Atlas of Marine Invasive Species in the NOWPAP Region

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Disclaimer

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In the Atlas, “Korea” means Republic of Korea, “China” – People’s Republic of China, and “Russia” – Russian Federation. Regional distribution means distribution within NOWPAP region. Bibliography includes only most important works of regional relevance. Authors responsible for information presented are shown in brackets at the end of relevant pages and are abbreviated as follows: TF, SN – Toshio Furota and Satoko Nakayama; KL – Konstantin A. Lutaenko, KS – Kyoungsoon Shin, XJ – Xu Jing. KL is responsible for overall editing.
Acronyms and Abbreviations

AMBACS - the Aegean Sea, the Sea of Marmara, the Black Sea, the Sea of Azov, and the Caspian Sea
APN - Asia-Pacific Network for Global Change Research
ASP - Amnesic Shellfish Poisoning
COBSEA - Coordinating Body on the Seas of East Asia
DINRAC - Data and Information Network Regional Activity Center
DSP - Diarrheic Shellfish Poisoning
EEZ - the exclusive economic zone
EKWC - the East Korean Warm Current
IMO - International Marine Organization
KIOST - Korea Institute of Ocean Science & Technology
MIS - marine invasive species
NB - Nearshore Branch
NIER - National Institute of Environmental Research
NKCC - North Korean Cold Current
PICES - North Pacific Marine Science Organization
PSP - Paralytic Shellfish Poisoning
YSWC - the Yellow Sea Warm Current
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CONTENTS

1. Introduction ................................................................................................................................. 1
2. NOWPAP region ........................................................................................................................... 4
3. Current status of the marine invasive species in the NOWPAP region .............................. 8
4. Main marine invasive species in the NOWPAP region .......................................................... 23
   4.1. Plants and phytoplankton .................................................................................................... 23
       Saccharina japonica ............................................................................................................. 24
       Macrocystis pyrifera ........................................................................................................ 26
       Undaria pinnatifida ........................................................................................................... 28
       Desmarestia ligulata .......................................................................................................... 30
       Cutleria multifida ............................................................................................................. 32
       Ulva fasciata .................................................................................................................... 34
       Spartina alterniflora .......................................................................................................... 36
       Spartina anglica .............................................................................................................. 38
       Pseudo-nitzschia calliantha .............................................................................................. 40
       Chattonella marina .......................................................................................................... 42
       Heterosigma akashiwo ...................................................................................................... 44
       Alexandrium catenella ....................................................................................................... 46
       Cochlodinium polykrikoides .............................................................................................. 48
       Karlodinium veneficum .................................................................................................... 50
       Heterocapsa circularisquama ........................................................................................... 52
   4.2. Animals ............................................................................................................................... 55
       Ficopomatus enigmaticus .................................................................................................... 56
       Hydroides elegans ............................................................................................................ 58
       Hydroides dianthus .......................................................................................................... 60
       Pseudopotamilla ocelata .................................................................................................... 62
       Haliotis discus .................................................................................................................. 64
       Haliotis gigantea .............................................................................................................. 66
       Haliotis rufescens ........................................................................................................... 68
       Haliotis fulgens .............................................................................................................. 70
       Crepidula onyx ................................................................................................................ 72
       Nassarius sinarus ............................................................................................................ 74
       Euspira fortunei ............................................................................................................... 76
<table>
<thead>
<tr>
<th>Species Present</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mytilus galloprovincialis</td>
<td>78</td>
</tr>
<tr>
<td>Perna viridis</td>
<td>80</td>
</tr>
<tr>
<td>Xenostrobus securis</td>
<td>82</td>
</tr>
<tr>
<td>Mytilopsis sallei</td>
<td>84</td>
</tr>
<tr>
<td>Argopecten irradians</td>
<td>86</td>
</tr>
<tr>
<td>Mizuhopecten yessoensis</td>
<td>88</td>
</tr>
<tr>
<td>Crassostrea gigas</td>
<td>90</td>
</tr>
<tr>
<td>Mercenaria mercenaria</td>
<td>92</td>
</tr>
<tr>
<td>Panopea japonica</td>
<td>94</td>
</tr>
<tr>
<td>Balanus glandula</td>
<td>96</td>
</tr>
<tr>
<td>Amphibalanus amphitrite</td>
<td>98</td>
</tr>
<tr>
<td>Amphibalanus improvisus</td>
<td>100</td>
</tr>
<tr>
<td>Amphibalanus eburneus</td>
<td>102</td>
</tr>
<tr>
<td>Amphibalanus zhuiangensis</td>
<td>104</td>
</tr>
<tr>
<td>Megabalanus coccopoma</td>
<td>106</td>
</tr>
<tr>
<td>Perforatus perforatus</td>
<td>108</td>
</tr>
<tr>
<td>Paracerceis sculpta</td>
<td>110</td>
</tr>
<tr>
<td>Portunus sanguinolentus</td>
<td>112</td>
</tr>
<tr>
<td>Plagusia depressa tuberculata</td>
<td>114</td>
</tr>
<tr>
<td>Pyromaia tuberculata</td>
<td>116</td>
</tr>
<tr>
<td>Rhithropanopeus harrisii</td>
<td>118</td>
</tr>
<tr>
<td>Carcinus aestuarii</td>
<td>120</td>
</tr>
<tr>
<td>Diogenes nitidimanus</td>
<td>122</td>
</tr>
<tr>
<td>Litopenaeus stylirostris</td>
<td>124</td>
</tr>
<tr>
<td>Litopenaeus vannamei</td>
<td>126</td>
</tr>
<tr>
<td>Marsupenaeus japonicus</td>
<td>128</td>
</tr>
<tr>
<td>Monocorophium acherusicum</td>
<td>130</td>
</tr>
<tr>
<td>Bugula neritina</td>
<td>132</td>
</tr>
<tr>
<td>Bugula stolonifera</td>
<td>134</td>
</tr>
<tr>
<td>Bugula californica</td>
<td>136</td>
</tr>
<tr>
<td>Tricellaria occidentalis</td>
<td>138</td>
</tr>
<tr>
<td>Conopeum seurati</td>
<td>140</td>
</tr>
<tr>
<td>Schizoporella unicorns</td>
<td>142</td>
</tr>
<tr>
<td>Strongylocentrotus intermedius</td>
<td>144</td>
</tr>
<tr>
<td>Styella plicata</td>
<td>146</td>
</tr>
</tbody>
</table>
1. Introduction

Biological invasions in marine environment represent a serious ecological and economic menace leading to biodiversity loss, ecosystem unbalancing, fishery and tourism impairment, and other ecological and environmental consequences. The problem of marine biological invasions is closely related also to treatment of ballast waters and biofouling of ships and hydro-technical structures. Bio-invasions create so-called “novel” ecosystems containing new combinations of species that arise through human action, environmental change, and the impacts of the deliberate and inadvertent introductions of species from other regions (Hobbs et al., 2006).

Biological invasions in the sea consist of natural range expansion due to changing climates or currents and human-mediated introductions. The latter are usually unpredictable and independent of the natural barriers of space and time (Carlton, 1996). The important role of ballast waters in the unintentional introductions was revealed in the beginning of the 20th century: in the 1880s ship building technology changed, and the existence of bulk-headed, metal-walled spaces, combined with motor-driven pumps, permitted ships to begin to switch from carrying rocks for ballast to carrying water for ballast (Carlton, 1985). For the first time in the history of the ocean, large amounts of plankton-rich water were being transported across and between oceans (Carlton, 1996).

Taking into account the importance of the biological invasions as part of global environmental changes and their significance to the NOWPAP member countries, the NOWPAP DINRAC implemented a project on the marine invasive species (MIS) in the NOWPAP region in 2009-2010 with compilation of four national reports from China, Japan, Korea, and Russia and a regional overview (DINRAC, 2010). The regional overview and national reports were important contributions to understanding of the MIS problem in the North-East Asia along with other regional international projects/activities by COBSEA, PICES (e.g., Lee, Reusser, 2012a, b) and other relevant organizations.
Recommendations of the regional overview included compilation and publication of an atlas of the common and economically/environmentally important alien species in the NOWPAP region with their illustrations and basic data on the biology, regional distribution and relevant references. Such an atlas may serve as a preliminary identification guide and it may summarize to some degree our knowledge on the common MIS in the region. Similar atlases and guides were published, for instance, for the Mediterranean region (Zenetos et al., 2003) and intercontinental Eurasian seas – AMBACS (the Aegean Sea, the Sea of Marmara, the Black Sea, the Sea of Azov, and the Caspian Sea) (Zaitsev, Ozturk, 2001).

When compiling the present Atlas, the authors used the following criteria for selection of species and we included 1) most established, visible and abundant species; 2) species having important ecological and economic impact; 3) species with reliable identification (properly identified by experts in taxonomy). We did not consider potential, or expected MIS although there are some suggestions in the literature about possible introduction of certain species. The Atlas contains information about taxonomic and common names, regional distributions, possible origins and ways of introduction, impact and bibliographies of 79 species of marine organisms including 15 species of plants (macroalgae, vascular plants and phytoplankton) and 64 species of animals.

We should be aware that the NOWPAP region is a vast area lying in different geographical zones – from subtropical in the south to temperate (boreal) in the north, with conditions approaching to arctic environment in winter in the northern part. This is why some species are regarded as native in the northern part of NOWPAP region (e.g., Saccharina japonica, Undaria pinnatifida, Mizuhopecten yessoensis, Panopea japonica, Oncorhynchus kisutch, etc.) but they were introduced to China and, therefore, same species may be invasive only in some parts of the NOWPAP region. Another problem in compilation of the Atlas was taxonomic status of some species regarded as synonyms in modern revisions and databases. Whenever possible, leading author made comments about doubtful status of some species.
Exact distributions of many invasive species are not clearly known and perhaps are rapidly changing, so we used a simplified way of representation of their local/regional distributions by dots or lines based on various literature sources. In fact, the maps are the first attempt to trace distribution of most common MIS in the region and, therefore, should be very useful for future work. References given at the end of the species information pages are most important literature sources whereas more detailed data can be found in papers cited or relevant databases. In general, the Atlas is a quick guide to common MIS and we hope it can be used by scientists and practitioners in understanding and management of the coastal and marine environment of the NOWPAP region.
2. NOWPAP region

The Northwest Pacific region features coastal and island ecosystems with spectacular marine life and commercially important fishing resources. The region is also one of the most densely populated parts of the world, resulting in enormous pressures and demands on the environment. The geographical scope of NOWPAP covers the marine environment and coastal zones from about 33° to 52° N and from approximately 121° to 143° E (Fig. 1). The whole sea area of NOWPAP can be divided into western part (between China mainland, Korea and Japan) and eastern part (between Russia mainland, Korea and Japan) (Regional Overview…, 2007; 2010).

![Fig. 1. Area of the NOWPAP region (http://cearac.nowpap.org/nowpap/coverage.html).](image)

The eastern part of the NOWPAP region is a semi-enclosed sea. It has the southern entrance (Tsushima Strait) and the northern exits (Tsugaru Strait and Soya Strait). In Japan, there are 44 prefectures with reverine systems that flow into the NOWPAP region. Japan consists of
four main islands. Japan has 29,751 km of shoreline from Hokkaido in the north to Okinotorishima Island in the south. A branch of the Kuroshio enters through Tsushima Strait, and then flows out the area passing the Tsugaru Strait located between Hokkaido and northernmost Honshu. Under these oceanographic conditions, there is a wide range of water masses, from tropical water in Okinawa archipelago and southern islands such as Chichijima archipelago in the Pacific Ocean to subarctic water in northern Hokkaido with large seasonal temperature fluctuations.

The Korean part of NOWPAP region includes inland and sea areas. Sea area extends from the coastline up to the exclusive economic zone (EEZ). Korea’s coastline stretches to some 11,942 km. In terms of relative proportion, the coastal area accounts for 31,641 km² (about 32%) of the total territorial land area of 99,514 km². Some 2,550 km² are tidal flats, which account for about 2.3% of the total land area. The territorial sea covers some 71,000 km², while the EEZ covers about 447,000 km². There are 3,169 islands that are distributed around Korea’s marine waters. Comparatively, the west coast is shallow while the east coast is deep (Regional Overview…, 2010).

To the south from Korean Peninsula, the semidiurnal tide is dominant (Ogura, 1933), and its current, about 75 cm/s, is similar to or stronger than other currents (Odamaki, 1989). The Yellow Sea Cold Water, the East China Water and Yellow Sea Warm Water enter through the Jeju Strait, where the speed of the eastward mean current is about 12.5 cm/s (Chang, Kim, 1995). The Tsushima Warm Current derived from the Kuroshio enters the water area between Korea and Japan through the Korea Strait, and the current of the Western Channel of the Korea Strait is approximately 50 cm/s or stronger (Lie, Cho, 1997; Kim, 1998; 2000).

It is known that the Tsushima Current splits into 3 branches after entering the water area between Korea and Japan through the Korea Strait between Korea and Japan in the south. The first one, called the Nearshore Branch (NB), flows along the Japanese coast which is topographically controlled (Yoon, 1982). The second branch, less clear,
may exist along the slope near Japan. According to Kawabe (1982), it becomes prominent only in summer due to the increase of Tsushima Current volume transport. The third branch, called the East Korean Warm Current (EKWC), flows northward along the Korean coast and separates from the coast where it meets the southward flowing North Korean Cold Current (NKCC). The EKWC and NKCC, after separation from the coast, form a strong front which runs in the east-west direction. Along the front, large meanders develop associated with warm and cold eddies (Seung, Kim, 1993).

The Chinese part of the NOWPAP region mainly belongs to the Yellow Sea, which bordering Liaoning, Shandong and Jiangsu Provinces. The total area of these provinces accounts for 10.8% of the entire national territory of China.

The Yellow Sea is a semi-enclosed body of water surrounded by the Asian continent and Korean Peninsula, with wide continental shelves and long coastlines. Its mean depth is about 55 m. The oceanographic conditions of the Yellow Sea are strongly affected by the monsoon where the wind blows toward the north in summer and the south in winter. General current circulation in the Yellow Sea is divided into two different currents in summer and winter (Suk, 1989). The Yellow Sea Warm Current (YSWC) originating from the Kuroshio flows into the northwest of the central Yellow Sea in summer and remains outside of Jeju in winter. Coastal currents of the Yellow Sea include the Shandong Coastal Current, Yellow Sea Coastal Current, Jiangsu Coastal Current and West Korea Coastal Current. The Shandong Coastal Current, Yellow Sea Coastal Current and Jiangsu Coastal Current flowing into the south along the western border of the Yellow Sea are stronger due to the northwest monsoon in winter (Martin et al., 1993). In the Yellow Sea, two different circulations are observed. One is a clockwise circulation formed at the junction of Yellow Sea Warm Current and West Korea Coastal Current, which flows along the east side of the Yellow Sea, and the other is a smaller and semi-permanent counterclockwise circulation formed in the south-west of Jeju (Mao et al., 1993; Kum, 2000).
The Russian Federation's part of the NOWPAP region is located between the Asia coast, the Japanese Islands and the Sakhalin Island. It is situated between 34º26' and 51º41' N and between 127º20' and 142º15’ E. It is connected with the Okhotsk Sea by the Nevelskoy and La-Perouse (Soya) straits in the north and northeast, with the Pacific by the Tsugaru Strait in the east. Far Eastern territories of Russia adjoining NOWPAP region are Primorsky and Khabarovsky regions (territories) and the Sakhalin Island. Overall shoreline length of the Russian part of the NOWPAP region sea is about 6,230 km.

The Russian continental coast of the NOWPAP region is clearly divided into two geomorphologic regions with different oceanography and environmental conditions. The northern region is characterized by a weakly indented coastline with open bays. Abrasional shores with rocky cliffs predominate along nearly the entire coastline, and accumulative areas with low marine terraces and sandy beaches occur in coastal concavities (Papunov, 1987). The northern shelf of the NOWPAP region is narrow (average 35 km), and occasionally narrows to only 10–11 km. The depth of the shelf edge varies from 100 to 200 m. Southern part of the Russian coast lies within large Peter the Great Bay with six ria-type embayments: Possyet, Amursky, Ussuriysky, Strelok, Vostok and Nakhodka bays. Temperature regime of Peter the Great Bay is characterized by contrasting conditions: in winter, coastal waters are approaching arctic conditions while in summer, waters of semi-enclosed shallow bays warm strongly (to 28º C in August).

Two cold currents wash the Russian continental coast of the NOWPAP region – Primorskoye and Schrenck’s (= Liman Cold Current) currents (Yurasov, Yarichin, 1991). The main stream of the Primorskoye Current flows at a distance of 15–20 km from the coast along the marginal part of the shelf. Generally, cold currents in the sea are much weaker than warm currents (Hidaka, 1966). Salinity in open areas is 33–34 ‰ but it can decrease in bays for a short time during rains. Salinity in shallow waters of Peter the Great Bay depends significantly on river runoff and semi-enclosed bays and inner embaymental areas may have decreased salinity (Podorvanova et al., 1989).
3. Current status of the marine invasive species in the NOWPAP region

Marine invasive species introductions can be divided into intentional, via aquaculture and via shipping and ballast water transfer.

Shipping and ballast water release are the most important ways of introduction of marine organisms into the NOWPAP region. In Japan, Otani (2004) reported that rich marine invasive species were found on ship hull and in sea chests and he estimated that about 44% of exotic marine species in Japan were brought with hull fouling.

In Japan, when the country opened to trade with foreign countries after 1900, especially with Europe and America, many exotic sessile marine organisms unintentionally arrived to Japanese coastal waters with cross-ocean vessels. After the World War II, due to growth of the international trade, frequency of arrivals of the vessels to Japanese ports rapidly increased. Some of these vessels brought ballast waters that had been pumped in tanks of the vessel at the departure port, then the water was drained out to the sea at the arrival port. Since the ballast water contained large number of planktonic organisms, including larvae of fishes and invertebrates, chances of unintentional introduction of exotic marine organisms into Japanese waters largely increased. Furthermore, intentional and unintentional introduction of the exotic marine organisms associated with import of living marine aquaculture animals, such as fishes, clams and snails also increased the chance to establish new marine exotic populations. At the end of the 20th century, 33 species of marine exotic organisms had been listed up, and then up to date, new invasions of the exotic species continue (The Regional Overview and National Reports…, 2010).

Until now in Japanese coastal waters, 29 exotic brackish/marine plant species have been identified by the national report for the MIS published in 2010 (Furota, Nakayama 2010). After the 2010, we added one new exotic species, so, up to date, 30 exotic species have been identified. Process for the identification of the exotic species adopted
the evaluation process proposed by the Committee for the Preservation of the Natural Environment, the Japanese Association of Benthology (Iwasaki et al., 2004). The committee cautiously evaluated information of non-indigenous marine and brackish water species through three aspects: the original habitat of the species, when and where it was found in Japan, and possible vector of the introduction.

Among 30 exotic brackish and marine species identified, 19 species are sessile. They may have been introduced with interoceanic trading ships (Iwasaki et al., 2004). Recently, ballast water and sea chest tended to have more responsibility for transoceanic introduction by the ships, since free-living organisms can easily survive in the ballast water and inside of the sea chest during long distance voyage (Otani, 2004). Furthermore, associating with increase of import of marine living aquaculture species such as Asari (Manila) clam *Ruditapes phillipinarum*, unintentional introduction of MIS species, that had been contaminated with imported species, has increased (Okoshi, 2004).

In Japanese coastal waters, the MIS populations tend to be abundant in eutrophicated enclosed bays near large urban cities, such as Tokyo Bay and Osaka Bay. Elimination of native marine organisms by deterioration of marine ecosystems caused by construction of artificial concrete hard surface and periodic mortality of native populations due to summer hypoxia may provide more opportunities for the MIS (Furota, Kinoshita, 2004).

Among plants, one phytoplankton species, five green macroalgae species, and one cordgrass species have been introduced in Japanese waters. The dinoflagellate phytoplankton species, *Heterocapsa circularisquama*, causes red tide in coastal waters. Sea lettuces, *Ulva* spp., sometimes overgrow on shoals and tidal flats in eutrophicated enclosed waters (Fig. 2, 3).
Recently, the invasive cordgrass, *Spartina alterniflora* was found in Mikawa Bay. This cordgrass covers lower intertidal flat surface where it is exposed to the air, and native animals such as crabs, clams and polychaetes abundantly inhabit these areas (Fig.4). Growth of the
cordgrass alters the sediment condition. Up to date, locations of the cordgrass populations are limited; however, special attention must be paid to its extermination to prevent the establishment of new population.

![Invasive cordgrass](image-url)

**Fig.4.** Invasive cordgrass *Spartina alterniflora* in a Japanese tidal flat. The cordgrass covers lower tidal flat surface, native reed *Phragmites communis* covers only upper tidal surface (Photo by E.Fujioka).

Until now, five barnacle species, one isopod, three crab species, three gastropod, six bivalve, one bryozoan species, three polychaete species and two tunicate species were found in Japanese waters as the MIS. Most of these exotic marine invertebrates are sessile species, and they easily hitchhike with vessels if they once attach to the ship hulls. Recently, free-living animals such as crabs and snails also are introduced directly in ballast waters and unintentionally with imported live aquaculture animals. Dense growth of exotic sessile animals causes biofouling of industrial water intakes, such as electric power plants, and aquaculture nets. On the other hand, recently introduced clam, *Mercenaria mercenaria*, has become important fishery object instead of native clams in eutrophicated enclosed bays where native clam populations have largely declined due to coastal development and bottom hypoxia.

Intentional introductions can also be shown on the example of China. In the 1980's, to protect beaches, promote sediment deposition, and open sea ranching, China introduced the English cordgrass...
(Spartina anglica) from Denmark, the Netherlands and the United Kingdom to retain solid shore beaches. However, due to mismanagement, the English cordgrass spread out of the original introduction sites and became a threat to local biodiversity. In 1979, smooth cordgrass (S. alterniflora) originated from southeast coast of the USA was introduced to China for retaining solid shore beaches. Recently, smooth cordgrass has gradually evolved into the main MIS to the China’s coastal areas and became a serious environmental and economic threat. China has introduced at least ten species of fish, two species of shrimp, nine species of shellfish, one species of echinoderms, four species of algae in mariculture. Failed introductions of alien marine organisms could be potential dangers to the marine environment of China.

In Japan, 21 exotic species were reported to be introduced intentionally for commercial selling or fishery studies and three species were unintentionally released with other commercial animal species. Since seed stock of fish and shellfish have been introduced to Japan from foreign countries, especially from China (including Taiwan area) and Korea, to cultivate in aquaculture systems, many exotic species may have escaped into natural marine environment. Furthermore, some species have been unintentionally released with such commercial animal species. Okoshi (2004, 2007) listed 22 animal species found in sacks of the imported Manila Clams R. philippinarum which were released at tidal flats in northern Honshu.

There are no data for intentional introductions of alien species to Korea and to the Russian part of the NOWPAP area. All aquaculture practices in the Russian NOWPAP area are based on local species, and there is no evidence of intentional release of marine organisms.

In Korea, there are many ports on the coastline despite the small country size. The indented coastline creates semi-closed topography with possibility for exotic species to spread quickly. Between 1960s and 1970s, when Korea was in the early stage of economic growth, the government, with the purpose of procuring protein resources, intentionally introduced domestic fish-raisers (Park et al., 2005). In fact, according to the report from National Institute of Environmental Research (NIER,
1996), the estimated number of exotic fishes introduced to Korea was more than 223 among which nearly 200 alien species were introduced as pets, as well as for fishing and fish-raising (NIER, 1996).

Every year harmful algal blooms or harmful organisms such as jellyfish appear near Korea, Japan and China causing social and economic problems. Also, Korea, China, Japan and Russia are geographically close, and there are many regions with similar marine environments in those countries. So, when such harmful organisms migrate to different regions, there is a high possibility that they can easily adapt to the new environment. Thus, it is necessary to develop measures to cope with the problem by making a joint effort.

In Korea, a program of ballast water risk assessment was first developed by Korea Institute of Ocean Science & Technology (hereafter referred as “KIOST” formerly “KORDI”, Korea Ocean Research & Development Institute) in 2010. The program was established based on the GloBallast project initiated by International Maritime Organization (IMO) and conducted relative overall risk assessment. Furthermore, Korea also considers the species-specific risk assessment, environmental matching risk assessment and species' biogeographical risk assessment which were outlined in G7 (Guidelines for risk assessment under regulation A-4) for assessing the risks in relation to granting an exemption in accordance with regulation A-4 (exemptions) of the Ballast Water Management Convention. The G7 guidelines suggest that environmental matching risk assessment should be used only in circumstances where the environments are at biological extremes, such as between purely freshwater and purely marine environments. In these circumstances, those species that can survive at both extremes should be individually assessed. On the contrary, species-based assessments should only be used within a single bio-province with the assumption that the majority of native species are shared. In these circumstances, the unknown species can be assumed to be native, reducing the number of species assessments required.

Currently, KIOST is building a MIS related database as a part of their research called Development of Port Environmental Risk Assessment
Technology. Also, Ministry of Oceans and Fisheries (hereafter referred as “MOF”) is making a list of marine alien species and their characteristics as a part of their Study on Management of Invasive Species in Marine Ecosystem.

There are a few published reports on the extent of marine invasive species in the Korean part of the NOWPAP region (Seo, Lee, 2009). However, a lot of marine invasive species have already invaded the region. There are 41 species suspected to be invaders in Korean coastal waters (Kim, 1992; Gong, Seo, 2004; Kim et al., 2008; Seo, Lee, 2009). These species belong to seven major groups, namely bivalves, echinoderms, barnacles, tunicates, bryozoans, phytoplankton and fishes.

In Russia, the rate of species distribution by means of vessels depends primarily on the intensity of the maritime traffic and the availability of harbors appropriate for colonization (Zvyagintsev, 2003, 2005). In Peter the Great Bay, about 16000 ships enter ports and harbours every year, and among them about 8000 ships operate on international lines (Zvyagintsev, 2007). A majority of ships (more than 10000) go into the Vladivostok Port. Such an intensive traffic favors introductions of alien species through fouling communities and release of ballast waters.

In Russian waters of NOWPAP region, 37 marine invasive species were known by 2010 (The Regional Overview and National Reports…, 2010) but this number may increase up to 66 (Zvyagintsev et al., 2011).

One of the important consequences of the naturalization of invasive species in Russia - in Peter the Great Bay - is predominance of new inhabitants over native species which leads to alterations in the ecosystem structure and trophic relationships and occasionally to unbalancing of coastal ecosystems. Ovsyannikova (2008) showed that a successful naturalization of the invasive barnacle *Amphibalanus improvisus* led to displacement of indigenous species (Fig. 5). Numerous settlements of the Mediterranean mussel *Mytilus galloprovincialis* with high population density in Peter the Great Bay provides an example of ecosystem alterations through engineering
activity of this mollusk. Predominance of the mussel may lead to suppression and displacement of other species. Increasing competition between native and alien species in general is an important ecological consequence of invasions.

![Image of Amphibalanus improvisus attached to a tree branch and shells of Corbicula japonica in Amursky Bay after Ovsyannikova, 2008.](image)

**Fig. 5.** The appearance of *Amphibalanus improvisus* attached to a tree branch (A) and shells of the bivalve mollusk *Corbicula japonica* (B) in Amursky Bay (after: Ovsyannikova, 2008).

In Russia, biofouling of ships, piers, buoys and other hydrotechnical structures consisting partly of invasive species has an important economic impact. The cost of cleaning ship hulls is very high. “Southern migrants”– fishes appeared in Peter the Great Bay – play an important role in local fishing and resulted in a positive economic effect of introduction of non-native species. The mussel *M. galloprovincialis* which became an abundant component of biofouling in Peter the Great Bay (Ivanova, Lutaenko, 1998) as well as barnacles may damage aquaculture installations but, at the same time, this mussel and its hybrids with local allied species *Mytilus trossulus* might be a perspective object of aquaculture. Conditionally pathogenic and toxicogenic mycelial fungi which are able to induce mycoses and mycotoxicosis of invertebrates and fishes were isolated from ballast waters of ships in Vladivostok Port (Zvyagintsev et al., 2009).
Sokolovsky et al. (2004) predict appearance of more subtropical fish species in Peter the Great Bay with global warming and intensification of warm currents in the NOWPAP region except the Yellow Sea. Zvyagintsev et al. (2009) believe that ascidian *Polyandrocarpa zorritensis*, barnacle *Balanus glandula*, polychaetes of the genus *Polydora* and bivalve mollusk *Perna viridis* are potential marine benthic invasive species into Peter the Great Bay. Zvyagintsev (2003) regarded as potential invaders species that are in the first stage of introduction and small-scale development. Some of these species have been introduced from subtropical waters; some did come from temperate and cold waters of the Pacific and even the Northern Atlantic. Another group of potential invasive species are related to migrations induced by global warming and current system modifications. Coastal warming and introduction of new species may also favor aquaculture and fisheries.

In Russian waters, in comparison with the late 1960s and early 1970s, the species richness of phytoplankton in Amursky Bay increased markedly and a greater number of bloom-forming species was recorded; some of them can be invasive species but it is difficult to prove as there was no long-term monitoring in the area (Orlova et al., 2009). Selina et al. (2009) mentioned that appearance of the dinoflagellate *Scrippsiella spinifera* in Possyet Bay in 1999 might be related to the introduction with warm waters from the coast of Japan. Another dinoflagellate *Gyrodinium instriatum*, new for Russian waters of Russia and found in Peter the Great Bay, probably, penetrated to the bay with ballast waters (Orlova et al., 2003). The diatom *Cerataulina dentata* was recorded for the first time in Peter the Great and previously was known in tropical-subtropical regions (Stonik, Orlova, 1998).

The impact of algal blooms might be related to fish and shellfish poisoning in this area. Some microalgae have ability to produce potential toxins that can find their way through the food chain to humans, causing a variety of gastrointestinal and neurological illnesses, such as Paralytic Shellfish Poisoning (PSP), Diarrheic Shellfish Poisoning (DSP) and Amnesic Shellfish Poisoning (ASP). Although there have been no reports of shellfish poisoning incidents in Russia as yet, the presence of various toxin-producing species have been recorded in Russian waters;
shellfish poisoning in Russia could become a major threat in the future, particularly due to the expansion of the aquaculture industry and appearance of invasive plankton species.

References


**Matin J.M., Zhang J., Shi M.C. and Zhou Q.** 1993. Actual flux of the Huanghe (Yellow River) sediment to the western Pacific Ocean. *Netherlands


The Regional Overview and National Reports on the Marine Invasive Species in the NOWPAP Region. 2010. UNEP/NOWPAP/DINRAC Publication No. 10. 149 p.


4. Main marine invasive species in the NOWPAP region

4.1. Plants and phytoplankton
**Saccharina japonica (Areschoug) Lane, Mayes, Druehl et Saunders, 2006**

**Common name:** Kelp.

**Taxonomy:** Ochrophyta, Phaeophyceae, Laminariales, Laminariaceae.

![Image of Saccharina japonica](image)

**Fig. 6.** *Saccharina japonica.*

![Map showing distribution](image)

**Fig. 7.** Distribution of *Saccharina japonica* in China.
Regional distribution: China: most coastal areas, including Huanghai Sea.

Possible origin: Japan.

Possible way of introduction: Intentional introduction for aquaculture.

Habitat: Marine areas at about 2 m deep, with summer seawater temperatures not exceeding 20° C for a prolonged period.

Impact: China is the largest kelp producer, and S. japonica brings great economic benefits. On the other hand, this species also occupies niches and biotopes of native species, and this may lead to suppression and displacement of other species.

Bibliography:


(XJ)
Macrocystis pyrifera (Linnaeus) C. Agardh, 1820

Common name: Giant kelp.

Taxonomy: Ochrophyta, Phaeophyceae, Laminariales, Laminariaceae.

Fig. 8. Macrocystis pyrifera.

Fig. 9. Distribution of Macrocystis pyrifera in China.
Regional distribution: China: Coastal areas from Dalian to Changdao Island.

Possible origin: Mexico.

Possible way of introduction: Intentional introduction for aquaculture.

Habitat: Shallow waters (5-25 m deep).

Impact: This species improves the coastal environment, providing food and habitat for marine organisms. It changes the structure, function and biodiversity of the marine ecosystem.

Bibliography:


**Undaria pinnatifida** (Harvey) Suringar, 1873

**Common name:** Asian kelp.

**Taxonomy:** Ochrophyta, Phaeophyceae, Laminariales, Alariaceae.

![Undaria pinnatifida](image)

*Fig. 10. Undaria pinnatifida.*

![Distribution map](image)

*Fig. 11. Distribution of Undaria pinnatifida in China.*

Possible origin: Japan.

Possible way of introduction: Intentional introduction for aquaculture.

Habitat: *U. pinnatifida* inhabits intertidal zone down to a depth of 15–20 m. It grows on hard substrata such as rocks and reefs.

Impact: *U. pinnatifida* brings great economic benefits, while filial generation of kelps may lead to genetic changes of both native and alien marine species in China.

Bibliography:


(XJ)
**Desmarestia ligulata** (Stackhouse) Lamouroux, 1813

**Common name:** Color changer.

**Taxonomy:** Ochrophyta, Phaeophyceae, Desmarestiales, Desmarestiaceae.

![Desmarestia ligulata](image1)

**Fig. 12.** *Desmarestia ligulata.*

![Distribution map](image2)

**Fig. 13.** Distribution of *Desmarestia ligulata* in China.
Regional distribution: China: Dalian, Lushun, and Shandong provinces.

Possible origin: Japan.

Possible way of introduction: Possibly dispersed with the introduction of Undaria pinnatifida (Harvey) Suringar, 1873.

Habitat: Rocks and shells in the low intertidal down to the upper subtidal zones in moderately sheltered to fully exposed coastal areas. This species often lives in kelp forest of other species.

Impact: Acid is excreted when this algae is dying, and it may lead to mortality of other algae and marine organisms.

Bibliography:


**Cutleria multifida** (Turner) Greville, 1830

**Common name:** Flat wipe-seaweed;  
**Japanese name:** Hiramuchimo.  
**Taxonomy:** Ochrophyta, Phaeophyceae, Cutleriales, Cutieriaceae.

![Image of Cutleria multifida](image)

**Fig. 14.** *Cutleria multifida* from Japan (photo by T. Horiguchi).

![Map of Japan showing distribution of Cutleria multifida](map)

**Fig. 15.** Distribution of *Cutleria multifida* in Japan.

**Possible origin:** Europe.

**Possible way of introduction:** Ship hull-fouling.

**Habitat:** Embayment waters.

**Impact:** Unknown.

**Bibliography:**


**Ulva fasciata** Delile, 1813

**Common name:** Ribbon sea lettuce.

**Japanese name:** Ribon Aosa.

**Taxonomy:** Chlorophyta, Ulvophyceae, Ulvales, Ulvaceae.

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**Fig. 16.** Overgrowing area of sea-lettuce (*Ulva* sp.) on Yatsu tidal flat at the innermost of Tokyo Bay, Japan.

**Fig. 17.** Distribution of *Ulva fasciata* in Japan.
Regional distribution: Japan: Pacific coast of central to southern Honshu, southern coast of the NOWPAP area, and Okinawa Archipelago.

Possible origin: Southwest Pacific?

Possible way of introduction: ballast water, ship hull-fouling.

Habitat: Rocky shore.

Impact: unknown.

Comments:

Based on a genetic analysis, three exotic sea-lettuce species have been identified in Japanese waters (Kawai et al., 2007). Morphological identification, however, is very difficult.

This species may be a synonym of Ulva lactuca Linnaeus; two other species are Ulva armoricana P. Dion, B. de Reviers et G. Coat, 1998 (a possible synonym of Ulva rigida C. Agardh, 1823) and Ulva scandinavica Bliding, 1969 (a possible synonym of Ulva rigida C.Agardh, 1823) (www.algaebase.org; comments by KL).

Bibliography:


Kawai H., Shimada S., Hanyuda T., Suzuki T. and Gamagori City Office. 2007. Species diversity and seasonal changes of dominant Ulva species (Ulvalae, Ulvophyceae) in Mikawa Bay, Japan, deduced from ITS2 rDNA region sequences. Algae. V. 22. P. 221–228. [In Japanese].

(TF, SN)
**Spartina alterniflora** Loisel, 1807

Common name: Smooth cordgrass; saltmarsh cordgrass.

Japanese name: Higata-ashi.

Taxonomy: Magnoliophyta, Liliopsida, Poales, Poaceae.

![Spartina alterniflora in China](image1)

![Spartina alterniflora in Japan](image2)

**Fig. 18.** *Spartina alterniflora* in China.  **Fig. 19.** *Spartina alterniflora* in Japan.

![Distribution map](image3)

**Fig. 20.** Distribution of *Spartina alterniflora* in China and Japan.
Regional distribution: China: coastal areas from Liaoning to Jiangsu Province;
Japan: Mikawa Bay, Ariake Bay.

Possible origin: unknown (native range – Atlantic coast of North America).
Possible way of introduction: aquaculture; ballast water.
Habitat: intertidal zone and estuarine tidal flats.
Impact: Spartina alterniflora occupies niches of native species, destroys habitat and threatens local biodiversity. They also clog waterways, affecting water exchange and cause red tide. Competition with native marsh reed.

Bibliography:


http://chubu.env.go.jp/pre_2011/data/1006a_1.pdf

(TF, SN, XJ)
Spartina anglica C.E. Hubbard, 1968

Common: Common cordgrass.

Taxonomy: Angiospermae, Graminales, Poaceae.

Fig. 21. Spartina anglica in China.

Fig. 22. Distribution of Spartina anglica in China.
Regional distribution: China: coastal areas of Jiangsu Province.

Possible origin: United Kingdom.

Possible way of introduction: Aquaculture.

Habitat: It grows on mud-flats and in salt marshes, estuarine wetlands, shorelines, etc., near the high tide mark.

Impact: Common cordgrass may destroy habitat for coastal living, and clog waterways, affecting water exchange.

Bibliography:


**Pseudo-nitzschia calliantha**
Lundholm, Moestrup et Hasle, 2003

**Taxonomy:** Ochrophyta, Bacillariophyceae, Bacillariales, Bacillariaceae.

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**Fig. 23.** *Pseudo-nitzschia calliantha.*

**Fig. 24.** Distribution of six phytoplankton species within NOWPAP area.
Regional distribution: Korea: Tongyeong, Maemul-do; Russia: Peter the Great Bay, Sakhalin Island; China: Hong Kong.

Possible origin: Tropical and temperate region (type locality: Ejby, Zealand, the Isefjord, Denmark).

Possible way of introduction: Via shipping.

Impact: Unknown.

Bibliography:


Chattonella marina (Subrahmanyan) Hara et Chihara, 1982

Taxonomy: Ochrophyta, Raphidophyceae, Chattonellales, Chattonellaceae.
Atlas of Marine Invasive Species in the NOWPAP Region  

**Plants and phytoplankton**

**Regional distribution:** 
**Korea:** Gunsan, Cheonsu Bay, Yeosu;  
**Japan:** Kagoshima, Seto inland Sea, Maizuru Bay; **China:** Tianjin, Qinhuaingdao Bay, Qingdao, Hong Kong.

**Possible origin:** Japan? (type locality: Malabar Coast) (see Fig. 24).

**Possible way of introduction:** Via shipping.

**Habitat:** Neritic regions including estuarine systems.

**Impact:** Invasive alien species causing mortality of fish. Gill damage. Decrease in heart rate of fish caused by brevetoxins, resulting in reduced flow of oxygen to the gills.

**Bibliography:**


Heterosigma akashiwo (Y. Hada)
Y. Hada ex Y. Hara et M. Chihsara, 1967

Taxonomy: Ochrophyta, Raphidophyceae, Chattonellales, Chattonellaceae.

Fig. 26. Heterosigma akashiwo.
Regional distribution: Korea: Jinhae Bay, Yeosu, Gunsan;
  Japan: Seto Inland Sea, Gokasho Bay, Sanriku coast, Onagawa Bay;
  China: Dalian Bay, Haizhou Bay, Hong Kong (see Fig. 24).

Possible origin: Japan? (type locality: Seto Inland Sea).

Possible way of introduction: Via shipping.

Habitat: Shallow water mostly within 10 m of the surface.


Bibliography:


Alexandrium catenella (Whedon et Kofoi)

E. Balech, 1985

Taxonomy: Dinophyta, Dinophyceae, Gonyaulacales, Goniodomataceae.

Fig. 27. Alexandrium catenella.
Regional distribution: Korea: Jinhae Bay; Japan: Seto Inland Sea, Yamakawa Bay, Harima-Nada Sea; China: Hong Kong, Changjiang estuary (see Fig. 24).

Possible origin: Neritic regions including estuarine systems.

Possible way of introduction: Via shipping.

Habitat: Neritic regions including estuarine systems.

Impact: Producer of paralytic shellfish poisoning toxins and fish mass mortality causative substance.

Bibliography:


Cochlodinium polykrikoides Margalef, 1961

**Taxonomy:** Dinophyta, Dinophyceae, Gymnodiniales, Gymnodiniaceae.

Fig. 28. *Cochlodinium polykrikoides.*
**Regional distribution:** Korea: Tongyeong, Busan, Goheung, Namhae, Wan-do, Gunsan;

**(Japan:** Tsushima Island, Nagasaki, Yatsushiro Sound;

**(China:** Quanzhou Bay, Hong Kong, Guangdong, East China Sea (see Fig. 24).

**Possible origin:** Oceanic regions.

**Possible way of introduction:** Via shipping.

**Habitat:** Oceanic regions.

**Impact:** Serious fishkiller. Toxic to juvenile fish.

**Bibliography:**


**Karlodinium veneficum** (Ballantine, 1956)

J. Larsen, 2000

**Taxonomy:** Dinophyta, Dinophyceae, Gymnodiniales, Kareniaceae.

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**Fig. 29. Karlodinium veneficum.**
Regional distribution: Korea: Gunsan, Jinhae Bay, Yellow Sea;
China: Quanzhou Bay, Hong Kong, Guangdong, East China Sea (see Fig. 24).

Possible origin: Cold waters.

Possible way of introduction: Via shipping.

Habitat: Cold waters.

Impact: Toxic to a range of marine invertebrates and fish. This species produces so-called karlotoxins that exhibit a broad-spectrum lytic effect on membranes from very diverse cell types.

Bibliography:


Heterocapsa circularisquama Horiguchi, 1995

**Taxonomy:** Dinophyta, Dinophyceae, Peridiniales.

*Fig. 30. Heterocapsa circularisquama in Japan.*

*Fig. 31. Distribution of Heterocapsa circularisquama in Japan.*

Possible origin: Southwest Pacific?

Possible way of introduction: Ballast water.

Habitat: Embayment waters.

Impact: Mortality of cultured mollusks and fishes.

Bibliography:


4.2. Animals
Ficopomatus enigmaticus (Fauvel, 1923)

Common name: Crab-inhabited tube-worm;
Japanese name: Kani-yadori Kanzashi: Crab hosted Kanzashi-worm
(Kanzashi=Japanese classic hiarpine).
Taxonomy: Annelida, Polychaeta, Canalipalpata, Serpulidae.

Fig. 32. Crab inhabited tube-worm, Ficopomatus enigmaticus.

Fig. 33. Distributional region of Ficopomatus enigmaticus in Japan.
**Regional distribution:** Japan: Miyagi Prefecture, Pacific coast from Ibaraki Prefecture to Mikawa Bay, Seto Inland Sea, Shimane Prefecture and northern Kyushu, Ishigaki Island.

**Possible origin:** Australia.

**Possible way of introduction:** Ship hull-fouling, ballast water.

**Habitat:** Shallow hard substrata in estuarine waters. A species of the small xanthid crab occasionally inhabits its tube.

**Impact:** Bio-fouling on oyster culture, compete with native serpulid species.

**Bibliography:**


(TF, SN)
**Hydroides elegans** (Haswell, 1883)

**Common name:** Calcareous tube-worm; piled tube-worm;
**Japanese name:** Kasane-kanzashi.
**Taxonomy:** Annelida, Polychaeta, Canalipalpata, Serpulidae.

![Image of Hydroides elegans](image)

**Fig. 34.** *Hydroides elegans.*

![Map of distribution](image)

**Fig. 35.** Distribution of *Hydroides elegans* in Japan and Russia.
Regional distribution: Japan: Pacific coast of Honshu and Shikoku, northern Kyushu;
Russia: Peter the Great Bay.

Possible origin: Southwest Pacific?

Possible way of introduction: Ballast water.

Habitat: This tube-worm occurs on artificial hard substrata and oyster shell in enclosed subtidal waters. In Russia, it is a dominant biofouling species of vessels, especially in Vladivostok Port (Zolotoy Rog Bay).

Impact: Mortality of aquaculture shells and fishes, biofouling.

Bibliography:


**Hydroides dianthus** (Verrill, 1873)

**Japanese name:** Nadeshiko-kanzashi; Pink (a plant of genus Dianthus) tube-worm.

**Taxonomy:** Annelida, Polychaeta, Canalipalpata, Serpulidae.

![Fig. 36. Pink tube-worm, *Hydroides dianthus*.](image.png)

![Fig. 37. Distributional region of *Hydroides dianthus* in Japan.](map.png)
Regional distribution: Japan: Osaka Bay, Tokyo Bay.

Possible origin: East coast of North America.

Possible way of introduction: Ship hull-fouling.

Habitat: Hard substrata in embayment shallow waters. Assemblage of the worm is usually found in shallow subtidal hard substrata as well as other exotic tube-worms. It is distributed in wide range of salinity conditions.

Impact: Mortality of aquaculture shells and fishes.

Bibliography:


(TF, SN)
Pseudopotamilla occelata Moore, 1905

Common name: Fun worm.
Taxonomy: Annelida, Polychaeta, Canalipalpata, Sabellidae.

Fig. 38. Pseudopotamilla occelata.

Fig. 39. Distribution of Pseudopotamilla occelata in Russia.
Regional distribution: Russia: Peter the Great Bay, Primorye, western Sakhalin.

Possible origin: Eastern Pacific.

Possible way of introduction: Ballast water.

Habitat: Hard substrata in shallow waters.

Impact: Biofouling. Impact on bottom subtidal communities due to high dominance.

Bibliography:


(KL)
**Haliotis discus** Reeve, 1846

**Common name:** Disk abalone.

**Taxonomy:** Mollusca, Archaeogastropoda, Haliotidae.

Fig. 40. *Haliotis discus*.

Fig. 41. Distribution of *Haliotis discus* in China.
Regional distribution: China: coastal areas of Dalian.
Possible origin: Japan.
Possible way of introduction: Aquaculture and self dispersion.
Habitat: Intertidal zone.
Impact: *H. discus* competes with native abalones and makes a competitive advantage, leading to decrease of the native abalone populations. It causes genetic diversity damage and contamination.

Bibliography:


(XJ)
**Haliotis gigantea** Gmelin, 1791

**Common name:** Giant abalone.

**Taxonomy:** Mollusca, Archaeogastropoda, Haliotidae.

![Image of Haliotis gigantea](image)

*Fig. 42. Haliotis gigantea.*

![Distribution map of Haliotis gigantea in China](image)

*Fig. 43. Distribution of Haliotis gigantea in China.*
Regional distribution: China: coastal areas of Liaoning and Shandong.

Possible origin: Japan, Korea.

Possible way of introduction: Aquaculture and self dispersion.

Habitat: Subtidally down to 10 m, hard bottom.

Impact: This species can hybridize and compete with native species, causing genetic diversity damage and contamination.

Bibliography:


(XJ)
**Haliotis rufescens** Swainson, 1822

**Common name:** Red abalone.

**Taxonomy:** Mollusca, Archaeogastropoda, Haliotidae.

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**Fig. 44.** *Haliotis rufescens.*

**Fig. 45.** Distribution of *Haliotis rufescens* in China.
Regional distribution: China: coastal areas of Liaoning and Shandong.
Possible origin: West coast of North America and Mexico.
Possible way of introduction: Aquaculture.
Habitat: Embayments (rocky shore), exposed rocky shore, kelp forest, protected rocky shore.
Impact: *H. rufescens* does not adapt to the environment of the NOWPAP area, but hybrids of this species with other abalones can compete with native species causing genetic diversity damage and contamination.

Bibliography:


(XJ)
**Haliotis fulgens** Philippi, 1845

**Common name:** Green abalone.

**Taxonomy:** Mollusca, Archaeogastropoda, Haliotidae.

![Image of Haliotis fulgens](image)

*Fig. 46. Haliotis fulgens.*

![Distribution map of Haliotis fulgens in China](map)

*Fig. 47. Distribution of Haliotis fulgens in China.*
Regional distribution: China: Coastal areas of Liaoning and Shandong.

Possible origin: Tropical waters.

Possible way of introduction: Aquaculture.

Habitat: In shallow water, in open/exposed coast from low intertidal to at least 9 m and perhaps as deep as 18 m deep. Individuals are found in rock crevices, under rocks and other cryptic cavities.

Impact: H. fulgens does not adapt to the environment of NOWPAP area, but hybrids of this species with other abalones can compete with native species causing genetic diversity damage and contamination.

Bibliography:


Crepidula onyx G.B. Sowerby I, 1824

Common name: Onyx boat-snail;
Japanese name: Shima-menou fune-gai.
Taxonomy: Mollusca, Gastropoda, Neotaenioglossa, Calyptraeidae.

Fig. 48. Crepidula onyx in Japan.

Fig. 49. Distribution of Crepidula onyx in Japan.
Regional distribution: Japan: Hokkaido, Miyagi and Fukushima Prefs, Pacific coast from Chiba Pref. to Shikoku, Seto Inland Sea, Northern Kyusyu, Ariake Inland Sea.

Possible origin: Eastern Pacific.

Possible way of introduction: Ship hull-fouling.

Habitat: Subtidal living shells, rocks. This sessile snail is commonly found in eutrophicated bay waters, usually on large snails such as Rapana venosa, but it also occurs on the hard substratum.

Impact: Unknown.

Bibliography:


(TF, SN)
**Nassarius sinarus** (Philippi, 1851)

**Common name:** Chinese scavenger snail;  
**Japanese name:** Kara-mushiro.  
**Taxonomy:** Mollusca, Gastropoda, Neogastropoda, Nassariidae.

Fig. 50. Chinese scavenger snail, *Nassarius sinarus* in Japan.

Fig. 51. Distribution of *Nassarius sinarus* in Japan.
Regional distribution: Japan: Ariake Inland Sea, Seto Inland Sea.

Possible origin: China, Korea.

Possible way of introduction: With imported aquaculture clams.

Habitat: Intertidal and shallow subtidal sediment bottoms. This snail lives on intertidal mud flats and subtidal mud bottoms. It crowds on fishes in fishermen’s bait traps, causing damage to the fishery.

Impact: Predation on trapped fishes, possibly compete with native scavenger snails.

Bibliography:


(TF, SN)
Euspira fortunei (Reeve, 1855)

Common name: Black top-point moon snail;
Japanese name: Sakiguro tama-tsumeta.
Taxonomy: Mollusca, Gastropoda, Sorbeoconcha, Naticidae.

Fig. 52. Euspira fortunei in Japan.

Fig. 53. Distribution of Euspira fortunei in Japan.
Regional distribution: Japan: Pacific coast from Aomori Pref. to Shizuoka Pref., Seto Inland Sea, Ariake Sea.

Possible origin: China, Korea.

Possible way of introduction: With aquaculture imports.

Habitat: Tidal flats. The moon-snail was unintentionally released in tidal flats with juvenile Asari clams (*Ruditapes philippinarum*) that were imported from China or Korea. In some tidal flats in Tohoku region, Asari clam fishing and recreational clam digging collapsed, due to high predation effect on the clam populations by the moon-snail.

Impact: Predation on fishery clams.


Bibliography:


(TF, SN)
**Mytilus galloprovincialis** Lamarck, 1819

**Common name:** Mediterranean blue mussel;  
**Japanese name:** Murasaki igai;  
**Korean name:** Ji-jung-hae-dam-chi;  
**Russian name:** Sredizemnomorskaya midiya.  
**Taxonomy:** Mollusca, Bivalvia, Mytilidae.

*Fig. 54.* Mediterranean blue mussel, *Mytilus galloprovincialis* in Japan, left; in Pusan Port, Korea, right.

*Fig. 55.* Distribution of *Mytilus galloprovincialis* in Japan, Korea and Russia.
Regional distribution: Japan: All Japanese main islands, Okinawa and Ogasawara islands;
Korea;
Russia: Peter the Great Bay, Vladimira Bay, Moneron Island.

Possible origin: Mediterranean Sea.

Possible way of introduction: Unintentional, via balast water and hull fouling of ships.

Habitat: Intertidal and shallow subtidal concrete walls, rocks and aquaculture crafts. Pier walls and other port structures. Fishery rope, net, and other aquaculture facilities; Depth range is intertidal to 5 m deep (mainly less than 3 m).

Impact: Biofouling, competition with native sessile organisms, genetic contamination with native mussels. Organic pollution by deposited mussels. One of the most abundant sessile bivalves on hard substrata in enclosed waters. *M. galloprovincialis* can reduce the productivity of mussels, oysters, or sea squirt aquaculture by fouling aquaculture gear massively. Deposited dead mussels that were peeled off from concrete walls cause organic pollution in ports and bays.

Comments:

Bibliography:


(TF, SN, KL, KS)
**Perna viridis** L., 1758

**Common name:** Green mussel;  
**Japanese name:** Midori igai.  
**Taxonomy:** Mollusca, Bivalvia, Mytilidae.

![Green mussel, *Perna viridis* in Japan.](image1)

**Fig. 56.** Green mussel, *Perna viridis* in Japan.

![Distribution of *Perna viridis* in Japan.](image2)

**Fig. 57.** Distribution of *Perna viridis* in Japan.
Regional distribution: Japan: Yamagata Pref., Pacific coast from Chiba to Kagoshima prefs., north Kyushu, western Ryukyu Archipelago.

Possible origin: Indian Ocean, Southeast Asia.

Possible way of introduction: Ship hull-fouling.

Habitat: Intertidal and shallow subtidal concrete, rocks and aquaculture crafts. Abundantly occurs on the concrete walls in enclosed eutrophicated waters during late summer to early winter. Since native habitats of the mussel are in tropical and subtropical warm waters, they usually die in late winter under low temperature. However, overwintering mussels were found in and near warm-water outlet channels of electric power plants.

Impact: Biofouling, organic pollution by deposited mussels, competition with native sessile organisms.

Bibliography:


(TF, SN)
**Xenostrobus securis** (Lamarck, 1819)

**Common name:** Canal-wall mussel;

**Japanese name:** Koroen kawa hibari-gai.

**Taxonomy:** Mollusca, Bivalvia, Mytilidae.

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**Fig. 58.** Small channel mussel, *Xenostrobus securis* in Japan.

**Fig. 59.** Distribution of *Xenostrobus securis* in Japan.
**Regional distribution:** Japan: Eastern half of Honshu, Shikoku and Kyushu; Korea.

**Possible origin:** Oceania.

**Possible way of introduction:** Ship hull-fouling.

**Habitat:** Intertidal and subtidal concrete and rocks in estuarine and enclosed waters. It occurs in similar habitats of the Mediterranean blue mussel, *Mytilus galloprovincialis*. However, it tends to be more abundant in estuarine intertidal hard substrata.

**Impact:** Biofouling, competition with native sessile organisms.

**Bibliography:**


(TF, SN)
**Mytilopsis salei** (Récluz, 1849)

**Common names:** Estuarine mussel; pseudo-blue-mussel; 
**Japanese name:** Igai-damashi. 
**Taxonomy:** Mollusca, Bivalvia, Dressenidae.

Fig. 60. Estuarine mussel, *Mytilopsis salei* in Japan.

Fig. 61. Distribution of *Mytilopsis salei* in Japan.
Regional distribution: Japan: Kanto to Northern Kyushu.
Possible origin: Southeast Asia.
Possible way of introduction: Ship hull-fouling, cargo fouling.
Habitat: Estuarine in enclosed waters. Intertidal hard substratum in estuarine and enclosed waters. Occurrence of this mussel is restricted in lower saline waters in estuaries comparing with other exotic mussels. It is usually found in the intertidal zone.
Impact: Unknown

Bibliography:


(TF, SN)
Argopecten irradians (Lamarck, 1819)

Common name: Atlantic bay scallop.
Taxonomy: Mollusca, Bivalvia, Pectinidae.

Fig. 62. *Argopecten irradians*.

Fig. 63. Distribution of *Argopecten irradians* in China.
Regional distribution: China: coastal areas of Liaoning and Shandong; Korea.

Possible origin: Atlantic coast of both Americas (eastern Canada to Colombia).

Possible way of introduction: Aquaculture and self dispersion.

Habitat: Shallow waters with rocky bottom.

Impact: \textit{A. irradians} can hybridize with native species, causing genetic diversity damage and contamination of the native marine ecosystem.

Bibliography:


(XJ)
**Mizuhopecten yessoensis** (Jay, 1857)

**Common name:** Japanese scallop.

**Taxonomy:** Mollusca, Bivalvia, Pectinidae.

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**Fig. 64.** *Mizuhopecten yessoensis.*

**Fig. 65.** Distribution of *Mizuhopecten yessoensis* in China.
Regional distribution: China: coastal areas of north China, especially Liaoning and Shandong provinces.

Possible origin: northern Japan, Russian part of the NOWPAP area and southern Sea of Okhotsk.

Possible way of introduction: Aquaculture and self dispersion.

Habitat: In China, shallow waters (6–60 m deep) with high salinity.

Impact: This species can hybridize with native species causing genetic diversity damage and contamination of the native marine ecosystem.

Bibliography:


**Crassostrea gigas** (Thunberg, 1793)

**Common names:** Pacific oyster, Japanese oyster, giant oyster.

**Taxonomy:** Mollusca, Bivalvia, Ostreidae.

![Fig. 66. Crassostrea gigas.](image)

![Fig. 67. Distribution of Crassostrea gigas in China.](image)
Regional distribution: China: All the coastal areas.

Possible origin: Japan?

Possible way of introduction: Aquaculture and self dispersion.

Habitat: C. gigas prefers to live on hard surfaces in sheltered waters within the intertidal zone. This species can survive in salinities between 10 and 32‰, and temperatures of –1 to 35º C.

Impact: Pacific oysters may have diseases that would negatively affect other species, with no apparent negative effects on themselves. They can also hybridize with native species, causing genetic diversity damage and contamination of the native marine ecosystem.

Comments:


Bibliography:


**Mercenaria mercenaria** (L., 1757)

**Common names:** Hard-shell clam; quahog;  
**Japanese name:** Hon-binosu gai.  
**Taxonomy:** Mollusca, Bivalvia, Veneridae.

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*Fig. 68. Mercenaria mercenaria.*

*Fig. 69. Distribution of Mercenaria mercenaria in China and Japan.*
Regional distribution: China: coastal areas of Shandong; Japan: Tokyo Bay, Osaka Bay.

Possible origin: Western Atlantic.

Possible way of introduction: Aquaculture and self-dispersion.

Habitat: Intertidal and shallow fine-mud bottoms in estuarine and enclosed waters.

Impact: This species can hybridize and compete with native species causing genetic diversity damage and contamination of the native marine ecosystem.

Bibliography:


Panopea japonica A. Adams, 1850

Common name: Pacific geoduck clam.
Taxonomy: Mollusca, Bivalvia, Hiatellidae.

Fig. 70. Panopea japonica.

Fig. 71. Distribution of Panopea japonica in China.
Regional distribution: China: coastal areas of Shandong.

Possible origin: Northwest Pacific Ocean.

Possible way of introduction: Aquaculture and self dispersion.

Habitat: Mud, from intertidal zone to 110 m deep.

Impact: Unknown.

Bibliography:


Balanus glandula Darwin, 1854

Common name: North American barnacle;
Japanese name: Kita-amerika fujitubo.
Taxonomy: Arthropoda, Maxillopoda, Thoracica, Sessilia, Balanidae.

Fig. 72. North American barnacle, Balanus glandula in Japan.

Fig. 73. Distribution of Balanus glandula in Japan.
Regional distribution: Japan: Northern Pacific coasts from Hokkaido to Sanriku, and Mutsu Bay.

Possible origin: Pacific coast of North America

Possible way of introduction: Ship hull-fouling

Habitat: Hard substrata in ports. Along the Pacific coast of North America, the barnacle *B. glandula* is one of the most common barnacle species on rocky intertidal shores. Exotic populations of this barnacle in Japanese waters have been reported after the year 2000.

Impact: Unknown.

Bibliography:


(TF, SN)
**Amphibalanus amphitrite** (Darwin, 1854)

**Common name:** Vertical stripe barnacle;

**Japanese name:** Tatejima fujitsubo;

**Korean name:** Ju-geog-dda-gae-bi (means spatula-shaped).

**Taxonomy:** Arthropoda, Maxillopoda, Thoracica, Sessilia, Balanidae.

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**Fig. 74.** Vertical stripe barnacle *Amphibalanus amphitrite* in Japan, left; in Pusan Harbor, right.

**Fig. 75.** Distribution of *Amphibalanus amphitrite* in Japan, Korea and Russia.
**Regional distribution:** Japan: Almost entire Japanese coasts, and Okinawa; Korea; Russia: Peter the Great Bay.

**Possible origin:** southwest Pacific and Indian Ocean.

**Possible way of introduction:** Ship hull-fouling, ballast-water.

**Habitat:** Intertidal concrete walls and rocks in embayment waters. One of the most dominant sessile animals on the intertidal hard substrata in enclosed waters in central to western Japan. It is shoreline species distributed from upper to mid intertidal zone; it inhabits intertidal hard substrates such as rocks, oyster bed, shell surface, ship bottom, pilings, seawalls and other hard substrates.

**Impact:** Compete with native barnacles, biofouling. *B. amphitrite* is a serious problem for ship hulls, buoy, and pilings. Probably some competition for space with native barnacles or other biofouling organisms. However, recent report suggested that *B. amphitrite* and the congener *B. eburneus* are capable of persisting side-by-side.

**Bibliography:**


**Amphibalanus improvisus** (Darwin, 1854)

**Common name:** European barnacle;

**Japanese name:** Yoroppa fujitsubo;

**Korean name:** Heuin-Dda-Gae-Bi.

**Taxonomy:** Arthropoda, Maxillopoda, Thoracica, Sessilia, Balanidae.

![Fig. 76. European barnacle, *Amphibalanus improvisus* in Japan; left; in Dasan harbor, Korea, right.](image)

![Fig. 77. Distribution of *Amphibalanus improvisus* in Japan, Korea and Russia.](image)
Regional distribution: Japan: Honshu, Shikoku, and Kyushu; Korea; Russia: Peter the Great Bay.

Possible origin: North Atlantic.

Possible way of introduction: Ship hull-fouling and ballast water.

Habitat: Hard substrata in estuary and embayment waters. The European barnacle tends to be abundant in eutrophicated brackish waters. Habitats are partially overlapped with the American barnacle that tends to prefer more saline waters than the European barnacle. Attached to rocks and other hard substrata such as submerged wood, ship hulls, and oyster or mussel shells. Frequently found in lagoons in Gangwon Province (Korea).

Impact: Fouling organism. It is common fouler caused to large aggregations on a variety of harbor structures, aquaculture gears, and ship hulls. Space competition is likely to occur with other hard fouling species. It can causes fouling of water intake pipes and heat exchangers.

Bibliography:


(TF, SN, KL, KS)
**Amphibalanus eburneus** Gould, 1841

**Common name:** American barnacle;  
**Japanese name:** Amerika fujitsubo;  
**Korean name:** Datch-dda-gae-bi (ivory banacle).  
**Taxonomy:** Arthropoda, Maxillopoda, Thoracica, Sessilia, Balanidae.

![Image of Amphibalanus eburneus in Japan and Tongyeong Harbor, Korea](image)

**Fig. 78.** American barnacle, *Amphibalanus eburneus* in Japan, left; in Tongyeong Harbor, Korea, right.

![Map showing distribution of Amphibalanus eburneus in Japan and Korea](image)

**Fig. 79.** Distribution of *Amphibalanus eburneus* in Japan and Korea.
Regional distribution: Japan: Honshu, Shikoku, and Kyushu; Korea; Russia: only ship fouling.

Possible origin: West Atlantic.

Possible way of introduction: Ship hull-fouling and ballast water.

Habitat: Concrete walls and rocks in estuaries and embayment waters. The American barnacle occurs in brackish and enclosed waters in Japan. This species sometimes competes with the European barnacle, but tends to be abundant in more saline waters compared with the European barnacle. Attached massively to the hard substrates such as rocks, oyster beds, shell surfaces, ship bottom, buoys.

Impact: B. ebruneus is a serious problem as fouling organism on ship hulls, buoys, and dock pilings. Space competition is likely to occur with native barnacle B. trigonus or other hard fouling species; however, recent report suggested that B. eburneus and the congener B. amphitrite are capable of persisting side-by-side.

Bibliography:


Amphibalanus zhujiangensis Ren, 1989

Common name: Zhujiang barnacle;
Japanese name: Zujan fujitsubo; Zujan barnacle.
Taxonomy: Arthropoda, Maxillopoda, Thoracica, Sessilia, Balanidae.

Fig. 80. Amphibalanus zhujiangensis in Taiwan, a, b: top views.

Fig. 81. Distribution of Amphibalanus zhujiangensis in Japan (only Okinawa, not shown).
**Distribution:** Japan: Okinawa.

**Possible origin:** China or Indonesia.

**Possible way of introduction:** Ship hull-fouling.

**Habitat:** Intertidal and shallow rocks.

**Impact:** Unknown.

**Bibliography:**


(TF, SN)
Megabalanus coccopoma (Darwin, 1854)

Common name: Titan acorn barnacle;
Japanese name: Kokopoma aka-fujitsubo; Coccopoma red barnacle.
Taxonomy: Arthropoda, Maxillopoda, Thoracica, Sessilia, Balanidae.

Fig. 82. Megabalanus coccopoma.

Fig. 83. Distribution of Megabalanus coccopoma in Japan.
Regional distribution: Japan: Iwate Prefecture to Tokyo Bay, Sagami Bay, Izu Peninsula, Kii Peninsula, Seto Inland Sea, Kochi Prefecture.

Possible origin: Tropical East Pacific.

Possible way of introduction: Ship hull-fouling.

Habitat: Shallow concrete and rocks, buoys. This barnacle occurs on subtidal rocks and aquaculture ropes in open and enclosed waters.

Impact: Unknown.

Bibliography:


(TF, SN)
Perforatus perforatus (Bruguière, 1789)

Common name: Perforate barnacle; Korean name: Hwa-san-dda-daebi (means volcano in habitus).

Taxonomy: Arthropoda, Maxillopoda, Thoracica, Sessilia, Balanidae.

Fig. 84. Perforatus perforatus in Guryongpo Harbor, Korea.

Fig. 85. Distribution of Perforatus perforatus in Korea.
Regional distribution: Korea; Russia: only ship fouling.

Possible origin: This species is an eastern Atlantic warm-water species, occurring commonly in the Mediterranean. Its range extends southward to the north-western coast of Africa.

Possible way of introduction: unintentional, via balastwater and hull fouling of ships.

Habitat: Lower tidal species distributed from Gangneung to Pusan in only harbor condition; mainly attached to the hard substrates such as dock pilings (or wall), buoys, and other hard substrates in harbor.

Impact: Fouling organism. It is common fouler caused to large aggregations on a variety of harbor structures such as dock pilings, buoys, and other hard substrates. May not spread to natural rocky shore and small harbor. Space competition is likely to occur among *B. perforatus* and other barnacles or other hard fouling species.

Bibliography


(KL, KS)
Paracerceis sculpta (Holmes, 1904)

Common name: Horn tail sea-cicada;
Japanese name: Tsuno umisemi; horn sea-cicada.
Taxonomy: Arthropoda, Crustacea, Isopoda, Sphaeromatidae.

Fig. 86. Paracerceis sculpta in Australia.

Fig. 87. Distribution of Paracerceis sculpta in Japan.
Regional distribution: Japan: Ehime Prefecture, Osaka Bay.

Possible origin: East Pacific.

Possible way of introduction: Ship hull-fouling.

Habitat: Intertidal and shallow subtidal artificial substrata and artificial sandy beaches.

Impact: Unknown.

Bibliography:


(TF, SN)
Portunus sanguinolentus (Herbst, 1783)

Common name: Blood-spotted swimming crab.
Taxonomy: Arthropoda, Malacostraca, Decapoda, Portunidae.

Fig. 88. Portunus sanguinolentus in Taiwan.

Fig. 89. Distribution of Portunus sanguinolentus in Russia.
Regional distribution: Russia: Peter the Great Bay.
Possible origin: Tropical Indo-Pacific.
Possible way of introduction: drifting buoys.
Habitat: This tropical species occurs only in warm seasons with transported marine litter that serves as substrate for crabs and other organisms.
Impact: Unknown.

Bibliography:


(KL)
**Plagusia depressa tuberculata** Lamarck, 1818

**Note:** A possible synonym of *Plagusia squamosa* (Herbst, 1790).

**Common name:** Scaly rock crab.

**Taxonomy:** Arthropoda, Malacostraca, Decapoda, Plagusiidae.

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**Fig. 90.** Crab *Plagusia depressa tuberculata* in Peter the Great Bay.

**Fig. 91.** Distribution of *Plagusia depressa tuberculata* in Russia.
Regional distribution: Russia: Peter the Great Bay.

Possible origin: Tropical Indo-Pacific.

Possible way of introduction: Drifting buoys.

Habitat: This tropical species occurs only in warm seasons with transported marine litter that serves as substrate for crabs and other organisms.

Impact: Unknown.

Bibliography:

**Pyromaia tuberculata** (Lockington, 1877)

**Common name:** Single-horn spider crab, American spider crab;  
**Japanese name:** Ikkaku kumo-gani, Uni-horn spider crab.  
**Taxonomy:** Arthropoda, Malacostraca, Decapoda, Majidae.

Fig. 92. Single-horn spider crab *Pyromaia tuberculata* in Japan.

Fig. 93. Distribution of *Pyromaia tuberculata* in Japan.
Regional distribution: Japan: Pacific coast from Sendai to Yamaguchi including Seto Inland Sea, northern Kyushu, Ariake Bay; Korea.

Possible origin: East Pacific.

Possible way of introduction: Ballast water and ship hull-fouling.

Habitat: Sand and mud shallow bottoms in enclosed waters. This crab abundantly occurs on subtidal bottom in eutrophicated enclosed waters where summer hypoxia tends to be severe. Rapid growth (reach maturity within 3 months after hatched) and omniseasonal breeding (breeds throughout the year) supports quick recovery of local populations which had disappeared by summer hypoxia.

Impact: Unknown.

Bibliography:


(TF, SN, KS)
**Rhithropanopeus harrisii** (Gould, 1841)

**Common name:** Estuarine mud crab, Harris mud crab;
**Japanese name:** Minato Ogi-gani, port panopeid crab.
**Taxonomy:** Arthropoda, Malacostraca, Decapoda, Panopeidae.

![Image of Rhithropanopeus harrisii](image)

*Fig. 94. Rhithropanopeus harrisii in Japan.*

![Distribution map of Rhithropanopeus harrisii in Japan](image)

*Fig. 95. Distribution of Rhithropanopeus harrisii in Japan.*
Regional distribution: Japan: Ise Bay, Osaka Bay, Tokyo Bay.

Possible origin: West Atlantic

Possible way of introduction: Ship hull-fouling.

Habitat: Enclosed low saline waters. This crab was abundantly found in brackish-water ports in enclosed areas. A small number of the crab was also found in upper small estuaries.

Impact: Unknown.

Bibliography:


(TF, SN)
Carcinus aestuarii Nardo, 1847

Common name: Mediterranean green crab;
Japanese name: Chichuukai Midori-gani; Mediterranean green crab.
Taxonomy: Arthropoda, Malacostraca, Decapoda, Portunidae.

Fig. 96. Mediterranean green crab *Carcinus aestuarii* in Japan.

Fig. 97. Distribution of *Carcinus aestuarii* in Japan.
Regional distribution: Japan: Pacific coast from Tokyo Bay to Osaka Bay, northern Kyushu.

Possible origin: Mediterranean Sea.

Possible way of introduction: Ballast water, ship hull-fouling.

Habitat: Artificial canals, ports and cobble shores. The green crab occurs on shores in brackish and eutrophicated enclosed waters, such as ports and artificial channels in urbanized bays. The crab migrates offshore to the bay bottom during winter when it breeds, but comes back to the shore in spring and stays there during warmer seasons. This migratory pattern is very well adapted to survive in eutrophicated waters, as the crab can avoid being captured in summer-hypoxic bottom water.

Impact: Unknown.

Bibliography:


(TF, SN)
**Diogenes nitidimanus** Terao, 1913

**Common name:** Sand-dwelling hermit crab.

**Taxonomy:** Arthropoda, Malacostraca, Decapoda, Diogenidae.

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**Fig. 98.** *Diogenes nitidimanus* from Peter the Great Bay.

**Fig. 99.** Distribution of *Diogenes nitidimanus* in Russia.
Regional distribution: Russia: Peter the Great Bay.

Possible origin: Japan.

Possible way of introduction: Ballast water.

Habitat: This hermit crab’s settlement was found in the estuarine part of Vostok Bay (eastern Peter the Great Bay) on a silty bottom at a depth of 2–3 m; the hermit crabs inhabits shells of the gastropod mollusks Batillaria cumingii, Linatia pallida, Littorina squalida, and Umbonium costatum (Korn et al., 2007). The larva of the hermit crab was found in the ballast waters of the tanker Minotaur that arrived from the Chinese port of Laizhou (Yellow Sea) (Zvyagintsev, Kornienko, 2008).

Impact: Unknown.

Bibliography:


**Litopenaeus stylirostris** Stimpson, 1894

**Common name:** Blue shrimp.

**Taxonomy:** Arthropoda, Malacostraca, Decapoda, Penaeidae.

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**Fig. 100.** Blue shrimp *Litopenaeus stylirostris.*

**Fig. 101.** Distribution of *Litopenaeus stylirostris* in China.
Regional distribution: China: coastal areas of Shandong and Jiangsu.

Possible origin: Eastern Pacific.

Possible way of introduction: Aquaculture and self-dispersion.

Habitat: Sandy, muddy bottom in subtidal zone.

Impact: The species can hybridize and compete with native species, causing genetic diversity damage and contamination of the native marine ecosystem.

Bibliography:


(XJ)
**Litopenaeus vannamei** Boone, 1931

**Common name:** White shrimp.

**Taxonomy:** Arthropoda, Malacostraca, Decapoda, Penaeidae.

![Fig. 102. White shrimp Litopenaeus vannamei.](image)

![Fig. 103. Distribution of Litopenaeus vannamei in China.](image)
Regional distribution: China: Jiangsu Province.

Possible origin: East coast of the Pacific Ocean.

Possible way of introduction: Aquaculture and self-dispersion.

Habitat: Muddy bottom, 0-72 m deep.

Impact: Imported white shrimps often carry pathogens leading to a shrimp disease. Farming white shrimps in pools also cause salinization of land.

Bibliography:


(XJ)
Marsupenaeus japonicus Bate, 1888

Common name: Kuruma prawn.
Taxonomy: Arthropoda, Malacostraca, Decapoda, Penaeidae.

Fig. 104. Marsupenaeus japonicus.

Fig. 105. Distribution of Marsupenaeus japonicus in China.
Regional distribution: China: coastal areas of the north China.

Possible origin: Japan.

Possible way of introduction: Aquaculture and self dispersion.

Habitat: Sandy and muddy bottom in coastal waters usually less than 30 m deep.

Impact: This species can hybridize and compete with native species causing genetic diversity damage and contamination of the native marine ecosystem.

Bibliography:


**Monocorophium acherusicum** (Costa, 1851)

**Common name**: Mediterranean corophiid, tube-building amphipod.  
**Taxonomy**: Arthropoda, Malacostraca, Amphipoda, Corophiidae.

![Fig. 106. Mediterranean corophiid Monocorophium acherusicum.](image1)

![Fig. 107. Distribution of Monocorophium acherusicum in Russia.](image2)
Regional distribution: Russia: Peter the Great Bay.

Possible origin: Atlantic.

Possible way of introduction: Ballast water, ship fouling.

Habitat: This species was first found in Peter the Great Bay only as a component of fouling communities (Zevina, Gorin, 1975) and then was recorded in benthic communities in southwestern Peter the Great Bay and around the mouth of the Tumen River (Budnikova, 2001).

Impact: *M. acherusicum* was found in the fouling of the water cooling system on Heat and Power Station No. 2 of Vladivostok (Zvyagintsev, Budnikova, 2003).

Bibliography:


(KL)
**Bugula neritina** (L., 1758)

**Common name:** Brown bryozoan;  
**Korean name:** Keun-da-bal-i-ggi-beol-re (means large bundle).  
**Taxonomy:** Bryozoa, Gymnolaemata, Cheilostomata, Bugulidae.

![Fig. 108. Bugula neritina in Tongyeong Harbor, Korea.](image)

![Fig. 109. Distribution of Bugula neritina in Korea.](image)
Regional distribution: Korea.

Possible origin: Western Atlantic.

Possible way of introduction: unintentional, via balastwater and hull fouling of ships.

Habitat: Submerged rope, fishery net, other aquaculture gears; harbor or marine structures and ship bottoms; natural rocks from lower intertidal to more than 20 m deep.

Impact: Fouling organism. *B. neritina* populations may tolerate high levels of pollution (including copper) which increases its potential to be a fouling pest. It is a common fouling organism growing in large aggregations on a variety of harbor structures, aquaculture gears, and ship hulls. Space competition is unclear but likely to occur with other fouling species.

Bibliography:


(KS)
**Bugula stolonifera** Ryland, 1960

**Taxonomy:** Bryozoa, Gymnolaemata, Cheilostomata, Bugulidae.

*Fig. 110. Bugula stolonifera* in Japan.

*Fig. 111. Distribution of Bugula stolonifera* in Japan.
Regional distribution: Japan: Tokyo Bay, Ise Bay, Osaka Bay.

Possible origin: Unknown.

Possible way of introduction: Ship hull-fouling.

Habitat: Artificial hard substrata in enclosed waters, in ports and canals.

Impact: Unknown.

Bibliography:

**Bugula californica** Robertson, 1905

Common name: Spiral bryozoan;

Korean name: Kael-ri-po-ni-a-i-ggi-beol-re (means California).

Taxonomy: Bryozoa, Gymnolaemata, Cheilostomata, Bugulidae.

Fig. 112. *Bugula californica* in Tongyeong Harbor, Korea.

Fig. 113. Distribution of *Bugula californica* in Korea.
Regional distribution: Korea.

Possible origin: British Columbia to the Galapagos Islands, Hawaii.

Possible way of introduction: unintentional, via balastwater and hull fouling of ships.

Habitat: Harbor or marina structures and ship hulls; aquaculture facilities such as submerged rope, fishery net, other culture gears; attached to rocks, sponges, macroalgal species, and invertebrate surfaces from lower intertidal to mainly below 10 m deep.

Impact: Fouling organism. It lives in large aggregations on a variety of harbor structures, aquaculture gears, and ship hulls. Space competition is unclear but likely to occur with other hard fouling species in the minor level.

Bibliography


(KS)
**Tricellaria occidentalis** (Trask, 1857)

**Korea name:** Se-bang-ga-si i-ggi-beol-re (means tri-cell spine as genus name).

**Taxonomy:** Bryozoa, Gymnolaemata, Cheilostomata, Scrupocellariidae.

![Fig. 114. Tricellaria occidentalis in Tongyeong Harbor.](image1)

![Fig. 115. Distribution of Tricellaria occidentalis in Korea.](image2)
Regional distribution: Japan; Korea.

Possible origin: California, and possibly British Columbia and Baja California.

Possible way of introduction: unintentional, hull fouling of ships and balast water.

Habitat: Intertidal to 40 m deep in fouling communities, on hard substrates and algae.

Impact: Fouling organism. It lives in large aggregations on a variety of harbor structures, aquaculture gears, and ship hulls. Space competition is unclear but likely to occur with other hard fouling species in the minor level.

Bibliography:


Mawatari S. 1951. On Tricellaria occidentalis (Trask), one of the fouling bryozoans in Japan. Miscellaneous Reports of the Research Institute of Natural Resources. V. 22. P. 9–16.
**Conopeum seurati** (Canu, 1928)

**Taxonomy:** Bryozoa, Gymnolaemata, Cheilosromatida, Electridae.

*Fig. 116. Conopeum seurati.*

*Fig. 117. Distribution of Conopeum seurati in Russia.*
Regional distribution: Russia: Peter the Great Bay.

Possible origin: Eastern Atlantic.

Possible way of introduction: Ship hull fouling.

Habitat: Fouling organism. It lives on hard substrata in the upper subtidal zone.

Impact: Unknown.

Bibliography:

**Schizoporella unicornis** (Johnston 1874)

**Common name:** Orange encrusting bryozoan.

**Taxonomy:** Bryozoa, Gymnolaemata, Cheilosromatida, Schizoporellidae.

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**Fig. 118.** *Schizoporella unicornis*.

**Fig. 119.** Distribution of *Schizoporella unicornis* in Russia.
Regional distribution: Russia: Peter the Great Bay.

Possible origin:

Possible way of introduction: Ship hull fouling.

Habitat: Fouling organism. It lives on hard substrata in the upper subtidal zone.

Impact: Unknown.

Bibliography:

**Strongylocentrotus intermidus** A. Agassiz, 1863

**Common name:** Grey sea urchin.

**Taxonomy:** Echinodermata, Echinoidea, Camarodonta, Strongylocentrotidae.

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**Fig. 120.** *Strongylocentrotus intermidus*.

**Fig. 121.** Distribution of *Strongylocentrotus intermidus* of China.
Regional distribution: China: Coastal areas of Dalian and Rongcheng, Shandong.

Possible origin: Japan, Russian Far East?

Possible way of introduction: Aquaculture and self dispersion.

Habitat: Rocky intertidal zone and upper subtidal zones, 0–50 m.

Impact: This species competes with native species for food and living space.

Bibliography:


(XJ)
Styella plicata Lesuer, 1823

Common name: Pleated sea squirt, rough sea squirt;
Korean name: Ju-reum-mi-deo-deog (means winkles or projection).
Taxonomy: Chordata, Ascidacea, Pleurogona, Styelidae.

Fig. 122. *Styella plicata* in Tongyeong sea farm, Korea.

Fig. 123. Distribution of *Styella plicata* in Korea.
Regional distribution: Korea.

Possible origin: Indo-Pacific?

Possible way of introduction: Ballast water, hull fouling of ships, live bivalve for aquaculture.

Habitat: Aquaculture cages, rope, net and other man-made facilities; also found on pier walls and other harbor constructions. It may not spread to natural rocky shore. Commonly attached from surface to 5 m deep.

Impact: *S. plicata* is an aquaculture species in Korea. It is widespread in the southern coast of Korea and common fouler of aquaculture rope, net, and other floating or submerged man-made structures. It is also a common fouling organism of harbor constructions.

Bibliography:


(KS)
**Ciona intestinalis** (Linnaeus, 1767)

**Common name:** Sea vase;

**Korean name:** Yu-ryeong-meong-ge (means ghost in habitus).

**Taxonomy:** Chordata, Ascidacea, Euterogona, Cionidae.

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**Fig. 124. Ciona intestinalis** in Tongyeong Harbor (photo by INTHESEA Korea, Inc.).

**Fig. 125. Distribution of Ciona intestinalis** in Korea.
Regional distribution: Korea.

Possible origin: northern Atlantic.

Comments: This species is considered as non-indigenous in northern Atlantic Canada. Molecular studies have identified two cryptic species: type A is now widely distributed in the Mediterranean and the Pacific, type B is widely distributed in the northern Atlantic, with both coexisting in the UK.

Possible way of introduction: Hull fouling of ships, ballast water, live aquaculture organisms.

Habitat: Aquaculture gear, farming organism surfaces; pier walls and other harbor or marina structures; it may not spread to natural rocky shore, however, sometimes observed in the natural rocky shore near sea farm, marina, and harbor. It is found from the lower intertidal down to at least 10 m deep.

Impact: Fouling organism. Ecological impact unstudied, but space competition is likely to occur with native or non-native invertebrates on the artificial constructions. C. intestinalis can reduce the productivity of mussel, oyster, or sea squirt farming by fouling aquaculture gear.

Bibliography:


Ciona savignyi Herdman, 1882

Common name: Pacific transparent sea squirt, solitary sea squirt.
Taxonomy: Chordata, Ascidacea, Euterogona, Cionidae.
Regional distribution: Russia: Peter the Great Bay.

Possible origin: Japan?

Possible way of introduction: Hull fouling of ships.

Habitat: Hard substrata in the upper subtidal zone, including mussel shell surface.

Impact: Fouling organism.

Bibliography:

**Molgula manhattensis** (De Kay, 1843)

**Common name:** Sea grape; Manhattan tunicate;

**Japanese name:** Manhattan boya.

**Taxonomy:** Chordata, Ascidiacea, Pleurogona, Molgulidae.

*Fig. 128. Molgula manhattensis* in Japan.

*Fig. 129. Distribution of Molgula manhattensis* in Japan and Russia.
Regional distribution: Japan: Pacific coast from Tokyo Bay and southward, northern Kyushu; 
Russia: Peter the Great Bay.

Possible origin: Northeast and northwest Atlantic.

Possible way of introduction: Ship hull fouling.

Habitat: Subtidal hard substrata in estuarine and enclosed waters. This tunicate is occasionally found on artificial substrata and introduced mussels in enclosed waters. It tends to be abundant during colder seasons.

Impact: Fouling organism. It competes with aquaculture bivalves.

Bibliography:


(TF, SN, KL)
**Polyandrocarpa zorritensis** (Van Name, 1931)

**Common name:** Black Polyandrocarpa tunicate;

**Japanese name:** Kuromameita-boyta.

**Taxonomy:** Chordata, Ascidacea, Enterogona, Asciidiidae.

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**Fig. 130.** Black Polyandrocarpa tunicate, *Polyandrocarpa zorritensis* in Japan.

**Fig. 131.** Distribution of *Polyandrocarpa zorritensis* in Japan.
Regional distribution: Japan: Toyama Bay, Izu Peninsula, Osaka Bay, southeastern Shikoku, Dokai Bay.

Possible origin: Unknown.

Possible way of introduction: Ship hull-fouling or ballast water.

Habitat: Subtidal hard substrata in port waters. This tunicate forms dense colony on artificial hard substrata in enclosed subtidal waters.

Impact: Compete with native sessile species.

Bibliography:


(TF, SN)
**Ascidiella aspersa** (Müller, 1776)

**Common name:** European rough-surface tunicate;  
**Japanese name:** Yoroppa zara-boya.  
**Taxonomy:** Chordata, Asciidae, Enterogona, Ascidiidae.

Fig. 132. European tunicate, *Ascidiella aspersa* in Japan.

Fig. 133. Distribution of *Ascidiella aspersa* in Japan.
Regional distribution: Japan: Funka Bay, Hokkaido and Northeastern Pacific coasts.

Possible origin: Europe.

Possible way of introduction: Unknown.

Habitat: Aquaculture gear. This tunicate aggregatively grows on scallop shells, causing damage of scallop aquaculture.

Impact: Damage on scallop aquaculture.

Bibliography:


(TF, SN)
Halocynthia roretzi (Drasche, 1884)

Common name: sea squirt.

Taxonomy: Chordata, Asciidiacea, Stolidobranchia, Pyuridae.

Fig. 134. Halocynthia roretzi.

Fig. 135. Distribution of Halocynthia roretzi in China.
Regional distribution: China: Coastal areas of Liaoning and Shandong.

Possible origin:

Possible way of introduction: Aquaculture and self dispersion.

Habitat: Upper subtidal rocky coast, 10−20 m deep.

Impact: Affecting aquaculture.

Bibliography:


(XJ)
**Lateolabrax sp.**

**Common name:** Continental sea bass, *Lateolabrax* sp.;

**Japanese name:** Tairiku Suzuki.

**Taxonomy:** Chordata, Pisces, Actinopterygii, Perciformes, Lateolabracidae.

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**Fig. 136.** Continental sea bass, *Lateolabrax* sp.

**Fig. 137.** Distribution of *Lateolabrax* sp. in Japan.
**Regional distribution**: Japan: Central to western Japan.

**Possible origin**: China.

**Possible way of introduction**: Import for aquaculture.

**Habitat**: Coastal waters. This imported Chinese bass have been cultured in the western part of the Japanese main islands. Amateur fishermen often catch basses in natural waters. These basses may have escaped from culturing nets. A scientific species name of the bass has not been given.

**Impact**: Predation on small fishes, compete with native sea bass.

**Bibliography**:


(TF, SN)
**Oncorhynchus kisutch** (Walbaum, 1792)

**Common name:** Coho salmon, silver salmon.

**Taxonomy:** Chordata, Pisces, Actinopterygii, Salmoniformes, Salmonidae.

![Oncorhynchus kisutch](image)

*Fig. 138. Oncorhynchus kisutch.*

![Distribution map](image)

*Fig. 139. Distribution of Oncorhynchus kisutch in China.*
Regional distribution: China: Liaoning Province.

Possible origin: Northern Pacific.

Possible way of introduction: Aquaculture and self-dispersion

Habitat: River and ocean with cold water. Anadromous species; born in freshwater, spends most of life in sea.

Impact: The species with biological advantage may compete with native species, causing genetic diversity damage and contamination.

Bibliography:


**Oncorhynchus mykiss** (Walbaum, 1792)

**Common names:** Rainbow trout, steelhead trout.

**Taxonomy:** Chordata, Pisces, Actinopterygii, Salmoniformes, Salmonidae.

![Oncorhynchus mykiss](image_url)

**Fig. 140.** *Oncorhynchus mykiss*.

![Distribution map](image_url)

**Fig. 141.** Distribution of *Oncorhynchus mykiss* in China.
Regional distribution: China: Liaoning and Shandong provinces.

Possible origin: North Pacific.

Possible way of introduction: Aquaculture.

Habitat: River and ocean with cold and clean water.

Impact: The species with biological advantage may compete with native species, causing genetic diversity damage and contamination.

Bibliography:


**Salmo salar** L., 1758

**Common names:** Atlantic salmon, black salmon, parr.

**Taxonomy:** Chordata, Pisces, Actinopterygii, Salmoniformes, Salmonidae.

![Salmo salar](image)

**Fig. 142.** *Salmo salar.*

![Distribution map](image)

**Fig. 143.** Distribution of *Salmo salar* in China.
Regional distribution: China: Liaoning Province.

Possible origin: Atlantic.

Possible way of introduction: Aquaculture.

Habitat: River and ocean with cold water.

Impact: Atlantic salmon has biological advantages in competing with native species. Reared Atlantic salmons also transmit diseases to wild salmons when they escape.

Bibliography:


Paralichthys dentatus (L., 1766)

Common names: Summer flounder, large-tooth flounder, arrow-tooth flounder.

Taxonomy: Chordata, Pisces, Actinopterygii, Pleuronectiformes, Paralichthyidae.

![Image of Paralichthys dentatus](image-url)

Fig. 144. Paralichthys dentatus.

![Map of Paralichthys dentatus distribution in China](image-url)

Fig. 145. Distribution of Paralichthys dentatus in China.
Regional distribution: China: Coastal areas of Shandong.

Possible origin: Northwest Atlantic.

Possible way of introduction: Aquaculture, self-dispersion.

Habitat: Central and shallow areas of bays, seaweed beds, muddy, sandy bottoms.

Impact: This species with biological advantage may compete with native species, causing genetic diversity damage and contamination.

Bibliography:


Paralichthys lethostigma Jordan et Gilbert, 1884

Common name: Southern flounder.
Taxonomy: Chordata, Pisces, Actinopterygii, Pleuronectiformes, Paralichthyidae.

Fig. 146. Paralichthys lethostigma.

Fig. 147. Distribution of Paralichthys lethostigma in China.
Regional distribution: China: all coastal regions.

Possible origin: Northwest Atlantic.

Possible way of introduction: Aquaculture, self-dispersion.

Habitat: Estuaries and bays in spring and summer, open ocean in autumn and winter.

Impact: This species with biological advantage may compete with native species, causing genetic diversity damage and contamination.

Bibliography:


(XJ)
**Verasper moseri** Jordan et Gilbert, 1898

**Common name:** Barfin flounder.

**Taxonomy:** Chordata, Pisces, Actinopterygii, Pleuronectiformes, Pleuronectidae.

![Fig. 148. Verasper moseri.](image)

![Fig. 149. Distribution of Verasper moseri in China.](image)
Regional distribution: China: Waters to east of northern China.

Possible origin:

Possible way of introduction: Aquaculture, self-dispersion.

Habitat: Shallow water areas with sandy substrate.

Impact: This species can compete with native species.

Bibliography:


Solea senegalensis Kaup, 1858

Common name: Senegalese sole.

Taxonomy: Chordata, Pisces, Actinopterygii, Pleuronectiformes, Soleidae.

Fig. 150. Solea senegalensis.

Fig. 151. Distribution of Solea senegalensis in China.
**Regional distribution:** China: Shandong Province.

**Possible origin:** Eastern Atlantic.

**Possible way of introduction:** Aquaculture, self-dispersion.

**Habitat:** Lagoons and other shallow waters with muddy substrate.

**Impact:** This species with biological advantage may compete with native species.

**Bibliography:**


**Solea solea (L., 1758)**

**Common names:** Common sole, Dover sole, slip.

**Taxonomy:** Chordata, Pisces, Actinopterygii, Pleuronectiformes, Soleidae.

![Fig. 152. Solea solea.](image)

![Fig. 153. Distribution of Solea solea in China.](image)
Regional distribution: China: Shandong Province.

Possible origin: Eastern Atlantic.

Possible way of introduction: Aquaculture, self dispersion

Habitat: Shallow waters (0–150 m), sandy or muddy bottom.

Impact: This species with biological advantage may compete with native species.

Bibliography:


(XJ)
Anguilla anguilla (L., 1758)

Common name: European eel.
Taxonomy: Chordata, Pisces, Actinopterygii, Anguilliformes, Anguillidae.

Fig. 154. Anguilla anguilla.

Fig. 155. Distribution of Anguilla anguilla in China.
**Regional distribution:** China: Jiangsu Province.

**Possible origin:**

**Possible way of introduction:** Aquaculture, self-dispersion.

**Habitat:** Marine environment for juveniles, rivers and streams for adult fishes. Muddy bottom.

**Impact:** The MIS with biological advantage may compete with native species.

**Bibliography:**


(XJ)
**Anguilla rostrata** (Lesueur, 1817)

**Common name:** American eel.

**Taxonomy:** Chordata, Pisces, Actinopterygii, Anguilliformes, Anguillidae.

![Fig. 156. Anguilla rostrata.](image)

![Fig. 157. Distribution of Anguilla rostrata in China.](image)
Regional distribution: China: Jiangsu Province.

Possible origin:

Possible way of introduction: Aquaculture, self-dispersion

Habitat: Marine environment for juveniles, rivers and steams for adult fishes. Muddy and sandy bottom, depth range 0–464 m.

Impact: This species with biological advantage may compete with native species.

Bibliography:


**Morone saxatilis** (Walbaum, 1792)

**Common name:** Striped bass;  
**Russian name:** Okun’ polosatyi.  
**Taxonomy:** Chordata, Pisces, Actinopterygii, Perciformes, Moronidae.

![Fig. 158. Morone saxatilis.](image1)

![Fig. 159. Distribution of Morone saxatilis in China.](image2)
Regional distribution: Shandong Province.

Possible origin: Atlantic?

Possible way of introduction: Aquaculture, self-dispersion.

Habitat: Benthic anadromous species. Estuarine environment for juveniles, shallow coastal waters for adult fishes.

Impact: Competing with native species.

Bibliography:


**Sciaenops ocellatus** (L., 1766)

**Common names:** Red drum, channel bass.

**Taxonomy:** Chordata, Pisces, Actinopterygii, Perciformes, Sciaenidae.

![Fig. 160. Sciaenops ocellatus.](image)

![Fig. 161. Distribution of Sciaenops ocellatus in China.](image)
Regional distribution: Shandong Province.

Possible origin: Northwest Atlantic.

Possible way of introduction: Aquaculture, self-dispersion.

Habitat: Shallow waters down to 30–40 m deep with muddy, sandy or rocky bottom.

Impact: Competing with native species.

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