	Authority	Family	Known range within Tonga	Pathway	References
Teleostei					
Mugil cephalus	Linnaeus, 1758	Mugilidae	Introduced from Hawaii to Lake Ano	Intentionally introduced for aquaculture	(Eldredge 1994)

[a] recorded from New Zealand, [c] recorded from Hawai'i

Table 19: Marine species identified as introduced to Tuvalu.

Taxon name	Authority	Family	Known range within Tuvalu	Pathway	References
Algae					
Kappaphycus alvarezii[c]	(Doty) Doty ex P.C.Silva, 1996	Solieriaceae	Introduced from Kiribati to Tuvalu	Intentionally introduced for aquaculture	(Eldredge 1994)
Mollusca					
Rochia nilotica	(Linnaeus, 1767)	Trochidae	Introduced from Cook Islands and Fiji to Funafuti	Intentionally introduced for re-stocking	(Gentle 1990)

[c] recorded from Hawai'i

Table 20: Marine species identified as introduced to Vanuatu.

Taxon name	Authority	Family	Known range within Vanuatu	Pathway	References
Algae					
Kappaphycus alvarezii[c]	(Doty) Doty ex P.C.Silva, 1996	Solieriaceae	Introduced from Kiribati (reported as *K. cottoni*, but probably *K. alvarezii*)	Intentionally introduced for aquaculture	(Eldredge 1994)
Mollusca					
Magallana gigas[a]	(Thunberg, 1793)	Ostreidae	Introduced from California, USA, to numerous locations, Espiritu Santo, Mounparap Bay, Port Sandwich, Malekula, Efate near Port Vila	Intentionally introduced for aquaculture	(Eldredge 1994)
Cirripedia					
Amphibalanus amphitrite[a b c]	(Darwin, 1854)	Balanidae	Port Vila	Shipping (ballast, biofouling)	(Sylverio et al. 2020)
Bryozoa					
Amathia distans[a b c]	Busk, 1886	Vesiculariidae	Port Vila	Shipping (ballast, biofouling)	(Sylverio et al. 2020)
Amathia verticillata[a b c]	(delle Chiaje, 1822)	Vesiculariidae	Port Vila	Shipping (ballast, biofouling)	(Sylverio et al. 2020)
Bugula neritina[a b c]	(Linnaeus, 1758)	Bugulidae	Port Vila	Shipping (ballast, biofouling)	(Sylverio et al. 2020)
Schizoporella errata[a c]	(Waters, 1878)	Schizoporellidae	Port Vila	Shipping (ballast, biofouling)	(Sylverio et al. 2020)
Watersipora subtorquata[a b c]	(d'Orbigny, 1852)	Watersiporidae	Port Vila	Shipping (ballast, biofouling)	(Sylverio et al. 2020)

[a] recorded from New Zealand, [b] recorded from tropical Australia, [c] recorded from Hawai'i

Table 21: Predominant origin countries of commercial shipping vessels to Pacific islands.

Destination	Origin
American Samoa	Fiji, French Polynesia, Samoa
Cook Islands	New Caledonia, New Zealand, Samoa
Federated States of Micronesia	Republic of the Marshall Islands, Northern Mariana Islands
Fiji	New Caledonia, New Zealand, Solomon Islands, Tonga, Vanuatu
French Polynesia	New Zealand, Tonga, USA
Guam	China
Kiribati	New Caledonia
Mariana Islands	Guam
Republic of Marshall Islands	South Korea, Fiji
Nauru	French Polynesia
New Caledonia	Australia, New Zealand, Tonga
Niue	Samoa
Palau	Federated States of Micronesia
Papua New Guinea	Australia, China, Solomon Islands
Samoa	American Samoa, Fiji, Tonga
Solomon Islands	Papua New Guinea
Tonga	American Samoa, New Zealand, Niue, Samoa
Tuvalu	Fiji
Vanuatu	Fiji, French Polynesia, Republic of the Marshall Islands
Wallis and Futuna	Fiji, Samoa

4 Discussion

4.1 Marine non-indigenous species in the Pacific Islands region

The numbers of reports of marine NIS intentionally and unintentionally introduced into the Pacific Islands region are unevenly distributed across the 21 countries and territories. Inventories compiled from the literature, databases and personal communications present island groups Nauru and Wallis and Futuna without any documented introductions or unintentionally introduced NIS. In contrast, Guam has 80 NIS reported (including 35 cryptogenic species) comprising a diverse range of taxa (Figure 2). Four of the five Pacific island countries and territories with the highest reports of NIS have carried out biological surveys, highlighting the benefit of primary data collection in understanding marine biodiversity and the presence of NIS. It is likely that with ongoing monitoring, further biological surveys, and improved records of species' distributions that the number of NIS present in the Pacific islands will be higher than is reported here. Inventories of NIS in Pacific islands presented here are essentially based on occurrence records (i.e. presence of a species) and data on whether these species are invasive within the Pacific islands are limited (see Section 4.2). An invasive species is an NIS if (i) the species has demonstrated impact anywhere outside its indigenous range, (ii) the species is widespread, abundant, fast-spreading or has a high population growth rate anywhere outside its indigenous range, or (iii) the species is widespread, abundant, fast-spreading or has a high population growth rate in the reporting country (McGeoch et al. 2012). Whilst categorising NIS as 'invasive' in Pacific islands is difficult given the paucity of data, these inventories provide a useful reference to monitor against and a platform to build upon to better understand the invasiveness of marine NIS in the Pacific.

Data on vectors and pathways on species without documented introductions (*cf.* trochus *Rochia nilotica*; see Eldredge 1994) are rare. Unless organisms are reported directly from transport pathways, their lifestyle and distribution often provide the best clue that they are not native (Chapman and Carlton 1991). Bryozoans, ascidians, sponges and hydroids are common fouling organisms that regularly attach to any natural and man-made structures. Mobile hard structures that can facilitate species movement include vessel hulls and niche spaces (i.e. sea chests and piping), shellfish and other hard-bodied organisms translocated for fisheries or aquaculture purposes, marine plastic pollution, flotsam and debris. The latter in particular was demonstrated following the 2011 Japan earthquake and tsunami when 49 species of western Pacific bryozoans where found in numerous floating debris (McCuller and Carlton 2018). Marine plastic pollution is an environmental hazard for the Pacific islands and the potential for these marine debris to act as settlement surfaces and transport vectors need to be ascertained to fully assess its risk (Miller et al. 2018). Most species that appear to have been introduced unintentionally in the Pacific have sessile lifestyles and are common fouling species. From the data available, it seems likely that vessel movements contribute to the largest numbers of NIS in the Pacific; however, plastic pollution is a pathway that requires further investigation. Figure 4 shows that connectedness of cargo vessels between Pacific islands as well as vessels entering the Pacific region from Pacific Rim countries. Currently, only 7 Pacific island countries have a specific Ballast Water Management Strategy in accordance with the Ballast Water Management Convention. Similar strategies across other Pacific island countries and territories will strengthen the management of marine invasive species across the Pacific region by reducing the risk of their movement in the first place.

Recreational vessels, fishing boats and other private vessels are known vectors for marine NIS, however, these vessels are more challenging to track because they do not have fixed itineraries but

are a known pathway for marine NIS (Clarke Murray et al. 2011). Niue estimated that approximately 200 yachts visit each year (NNISSAP 2013). A high number of recreational yachts visit the Pacific region from the USA through the Panama Canal providing a pathway for marine species into the Pacific region and their subsequent spread within the Pacific region; visiting yachts are often referred to as 'puddle jumpers', because of their propensity to 'jump' from one Pacific island to the next (NNISSAP 2013). Monitoring sites commonly visited by yachts may reveal previously unknown marine NIS in the Pacific region.

This desktop review identified 168 taxa across the Pacific islands, with 121 of the total taxa recorded as species without any documented intentional introductions. Cryptogenic species were reported from six countries and territories, comprising 55 species across 10 taxa groups. The taxa with the highest number of cryptogenic species were ascidians, with 20 different species reported. Ascidians are challenging to taxonomically resolve because of a general limit of literature and descriptions of ascidians worldwide precluding an understanding of biogeographic ranges (Monniot and Monniot 2001). For instance, the ascidian *Ascidia sydneiensis* in French Polynesia has recently been split into two species: the native *A. paulayi* sp. nov. and the introduced *A. sydniensis* (Bonnet and Lotufo 2015). *Ascidia sydniensis* occurs throughout the Pacific region and whether this represents native biogeographic ranges is difficult to infer because of lack of previous taxonomic records (Monniot and Monniot 2001). Marine sponges can be similarly challenging to identify because many non-indigenous sponge species belong to genera that lack strong differentiating characters making it difficult to differentiate between native and introduced species. This is certainly the case for the four sponges in genera *Callyspongia*, *Mycale, Niphates,* and *Tedania* from Apra Harbour in Guam (Kelly et al. 2003), listed in Table 7 (M. Kelly pers. com.)

Taxonomists are critical to ensuring the correct identification of native and introduced species, and differentiation of one from another. The NIS from Palau presented by Campbell et al. (2016) were predominately identified by parataxonomists, i.e. less specialised and experienced individuals than taxonomists. Consequently, some of NIS reported from Palau are disputed by taxonomists. The sponges *Mycale* sp. and *Haliclona caerulea* and the goby are considered by taxonomists familiar with Palauan fauna to in fact be native to Palau (L. Colin and M. Kelly pers. comm.). The record of the potentially introduced Gobiidae is impossible to assess given the family has over 2,000 species in 200 genera (L. Colin pers. comm.). Similarly, the black striped mussel *Mytilopsis sallei* reported from Fiji is a well-known invasive species native to the Caribbean (https://nimpis.marinepests.gov.au/species/species/10). However, the identification of this species as *M. sallei* is disputed by taxonomists because based on the current understanding of its distribution the species is likely to be *M. adamsi*, a native to the Indo-Pacific region (Marelli 2020). *M. sallei* has been reported from Darwin, northern Australia, presumably introduced via international fishing vessels, but was successfully eradicated before the population could establish (Bax et al. 2002). Until new data come to light the identification of *M. adamsi* is valid and is the animal likely to be in Fiji, yet the introduction of *M. sallei* to Australia highlights a potential invasive species that could be introduced to Pacific (Section 4.2). Uncertainty over species identifications and biogeographic ranges are common in marine biosecurity with some taxa more problematic than others, such as ascidians and sponges described above. Collecting and archiving specimens as reference material provide invaluable future opportunities to revisit disputed identifications in order to produce accurate lists of NIS to help inform the design and implementation of monitoring programs.

Some species such as the octocoral *Carijoa riisei* may have a wider distribution than reported here. Colin and Arneson (1995) published photos of a *Carijoa* sp. from Chuuk (FSM) and from a fouled ship

in Enewatek (RMI) that could be the introduced *C. riisei* but there is no record of the identification being confirmed and therefore it was not reported here. Similarly, the ascidian *Phallusia nigra* was reported from FSM, but no citing material accompanied the report (Eldredge and Smith 2001) so has similarly not been included in this report. Documenting marine biota of the Pacific islands in order to identify native species to understand their biogeography and so elucidate NIS will take a structured approach requiring investment of time and resources.

4.2 Long-term monitoring gaps of marine NIS in the Pacific islands

The largest numbers of unintentionally introduced NIS have been recorded from countries or territories where biological surveys have been carried out (Table 1; Figure 2). All biological surveys carried out have included at least one site within a harbour or embayment where vessel traffic is common (Skelton et al. 2008; Coles et al. 2003). The patterns of ship movements into and around the Pacific region have important implications for the introduction and translocation of marine pests (Ruiz et al. 2000). Campbell et al. (2016) reported four introduced (or potentially introduced) species from an area outside of commercial boating activity, whereas 20 cryptogenic or potentially introduced species were reported from within Malakal Harbour, Palau. The high volume of vessel traffic into Pacific islands from Pacific Rim countries as well as inter-island movement presents opportunities for ongoing species translocations (Table 21). Fiji is an important hub for commercial vessels entering the Pacific region, yet there is a comparatively less known on the status of NIS present in high risk area such as Suva Harbour compared to other ports such as Apra Harbour, Guam, which has been surveyed for NIS. Most marine NIS in Fiji have been documented as intentional introductions for aquaculture, with few reports on unintentionally introduced species (Table 5). The large number of NIS reported from Apra Harbour, Guam (Table 7) during a biological survey demonstrates the preponderance of NIS in ports of entry. Similar surveys will be needed to identify the status of NIS in Fiji and in the jurisdictions of other Pacific islands.

Generally, marine invasive species are mentioned less frequently than terrestrial invasive species in the national state of environment report for Pacific island countries (e.g. SPREP 2018; SPREP 2019). The regional status on monitoring of marine invasive species in the Pacific is considered poor according to the *State of the Environment and Conservation in the Pacific Islands* (SPREP 2021). There are currently 16 priority marine invasive management programmes in the Pacific region but include programmes that monitor the native invasive crown of thorns starfish and rarely marine NIS (SPREP 2021). As such, there is comparatively less attention on marine NIS and their status than terrestrial invasive species. Consequently, the number of marine NIS present in Pacific region is likely underreported and higher than what this report presents. Pacific island countries and territories with a specific National Invasive Species Strategy and Action Plan highlight the need for monitoring marine NIS in their jurisdictions (e.g. TISSAP 2020), so this report serves as a benchmark for those monitoring programmes to measure against.

An ongoing monitoring programme in Palau from 2003 to 2012 clearly documented the introduction, proliferation, and establishment of a NIS sea anemone *Exaiptasia diaphana* (= *E. pallida*) in Jellyfish Lake (Patris et al. 2019). The sea anemone was first spotted in 2003 at the tourist entry of the lake suggesting it hitch-hiked as a fouling species rather than being a natural colonisation (Patris et al. 2019). In the first six years following its discovery, the introduced sea anemone rapidly expanded its population and established an invasive population, covering mangrove roots and shallow rocky slopes around the perimeter of the lake; however, the rapid population expansion of the sea anemone has had little measurable impact on the native diversity of Jellyfish Lake. Despite this, the

case study of *E. diaphana* in Palau demonstrates how NIS could impact Pacific island marine habitats as well as the benefit of monitoring NIS following their introduction (Patris et al. 2019).

Observations in Hawai'i indicated that some time (10–20 years) may need to pass before a species can establish and propagate to a point where it has substantive impacts and could be considered invasive. For example, the alga *Graciliaris saliconria* (Smith et al. 2002); the octocoral *Carijoa riisei* (Eldredge and Smith 2001); and the barnacle *Chthamalus proteus* (Southward et al. 1998). *C. riisei* is present in Samoa and *C. proteus* is present in Guam, Northern Mariana Islands, Palau and French Polynesia but there are no reports of negative impacts since their introduction into Samoa and Guam. *C. riisei* in particular has demonstrated impacts on black corals in Hawai'i (Kahng and Grigg 2005) and does so by overgrowing shallow reefs in the eastern Pacific (Sánchez and Ballesteros 2014). It is possible therefore that its invasiveness may emerge over time. Moreover, because *C. riisei* is a well-known fouling organism (Eldredge and Smith 2001), there is a pathway to other Pacific islands via vessel traffic.

Many of the introduced and cryptogenic species compiled in this report may present no discernible impact on Pacific islands. Many of the unintentionally introduced species reported here are fouling species, such as barnacles that can become a nuisance, colonising space quickly. Other species like the green alga *Codium arenicola* and the brown alga *Spatoglossum macrodontum*, which are well established in Samoa and has been reported from Fiji, occupy disturbed environments around Apia Harbour and appear likely to spread to other areas (Skelton et al. 2008). *Codium* spp. are known to be invasive in other countries and a sub-species is established in Australia, New Zealand, Europe, and North America. The speed that *Codium* species can colonise disturbed areas, and their tendency to form large clumps that can smother benthos including coral reefs is of particular concern for Pacific islands. Seaweeds like *Codium* species have been used to pack oysters and other shellfish for aquaculture, potentially supplying a pathway for introduction in addition to transfer via shipping.

The potential of an NIS to cause harm in a recipient environment can be difficult to quantify (Hayes and Sliwa 2003). All introduced species will have some level of impact, whether it is outcompeting native species, driving economic impacts through loss of commercial fisheries or aquaculture harvests, or even more subtle impacts such as bioturbation (Atalah et al. 2019). The proliferation in abundance of a species is usually obvious and their impacts noticeable, for instance extirpating native fauna and flora. Yet, more subtle effects can still be significant. For instance, the invasive fanworm *Sabella spallanzanii* had significant effects on denitrification in marine soft bottom sediments in New Zealand that resulted in compositional changes of soft-sediment benthic communities that could impact ecosystem functioning (Tait et al. 2020). Critical to a species ability to become invasive is whether they can successfully establish, often predicated on environmental tolerances. The black-striped mussel, *M. sallei*, a native to the Caribbean Sea, was discovered in Darwin, Australia but the mussel was possible to extirpate. Had the intervention not been successful, it was estimated that AUD 145 million to AUD 286 million of damage to port and coastal infrastructure in Australia would have resulted over a 30-year period (Summerson et al. 2013). Similar environmental conditions between the Caribbean and Pacific islands coupled with the documented environmental resilience of *M. sallei* (Morton 1981) highlights its potential as an invasive in the Pacific region. In contrast, the green mussel *Perna viridis* which has established dense, problematic populations in the tropical Atlantic has been intentionally introduced from the Indo-West Pacific widely throughout the Pacific, but no extant populations exist.

The overall dearth of data on impacts of marine NIS in the Pacific Islands region is not unique. A survey of NIS in the Galapagos Islands found only 23 marine NIS out of 1,579 known NIS across the

terrestrial and aquatic systems in the Galapagos (Toral-Granda et al. 2017). The risk posed by NIS and their ability to become invasive is probably not homogenous across the Pacific region. Indeed, the larger numbers of NIS detected in areas where biological surveys have been carried out is probably related to the greater survey effort. However, Hutchings et al. (2002) suggested that some tropical ports may be more resistant to marine NIS introductions, at least in the central Indo-West Pacific and especially in comparison to other temperate ports. Hutchings et al. (2002) put forward high biodiversity as the primary reason for suspected resistance to marine invasive species. The 'coral triangle' in the Indo-West Pacific possesses the highest species diversity that declines eastward across the Pacific (Briggs 1999). This could suggest that, perhaps, eastern Pacific islands, for example Samoa and French Polynesia, may be more vulnerable to invasive species. Already in Samoa the algae *C. arenicola* and *S. macrodontum* and the hydroid *P. disticha* are quickly colonising disturbed areas of coral reef (Skelton et al. 2008).

Such observations, the limited data of NIS in the Pacific Islands region and potential greater risk to eastern countries and territories underscores the importance of establishing monitoring in order to ascertain species abundance and distribution over time. The inventories of NIS for each Pacific islands country and territory presented here is the first step to a better understanding of NIS in the Pacific.

5 Glossary of abbreviations and terms

EEZ	Exclusive Economic Zone
FSM	Federated States of Micronesia
GEF	Global Environment Facility
NIS	Non-indigenous species
PNG	Papua New Guinea
RMI	Republic of the Marshall Islands
SPREP	Secretariat of the Pacific Regional Environment Programme

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[i] Website: https://www.webofscience.com/wos/woscc/advanced-search. Note the asterisk in the search terms is a wildcard character intended to broaden the search. For instance, introduc* will include search results for 'introduction' and 'introduced'.