Report on the Current Status of **Marine Non-Indigenous Species** in the Western Pacific Region

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Foreword

Marine non-indigenous species (NIS) are marine species living outside their native distributional range, which they have been translocated there either accidentally or deliberately. The last several years has seen an explosion of interest in marine non-indigenous species as some of them damage the ecosystems they are introduced to, others negatively affect the fisheries and aquaculture. There are many examples of disastrous invasions by such species that resulted in the loss of native species, significantly altered the community structure and function, and caused great economic harm or harm to human health. Most of these invasions result from anthropogenic dispersal. Although the different dispersal mechanism varies both spatially and temporally, the evidence shows that biofouling, ballast water and deliberate introduction to fisheries and aquaculture for more economic benefits are the primary vectors or pathways for such translocation.

Despite ever-increasing attention having been paid to the marine NIS invasions by coastal countries in the Western Pacific region, particularly their relevant governmental agencies, the limited information on the presence, impacts and lack of technical identification methods of marine non-indigenous species still remain major impediments to the development of practical measures and tools at national and regional level for the management of the marine NIS invasions. The Intergovernmental Oceanographic Commission's Sub- Commission for the Western Pacific (WESTPAC) is in a unique regional position to assist countries in the study and management of their coasts and oceans through the promotion and coordination of associated scientific activities, providing relevant scientific guidelines and criteria and educating general public as well as transferring knowledge among countries on marine NIS. WESTPAC has organized two regional workshops and published one poster on marine NIS with other planned workshops to be conducted since the establishment of its coastal biodiversity project at the Seventh Intergovernmental Session in Sabah, Malaysia, May 2008.

The regional status report attempts to provide a general review on the marine MIS in the Western Pacific region based on the on-going research at each country. Although some scientific uncertainties still exist on the identification of some marine species, the report, serving as a reference or baseline document, is of great use to provide scientists working in this field with the different scientific understanding on the identification, and stimulate new cooperation for the improvement of the relevant scientific knowledge. We hope this report helps countries in the Western Pacific to foster the technical capacity building to better manage their ecosystems.

Wenxi Zhu
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Background

In contributions to the High Level Objective of IOC/UNESCO (2008-2013) on the "safeguarding the health of ocean ecosystem", the UNESCO/IOC Sub-Commission for the Western Pacific (WESTPAC) unanimously approved, at its Seventh Intergovernmental Session in Sabah, Malaysia, 25-29 May 2008, one regionally rooted project on the **"Coastal Marine Biodiversity and Conservation"**, taking into account broad interests received from its member states. The project composes of three programs:

1) Biodiversity and taxonomy of marine organisms
2) Effect of disturbance and current stressors on biodiversity
3) Restoration and rehabilitation of ecosystems

The objectives of the Coastal Marine Biodiversity and Conservation Project are: 1) to understand and provide the scientific basis for biodiversity management by articulating the state of the science with respect to current and emerging stressors; 2) to establish the effective management plan and monitoring programs for marine biodiversity among WESTPAC country members; and 3) to encourage research collaboration and to exchange knowledge among WESTPAC countries.

One of the issues related to the threat of marine biodiversity is the marine non-indigenous species (NIS) and their impacts to marine ecosystems. There are many examples of disastrous invasions by such species that have resulted in the loss of native species, changes in community structure and function, and damage fisheries and aquaculture in several parts of the world (Carlton, 1999; Chapman, 1999; Chavanich and Harris, 2004; Cohen and Carlton, 1998; Crooks, 2001; Harris and Tyrrell, 2001; Lambert et al., 1992; Ruiz et al., 1999; Williams, 2007; Wittenberg and Cock, 2001). In order to prevent and control the marine NIS, much better understanding of following are needed: 1) regional status on the marine NIS and their impacts; 2) pathways of carrying marine NIS, and 3) the environmental factors that facilitate the establishment of marine NIS. The problems created by these marine NIS are of concern to marine park managers, conservationists, government agencies and the public worldwide. However, few studies related to marine NIS have been done in the Western Pacific region, particular in Southeast Asia region (Chavanich et al., 2009; Liang and Wang, 2001; Senanan et al., 2009; Seo and Lee, 2009; Wangkulangkul and Lheknim, 2008).

This report aims to consolidate the available information on the current status of marine NIS as of March 2010 in the Western Pacific region. Since there are still some difficulties to identify whether a species is native or non-native species, the information provided in this report are focused primarily on macroorganisms. In addition, the information from this report serves as a baseline data for further research on marine NIS in the region.

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Glossary related to marine non-indigenous species*

Accidental introduction
Introduction of an aquatic organism, including fellow travellers, by chance, not by design, e.g., release of an organism in ship's ballast water.
Synonym: unintentional introduction

Alien species
Species of plants, animals, and micro-organisms introduced by human action outside their natural past or present distribution.
Synonyms: exotic, foreign, non-indigenous, non-native, introduced species

Aquarium species
All species imported or transferred into confinement for ornamental indoor or outdoor use.
Synonym: ornamental

Ballast water
Water with its suspended matter taken on board a ship to control trim, list, draught, stability or stresses of the ship.

Biodiversity
Variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

Country of origin
The country where the species is native.

Cryptogenic species
Species whose biogeographic history in the community is not unknown.

Eradication
Application of measures to eliminate an invasive alien species from a defined area.

Hybrid
Offspring of two animals or plants that are of different species.

Import
Movement of aquatic organisms across national or subnational boundaries.

Indigenous species
Existing and having originated naturally in a particular region or environment.
Synonym: native species

Intentional introduction
The deliberate movement and/or release by humans of an alien species outside its natural range.

Glossary related to marine non-indigenous species*

Introduced species

Any species intentionally or accidentally transported and released by humans into an environment or facility with effluent access to open-water or flow-through system outside its present range.
Synonyms: exotic, alien, foreign, non-indigenous, non-native species

Invasive species

1) Harmful alien organisms whose introduction or spread threatens the environment, the economy, or society;
2) Alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health;
3) Alien species which becomes established in natural or semi-natural ecosystems or habitat, is an agent of change, and threatens native biological diversity.
Synonyms: nuisance, pest species

Native range

Natural limits of geographic distribution of a species.

Pathway

The routes by which species move from one local to another, either within a country or between countries.

Range expansion

Species dispersal by natural mechanisms into a region where the species did not formerly exist.

Release

The liberation of aquatic organisms to the natural environment; release can be unintentional, as in the escape of organisms from aquaculture facilities or during use as live bait.

Risk

The probability of a negative or undesirable event occurring; the likelihood of the occurrence and the magnitude of the consequences of an adverse event, a measure of the probability of harm and the severity of impact of a hazard.

Risk assessment

The process of identifying and describing the risks of introductions or transfers of aquatic organisms having an impact on fisheries resources, habitat or aquaculture in the receiving waters before such introductions or transfers take place; the process of identifying a hazard and estimating the risk presented by the hazard, in either qualitative or quantitative terms.

Species

A group of interbreeding organisms that differs from and is reproductively isolated from other such groups.

Vector

Any living or non-living carrier that transports living organisms intentionally or unintentionally.

Glossary related to marine non-indigenous species*

* Definitions are adopted from:

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General background

China is located in Eastern Asia, bordering the East China Sea, Korea Bay, Yellow Sea, and South China Sea, between North Korea and Vietnam. The total area of the country is 9,596,960 km^2, 2,270,550 km^2 of which are bodies of water. The total coastline is 14,500 km long. The territorial seas, the contiguous zone and the exclusive economic extend to 12 nautical miles, 24 nautical miles and 200 nautical miles from the coast, respectively. China borders the following countries; Afghanistan (76 km), Bhutan (470 km), Myanmar (2,185 km), India (3,380 km), Kazahkstan (1,553 km), North Korea (1,416 km), Kyrgystan (858 km), Laos (423 km), Mongolia (4,667 km), Nepal (1,236 km), Russia (3,605 km), Tajikistan (414 km), Vietnam (1,281 km) and borders the following regions; Hong Kong (30 km) and Macau (0.34 km).

The climate of China is extremely diverse ranging from tropical in the south and subarctic in the north. The landscape consists of mainly mountains, high plateaus, deserts in the west and plains, deltas in the eastern seaboard. The highest point is Mount Everest on the border with Nepal at 8,850 meters.

Current status

In the past 20 years, the speed of introduced marine alien species accelerated in China. Until 2010, there are altogether 110 marine alien species recorded in China. These species include 58 species of fish; 4 species of shrimps; 16 species of shellfish; 1 species of reptile; 9 species of algae; 9 species of plant; 6 species of microbe and other 7 species. Over 80% alien species were introduced after the 1980s. According to the list of "First batch of invasive alien species in China" issued by State Environmental Protection Administration and the Chinese Academy of Sciences in 2003, 16 marine invasive species more published. The marine invasive species *Spartina alterniflora* and *Spartina anglica* have already caused great damage to the environment and resulted in huge losses to the economy in China.
In fact the actual number of the harmful marine invasive species is much higher than these figures.

The recognized marine invasive species with high degree of hazard and risk in China were as follows,

Marine phytoplanktons and plants, including *Chaetoceros concaricornis, Cyclindrotheca closterium, Melosiar cancellate, Nitzchia deicatissima, Pinnularia viridis, Prorocentrum minimum, Prorocentrum sigmoides, Perocentrum balticum, Alexandrum catenclla, Scrippsiella trochoidea, Peridinium pardiforme, Spartina alterniflora, Spartina anglica,* etc.

Marine invertebrates, including *Mytilopsis sallei, Crepidula onyx, Balanus eburneus, Balanus*

improvisus, Balanus amphitrite, Bryozoa, *Ciona intestinalis, Molgula manhattensis, Styela canopus, Stronglocentrotus nudus,* etc.

Fishes, including *Oreochromis airrelzs, Micropterus salmoides, Oncorhyn chuomykiss,* etc.

Microorganisms, including White spot syndrome virus, Taura syndrome virus, Iridoviridae, Infectious hematopoietic necrosis virus, Viral hemorrhagic septicemia virus, Epizootic haematopoietic necrosis virus.

Case studies

Case 1: *Spartina alterniflora*

Spartina alterniflora or smooth cordgrass is a saltmarsh grass native to the eastern temperate to warm temperate coasts of the Americas from Newfoundland, Canada to the Gulf coast and Florida in the USA. It is also found in Southern Brazil to northern Argentina in the Southern Hemisphere. In the tropical region, it is replaced by mangroves. The species is invasive since it can hybridize with indigenous congeneric species where they are found. In China, the species was introduced in 1979 for eco-engineering processes and had displaced native Chinese saltmarsh grasses. Their impacts are as follows :

1. Destroying the habitat of inshore organisms as well as impact on beach breeding;
2. Jamming the navigation way, thereby barring ships moving in and out of harbours;
3. Impact on seawater exchange, then causing the degradation of seawater quality, further inducing red tide;
4. Threatening the native coast ecosystem, thus contributing to the disappearance of mangroves in southern China

Case 2: *Spartina anglica*

Spartina anglica was introduced in 1963 to prevent coastal erosion. It has a growth rate exceeding the ability of coastal managers to control it, and results in beach ecological imbalance, waterway blockage, death of marine life and red tide, etc. The species is known as "harm grass " or "cannibalism grass". *Spartina anglica* has spread rapidly in the coastal province, especially at the National Nature Reserve of the City of Dongying in the Yellow River Delta. *Spartina anglica* is rampant in Shoal of Dongying, covering an area of 86,616 km^2, sporadic grass can be seen as an area of more than 3333 ~ 4000 km^2. In addition, isolated *Spartina anglica* can also be found in the city of Binzhou, Weifang and Yantai.

Case 3: *Mytilopsis sallei*

Mytilopsis sallei seriously impacts the local marine aquaculture and excludes the native species such as *Balanus* sp. and the commercially important oysters, *Crassostrea* sp. It has had a significant impact

on aquaculture and ecosystems. It can be attached to the oysters, shellfish and barnacles. With a higher density, *Mytilosis sallei* is able to invade a larger area, which leads to death of other organisms and have a negative effect on cultured shellfish production. Its large amount of organic waste will also intensify water pollution, resulting in lack of oxygen which limits the survival of other organisms.

Recommendations

Research aspects

It is recommended that a standard method to be developed in identifying and detecting marine invasive species. This is especially urgent for detecting and controlling invasive microorganism species in ballast water. It is also recommended that an ecological risk assessment should be done before species are introduced and this will include a study on whether the species may become invasive. For invasive species that have already established, a study on how these species may be economically utilized is necessary.

Governmental actions

It is recommended that a systematic survey program is carried out for introduced species in order to understand their current status. For example a rapid assessment survey needs to be carried out and the information placed in the database. It is also needed to assess the full scope of the threat of invasive species so that an effective strategy can be designed to deal with it. Regulations and laws must be developed especially for ballast water management. It is also suggested that international cooperation must be promoted in order to prevent invasions at their source and to foster the sharing of lessons learned in dealing with invasions.

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General background

Indonesia is the largest archipelagic country located between the Indian Ocean and the Pacific Ocean, ca. 5°S 120°E, and is believed to hold the world's largest marine biodiversity, although detail reports and status were still poorly developed (Hutomo and Moosa, 2005). Marine biogeographic realms in Indonesia are very complex, comprising thousands of islands and body of waters that serve as the only low-latitude connection between Indian Ocean and Pacific Ocean, which cover at least 78% of its jurisdiction. Endowed with vast marine environment and rich types of habitats, ranging from shallow coastal waters to the deep seas, the work of recording marine biodiversity in this country remains difficult. Nevertheless, marine fishery and marine aquaculture play an important role in supporting national economy of the country. Commodities from marine fishery are ranging from pelagic fishes, demersals, reef fishes, squids, prawns, shrimps, and other crustaceans, while marine aquaculture production consists of seaweed, shells, and several species of reef fishes (groupers, sea bass). The country's GDP reached US$ 287.2 billion in 2005, and 14% was contributed from agricultural sector, included therein marine fisheries and aquaculture (FAO, 2010).

Current status

Introduction of non-indigenous aquatic species in Indonesia was probably originated during Dutch colonialism, when Atlantic salmon *(Salmo salar)* was introduced to the country from Netherlands in 1929 (Eidman, 1989). Ever since, most of fish and other marine species introduction to the country was related with the intention to boost fishery production and economic benefit for fish farmers. FAO (2010) recorded 88 species of non-indigenous aquatic species in Indonesia, and only 7 species were related with marine environment. One species inhabits coastal waters *(Eucheuma cottonii),* while the other 6 species inhabit mixed habitats, ranging from fresh, brackish, and coastal waters *(Anguilla anguilla, Salmo salar, Litopenaeus vannamei, Penaeus stylirostris, Poecilia latipinna,* and *P. sphenops).* Another fish species that has been recently introduced to the country is *Rachycentron canadum* with particular site in Gulf of Pegametan, Bali (Priyono et al., 2005) and Batam Islands (BIDA, 2006).

Four introduced species were related with the country's aquaculture activities, i.e. *Eucheuma cottonii* (this species name had been revised to *Kappaphycus alvarezii*) from Zanzibar, *Litopenaeus vannamei* (white shrimp), *Penaeus stylirostris* (blue shrimp) from Central America, and *Rachycentron canadum* (cobia fish) from Taiwan. However, detail information regarding the introduction of non indigenous species in Indonesia, despite the reasons of introduction, are mostly elusive. Taking *Eucheuma cottonii* and *Litopenaeus vannamei* as examples, which at present are widely used in mariculture, both species are missing information on the introducer and status of the introduced species in the wild.

Other point of consideration with respect to non-indigenous species in Indonesia is related with geographic nature of the country, which represents several endemic species, the potential of ecological isolation, and geological barrier preventing migration of certain marine species. In nature, *Pterapogon kaudernii* or the Banggai cardinalfish has restricted distribution only in Banggai Islands (5,500 km^2), Province of Central Sulawesi. Conversely, the fish was reported to be seen in Lembeh Strait (Erdmann and Vagelli, 2001) and recently in Seribu Islands (pers. obs.), and ornamental fish trade is responsible for the introduction of the species outside its nature habitat. Other species subjected to type of this practice is *Tubastrea* spp. or sun corals, which often found in deep waters at certain bioregion, that were flourish in shallow reef habitats of Seribu Islands (pers. obs.). Both reef species were collected from its distant original habitats, and during the course of trade the specimens were accidentally (or intentionally?) released from holding facility prior to export, resulting in different case of non-indigenous species introduction within one local jurisdictional area. Unlike *Strombus canarium,* which was featured in Parker (1922), the gastropod was suspected to be established by means of ballast waters at several small islands in Riau, Sumatera.

Case studies

Developing a case study of introduced marine species in Indonesia is a challenging task, since most of the published works related with the intentionally introduced marine species are designated to improve their production performance (e.g.: biological reproduction, larval rearing, feed supply and variation, virus and parasite control, water quality, and polyculture). The white shrimp *(Litopenaeus vannamei)* was deliberately introduced to the country in 1999, to replace the poor performance of cultured *Penaeus monodon*. Although Central America is the species native habitat, imported broodstock and larvae of the first *Litopenaeus vannamei* in Indonesia was originated from Hawaii, via Taiwan (Sugama et al., 2006). No information is available regarding adverse ecological impact of *Litopenaeus vannamei* in the wild habitat, yet the species has been cultured in more than 18 provinces by the end of 2007. One control method applied for the introduced species was when the government implemented ban on the imported white shrimp in 2005 and extended continuously every 6 months until 2009, following viral pathogen outbreaks in 2003. At present, commercial culture of the white shrimp still in practice, with Situbondo and Banyuwangi (East Java) as major broodstock supplier and national shrimp production centers.

Recommendations

Evidences of catastrophic changes in natural ecosystem by intentionally introduced species that become invasive are documented for most terrestrial and freshwater species. Being the country with most introduced species for mariculture, Indonesia should take measures in examining importation of diseases and pathogens, as well as studying the potential escape of cultured species into the wild. Previously aimed to help economic development, the introduced mariculture species can also initiate economic hardships along with ecological damages.

Another recommendation addressed here is related with unintentionally introduced species or species carried in ballast tanks of trans-national ships. Indonesia has no specific regulation regarding the cast of ballast water in its international and national ports, yet its ports are among the busiest in the region. Several incidences of sudden phytoplankton blooms in the country (e.g.: Jakarta Bay and Cape of Benoa), which usually considered as the effect of coastal eutrophication, could well be biological invasions of non-indigenous species transferred by ballast waters. Further eleterious impacts of the toxic plankton blooms may affect native economic and social activities, including operational fishery collapse and serious human health consequences.

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Toshio Furota and Satoko Nakayama

General background

The island of Japan is in East Asia region, located in the Pacific Ocean. The island is surrounded mainly by the Sea of Japan, Sea of Okhotsk, as well as East China Sea. Japan has a total of 6,852 islands with Honshu, Hokkaido, Kyushu and Shikoku being the four largest islands. More than 50% of the islands are mountainous and many are volcanic. The total land area of Japan is about 377,944 square km and the coastline estimated at 35,000 km. Of the total coastline, rocky shores constitute about 10,000 km. The major shipping ports of Japan include Port of Hakata, Port of Kawasaki, Port of Kitakyushu, Port of Kobe, Port of Maizuru, Port of Nagoya, Port of Osaka, Port of Shimonoseki, Port of Tokyo, Port of Yokkaichi, Port of Yokohama, Port of Yokosuka, Port of Aomori, Port of Chiba, Port of Ibaraki, and Yokohama Port Development Public Corporation.

Current status

Currently there are 23 marine invasive species in Japan. These invasive species are mostly invertebrates, including barnacles, crabs, and polychaetes, and they entered Japan primarily via ship hulls. The earliest record of marine invasive species is the calcareous tube worm, *Hydroides elegans*, initially reported at Lake Kojima, Okayama Prefecture, in 1928. Since the initial record of this species, it has been found in other parts of Japan, mainly at the Pacific coast of Honshu and Shikoku, Northern Kyushu.

Case studies

A number of case studies have been conducted on the impact of marine invasive species in Japan.

Case 1: *Amphibalanus amphitrite*
This exotic barnacle *A. amphitrite* may reduce native barnacle *Balanus reticulatus* populations as well as compete with native oyster *Crassostrea gigas* and pearl shell *Pinctada martensii* by reducing their growth. The invasive barnacle was also found to foul sluice systems in estuarine area.

Case 2: *Carcinus aestuarii*
Originally from the Mediterranean region, the green crab *C. aestuarii* might cause negative impact by predation on native species at coastal community. However, its impact is difficult to be determined since this species is distributed at urbanized estuarine areas where local shore community has been dominated by other exotic/invasive species.

Case 3: *Euspira fortunei*
This gastropod species is found in Northeastern Pacific coast of Japan. It feeds on the exotic moon snail and is found to impact negatively on local clam *Ruditapes philippinarum* aquaculture.
Euspira fortunei has been also found to feed on native tidal flat clams such as *Mactra veneriformis*.

Case 4: *Nassarius sinarus*

The exotic snail, *N. sinarus,* is found to occur together with native endangered snails, such as *Varicinassa vericifera* and *Zeuxis succinctus*. This might result in competition with these endangered snails. This invasive exotic snail was also found to cause damage to local fisheries due to feeding on gobies trapped in fishery bait traps.

Case 5: *Mytilus galloprovincialis*

Found on intertidal rocky shores and artificial hard surfaces, the exotic blue mussel *M. alloprovincialis* eliminates native sessile species due to competition for space. The introduction of *M. galloprovincialis* has largely changed community structure in intertidal rocky shores by development of dense mussel beds. In rocky shores in bays, the coverage of *M. galloprovincialis* caused mortality of native sessile species, such as the oyster *Crassostrea gigas,* rocky shore mussel *Septifer virgatus,* the small barnacle *Chthamalus challengeri* and the edible sea weed *Sargassum fusiforme.* Hybridization in the native mussel *M. trossulus* in northern Japanese waters with the *M. galloprovincialis* had been suggested, causing great concern with genetic disturbance in native species. Mass mortality of *M. galloprovincialis* brings organic matter deposition on the sea bottom, causing deterioration of bottom sediment and bottom water layer. In 1973, mass growth of *M. galloprovincialis* in Hiroshima Bay, western Seto Inland Sea, caused 35% reduction (about 500 million JY) of oyster aquaculture. In the 1950s, antifouling agent such as TBTs had been used on ship and boat hauls to prevent growth of *M. galloprovincialis* and other sessile organisms. However, the use of TBTs caused imposex in native snails.

Case 6: *Perna viridis*

Found on rocky shores in Enoshima Island in Sagami Bay, the massive growth of the mussel *P. viridis* dominated local community together with other exotic species, such as *M. galloprovincialis* and the European barnacle *Balanus improvisus.* In Tokyo Bay, *P. viridis* repopulate during warmer season but its population was found to contract in the following winter due to extreme low temperature. The deposition of dead *P. viridis* may cause deterioration of bottom conditions. Competition for space between *P. viridis* and other sessile native species may change local community structure. In addition, the presence of *P. viridis* found attached on cultured shells, such as oyster, may inhibit growth of the cultured shells.

Case 7: *Xenostrobus secures* and *Mytilopsis sallei*

Predominance of the bivalves *Xenotrobus securis* and *Mytilopsis sallei* might change local coastal community structures by competing with other native sessile organisms in Japan.

Case 8: *Mercenaria mercenaria*

The bivalve, *Mercenaria mercenaria,* may compete with native bivalves for space and suspended food resource. Sediment disturbance caused by *M. mercenaria* may have a negative effect on

eelgrass growth. Furthermore, hybridization with native *M. stimpsoni* by the *M. mercenaria* is of great concern.

Case 9: *Ficopomatus enigmaticus*

Reef construction by the calcareous tube worm *F. enigmaticus* provides new space for other species that inhabit among these tubes worm might alter local community structure. This species may compete for space and suspended food resource with native species. In Hamana Lake, Shizuoka Prefecture, large growth of *F. enigmaticus* was found to cause damage on local oyster culture.

Case 10: *Hydroides elegans*

The polycheate, *H. elegance,* may compete for suspended foods with other suspension feeders. This species may also compete for the space with other native species. Since construction of calcareous tube assemblage changes substratum character, growth of *H. elegans* may change local community structure as well. Growth of the *H. elegans* on cultured oyster shells resulted in death of the cultured oysters, causing several billion Japanese Yen damage on local oyster industry.

Case 11: *Neobenedenia girellae*

Infection of the platyhelminthes, *N. Girellae,* caused price reduction of 15 species of cultured fishes, including *Takifugu rubripes*, *Paralichthys olivaceus*, groupers, *Seriola dumerili*, *Pseudocaranx dentex, Pagrus* major.

Case 12: *Neoheterobothrium hirame*

Infection of the platyhelminthes, *N. irame*, on juvenile halibut *P. olivaceus* caused decline of locomotion ability and abnormal behavior of the host fish. This may induce increase of predation on juvenile halibut, resulting in the reduction of the halibut catch.

Case 13: *Heterocapsa circularisquama*

Red tide blooming of the exotic dinoflagellate *H. circularisquama* was found to cause mass mortality of cultured bivalves, *Ruditapes philippinarum*, *Crasostrea gigia*, and *Pinctada martensii.*

Case 14: *Lateolabrax* sp.

The exotic bass *Lateolabrax* sp. may compete with the native bass, *L. japonica.* Damage of local fish and shellfish populations by predation of this exotic species is of great concern.

Recommendations

In order to implement any effective control measures on marine invasive species in Japan, the following recommendations have been suggested:

1. Prohibit intentional introduction of living marine organisms collected in foreign waters that is too far for natural dispersal of marine organisms.
2. Reduction of unintentional introduction of marine invasive species associating with attaching on the ship hulls and captured in sea chest. Periodic cleaning of the ship hulls and sea chest must be required.

3. Rapid development and application of ballast water treatment system
4. Establishment of monitoring observation system for marine invasive species. Rapid eradication of newly found introduced population before it spreads to adjacent waters.

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Heung Sik Park and Jung Hoon Kang

General background

South Korea has a land mass of 100,032 square km and is located at the southern half of the Korean Peninsula on the far east of the Asian land area. The country is largely surrounded by water and consists of 2,413 km of coast line bordering three seas namely, Yellow Sea, Southern Sea, and Sea of Japan (East Sea). Each of these seas is characterized by special environmental. For example, the macro tidal flats spread on the Yellow Sea, a complex coastlines developed by the 2,100 of islands on the Southern Sea and well circulated by seasonal currents along the East Sea. Most areas have developed port systems since 1970 due to trade and economic ties between nations. Previously, the ballast water discharges were popular around the coast. Consequently, this leads to severe recruitment of invasive species.

Current status

Inventory studies on aquatic alien species around Korea started in 1980 because of a serious problem of red tide blooms. The government then recognized the effects of alien species around the coasts. Studies on alien species in Korea focused on only ballast waters because ships transport over 80% of goods worldwide and ship ballast water is a known vector for the movement of small organisms beyond their bio-geographical ranges. Now we hypothesize that several pathways have introduced the alien species into Korea. The pathways include shipping, import goods and aquaculture. Among these, the main vector is ballast water. In addition, since 1970, Korea has developed economically. Many ports have been expanded and established. Around the ports, some alien species recruited massively. The government has tried to monitor alien species around coasts area through oceano graphic modelling. A total of 83 species were identified as potential marine alien species. 12 species have been designated as marine alien species because there are well mixed condition of current by season, topographically. Some species supposed to be recruited by current since settled around neighboring country.

Case studies

Since adoption of "International Convention for the Control and Management of Ship's Ballast Water and Sediments" in 2004 by International Maritime Organization (IMO), our government has taken several steps to reduce the risks arising from the transfer of harmful aquatic organisms and pathogens via ship ballast water. As concern about biological invasions via ballast water grows, project PERAT (Port Environmental Risk Assessment Technology) began as a government program in 2007.
The project was designed to develop the ballast water management program which control discharge of ballast water of ships entering harbors of Korea. Risk assessment of ballast water is inevitable when considering discharge of ballast water beyond bioregion.

For implementation of risk assessment defined by G7 guideline under the Convention, port baseline surveys, survival tests, and vector analysis are inevitable fundamental stages in the viewpoint of a whole-of-port approach. However, until recently, despite growing concern about biological invasions via discharged ballast water at major ports, any attempt has not been made on discerning introduced or invasive species from the native community in Korea. Thus, as part of project PERAT, we have conducted port baseline surveys seasonally at major ports (Incheon, Gwangyang, Pusan and Ulsan) and listed up the species composition and abundance of plankton and benthic community since 2007. Concurrently, we visited many ships as possible to investigate biological and environmental information inside ballast water with a variety of ballasting source. By investigating the commercial ships anchoring at the ports, their particulars and information of intake and uptake of ballast water were also summarized as a basis for consideration of risk assessment for exemption.

By putting the above mentioned information together through the database system, ballast water management program suitable for our nation is under development. In addition, diverse investigation for risk assessment has been carried out as part of currently ongoing project in Korea.

Recommendations

There is a lack of data and information about native species which makes identifying alien species in coastal areas around Korea confusing. To elucidate the route of species, we suggest to our government that it seeks international cooperation to trace the movement of alien species.
Now we are carrying on the long-term monitoring program of the effects of ballast water. This will allow Korea to develop the regulations for ballast water management.

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MALAYSIA

Zulfigar Yasin, Muhammad Ali Syed Hussein, Aileen Tan Shau Hwai, and Lik Tong Tan

General background

Malaysia, a Southeast Asian country, consists of 13 states and three Federal Territories with a total landmass and coastline of about 329,845 km^2 and 4675 km, respectively. The country comprises of two regions, namely Peninsular Malaysia and Malaysian Borneo separated by the South China Sea. The west coast of Peninsular Malaysia faces the Andaman Sea to the north and Straits of Malacca to the south. It is located near the equator and the borders Singapore, Thailand, Indonesia and Brunei. There are seven major container ports in Malaysia, including Northport (Klang), Westport (Klang), Penang Port (Penang), Port of Tanjung Pelepas (Johor), Johor Port (Johor), Bintulu Port (Sarawak), and Sapangar Bay Container Port (Sabah). Peninsular Malaysia is also located along the Straits of Malacca, which is a major shipping land of the world. This and its position straddling the Indian and Pacific Ocean makes it an important location for the monitoring of marine introduced species.

Current status

Most of the information on introduced aquatic alien species in Malaysia is on freshwater species. To date, only two marine non-indigenous species have been documented and these are *Mytilopsis sallei* (black striped mussel) and *Etroplus suratensis* (a cichlid), while a freshwater fish, the tilapia (*Oreochromis* spp.) has been able to adapt to love in a brackish waters. These species has been found to establish mainly in degraded estuaries, tidal monsoon drains and coastal waters.

The black striped mussel, *M. sallei,* is an invasive marine species commonly found in coastal areas, particularly in Southern Peninsular Malaysia and parts of Singapore (Tan and Morton, 2006). The bivalve can be found in monsoon drains up to several kilometers inland from the sea. It is also recently collected in shrimp pong inlets in Kuala Inanam Sabah. This species is highly adaptable and able to tolerate salinity ranging from 2 to 22 ppt. The main introduction pathways of *M. sallei* is international shipping (via ballast water discharge and hull fouling).

Etroplus suratensis and *Oreochromis* spp. were introduced through aquaculture and the aquarium trade in the past. Due to intentional and non-intentional release, these species are now found in the wild. This particular route has been seen to be an important source of non-indigenous species. Although not formally recorded in the wild, *Litopenaeus vannamei* (white-legged prawn) is a likely candidate of a potential non-indigenous species to establish itself in Malaysian waters. It was originally illegally imported from Taiwan and Thailand in 2001 and 2002, respectively. The import of the white-legged prawn was subsequently banned in 2003 for a short duration in order to revent the introduction of TSV and other viruses to Malaysia (DOF, 2007). After the lifting of the ban in 2005, it has since established itself as a species of choice for shrimp aquaculture.

Case studies

Currently there are no case studies performed on the impact of marine invasive species in Malaysian waters.

Recommendations

Various laws to control import/export of live organisms, protected species and quarantine procedures provide a limited barrier to introduction of non-indigenous species. However, there are no specific policies currently in place to control, manage, and eradicate marine invasive species in Malaysia. Unfortunately, very little or insignificant efforts is given to address such impacts by the government. In order to implement any effective control measures on marine invasive species in Malaysia, the following shortcomings have to be addressed:

a. Changing the perceived benefits of introduced marine species;
b. Limitations of law enforcement and identification expertise;
c. Inadequate testing facilities and protocols;
d. Lack of understanding of transfer pathways;
e. The need for a comprehensive inventory of invasive marine species;
f. The need for a monitoring system for the importation and farming of alien species;
g. Effective monitoring of the Straits of Malacca maritime traffic.

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PHILIPPINES

Benjamin Vallejo Jr.

General background

The Philippines is an archipelago in Southeast Asia and the western Pacific consisting of 7,107 islands. It is located between 116° 40', and 126° 34' E. longitude, and 4° 40', and 21° 10' N latitude. It has a savanna and tropical rainforest climate (Köppen climate classification ASW and AF). The land area is approximately 300,000 km^2 and coastal length at 33,900 km. The GDP is 380.22 B USD. Aquaculture contributes 1,044,311 MT to fisheries and 82.23% of this is from mariculture. There are 23,000 km^2 of mangroves. One hundred percent of the population of approximately 92.2 million people live within 100 km of the coast. Thus the whole population can be considered as a coastal population.

Current status

Introduction of aquatic alien species in the Philippines started in 1905 when the country was under American rule. These introductions of American cyprinodonts, *Poecilia latipinna*, *Gambisia affinis* and *Fundulus heteroclitus* were done to control mosquito borne diseases (Herre, 1924). Introduction of other fish species were done to boost fishery production and to start a recreational game fishing industry.

However none of the species introduced have a marine origin except probably for *P. latipinna* and *G. affinis* whose native southeastern United States habitat consists of salt marshes. *P. latipinna* is not strictly marine but euryhaline. Subsequent introductions since the 1930s were mainly freshwater species for ornamental and aquaculture purposes. It was only in the 1970s that species of a purely marine origin were introduced to the country for aquaculture purposes. Beginning with Eastern Pacific penaeids and the north Pacific giant oyster, these species were introduced to boost aquaculture production since they grew faster than co-generic indigenous species (Juliano, et al., 1989). The impacts of these species and whether they have established reproductive populations is currently unknown. No study to date has been done.

The liberalized trade environment in the 1990s has seen the Philippine aquarium trade grow and a viable domestic market for exotic marine ornamentals was created. While the market is small compared to other countries, around 20 species of non-native coral reef fish and invertebrates have been imported. There has been no documented case of an accidental or deliberate introduction of any of these species. However, there is an unconfirmed report of the Banggai Cardinalfish *Pteragon kauderni* being sighted in one dive resort in Batangas in 2009.

Other routes for accidental introduction could be ship ballast water. Professor Edgardo D Gomez of the University of the Philippines Marine Science Institute opines that there could be an accidental introduction of a Caribbean gorgonian in Manila Bay in the 1980s. There is also one unconfirmed report of *Mytilopsis sallei* found on harbour pilings in Manila Bay. Also the introduction of

macroalgal species *Cochlodinium polykrikoides, Alexandrium minutum and Chatonella marina* in the port of Sual, Pangasinan and in Palawan may have been due to ballast water exchange (Azanza, pers. comm.) These invasive potential of these species have not been verified although the presence of the microalgal species has been confirmed.

The Philippine Fisheries Code of 1998 regulates the introduction of alien aquatic species and mandates an "import risk assessment" (Guerrero, 2006). However the law's regulatory framework is unclear about species intended for aquarium systems and those for aquaculture systems. Ornamental fish are usually exempt from import risk assessment unless they are to be commercially cultured for food fisheries. The major recent instances of aquatic species invasion are by aquarium species that have accidentally escaped (Vallejo, 2006). A bill has been introduced in the Philippines House of Representatives to include tighter introduced species regulations in a proposed harmonization of Philippine environmental laws (House Commitee on Environment, 2009).

Case studies

Poecilia latipinna may be the only known marine invasive species that has sufficient documentation on its effects on coastal ecosystems in the Philippines. In the Philippines, this species has colonized degraded mangrove and estuarine habitats up to freshwater streams on lower elevations. In higher elevations, *P. reticulata* replaces *P. latipinna*. *G. affinis* seems to have been displaced by *P. latipinna* in estuarine and mangrove habitats.

Wherever it is found, it is the dominant species in brackishwater shrimp and fish ponds and competes with indigenous species and species for aquaculture. It has probably displaced indigenous species like *Dermogenys* that occupy a similar niche (Vallejo, 2006). In heavily polluted estuarine creeks and rivers in Manila and neighbouring areas, the fish is the only species found. It supports a minimal commercial baitfish industry. It has been observed in purely marine habitats.

The species is also found in other Philippine islands in the Visayas and Mindanao where there is extensive brackishwater aquaculture. In places where brackishwater aquaculture is not extensive and the mangroves have been largely preserved, the species is absent. This species tolerates deteriorating estuarine habitats. Ponds that are no longer viable for commercial aquaculture are favoured habitats.

Recommendations

Documentation and information on marine invasive species is lacking and previous records are hard to trace aside from anecdotal accounts. Most introductions have been made by aquaculturists and aquarists. They usually brought in species in non-commercial quantities and thus were exempt from import permit regulation. While this policy has changed and permits are required for all imports regardless of volume, a focused research, monitoring and permit scheme programme is needed to

assess the effects of marine invasive species. The information collected needs to be placed in a centralized database system for easy access.

At present economic considerations is one of the major reasons why alien species are introduced for aquaculture. A major priority of government is on small scale backyard aquaculture that is applicable for rural and urban communities. If an alien species is to be introduced, a thorough study on ecological risks is needed. An improved system of recording species importation and assessing them for ecological risk is needed before a decision to propagate them is made. Once that decision is made, importation should be from reliable sources where stocks can be certified as disease free and the genetic lineage is ascertained. Also no organisms should be released or distributed to users until the F2 generation. Lastly the introduced species must be well monitored after release.

For ship traffic mediated introductions, there are no studies that have been made and no baseline survey on introductions is available. An intensive survey for possible invasive species should be made in the country's busiest ports of Manila and Cebu to determine if an invasive has been established. A coordinated effort with harmful algal bloom researchers is needed in the survey and documentation of possible ship mediated introductions.

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Lik Tong Tan

General background

Singapore is an island nation located at the narrowest point of the Strait of Malacca between Malaysia and Indonesia. Total land area of Singapore is approximately 700 km^2 with a total coastline of 193 km. Its location makes it a strategic position for sea route linking the Indian Ocean with the South China Sea. The Port of Singapore is currently, the world's busiest trans-shipment port, handling about a fifth of the world's shipping containers.

Current status

Currently, there are only two reports of non-indigenous marine species in Singapore, including the bivalves *Mytilopsis sallei* and *Brachidontes striatulus*.

Mytilopsis sallei

Mytilopsis sallei, also known as the black-striped mussel, is a small sized bivalve and has an average maximum size of 25mm. Coloration of shell can be varied ranging from black to light hue. This organism occurs as clusters in their byssal threads and can tolerate a wide temperature and salinity range from 5 to 40^{O}C and 0 to 50 parts per thousand, respectively.

Brachidontes striatulus

This bivalve species can be found together with the byssal mats of *M. sallei*. Shell lengths can be varied ranging from 11 to 22 mm. It has been reported that this species is highly variable in terms of shell length as well as the degree of radial ray development and stripping. Pictures of this species from Singapore can be found in the journal article by Morton and Tan (2006).

Case study

Research data on the impact of specific marine non-indigenous species in Singapore is currently not available.

Recommendations

Governmental grant should be made available to fund research on marine non-indigenous organisms in Singapore. Such research could include biodiversity studies as well as specific case studies on the impact of non-indigenous species in Singapore. As of early 2010, the Coastal and Marine Environment Grant administered by National Parks, Singapore, was made available to study the impacts of shipping related activities on coastal and marine habitats in Singapore. Data from such studies could form baseline data and guide policy makers to form regulations on lowering the impact of non-indigenous species in Singapore waters.

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THAILAND

Suchana Chavanich, Voranop Viyakarn, Suwanna Panutrakul, Wansuk Senanan, Sumaitt Putchakarn, Somchai Bussarawit, and Ukkrit Satapoomin

General background

Thailand is a peninsular country, located between 5° and 20° N and between 97° and 106° E. A total area of Thailand is 513,115 km^2. There are 23 coastal provinces surrounding the two main coastal areas, the Gulf of Thailand and the Andaman Sea.

The Gulf of Thailand and the Andaman Sea have total EEZ areas of 304,000 and 116,280 km^2 respectively. The total coastline is approximately 3,219 km. More bays and more islands are found in the west coast of the peninsular. Varieties of coastal habitats such as tidal flats, mud flats, estuaries, mangroves, seagrasses, and coral reefs also can be found. Thailand's coastline habitats are biologically complex, and are rich in marine life, many of which are considered economic important species whether through directly exploitation or through the tourism.

The health of the ecosystems is between good and fair conditions. Anthropogenic disturbance has significantly contributed to the declining of the ecosystem health. The examples are overfishing, changes in land use, increase in nitrogen fertilizers and eutrophication in the water, and harmful algal blooms (Longhurst, 1998; Piyakarnachana, 1999).

Current status

Recently, the non-indigenous species have raised a concern since their impact can be visible and pose a serious problem. Approximately 3,500 species of non-native animal and plant species live and breed successfully in Thailand (Office of Natural Resources and Environmental Policy and Planning, 2009). In 2009, the Measures for the Prevention of the Introduction, Control, and Eradication of Alien Species were approved by the cabinet. It composes of 4 measures and 15 guidelines.

An inventory of non-indigenous species has been compiled by the Office of Natural Resources and Environmental Policy and Planning (2009). However, at present, little information has been provided, and few studies have been done related to marine and brackish non-indigenous species. This may be due to the high biodiversity in the marine ecosystems and the lack of the complete database of marine biodiversity. Thus, many species are still discovered as first records in Thailand, and are not certain whether they have been there for a long time, but simply overlooked in the past, or they are new comers. In addition, Thailand has no single national authority responsible for prevention and management of marine non-indigenous species. The responsibility is shared among different governmental offices and ministries.

In this report, 7 species of marine and brackish non-indigenous species found in Thai waters are listed. The species include the sponge *Tetilla japonica* Lampe, 1886, the white shrimp *Litopenaeus*

vannamei (Boone, 1931), the amphipod *Leucothoe spinicarpa* (Abildgaard, 1789), the mussel *Mytilopsis adamsi* Morrison, 1946, the tunicate *Clavelina cyclus* Tokioka and Nishikawa, 1975, the tunicate *Ecteinascidia thurstoni* Herdman, 1891, and the fish *Cichlasoma urophthalmus* (Gunther 1862). The white shrimp, *L. vannamei* was intentionally introduced for aquaculture, and *C. urophthalmus* was probably introduced as an ornamental species (Nico et al., 2007; Senanan et al., 2007). Other species were likely to be transported unintentionally by ballast water or as ship hull fouling. The tunicate, *C. cyclus* can be found in the tropical Indo-West Pacific including the Andaman Sea; however, there was no record in the Upper Gulf of Thailand until recently when it is found spreading on cement pilings of the pier and in coral reefs (Chavanich et al., 2009).

Case studies

Even though, Thailand is now concerning with the invasion of non-indigenous species, little has been done on marine non-indigenous species. One of the prominent case studies in Thailand is the assessment of likelihood of escapes, distribution, and reproductive capacity of white shrimp *(Litopenaeus vannamei)* in the Bangpakong river basin and eastern seaboard of Thailand. This project was funded by the National Research Council of Thailand. The other is the study of the mussel, *Mytilopsis adamsi*.

The white shrimp (Litopenaeus vannamei)

This white shrimp was first introduced to Thailand for an aquaculture purpose because of the species' fast growth, low incidence of native disease, and availability of domesticated strain. 3-year study of the white shrimp from 2005-2007 focused on five aspects: 1) the quantity of escapees from farms located in the Bangpakong River watershed, 2) the ability of escapees to survive natural conditions, 3) the reproductive capacity of escapees, 4) the spread of Taura Syndrome Virus (TSV), and 5) the ability of the white shrimp to compete for food with local species (Chavanich et al., 2008; Panutrakul et al. in press; Senanan et al., in press; Senanan et al., 2009). The results showed that the white shrimp is now already present in the natural waters in Thailand (Senanan et al., 2007). These shrimp escapees can also likely survive the natural environment conditions (Panutrakul et al. in press; Senanan et al., in press; Senanan et al., 2009). However, the study could not conclude that escapees can establish a feral population. The data generated from this study have raised some important management issues and provided some guidance for the introduction of marine non-indigenous species to the country for aquaculture purpose.

The mussel (Mytilopsis adamsi)

Mytilopsis adamsi is a brackish water bivalve, and is native to tropical Western Pacific coast of central America. Some countries have recognized this mussel as a *M. sallei* Marelli and Gray (1985) (Tan and Morton, 2006). This species can be found in the lower part of the Gulf of Thailand, and is continuing to spread (Wangkulangkul and Lheknim, 2008). *Mytilopsis adamsi* was probably accidentally introduced via international commercial cargo ships (Wangkulangkul and Lheknim, 2008).

Recommendations

Implementation of mandates and procedures for the prevention, monitoring, and control of the spreading of marine non-indigenous species is essential at the national level. These mandates and procedures should be integrated throughout the agencies. Moreover, monitoring needs to be con sistent since some species can take a long period of times to establish their populations in an invaded area due to the environmental conditions and individual species characteristics.

At present, the climate change is also expected to worsen the world's invasive species problems because disturbance events can create opportunities for marine non-indigenous species to invade and take places of native species in ecosystems. Thus, there is a need for more research on the interactions between climate change and the invasion of marine non-indigenous species. In addition, protecting marine ecosystems and building ecosystem resilience are necessary. Healthy marine ecosystems are more likely to have invasion resistance. Even though, it may be impossible to avert the climate change or eradicate marine non-indigenous species, it is possible to reduce other threats such as overfishing, pollution, eutrophication, etc. This can lead to healthier marine ecosystems.

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Vo Van Quang

General background

Vietnam is located on the eastern seaboard of the Indochinese Peninsula. Vietnam's northern border abuts China's Yunnan and Guangxi Provinces just below the Tropic of Cancer (23° 30'N), and its southern tip meets the Gulf of Thailand. Laos and Cambodia bound the country to the west, and the East Sea (also known as the South China Sea) lies to the east with a mainland area of 330,591 km^2. The Vietnam Sea is also situated on a strategically important trade route between the Indian and Pacific Oceans.

Vietnam's mainland is edged by a substantial area of shallow, submerged continental shelf (part of the Sunda Shelf) and thousands of islands are distributed along the coastline from north to south. The coastal zone of Vietnam forms a large interface between land and sea. Its nature is almost different from neighbouring sea and land areas. It also contains a number of unique coastal ecosystems with valuable tropical natural resources such as; deltas, lagoon, coral reef, estuaries, tidal marshes, mangrove and upwelling areas etc. Vietnam has 3,260 km of coastal line with more one millions sq. km of Exclusive Economic Zone (EEZ).

Vietnam's two major delta regions, the Red River Delta in the north and the Mekong Delta in the south, are perhaps its best known topographic features. Both lie on average only a few yards (meters) above sea level and are heavily populated and largely agricultural. The two deltas differ greatly in their hydrology, in the timing and extent of flooding, and in their floral and faunal communities. Such divergence arises from climatic and geological differences between the two regions and from the nature of the rivers that flow into them.

Current status

In Asia, international trade and human migration have recently caused invasion of non-indigenous marine species as a serious problem. These invasive alien species would not only influence local biodiversity, but also damage agriculture and aquaculture further.

Aquaculture in Viet Nam is challenging with very limited numbers of domestic species being economically significant. To address this issue, for the last five decades, several alien species have been introduced in aquaculture practice. The introduced species have usually obtained good growth and high productivity. Presently, alien species are dominant in freshwater aquaculture contributing to more than 50% of the total freshwater aquaculture product in Viet Nam. For example, it is estimated that the volume of Chinese (three species) and Indian (two-species) carps shares about 40-45% of freshwater production and this accounted for approximately 600000 MT in 2002. Alien species are stocked in all water bodies/ponds such as paddy fields, reservoirs, ponds and cages. In brackish water and marine aquaculture non-indigenous species have not had a significant role. To date, very few species have been introduced; mainly for

experimental trial such as red drum, pacific oyster through the private sector or government arrange ments. The white shrimp (*Penaeus vannamei*) has also been imported and aquaculture in permitted areas. Despite official restrictions, it is estimated that approximately 10 percent of the countrtry' s 479000 ha of shrimp ponds are now being used to culture *P. vannamei* (Brigss et al., 2004).
Now, some provinces have permitted in planed areas.

Case studies

In Vietnam, alien invasive species have also dramatically impacted the freshwater and agricultural systems and caused severely economic damage. For example, Golden Apple Snail has become established as one of the most serious rice pests in Vietnam, costing millions of dollars in lost rice duction each year (MoNRE et al., 2005).

To date, the research and assessment on negative impacts of introduced marine species have not been carried out. On the other hand, there was not any complaint from farmers about harmful or negative impacts from the introduced fish, shrimp, etc.

Recommendations

It is recommended that the Vietnamese government should develop a strategic plan for use of non-indigenous species. The existing technical guidelines should be further improved with a focus on control mechanism and responsible use of non-indigenous species.

It is recommended that the exchange of information between countries should be strengthened. Technical guidelines on the control and responsible use of non-indigenous species at regional level should be developed in consultation with the participating countries.

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List of marine non-indigenous species found in each country in the Western Pacific region

Group of organisms	Species	First recorded (year)	Location of 1st record	Verification of the first record	Vector	Current distribution	Native range	Origin (introduced from)	Impact (Yes/No)
Plant	*Eichhornia crassipes*	1901	unknown	unknown	Intentional introduction	17 provinces, Sichuan, Hubei, Henan, Shanghai, etc. Northern, Western, Wouthern, and Central China	South America	Brazil	Y
	Salicornia bigelovii Torr.	2001	Guangxi Province	unknown	Intentional introduction	Southern Coast of China: City of Sanya, Leizhou, Shantou, Fangcheng, Nantong, Shandong	North temperate zone and Subtropical of north America	unknown	unknown
	Spartina anglica C.E. Hubb.	1963	Jiangsu Province	Zhong and Zhuo (1985)	Intentional introduction	Coast shoal of China from Jinxi in Liaoning Province to Hepu in Guangxi Province; the Yellow River Delta; Bohai Bay	South Seacoast of England	England	Y
	Spartina alterniflora Loisel	1979	unknown	Zhong and Zhuo (1985)	Intentional introduction	Coast of China: Fujian, Zhejiang, Shanghai, Jiangsu, Shandong, Tianjin, and Liaoning, etc.	North American Coast of Atlantic Ocean, Gulf of Mexico	unknown	Y
Algae	*Bidduiphia sinensis*	unknown	unknown	unknown	unknown	Yellow Sea, South China Sea, Donghai Sea	unknown	unknown	unknown
	Desmarestia ligulata Lamouroux	unknown	Dalian	unknown	Unintentional introduction	unknown	Scotland	Hakodate of Japan	Y

Group of organisms	Species	First recorded (year)	Location of 1st record	Verification of the first record	Vector	Current distribution	Native range	Origin (introduced from)	Impact (Yes/No)
Algae	*Dinophysis caudata*	2003	Yantai	unknown	Ballast water	Nansha and Xisha archipelago, Hainan island Pearl River, Guangdong,Mirs. Daya Bay	unknown	unknown	Y
	Eucheuma striatum	May, 1985	unknown	unknown	Introduction	Hainan, Taiwan, Xisha Islands, etc.	Zanzibar in Tanzania, Philippines, Indonesia, Ryukyu Islands	Philippines	unknown
	Laminaria japonica Aresch	1927	Dalian	unknown	unknown	Liaoning to Lianjiang Fujian Province	Bering Strait, Kuril Islands in the Sea of Okhotsk, Japan	Japan	unknown
	Palmaria palmata	2005	unknown	unknown	Introduction	unknown	Spain, Atlantic Coast, Canadian Coast	German	unknown
	Peridinium perardiforme	1996	Hong Kong	unknown	Ballast water	National distribution	Coast of North America	unknown	Y
	Porphyra yezoensis	unknown	unknown	unknown	unknown	Yellow Sea, Bohai Sea, Donghai Sea of China	unknown	unknown	unknown
	Undaria pinnatifida	1984	unknown	unknown	Intentional introduction	Coast of Liaoning, Shandong, Zhejiang, and Jiangsu Province, etc.	unknown	Japan	Y
Annelid	*Hydroides elegans*	unknown	unknown	unknown	Unintentional introduction-bilge carry	Coastal area of China	unknown	unknown	Y

Group of organisms	Species	First recorded (year)	Location of 1st record	Verification of the first record	Vector	Current distribution	Native range	Origin (introduced from)	Impact (Yes/No)
Barnacle	*Balanus amphitrite*	unknown	unknown	unknown	Unintentional introduction-bilge carry	coastal area of China	unknown	Pacific coast of North America	Y
	Balanus eburneus	1978	Qingdao,	unknown	Unintentional introduction-bilge carry	coastal area of China	unknown	unknown	Y
	Balanus improvisus	1978	Qingdao	unknown	Unintentional introduction-bilge carry	unknown	unknown	unknown	Y
Shrimp	*Macrobrachium rosenbergii*	1976	unknown	unknown	Introduction	Southern China	Pacific Ocean near India	Japan	unknown
	Metapenaeus affinis	unknown	unknown	unknown	unknown	East China Sea, South China Sea	unknown	unknown	unknown
	Penaeus (Marsupenaeus) japonicus Bate	unknown	unknown	unknown	unknown	Coastal of China	unknown	unknown	unknown
	Penaeus merguiensis	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown
	Penaeus monodon Fabricius	unknown	unknown	unknown	unknown	Taiwan, Fujian, Guangdong, Guangxi Province	unknown	unknown	unknown
	Penaeus penicillatus	unknown	unknown	unknown	unknown	Fujian, Tai wan, Guangdong Province	unknown	unknown	unknown
	Penaeus stylirostris	2000	unknown	unknown	Introduction	unknown	Latin American	Hawaii	unknown
	Penaeus vannamei	1988	unknown	unknown	Introduction	unknown	Central America, Ecuador	America	Y
Mollusc	*Argopectens irradias*	1982	unknown	unknown	Introduction	Shandong, Liaoning, Hebei	unknown	Atlantic coast of the U.S.	unknown
	Crepidula onyx	unknown	unknown	unknown	Unintentional introduction-bilge carry	Hongkong, Shenzhen	Puerto Rico, USA	unknown	Y
	Crasostrea gigas	1979	unknown	unknown	Introduction	Liaoning, Shandong, Guangdong, Fujian	unknown	Japan	Y

Group of organisms	Species	First recorded (year)	Location of 1st record	Verification of the first record	Vector	Current distribution	Native range	Origin (introduced from)	Impact (Yes/No)
Mollusc	*Holiotis diversicoler eeue*	unknown	unknown	unknown	unknown	Zhejiang, Shandong, Hainan	Taiwan	unknown	unknown
	Haliotis diversicolor supertexta LischRe	unknown	unknown	unknown	unknown	Mawei, Fuzhou, Hainan, Shandong, Hainan	Taiwan.	unknown	unknown
	Haliotis iris Martyn	1990s - 2000	unknown	unknown	Introduction	unknown	West Pacific Ocean	New Zealand	unknown
	Haliotis laevigata	1998	Shenzhen	unknown	Introduction	unknown	unknown	the nursery near Adelaide, Australia	unknown
	Loligo japonica	unknown	unknown	unknown	unknown	Bohai Sea, Yellow Sea, North of East China sea	unknown	unknown	unknown
	Mercenaria mercenaria	1997	Laizhou Bay	Fusui Zhang	Introduction	unknown	Western Coast of Atlantic Ocean	America	unknown
	Mytilopsis sallei Reeluz	1977	Taiwan	unknown	unknown	Fujian, Guangdong, Guangxi, Hongkong, Taiwan.	Central America	unknown	Y
	Panopea abrupta	1998	unknown	unknown	Introduction	unknown	Alaska to California	America, Canada	unknown
	Patinopecten (Mizuhopecten) yessoensis (Jay)	unknown	unknown	unknown	Introduction	Liaoning, Shandong	Southern Sea of Kuril Islands of Russia, Hokkaido, Honshu	unknown	unknown
	Pecten maxima	1990s - 2000	unknown	unknown	Introduction	unknown	unknown	France	unknown
Sea urchin	*Strongylocentyotus intermedius*	1989	Dalian	unknown	Introduction	unknown	Hokkaido, Sakhalin Island of Russia	Japan	Y

Group of organisms	Species	First recorded (year)	Location of 1st record	Verification of the first record	Vector	Current distribution	Native range	Origin (introduced from)	Impact (Yes/No)
Seastar	*Asterias amurensis*	unknown	unknown	unknown	unknown	unknown	Russia, China, Japan and Korea	unknown	unknown
Bryozoa	*Bugula californica*	unknown	unknown	unknown	Unintentional introduction-bilge carry	Shandong Peninsula to Yulin harbour of Hainan, and also South China Sea	unknown	Europe, Americas	Y
	Bugula neritina	unknown	unknown	unknown	Unintentional introduction-bilge carry	Shandong Peninsula to Yulin harbour of Hainan, South China Sea	unknown	Europe, Americas	Y
	Tubulipora flabellaris	unknown	unknown	unknown	Unintentional introduction-bilge carry	Qingdao	unknown	Europe, America	Y
Ascidian	*Ciona intestinalis*	unknown	unknown	unknown	unknown	Bohai Sea, Yellow Sea	unknown	unknown	Y
	Halocynthia roretzi Drasche	unknown	unknown	unknown	Introduction	Liaoning, Shandong	Sanriku Coast, Oga Peninsula, Korea	Japan, Korea	unknown
	Styela canopus	unknown	unknown	unknown	unknown	Hong Kong, Shenzhen	Puerto Rico, USA	unknown	Y
	Styela clava	unknown	unknown	unknown	Unintentional introduction	Bohai Sea and Yellow Sea	unknown	unknown	Y
	Styela plicata	unknown	unknown	unknown	Unintentional introduction-bilge carry	Xiamen, Luoyuan Bay, Fujian Province	unknown	unknown	Y
Fish	*Acipenser nudiventris* Lovetzky	unknown	Ili river system	unknown	Introduction	unknown	Black sea, Caspian sea, Aral sea	Sil river, Aral sea	unknown
	Anguilla anguilla	1991	unknown	unknown	Introduction	unknown	unknown	France	unknown
	Anguilla japonica	1990s-2000	unknown	unknown	Introduction	unknown	unknown	Japan	unknown
	Common sole	2003	unknown	unknown	Introduction	Shandong and Hebei province	Europe	nknown	unknown

Group of organisms	Species	First recorded (year)	Location of 1st record	Verification of the first record	Vector	Current distribution	Native range	Origin (introduced from)	Impact (Yes/No)
Fish	*Leuciscus brandti* Dybowski	unknown	unknown	unknown	unknown	Tumen River, Suifen stream	unknown	Japan	unknown
	Nemipterus japonicus	unknown	unknown	unknown	unknown	South China Sea and East China Sea, Leizhou Peninsula, Beibu Gulf	unknown	unknown	unknown
	Oreochromis aureus	unknown	unknown	unknown	Introduction	unknown	Africa	unknown	Y
	Oncorhynchus kisutch	2001	Harbin	unknown	Introduction	unknown	Eastern coast of America and Canada	unknown	unknown
	Platichthys stellatus	unknown	unknown	unknown	Introduction	Yellow Sea, Lianyungang, Jiangsu Province, Tumen River	Asia, North America	unknown	unknown
	Salmo gairdnerii	unknown	unknown	unknown	Introduction	unknown	Pacific coast of North America	Korea	unknown
	Salmo salar	2004	Dalian	unknown	Introduction	unknown	North of Atlantic Ocean,	America	unknown
	Scophthalmus maximus	1992	unknown	unknown	Introduction	unknown	Atlantic Ocean	England	unknown

Group of organisms	Species	First recorded (year)	Location of 1st record	Verification of the first record	Vector	Current distribution	Native range	Origin (introduced from)	Impact (Yes/No)
Shrimp	*Litopenaeus vannamei*	1999	Situbondo, East Java and Gondol, Bali	Sugama et al. (2006) ;Utojo and Tangko (2008)	Mariculture	Situbondo, East Java; Gondol, Bali; Maros, South Sulawesi; Luwu, Central Sulawesi; Gresik, Jember, Tuban, Malang, Blitar, Probolinggo, Pasuruan, and Lamongan, East Java	South America	Hawaii, Thailand, and Situbondo	Y
Fish	*Pterapogon kaudernii*	2001	Banggai Islands, Central Sulawesi	Erdmann and Vagelli (2001)	Ornamental fish trade	Lembeh Strait, North Sulawesi	Banggai Islands, Central Sulawesi	Banggai Islands, Central Sulawesi	N
	Rachycentron canadum	2005	Gondol, Bali	Priyono et al.(2005); BIDA (2006)	Mariculture	Gondol, Bali; Galang Baru, Batam	Central America	Taiwan	N
	Salmo salar	1929	Jakarta Bay	Eidman(1989)	Fishing activity (during colonialism)	unknown	Atlantic	The Netherlands	N

Group of organisms	Species	First recorded (year)	Location of 1st record	Verification of the first record	Vector	Current distribution	Native range	Origin (introduced from)	Impact (Yes/No)
Dinoflagellate	*Heterocapsa circularisquama*	1988	Western Japan	Iwataki and Matsuoka (2007)	Ballast water	Western Japan	Southwest Pacific?	unknown	unknown
Macroalgae	*Cutleria multifida* (Turnaer) Greville	1957	Sasebo Bay	Migita and Hitotsugi (1962)	Ship hull-fouling	Kyusyu, Ehime Pref., Hiroshima Pref., Mie Pref., Noto peninsula	Mediterranean	unknown	N
	Ulva armoricana Dion et al.	2003	Mikawa Bay, Osaka Bay	Kawai et al. (2007)	Ballast water	Mikawa bay, Osaka bay	Northeast Atlantic	unknown	unknown
	Ulva californica Wille	2003	Mikawa Bay, Osaka Bay	Kawai et al. (2007)	Ballast water	Mikawa Bay, Osaka Bay, Pacific Coast from Tohoku to Kanto	West Coast of North America	unknown	unknown
	Ulva fasciata Delile	1970's	Seto Inland Sea, Ise Bay, Mikawa Bay	Arasaki (1984)	Ballast water	Pacific Coast of Central to Southern Honshu, Southern Coast of Sea of Japan	Mediterranean	unknown	unknown
	Ulva scandinavica Bliding	2003	Mikawa Bay, Osaka Bay	Kawai et al. (2007)	Ballast water	Mikawa bay, Osaka bay	Northeast Atlantic	unknown	unknown
Platyhelminthes	*Neobenedenia girellae* Hargis	1991	Western Japan	Ogawa et al. (1995)	Fisheries	Western Japan	Subtropical Tropical	unknown	unknown
	Neoheterobothrium hirame Ogawa	1993	Japan Sea	Ogawa (1999)	Fisheries	Entire Japanese Coasts, except around Okinawa	Atlantic, North America	unknown	unknown
Polychaete	*Ficopomatus enigmaticus* (Fauvel)	1966	Lake Kojima, Seto Inland Sea, Okayama	Arakawa (1980)	Ship hull-fouling	Pacific coast from Miyagi Pref. and southward, Northern Kyushu	unknown	South Asia-Southwest Pacific, Australia?	Y

Group of organisms	Species	First recorded (year)	Location of 1st record	Verification of the first record	Vector	Current distribution	Native range	Origin (introduced from)	Impact (Yes/No)
Polychaete	*Hydroides dianthus* (Verrill)	1997	Osaka Bay	Otani and Yamanishi (2007) Link et al. (2009)	Ship hull-fouling	Osaka Bay, Tokyo Bay	East coast of North America	Atlantic, Mediterranean	N
	Hydroides elegans (Haswel)	1928	Wakayama Pref. Lake Kojima	Iwasaki et al. (2004)	Ship hull-fouling	Pacific coast of Honshu and Shikoku, Northern Kushu	unknown	South Asia-Southwest Pacific, Australia?	Y
Barnacle	*Amphibalanus amphitrite* Darwin	1935	Sagami Bay	Henry and McLaughlin (1975)	Ship hull-fouling,	Entire Japanese coasts, except around Okinawa	unknown	South Asia-Southwest Pacific	Y?
	Amphibalanus eburneus Gould	1950	Yokosuka, Kanagawa Pref.	Henry and McLaughlin (1975)	Ship hull-fouling	Yamagata (Japan Sea) or Miyagi (Pacific) Prefs to Kyushu	West Atlantic	West Atlantic	Y?
	Amphibalanus improvisus Darwin	1952	Ago Bay, Mie Pref.	Kosaka (1985)	Ship hull-fouling	Honshu, Sikoku, Kyushu	Northeast Pacific	unknown	Y?
	Amphibalanus zhujiangensis (Ren)	1998	Gushi Rv., Okinawa Pref.	Plankton Society of Japan and Japanese Association of Benthology	Ship hull-fouling?	Okinawa Main Island, Indonasia, Australia	China	unknown	unknown
	Balanus glandula Darwin	2000	Iwate Pref.	Kado (2003)	Ship hull-fouling	Pacific ocean in Western Hokkaido to Miyagi Pref.	Northeast Pacific	North east Pacific	Y?
	Megabalanus coccopoma (Darwin 1854)	2005	Chigasaki, Kanagawa Pref.	Henry and McLaughlin (1986)	Ship hull-fouling?	Boso Peninsula, Tokyo Bay, Sagami Bay, Izu Peninsula, Kii Peninsula, Seto Inland Sea	Tropical East Pacific	Brazil, Northern Europe, North America, Western Indian Ocean, Australia	N

Group of organisms	Species	First recorded (year)	Location of 1st record	Verification of the first record	Vector	Current distribution	Native range	Origin (introduced from)	Impact (Yes/No)
Isopod	*Paracerceis sculpta* (Holmes)	1986	Uwajima, Ehime Pref.	Ariyama and tani (2004)	Ship hull-fouling	Ehime Pref., Osaka Bay	East Pacific	unknown	N
Crab	*Carcinus aestuarii Nardo*	1984	Tokyo Bay	Watanabe (1995)	Ship hull-fouling	Pacific Ocean from Sendai Bay to Ise Bay, Seto Inland Sea, Dokai Bay	Mediterranean, Black Sea	Mediterranean, Black Sea	N
	Pyromaia tuberculata (Lockington)	1970	Miura Peninsula	Iwasaki et al. (2004)	Ship hull-fouling	Pacific Ocean from Sendai Bay to Ise Bay, Seto Inland Sea, Ariake Sea	East Pacific	Northeast Pacific	N
	Rhithropanopeus harrisii (Gould)	2006	Ise Bay (Port of Nagoya)	seda et al. (2007)	Ship hull-fouling	Ise Bay, Osaka Bay, Tokyo Bay	West Atlantic	West Atlantic, Northeast Pacific	N
Gastropod	*Crepidula onyx* Sowerby	1968	Miura Peninsula	Egawa 1985)	Ship hull-fouling	Hokkaido, iyagi, Fukusima, Pacific coast from Chiba prefecture to Shikoku, Seto Inland Sea, Nothern Kyusyu	East Pacific	Northeast Pacific	Y?
	Euspira fortunei (Reeve)	Later 1980's	Shizuoka Pref.	Okoshi (2004)	Fisheries	Pacific coast from Iwate Pref. to Shizuoka Pref.	Ariake Inland Sea, Seto Inland Sea, Mikawa Bay	unknown	unknown
	Nassanus Sinarus (Philippi)	2000	Ariake Inlet	Tamaki et al (2002)	Fisheries	Ariaka Inland Sea, Seto Inland Sea	China	China	Y
Bivalve	*Mercenaria mercennaria* Linnaeus	1998	Chiba City, Tokyo Bay	Nishimura (2003)	unknown	Tokyo Bay, Osaka Bay	West Atlantic	East and West Atlantic, East and Northeast Pacific	Y?
	Mytilopsis sallei (Recluz)	1974	Port of Shimizu, Suruga Bay	abeshima (2002)	Ship hull-fouling, cargo	Kanto and southward	Caribbean Sea	Southeast Asia	Y?

Group of organisms	Species	First recorded (year)	Location of 1st record	Verification of the first record	Vector	Current distribution	Native range	Origin (introduced from)	Impact (Yes/No)
Bivalve	*Mytilus galloprovincialis Lamarck*	1932	Osaka Bay (Port of Kobe)	Uchihashi (1939)	Ship hull-fouling	All Japanese coast	Mediterranean, East Pacific	East Pacific, Mediterranean, East Atlantic, Oceania?	Y
	Perna viridis (Linnaeus)	1967	Okitsu Osaka Bay, Hyogo Pref.	Ueda (2001)	Ship hull-fouling	Pacific coast from Chiba to Kagoshima Pref.	Indian Ocean. Southeast Asia	Indian Ocean. Southeast Asia	Y
	Petricola sp. cf. *lithophaga*	1985	Sano, Osaka Bay	Kojima and Nishikawa (1995)	Ship hull-fouling	Osaka Bay, Tokyo Bay, Sagami Bay, Mikawa Bay	unknown	unknown	Y?
	Xenostrobus securis (Linnaeus)	1972	Lake Kojima, Seto Inland Sea	Kimura et al. (1999)	Ship hull-fouling	Kanto and southward	Oceania	Oceania	Y?
Ascidian	*Molgula Manhattensis* (De Kay)	1972	Takeoka, Seto Inland Sea, Hirosima Pref.	Iwasaki et al. (2004)	Ship hull-fouling	Pacific coast from Tokyo Bay and southward, Northern Kyushu	Northeast and Northwest Atlantic	Northwest Atlantic, Gulf of Mexico, East Pacific	Y?
	Polyandrocarpa zorritensis (Vanname)	1991	Usa, Tosa Bay	Nishikawa et al. (1993)	Ship hull-fouling	Toyama Bay, Dokai Bay, Izu Peninsula, Osaka Bay, Shikoku	unknown	Australia	Y?
Fish	*Lateolabrax* sp.	1992	Shikoku	Konishi (1993)	Fisheries	Central to Western Japan	China	unknown	unknown

Group of organisms	Species	First recorded (year)	Location of 1st record	Verification of the first record	Vector	Current distribution	Native range	Origin (introduced from)	Impact (Yes/No)
Microalgae	*Noctiluca scintillans*	1970s	Inchon	unknown	Ballast	Coast	Europe	Shipping	Y
Sea anemone	*Anthhopleura kurogane*	1980s	unknown	Song (1984)	Shipping	Coast	Asia	unknown	unknown
Polychaete	*Hydroides ezoensis*	1980s	unknown	Paik (1975)	Ballast	Ports	Southern Asia	unknown	Y
Crustacean	*Acartia clausi*	1980s	Inchon	unknown	Ballast	Coast	Asia	unknown	unknown
	Acarcia hongi	1990s	Namhae	unknown	Ballast	Ports	Asia	unknown Japan by shipping	unknown
Barnacle	*Balanus albicostatus*	1970s	Inchon	Kim and Kim (1980)	Ballast	Estuaries	Southern Asia	unknown	unknown
	Balanus trigonus	1970s	Busan	Kim and Kim (1980)	Ballast	Southern coast	Southern Asia	Japan by shipping	unknown
Sea star	*Asterias amurensis*	1960s	Kangwon	Rho and Kim (1966)	Ballast	Coast	North Pacific	Italy during Korean war	Y
Mussel	*Mytilus galloprovincialis*	1960s	Busan	Je (1991)	Ballast	Coast	Europe	unknown	Y
Ascidian	*Ciona intestinalis*	1965s	Busan	Rho (1968)	Ballast	Coast	Asia	unknown	Y
Bryozoa	*Bugula californica*	1980s	unknown	Rho and Song (1980)	Ballast	Southern coast	Southern Asia	USA and China for	unknown
Fish	*Sciaenops ocellatus*	1990s	Tongyong	unknown	Aquaculture	Southern coast	North America	aquaculture	Y

Group of organisms	Species	First recorded (year)	Location of 1st record	Verification of the first record	Vector	Current distribution	Native range	Origin (introduced from)	Impact (Yes/No)
Shrimp	*Litopenaeus vannamei*	2000	unknown	Department of Fisheries (2007)	Aquaculture	Throughout Malaysia (not in wild)	South America	Thailand	unknown
Bivalve	*Mytillopis sallei*	1996	Johor	Tan and Morton (2006)	Biofouler	Johor Bahru, Johor, Inanam River, Sabah	Tropical and Subtropical Western Atlantic	unknown	unknown
Fish	*Etroplus suratensis*	1975	unknown	Department of Fisheries (2007)	Aquarium/ Aquaculture	Estuaries around Kota Kinabalu, Sabah	Indian Sub-continent Africa	Sri Lanka	unknown
	Oreochromis mossambicus	1944	unknown	Department of Fisheries (2007)	Aquaculture	Throughout Malaysia		Java, Indonesia	unknown

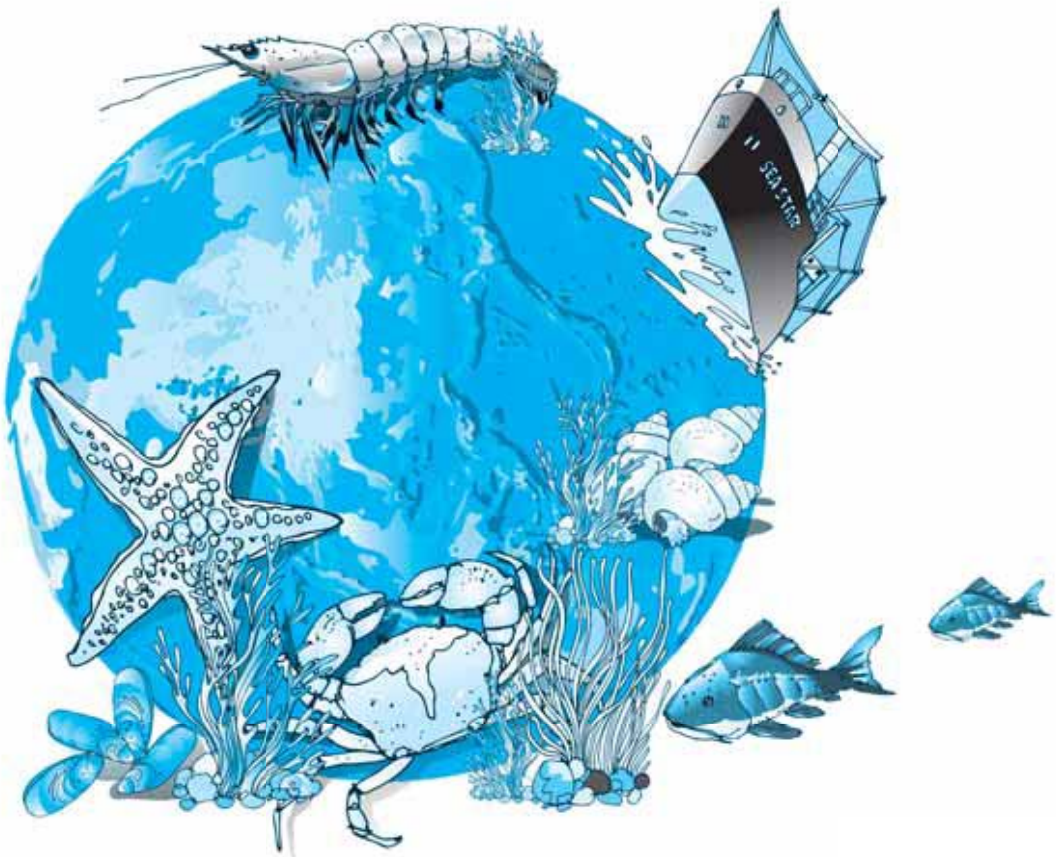
Group of organisms	Species	First recorded (year)	Location of 1st record	Verification of the first record	Vector	Current distribution	Native range	Origin (introduced from)	Impact (Yes/No)
Microalgae	*Alexandrium minutum*	mid 1980s	Lingayen Gulf	Guerrero (2006)	Ballast water	unknown	Worldwide	unknown	Y
	Chatonella marina	1992	Lingayen Gulf	Guerrero (2006)	Ballast water	unknown	Indo West Pacific	unknown	Y
	Cochlodinium polykrikoides	1992	Lingayen Gulf	Guerrero (2006)	Ballast water	unknown	Indo West Pacific	unknown	Y
Coral	*Tubastrea coccinea*	2005	Manila	under verification	Aquarium trade	unknown	Caribbean	Singapore	N
Cnidaria	*Amakusa* sp.	2010	Manila Bay	Manila Ocean Park	Ballast water	Western Pacific	Japan	unknown	N
Shrimp	*Litopenaeus stylilostris*	1980s	Iloilo	Guerrero (2009)	Aquaculture	unknown	Eastern Pacific	unknown	N
	Litopenaeus vannamei	1997	Iloilo	http://www.fao.org/docrep/007/ad505e/ad505e05.htm	Aquaculture	unknown	Eastern Pacific	unknown	N
Bivalve	*Crassostrea gigas*	1970s	Pangasinan	Juliano, Guerrero, Ronquillo (1987)	Aquaculture	Lingayen Gulf	North Pacific	Japan	N
	Mytilopsis sallei	2009	Manila Bay	Manila Ocean Park	Ballast water	Singapore	Caribbean	unknown	N
Fish	*Glossogobius giurus*	1960	Lanao Lake	Guerrero (2009)	Aquaculture	Coastal Philippines	Indo West Pacific	Lake Mainit, Mindanao	Y
	Poecilia latipinna	1912	Manila	Herre (1929)	Health Department	Luzon	SE USA	South Carolina, USA	Y
	Pteragon kauderni	1996	Manila	Under verification	Aquarium trade	Batangas	Sulawesi	Singapore	N
Octocoral	Unidentied gorgonian	1970s	Manila Bay	Professor Edgardo D Gomez	Ship hulls?	unknown	Caribbean	unknown	N

Group of organisms	Species	First recorded (year)	Location of 1st record	Verification of the first record	Vector	Current distribution	Native range	Origin (introduced from)	Impact (Yes/No)
Bivalve	*Brachidontes triatulus*	early 2000	Rochor Canal, Siglap Canal	Morton and Tan (2006)	Ballast water	Rochor Canal, Siglap Canal	India	Bay of Bengal, India	un known
	Mytilopsis sallei	1970s	Pulau Semakau, Sungei Buloh, Kallang Basin, Singapore River	Tan and Morton (2006)	Ballast water	Kim Seng Canal, Kallang River, Rochor Canal, Sungei Serangoon, Sungei Sembawang, Sungei Pandan	Tropical and sub-tropical Eastern Pacific waters	un known	un known

Group of organisms	Species	First recorded (year)	Location of 1st record	Verification of the first record	Vector	Current distribution	Native range	Origin (introduced from)	Impact (Yes/No)
Sponge	*Tetilla japonica* Lampe, 1886	2001	Captain Yuth Beach, Gulf of Thailand	Watanadilok et al. (2001)	Ballast water	Gulf of Thailand	Japan	unknown	unknown
Shrimp	*Litopenaeus vannamei* (Boone, 1931)	2005	Bangpakong River	Senanan et al. (2007)	Aquaculture	Bangpakong River	Pacific coasts of Central and South America	Taiwan	Y ?
Amphipod	*Leucothoe spinicarpa* (Abildgaard, 1789)	2004	Phuket	Chavanich et al. (2007)	unknown	Phuket	Mediterranean, Scandinavia, North Atlantic	unknown	unknown
Bivalve	*Mytilopsis adamsi* Morrison, 1946	During 2001-2003	Haad-kaew Lagoon	Wangkulangkul and Lheknim (2008)	Ships	Lower part of the Gulf of Thailand	Western Pacific coast of Central America	unknown	unknown
Ascidian	*Clavelina cyclus* Tokioka and Nishikawa, 1975	2007	Chonburi Province	Chavanich et al. (2009)	unknown	Chonburi Province	Tropical Indo-west Pacific (in Thailand, only found in the Andaman Sea)	Maybe from the Andaman Sea of Thailand	unknown
	Ecteinascidia thurstoni Herdman, 1891	2002	Phuket	Suwanborirux et al. (2002)	unknown	Phuket	Sri Lanka, South Africa, Australia, Gulf of Suez	unknown	unknown
Fish	*Cichlasoma urophthalmus* (Gunther 1862)	2004	Lower Chao Phraya River Delta	Nico et al. (2007)	Probably aquarium	Lower Chao Phraya River Delta	Atlantic slope of Middle America	unknown	unknown

Group of organisms	Species	First recorded (year)	Location of 1st record	Verification of the first record	Vector	Current distribution	Native range	Origin (introduced from)	Impact (Yes/No)
Macroalgae	*Caulerpa lentilifera*	unknown	unknown	Nguyen et al. (2009)	Aquaculture	Khanh Hoa, Binh Thuan	Japan, Philippines, Vietnam	Japan	N
Gastropod	*Crassostrea gigas*	unknown	unknown	Le and Nguyen (2005)	Research/ Aquaculture	Quang Ninh	Japan?	China, Australia	N
Shrimp	*Litopenaeus vannamei*	2009	Mekong delta	Le et al. (2007), Le and Nguyen (2005)	Aquaculture	Binh Dinh, Khanh Hoa, Ben Tre, Bac Lieu, Ca Mau	South America	America, China	Y
Crustacean	*Artemia salina*	unknown	unknown	Le et al. (2007)	Aquaculture	Binh Dinh, Khanh Hoa, Ben Tre, Bac Lieu, Ca Mau	America, China	America	N
Fish	*Oreochromis aureus*	unknown	unknown	Le et al. (2007)	Aquaculture	Ben Tre, Bac Lieu, Binh Dinh, Khanh Hoa	Africa and Eurasia: Jordan Valley, Lower Nile, Chad Basin, Benue, middle and upper Niger, Senegal River	China	N
	Oreochromis mossambicus	unknown	unknown	Le and Nguyen (2005)	Aquaculture	Ben Tre, Bac Lieu, Binh Dinh, Khanh Hoa, Quang Ninh	Africa: Lower Zambezi, ower Shiré and coastal plains from Zambezi delta to Algoa Bay	Africa, Philippines	N

Group of organisms	Species	First recorded (year)	Location of 1st record	Verification of the first record	Vector	Current distribution	Native range	Origin (introduced from)	Impact (Yes/No)
Fish	*Oreochromis niloticus*	unknown	unknown	Le and Nguyen (2005)	Aquaculture	Ben Tre, Bac Lieu, Binh Dinh, Khanh Hoa, Quang Ninh	Africa: Nile Niger, Benue, Volta, Gambia, Senegal, and Chad	Taiwan islands province of China, Philippines, Thailand	N
	Sciaenops ocellatus	unknown	unknown	Le and Nguyen (2005)	Aquaculture	Khanh Hoa, Quang Ninh	America	China	N



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