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The Regional Overview and National Reports on the Marine Invasive Species in the NOWPAP Region

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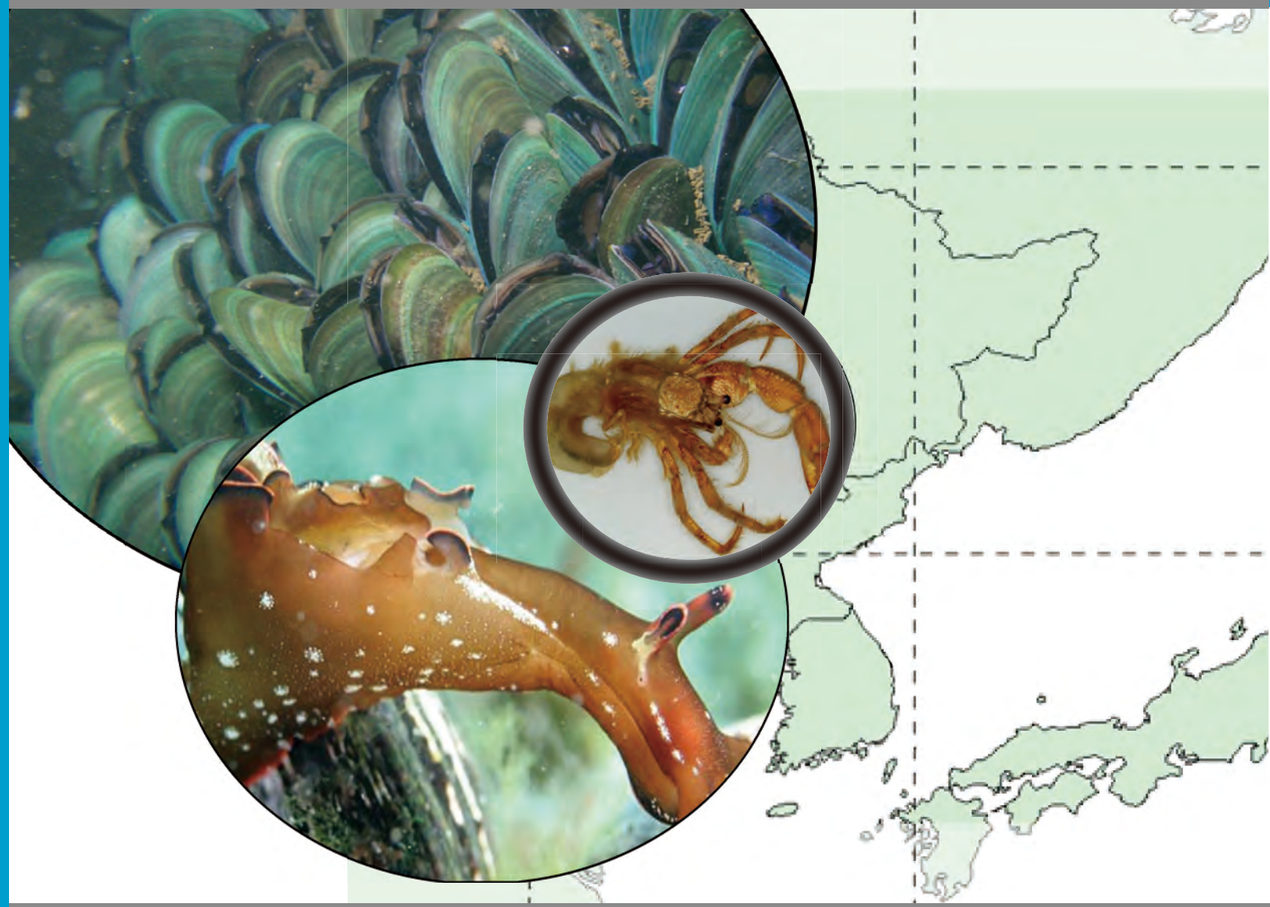

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This regional overview and national reports have been compiled based on the latest data and information provided by NOWPAP member countries. It might be useful for people who are interested to the current situation in the region.

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Disclaimer

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Regional Overview on Marine Invasive Species in the NOWPAP Region

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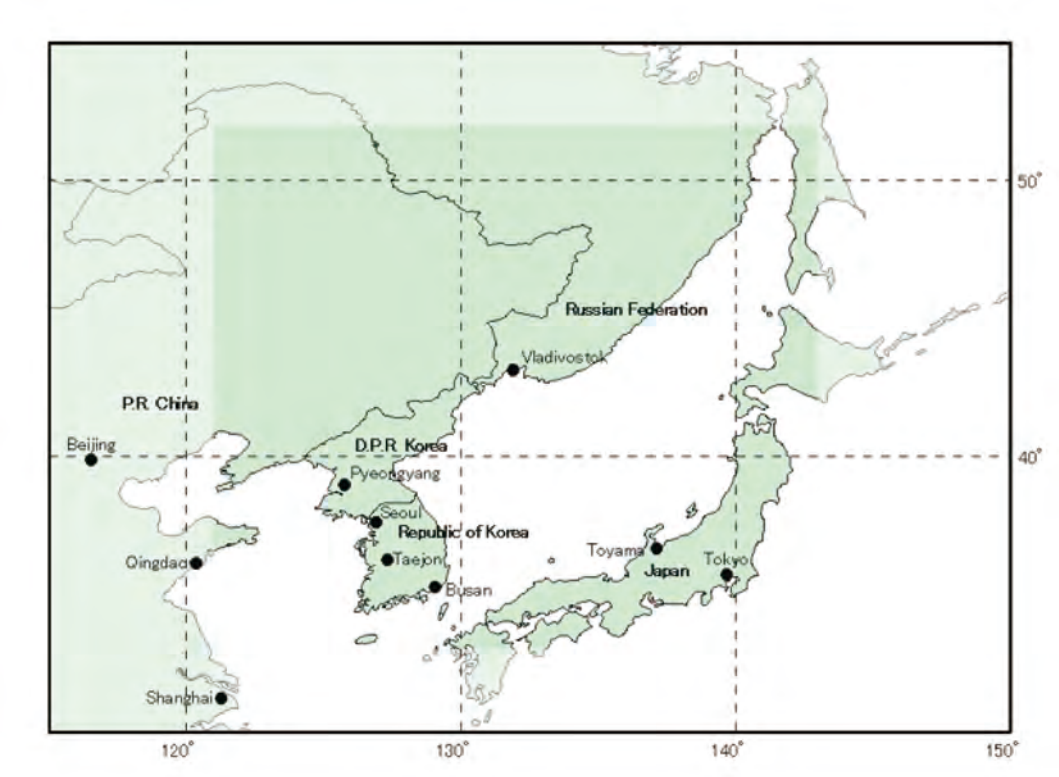
1. Introduction: marine invasive species (MIS) in the NOWPAP region

Biological invasions in marine environment represent a serious ecological and economic menace leading to biodiversity loss, ecosystem unbalancing, fishery and tourism impairment; they are lesser known aspect of global change and important phenomena as a result of an increasing number of unintentional invasions of marine organisms due to the release of ballast water through international shipping activities, and of increasing aquaculture purposes and for open sea fisheries enhancement (Carlton, 1992; Occhipinti-Ambrogi, Savini, 2003). Bioinvasions create so-called "novel" (or "emerging") 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. And they are relatively little studied (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 species, 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 and its subdivision, DINRAC (Data and Information Network Regional Activity Center) developed a proposal and then implemented a project on the marine invasive species (MIS) in the NOWPAP Region in 2009-2010 (Activity Q: Investigation on alien species and its potential damage evaluation in NOWPAP Region). This project was approved at the 8th NOWPAP DINRAC Focal Points Meeting in Beijing, the People's Republic of China (19 – 21 May 2009) with formation of the Working Group under leadership of Dr. Konstantin A. Lutaenko (Far Eastern Branch of the Russian Academy of Sciences, Vladivostok, Russia). The activity included compilation of four national reports and a regional overview. The present overview and four national reports are outcomes of the NOWPAP DINRAC MIS project and represent an important contribution to understanding of the MIS problem in the North-East Asia along with other regional international projects/activities by COBSEA, PICES and other relevant organizations and would increase visibility of the NOWPAP efforts in dealing with biodiversity issues in the region.



NOWPAP Region (http://cearac.nowpap.org/nowpap/coverage.html).

Hereafter, "Korea" means Republic of Korea, "China" – People's Republic of China, and "Russia" – Russian Federation.

2. Current status of the MIS within the NOWPAP region

Pathways (vectors and routes) of introduction of MIS to the country
Shipping and ballast waters

Shipping and ballast water release are the most important ways of introduction of marine organisms into the NOWPAP region.

In China, the microalgae brought by ballast water can trigger the occurrence of red tide. In April 2005, several important red-tide algae were detected in samples of ballast water sediments by Xiamen Inspection and Quarantine Bureau (Guandong), which confirmed the speculation that the occurrence of red tide is in relationship with the alien planktonic algae carried by ballast water.

In Japan, "Otani (2004) reported that rich marine invasive species were found on ship hull and in sea chests. He estimated that about 44% of exotic marine species in Japan were brought with hull fouling."

In Russia, the rate of species distribution by means of vessels with different regimes of

exploitation depends primarily on the intensity of the maritime traffic and the availability of harbours 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 favours introductions of alien species through fouling communities and release of ballast waters. It is believed that more than 1 million tons of ballast waters release into Peter the Great Bay every year. There are two major vectors of introductions of different taxonomic groups of organisms into the Russian NOWPAP waters – Asian and Trans-Pacific.

Intentional introductions

In the1980's, to protect beaches, promote deposition, and open sea ranching, China introduced the English cordgrass (Spartina anglica) from Denmark, the Netherlands and the United Kingdom to retaining 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 (Spartina alterniflora) originated from southeast coast of the USA was introduced into China for retaining solid shore beaches. Recently, smooth cordgrass has gradually evolved into the main MIS to the China's coastal belt and became a serious environmental and economic threat. In Japan, 21 exotic species among 49 marine and brackish water animal species or higher taxa that had brought into the Japanese waters were reported to be introduced intentionally for commercial selling or fishery studies, and three species were unintentionally released with other commercial animals. There are no data for intentional introductions of alien species to Korea and to the Russian part of the NOWPAP Region.

Aquaculture

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, but few breeding species can bring enormous economic benefits. Failed introductions of alien marine organisms could be potential dangers to the marine environment of China.

Since seed stock of fishes and shellfishes have been introduced to Japan from foreign countries, especially from China, Taiwan 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 animals. Okoshi (2004, 2007) listed 22 animal species found in sacks of the imported Manila clams Rudtapes philippinarum which were released to tidal flats in northern Honshu.

All aquaculture practices in the Russian NOWPAP Region are based on local species, and there are no evidences of intentional of marine organisms.

3. List of the MIS within the NOWPAP region

3.1. Lists/species compositions of the MIS in the NOWPAP region

The detailed taxonomic lists of benthic organisms for all four countries are provided in each national report. As we can see from the reports, 14 benthic species are known from China coast, 22 – from Korea, 29 species – from Japan, and 37 species – from Russia. Less number of species of introduced planktonic organisms are known in the NOWPAP Region (see Table), but there is a problem of recognition of true invasive species in plankton. One to six nektonic and nektobenthic species were found in the NOWPAP Region, mostly fishes, but, again, it is difficult to regard them for sure as "established populations".

Table: The number of MIS in the NOWPAP Region by country

	China	Japan	Korea	Russia
Benthic species	14	29	22	37*
Planktonic	13	1	13	4
Nektonic and nektobenthic	?	1	6	4**

Notes: * According to Yu.A. Zvyagintsev (pers. comm.), the number of introduced benthic species might be about 60 but there are no published data;** 55 species of southern fishes are known from Russian waters.

3.2. Potential (expected) MIS in the NOWPAP sea area

According to the Seo and Lee (2009), there are 136 species suspected to be invaders in Chinese and Korean coastal waters. In case of Japan (Otani, 2004), over 40 marine invasive species have been recognized. Therefore, more than 180 species may have been expected as MIS in the NOWPAP region. During the later half of the 20th century, 7 to 8 new exotic marine species have been recorded every decade in the Japanese coastal waters. Fishery associated introduction of abroad marine species is an important vector for new introduction of the exotic species (Iwasaki, 2007).

In Russia, 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-scaled 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 favour aquaculture and fisheries. Kharin (2008) believes that one more species of sea turtle and seven more species of sea snakes may appear in the Russian part of the NOWPAP Region due to global warming.

4. Threats and impact of the MIS to native communities and ecosystems

4.1. Ecosystem changes (ecological)

In China, the genetic diversity of marine organisms is facing various threats. The MIS is the biggest threat to the genetic diversity because alien organisms can easily move to new environment through many channels, such as attached to ships hulls, in ballast waters, intentional introduction of alien species, etc. The MIS can hybridize with local species and compete with them which may affect or change the original genetic diversity. In recent years, China has introduced many alien species for aquaculture, such as prawn, turbot (Scophthalmus maximus), scallops (Argopectens irradias, Mizuhopecten yessoensis), and also carried out some cross-breeding experiments in different degree and extent. In Japan, the exotic species have caused large disturbances in native benthos genes and communities. Hybridization occurred between Mediterranean mussel Mytilus galloprovincialis and native Pacific mussel Mytilus trossulus mussels in northern Japan (Inoue et al., 1997) as well as in the Russian waters of the NOWPAP Region (Ivanova, Lutaenko, 1998). Possibility of genetic disturbance through hybridization or introgression was pointed out in some genetically close species such as crabs and bivalve mollusks. Exclusion by ecological pressure to native species by growth and abundance of the exotic species has been reported in Japan on the examples of the Mediterranean mussel M. galloprovincialis and striped barnacle Amphibalanus amphitrite. Ecosystem-based impact of marine bioinvasions on the ecosystem has not been studied in Korea.

One of the important consequences of the naturalization of invasive species in Russia - in Peter the Great Bay - is predominanance of new inhabitants over native species which lead 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 cirripeds from dominating macrobenthic species of the local fauna. Numerous settlements of the Mediterranean mussel Mytilus galloprinciallis with high population density in Peter the Great Bay provides an example of ecosystem alerations 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. In case of microalgae blooms caused by possible invasive phytoplankton species, the effect of oxygen-deficient water and eutrophication may lead to mass mortality of benthic animals and fishes. Large quantities of decomposing phytoplankton biomass are harmful for ecosystem

stability especially in semi-enclosed bays and estuaries. Development and prevalence of oxygen-deficient waters have been reported in most bays of Japan (Uzaki et al., 2003) and occasionally take place in Amursky and Ussuriysky bays in the Russian part of the NOWPAP region.

4.2. Economic impacts

In China, since 1993, shrimp virus disease started to spread on a large-scale in aquaculture, one major reason of which is the large-scale death of the bivalve mollusk Chlamys farreri introduced from Taiwan. In Korea, the Mediterranean mussel Mytilus galloprovincialis was introduced by ocean-going ships during the 1950s and this species spread along the shores of Korea and has become dominant over the regional species Mytilus coruscus. Most power plants in Korea are located along seashores and massive fouling by M. galloprovincialis throughout the inlet pipe to draw sea water makes the operation of power plants periodically stopped to eradicate mussel fouling. This process causes a lot of losses in terms of unnecessary labour and money. In Japan, the Chinese snail, Nassarius sinarus, has populated Ariake Inland Sea, Kyushu and feed on gobies captured in fishery traps (Fukuda, 2004). Alien sessile organisms such as mussels, M. galloporovincialis and Perna viridis, calcareous tube-building warms, Ficopomatus enigmaticus and Hydroides elegans, construct massive clusters on the hard substratum. They caused damage in the water pipes of electric generation plants and aquaculture nets (Iwasaki, 2005, 2006). Other examples of economic damages include out-break growth of H. elegans in oyster culture in Hiroshima Bay (fouling on oyster shells), catastrophic damage in Manila clam (Ruditapes philippinarum) fisheries in Sendai Bay, northern Honshu by the predator, the moon snail, Euspira frotunei, unintentionally introduced from China. In Russia, biofouling of ships, piers, buoys and other hydrotechical 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. galloprovinciallis which became an abundant component of biofouling in Peter the Great Bay (Ivanova, Lutaenko, 1998) as well barnacles may damage aquaculture installations but, at the same time, this mussel and its hybrids with local allied species Mytilus trossulus are perspective object of aquaculture. Conditionally pathogenic and toxinogenic mycelial fungi which are able to induce mycoses and mycotoxicoses of invertebrates and fishes were isolated from ballast waters of ships in Vladivostok Port (Zvyagintsev et al., 2009).

4.3. Public health impacts

Up to now, no systematic health risk assessment research of MIS is carried in China. No evidence associated with public health caused by exotic marine species has been reported in Japan. However, Iwasaki (2007) stated that unintentional introduction of human-parasite trematode Paragnimus westernmanii with the intermediate host, the Chinese mitten crab Eriocheir sinensis, should be dangerous. In Korea, mariculture can serve as a vector for

transfer of alien pathogens. Indigenous shrimp culture farming has been seriously damaged by the White-Spot Syndrome Virus (WSSV) by 28.4% of shrimp farms in Korea during 2004. Similarly, human papillomavirus (HPV) was recently found in 76% of shrimp farms, and is spreading gradually around the world. 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 (Orlova et al., 2009). The impact of algal blooms might be related to fish and shell-fish 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.

5. Prevention, detection and management of MIS

5.1. National and regional authorities dealing with MIS monitoring

In China, the prevention, detection and management of the MIS are primarily done by the State Oceanic Administration, the Ministry of Agriculture, Ministry of Transport, Maritime Bureau and State General Administration of Quality Supervision. In Korea, Korea Ocean Research and Development Institute (KORDI) is responsible for the part of the project "Development of Port Environmental Risk Assessment Technology" which is aimed in consistent monitoring of the port environment, ecosystem and alien species. This project consists of environmental and biological monitoring of the port and ballast waters, set-up of environmental and biological parameter's database of port and ballast waters, establishment of information for a ship's routes and ballast water and set-up of integrated management for risk analysis. The Ministry of Land, Transport and Maritime Affairs of Korea (MLTM) implements the project "Study on the Management of Marine Invasive Species" which aims to set up integrated management method of marine invasive species for the conservation of marine diversity. In frames of the project, investigations to find out the current status of invasive species have been carried out in the coastal ports and trading ports adjacent to industrial complexes, and in Jeju Island, and potential foreign species were listed through a taxonomical analysis of 10 major ports. In Japan, the Council of Marine Exotic Species Study (CMESS) in the Japanese coastal waters was organized in 2009 by three aquatic science associations, the Japanese Society of Phycology, the Plankton Society of Japan, and the Japanese Association of Benthology. The group would report annually results of the analysis of exotic marine species. In Russia, the federal government has not created a centralized agency that has had the necessary resources or the authority for nimble management of introduced species. The only research lab, Center for Monitoring of Marine Bioinvasions and Ballast Waters belonging to

the A.V. Zhirmunsky Institute of Marine Biology, Far Eastern Branch of the Russian Academy of Sciences (IMB FEB RAS) is responsible for MIS monitoring in the NOWPAP Region.

5.2. Existing control and preventive measures, including status and risk assessments

China. Pest Risk Analysis (PRA) is a process of investigation, evaluation of information and decision making with respect to a certain pest; it includes three aspects: Pest Risk analysis for start-up; Pest Risk assessment; Pest Risk Management. In 1990, the concept of PRA was formally introduced into China, after ten years, China's first PRA institutions, the "PRA Office" was formally established by the plant and animal laboratory approved by the State Administration of Quality Supervision, Inspection and Quarantine. The Ministry of Agriculture and some agricultural colleges and universities have begun to work in PRA. PRA has become the backbone of China's animal and plant quarantine policy. Another action is Risk Assessment of China Global Ballast Water Management Project. In September 2002, Risk Assessment Implementation Team was formed by the experts from the Liaoning Maritime Bureau, Dalian Maritime University and Institute of Marine Environmental Protection. Through the simulation analysis of multi-environmental variables and the study of ship's loading and discharge mode of ballast water, the risk assessment team judged the risk of the MIS with ballast waters. At present, similar risk assessments of ballast water have been launched in many ports of China.

The State Oceanic Administration of China also increases its efforts to monitor red tides. Up to now, 33 red tide monitoring zones have been established in the national key areas. The National Red Tide Monitoring Network was established with support of national and local governments and scientists and carried out monitoring activities by using such advanced technologies and equipment as ocean satellites, maritime surveillance aircrafts, ships and shore-based stations.

In Korea, a prototype program of ballast water risk assessment was first made by Korea Ocean Research and Development Institute (KORDI) in 2009. The program was established based on the GloBallast program initiated by International Maritime Organization (IMO) and conducted by relative overall risk assessment. Korea also considers the species-specific risk assessment, environmental matching risk assessment and species' biogeographically risk assessment which were outlined in G7 for assessing the risks in relation to granting an exemption in accordance with regulation A-4 of the Ballast Water Management Convention.

There are no special control and prevention at present with regard to MIS in the Russian part of NOWPAP region. International Convention for the Control and Management of Ships' Ballast Water and Sediments was not ratified by Russian Federation. Administration of the Vladivostok Port under the auspice of Federal Agency of Marine and River Transportation started recently to collect and analyze data on ballast waters of ships entering the port (Zvyagintsev et al., 2009).

5.3. Existing databases used for monitoring, control and prevention

Chinese Government has established a number of databases for the control and management of the MIS: 1, China Invasive Species Database (http://www.biodiv.org.cn/ias/index.htm) was established by the Nanjing Institute of Environmental Science, National Environmental Protection Ministry and it records the details of all the alien species discovered in China's land territory and marine area; 2, The information database of the China alien marine species (http://bioinvasion.fio.org.cn); it consists of two basic databases: alien marine species database and alien marine invasive species database. In Japan, there is no available database for marine exotic species. Working group 21 (WG21) in PICES which was founded by the Government of Japan has started to develop global database system for marine invasive organisms; activities of the WG21 will end in 2012, but the database system will be established by 2011. The Government of Japan contributed 925,000 Canadian dollars for the PICES to support establishment of global database system for the MIS. In Korea, Korea Ocean Research and Development Institute (KORDI) is building a MIS-related database as a part of the initiative "Development of Port Environmental Risk Assessment Technology", and the Ministry of Land, Transport and Maritime Affairs (MLTM) is preparing a list of marine alien species and their characteristics as a part of the project "Study on Management of Invasive Species in Marine Ecosystem". The local database on the MIS in the Russian Far Eastern seas is currently under construction in the Institute of Marine Biology FEB RAS (Vladivostok) as an initiative of the Center for Monitoring of Marine Bioinvasions and Ballast Waters but it is not available in the Internet yet. There are four databases on invasive plants, insects, fishes and mammals managed as a part of the national project "Alien Species on the Territory of Russia" (http://www.sevin.ru/invasive/dbases.html#) but they do not include marine species at present.

5.4. Future plans on monitoring, control and prevention

The Government of China needs to take following actions: 1, to establish the rules and regulations of the implementation on the MIS management system; 2, to strengthen the management of introduction of marine plants and animals; 3, to strengthen animal and plant quarantine measures; 4, to take measures to eradicate pests which have already been admitted; 5, establish the eco-environmental impact assessment procedures of MIS; 6, to make the management institutions of the MIS clear, and to establish appropriate advisory institutions; 7, to establish the risk assessment and risk management technology system on MIS; 8, to establish the MIS information systems; 9, to strengthen scientific research on management and monitoring of MIS; 10, to strengthen the education on MIS prevention, and raise public awareness; 11, to expand international cooperation on biological invasions.

In Japan, it could be implemented to regulate the importation etc. of alien species and to control them by designing them based on the IAS Act. The Council of Marine Exotic Species Study (CMESS) was also established in 2009 for annual analysis of the information on the marine exotic species in the Japanese waters.

In Korea, the Government needs to achieve the following aspects for the plans on monitoring, control and prevention: 1, establishment of law, regulations and guidelines for the implementation of MIS management system; 2, establishment of infrastructure (manpower, equipment, among others) for the monitoring, prevention and control of MIS; 3, to strengthen the port baseline surveys (environmental factors, pathogenic bacteria, plankton, benthic and sessile animals); 4, to strengthen the management of introduced marine organisms; 5, to strengthen the marine organism quarantine; 6, to strengthen the management and selection of target species of MIS which have already been admitted; 7, establishment the eco-environmental risk assessment procedures and database of MIS; 8, development of the detection and spreading prevention techniques of MIS; 9, development of rapid detection technology of harmful MIS by controllable inflow source (ballast water, ship bio-fouling, among others); 10, to strengthen R&D on management and monitoring of MIS; 11, establishment of the alarm system for emergency situations (increase of pathogenic bacteria, harmful (or toxic) organisms) related to MIS; 12, development of the general public education and information program of MIS; 13, establishment of MIS information system and network service.

In the Russian part of the NOWPAP Region, the following activities could be implemented: 1,baseline assessments of invasive species – as a part of biodiversity surveys; 2, analysis of risks/ pathways of MIS; 3, training; 4, awareness-raising; 5, development and implementation of management strategies for priority invasive species.

6. Current national and international research projects and other initiatives on the MIS in the NOWPAP region, including priority research fields, ongoing projects and initiatives

In China, research on MIS focuses on characteristics of MIS; relationship between alien species and native species, as well as the relationship between their communities; the impact of habitat changes to invasion. The Ministry of Environmental Protection and the Ministry of Agriculture supported relevant research institutions and universities to carry out risk analysis projects research to establish China's own risk assessment system of alien species. The Ministry of Environmental Protection and experts on MIS summed up economic losses and control costs of harmful diatoms and alien fish in China, which included both overall national research and regional case studies. Researches on ballast waters mainly focus on treatment technology research of ballast waters, dynamic testing system of ballast water exchange, ballast water testing standards and operating mechanism, mechanisms causing red tides. China started to establish the “National Marine Environment Monitoring Network” since the 1980s.

Current initiatives related to marine biodiversity and alien species in China include: 1, Census of Marine Life (CoML) (since 2000), Institute of Oceanology, Chinese Academy of Sciences, with support from Sloan Foundation. Two symposia were held in 2004 and 2005, and CoML China Committee was established as well as China Ocean BiogeographicInformation System (http://www.iobis.org.cn); 2, The ship ballast water management work (since 2000), Maritime Administration of the Ministry of Transportation;

as a result, national implementation team of ballast water project was set up; projects include security study and port biological baseline survey; 3, Ballast water risk assessment of China (since 2002), Ministry of Transport Maritime Bureau, Liaoning Maritime Bureau; results include determination of possible risk of the species introduction; undertaking appropriate measures to reduce the risk; study on the localization of risk assessment; preparatory work for implementation of the International Convention for the Control and Management of Ship's Ballast Water and Sediments; 4, Strong Ionization Discharge method for ballast water treatment (2003), Institute of Environmental Engineering, Dalian Maritime University; 5, The impact of MIS, risk assessment and application (since 2004); results include initial establishment of some databases on alien marine species, laws and regulations, research papers database, dynamic database of science and technology, foreign language research papers database; 6, The National Biological Species Resources Survey Project (since 2006), Ministry of Environment Protection. National taxonomy initiatives also resulted in publication of the book "Inventory Invasive Species in China" which describes the classification and distribution information of China's invasive alien species from the terrestrial, freshwater aquatic and marine ecosystems.

In Japan, the Council of Marine Exotic Species Study (CMESS) will analyze annually information on the exotic species collected by members of various associations and related scientists; some members of the CMESS also have been worked as members of the WG 21 in PICES. Rapid assessment for marine invasive species was conducted in western Seto Inland Sea in June of 2010. After the end of the WG 21 activity in PICES, there is no plan to initiate the taxonomical studies on the marine invasive species.

Priority research fields on the MIS in Japan may include study on restoration of marine environment including shore structure and water quality as the basic measure for recovery of the native marine communities because deterioration of natural ecosystems and changes of bottom structure could provide new habitats for marine invasive species; ecological studies on the effect of exotic species on native communities and ecosystems; and periodic monitoring on the occurrence of the exotic species at sites potentially available for appearance of alien species by cross-ocean ships or intentional release of fishery species for aquaculture.

In Korea, there are several projects/initiatives with regard to study and management of the MIS: 1, Development of port environmental risk assessment technology (Korea Ocean Research and Development Institute, KORDI); project PERAT (Port Environmental Risk Assessment Technology) began as a government program in 2007. The project was designed to develop the ballast water management program which controls the discharge of ballast water of ships entering the harbours of Korea; 2, Coastal Marine Biodiversity and Conservation project (IOC/WESTPAC). Term of References (TOR) of the sub-project on marine invasive speciesas a part of the project "Coastal Marine Biodiversity and Conservation" include: assessment of the status of non-indigenous species in the WESTPAC region; sharing information on accidental release cases and their ecological and economical consequence; compilation of a list of expertise and programs related to non-indigenous marine species, vectors etc.; development of a comprehensive Non-Indigenous Marine Species Database; alien species alert report; development of risk assessment guidelines; promotion of

the collaboration among WESTPAC member countries and between ICES, PICES, NaGISA, and other organizations/programs; and promotion of public awareness and education; 3, PICES WG 21 Rapid Assessment Surveys (RAS). Second RAS was conducted in October 2009 in Korea;the study sitesin Korea were Seogwipo Port and Seongsan sand beach in Jeju Island.

Priority research fields on MIS in Korea are port baseline surveys (environmental factors, plankton, benthic and sessile animals etc.); ship ballast water surveys (foreign invasive species, resting cells and eggs); aquaculture organisms surveys; ship bio-fouling organisms surveys; eco-environmental risk assessment of MIS.

In Russia,a number of research institutions are currently involved in the studies on MIS and biodiversity in the NOWPAP Region conducting annual field-works, collecting and monitoring biodiversity: 1, A.V. Zhirmunsky Institute of Marine Biology (IMB), Far Eastern Branch, Russian Academy of Sciences (FEB RAS); in 2008, the Institute established the only in the Russian Far Eastern Center for Monitoring of Marine Bioinvasions and Ballast Waters with aims to collect, process and analyze the information on marine invasive species and to transfer these data to the PICES database. During the last decade, the staff members of the IMB published two important books on marine fouling and bionvasions (Zvyagintsev A.Yu. 2005. Marine Fouling in the North-West Part of Pacific Ocean. Vladivostok: Dalnauka. 431 p.; Zvyagintsev A.Yu., Ivin V.V., Kashin I.A. 2009. The Methodical Advisories to Research of Ship Ballast Waters during Realization of Marine Bioinvasions Monitoring. Vladivostok: Dalnauka. 123 p.). A project supported by the APN (Asia-Pacific Network for Global Change Research) Marine Biodiversity of the Coastal Zones in the NW Pacific: Status, Regional Threats, Expected Changes and Conservation (ARCP2008-05CMY) with participation of three countries (Russia, China and Republic of Korea) was implemented by the IMB and included a significant portion on the MIS (website of the project: http://www.imb.dvo.ru/misc/apn/bio/index.htm); 2, V.I. Il'ichev Pacific Oceanological Institute (POI), Far Eastern Branch, Russian Academy of Sciences (FEB RAS); 3, Pacific Research Fisheries Center (TINRO-Center), Federal Agency of Fisheries; TINRO-Center carries on large-scale fisheries research including monitoring of fish migrations which is relevant to climatically-induced appearance of MIS; benthic surveys regularly conducted by this institution provide an important information on ecology and distributions of marine organisms and state of environment; 4,Far Eastern Regional Hydrometeorological Research Institute (FERHRI), Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet). Regular benthic surveys conducted by the FERHRI provide a necessary information on the state of communities including MIS; staff members of the institute participated in the APN projects on biodiversity in cooperation with the IMB; 5, Far Eastern National University (FENU), Ministry of Science and Education.

In 2008, a Russian national periodical devoted to problems of bioinvasions start was established - Russian Journal of Biological Invasions (ISSN 1996–1499, Russian version) with free download of papers (http://www.sevin.ru/invasjour/index_eng.html); English version is published by Springer (ISSN: 2075-1117, print version; ISSN: 2075-1125, electronic version).

National projects related to biodiversity and partly to invasive species include: 1,"Alien

Species on the Territory of Russia" (http://www.sevin.ru/invasive/, only in Russian); implemented by the Institute of Problems of Ecology and Evolution RAS with support of the Ministry of Education and Science of the Russian Federation and aims at public awareness raising, informing legislative organs and scientific community on the problems related to invasive species; coordination of the activities of specialists and relevant organizations in the invasive species; creation of the databases; 2, "Biota of the Russian Waters of the Sea of Japan"; implemented since 2004 by the A.V. Zhirmunsky Institute of Marine Biology FEB RAS and aims in publication of about 40 volumes of guide-books on the biota of the Russian waters of the NOWPAP region except the Yellow Sea; seven volumes were published until 2009; 3, "Biodiversity in Russia" (http://www.zin.ru/biodiv/index_e.html); began in 2002 by the Zoological Institute (ZIN) of the Russian Academy of Sciences (St.-Petersburg) with major objective to create a complex of software and databases for working on classification of animals and plants which would serve as a basis of information retrieval system (IRS) on the biodiversity of Russia, supporting heterogeneous collections of dispersed information resources containing systematic, collection and ecological information. Russia also participates in two international projects on MIS: 1, REABIC, The Regional Euro-Asian Biological Invasions Centre (REABIC, http://www.reabic.net), a virtual institute providing on-line information services in the area of biological invasions and biodiversity research and management;the REABIC is started in 2001 and since 2006 is serving also as an official publisher of Aquatic Invasions, (http://www.aquaticinvasions.net), an international journal on applied research on biological invasions in aquatic ecosystems; and 2, PICES Working Group on Non-Indigenous Aquatic Species (WG 21); there are two members of the WG 21 from Russia.

Priority research fields on marine invasive species in Russia include study on species composition, ecology and distribution of biofouling and countermeasures against ship fouling; taxonomic position of new invaders; ecological and environmental impacts of MIS; study on ballast waters, vectors of introduction of MIS; economic impacts.

7. Existing gaps in relation to the global and regional developments dealing with marine and coastal biodiversity, including invasive alien species

7.1. Compliance with relevant global conventions and agreements

Convention on Biological Diversity (CBD)

China has actively participated in preparation and negotiations on the CBD and was the one of the prior countries signing the convention. Since the CBD entered into force in 1993, Chinese Government has made great efforts to implement the convention, and carried out a series of actions for marine biodiversity conservation; namely, 1) Development of national strategy; the State Oceanic Administration and Ministry of Environmental Protection developed action plans for the protection of marine biodiversity, wetlands biodiversity, and special germplasm resources; 2) Strengthening the investigations of marine biodiversity,

public outreach and awareness raising; 3) Establishment of nature reserves; the Ministry of Environmental Protection, State Oceanic Administration, Ministry of Agriculture and local governments have established 72 marine nature reserves along the coast, 4) Information technology exchange and international cooperation; in recent years, China has carried out a number of multilateral cooperation with such international organizations as UNDP, UNEP, FAO, UNESCO, the World Bank and GEF, and some countries.

Japan. In 1993 Japan entered into the Convention on Biological Diversity, which led to the 1995 establishment of the first National Biodiversity Strategy Plan of Japan. The strategy has been reviewed and updated three times so far. Based on the strategies so far, the Ministry of the Environment began the establishment of the Strategy for Conservation of Marine Biodiversity. The Basic Act on Ocean Policy enacted in 2007 has described the conservation of marine biodiversity. And then, in 2008, the Basic Act on Biological Diversity was enacted. According to the Article 8(h) of the CBD, each contracting party shall prevent the introduction of, control or eradicate those exotic species which threaten ecosystems, habitats or species. In response to this convention, IAS Act ("Invasive Alien Species Act") was established in Japan in 2005 with the aim of preventing the adverse effects on ecosystem, human safety, agriculture, forestry or fisheries by alien species that have populated terrestrial, freshwater, brackish and marine water habitats in Japan.Japan has carried out a number of multilateral cooperation with such international organizations as UNDP, UNEP, FAO, UNESCO, the World Bank, GEF and CEPF (CEPF: Critical Ecosystem Partnership Fund), and some countries.

Korea ratified CBD in 1994 and joined Ramsar Convention in 1997. At present, various projects for documenting biological diversity and resources conservation are being carried out by Ministry of Education, Science and Technology, Ministry for Food, Agriculture, Forestry and Fisheries, Ministry of Environment. However, most of those efforts are devoted to terrestrial organisms, and there are very few action plans for conserving and monitoring diversity of marine organisms.

The CBD was ratified by the Russian Federation in 1995. In accordance with the Convention, the National Strategy of Biodiversity Conservation in Russia has been elaborated. Within the plans of development and realization of National Strategy of Biodiversity Conservation in Russia, the federal laws "On Specifically Protected Natural Territories", "On the Animal World", "On Fishery and Conservation of Water Biological Resources" and others were enacted. The law "On Aquaculture" is on the project stage. The law "On the Plant World" and other regulating the issues of biodiversity are being developed.

International Convention for the Control and Management of Ship's Ballast Water and Sediments

From 2000, China participated in projects of ballast water and sediments management. As the leading agency, China Maritime Safety Administration set up a national project implementation team and conducted a number of ballast water management projects in Dalian Port. The Republic of Korea deposited ratification of the Convention in December 2009. Russian Federation is not a party to the International Convention for the Control and Management of Ships' Ballast Water and Sediments. The systems of ballast water management

are not developed in the Russian seaports located in the north-west part of Pacific Ocean. Russia is also not a member of International Program "The Elimination of Barriers on the Way of Effective Realization of the Measures to Control and Manage Ballast Water in Developing Countries" (GloBallast Program), founded in 1999 with the participation of GEF, UNDP andIMO.

The Russian Federation has traditionally taken an active part in activities of international organizations partly dealing with biodiversity problems such as the United Nations Environment Programme (UNEP), the International Union for Conservation of Nature (IUCN), the United Nations Educational, Scientific and Cultural Organization (UNESCO), Food and Agriculture Organization of the United Nations (FAO), etc.

7.2. Status of expertise and capacity building as related to MIS research; taxonomic ability to identify MIS in member countries

In Japan, the number of taxonomists studying marine organisms is decreasing, because professional job positions are very limited in natural history museums, universities, and research institutes. Since the limited number of taxonomists exists, information on local marine faunas and floras is insufficient even for native species which include potential donors for future marine invasion around the world. Researches on the marine exotic species are basically conducted by personal or volunteer activities of marine taxonomists, ecologists and amateur naturalists. The Council for Marine Exotic Species Study (CMESS) collects information from specialists and amateurs who are interested in marine species.

Korea is going to establish a specialized research institute to control the introduction of harmful marine organisms via ship ballast water. The institute will conduct the following researches and studies: status of marine organisms in Korean ports and the nearby waters; designation of waters where ship ballast water injection is prohibited; prevention of introduction of harmful organisms due to ship ballast water; support for technology development of ship ballast water management; support for related international convention. The Korean Government is constructing National Institute of Marine Biological Resources and the construction is going to be completed by 2013. Also, KORDI is constructing Library for Marine Samples which is to be completed by 2012. However, there is a need to train more taxonomists and there is a lack of professional taxonomists for many animal groups in Korea.

In Russia, several institutions manage museum/research collections which form a basis for a long-term monitoring and taxonomic databases. The potential and taxonomic expertise of the institutions and specialists are high in Russian Federation which is manifested in numerous publications and biodiversity projects. Traditionally, biodiversity researches have strong development in Russia. Numerous publications and launch of new periodicals directly related to invasive species make it easier to exchange information, building databases and international involvement. However, there are few young generation taxonomists were trained in Russia for past two decades.

7.3. Future needs in capacity building (including training and equipment), public awareness raising, communication, compliance and enforcement

China. Chinese experts believe that following actions should be taken with regard to future needs: 1, to improve laws and regulations of alien invasive species; 2, to establish the risk assessment system of MIS; the environmental protection, agriculture, forestry, quality control, marine and other departments should join together in this effort; 3, to establish the early warning and rapid response system of MIS; 4, to carry on scientific research on MIS with emphasis tocomprehensive analysis of the distribution and the role of alien species; research on the mechanisms of invasive process, occurrence, development, etc.; building different risk assessment and management technology systems; establishment of the quarantine inspection system and the technology platform for environmental monitoring and prediction.

Japan. Establishment of a new monitoring system is required to understand current status of exotic marine species and also of native species which are potential invasive immigrants to other countries. Well-trained specialists are necessary to identify marine species; training of professional taxonomists in universities, natural history museums and research institutes is much in need.

Korea. The following actions should be taken with regard to future needs: 1, establishment by law regulations on management and control of marine invasive species; 2, early warning system and rapid detection of marine invasive species, and development of action plans; 3,construction of risk assessment system against marine invasive species (including ecological risk assessment, risk assessment of marine resources, risk assessment after human exposure); 4, preparation and distribution of a brochure including information about marine invasive species, action plans, and preventive measures; 5, planning for research activity for surveillance and management of invasive species.

Russia. The following needs in capacity building, management and public awareness raising exist in the Russian part of the NOWPAP Region which are common with other regions as identified by COBSEA Secretariat: 1, improvement of limited and incomplete information on the presence, impacts and pathways of marine invasive species; 2, training of personnel (managers, scientists, taxonomists, technical experts and enforcement officers); 3, raising of awareness of marine invasive species and their impacts, public outreach.

8. Legislation, programmes and responsible organizations related to marine and coastal biodiversity, including invasive alien species

China. There are 15 laws and regulations related in one way or another to biodiversity and alien species control and management; detailed descriptions of them are given in the national report. Here we enumerate these laws:

Entry and Exit Animal and Plant Quarantine Law of the People's Republic of China (hereafter PRC);

Frontier Health Quarantine Law of the PRC;
Animal Epidemic Prevention Law of the PRC;
Entry and Exit Animal and Plant Quarantine Regulations of the PRC;
Rules for the Implementation of Health and Quarantine Law of the PRC;
Plant Quarantine Regulations of the PRC;
Disease Prevention Ordinance of Livestockand Poultry;
Implementation Details of Disease Prevention Ordinance of Livestock and Poultry;
Animal Husbandry Law the PRC;
Fisheries Law of the PRC;
Seed Law of the PRC;
Marine Environmental Protection Law of the PRC;
Chartered Management Measures of Aquatic Wildlife Utilization;
Regulations on Prevention of Ships Pollution and Sea Management;
Management Measures on Entry-Exit Inspection and Quarantine of International Voyages.

The following five authorities in China are responsible for control/management of biodiversity/alien species-related issues: 1, Ministry of Environmental Protection (MEP); based on the "Marine Environmental Protection Law", the Ministry of Environmental Protection coordinates, supervises and guides the work on marine environmental protection, and is also responsible for the implementation of the Convention on Biological Diversity (CBD); 2, Ministry of Transport Maritime Bureau; this agency develops, organizes and implements national guidelines, policies, regulations and technical norms and standards to supervise and manage the national water safety, prevention of ship pollution, inspections of ships and marine facilities, and maritime security; supervises and manages the safety production conditions of the ship owners and water enterprise security management system; investigates and processes water traffic accidents, shipping accidents and water pollution cases; 3, State Oceanic Administration (SOA); the administration develops the plans and standards of marine environmental protection and remediation; develops standards and norms to control the total amount of sea-system pollutant emission; supervises the land-based pollutants emissions into the ocean, takes charge of the prevention of marine oil exploration and recovers the damage caused by marine pollution; manages the investigation, monitoring, surveillance and evaluation of the marine environment; monitors the marine biodiversity and marine ecological environmental protection; supervises and manages nature reserves and the special protected marine areas; 4, Central Administration of Quality Supervision, Inspection and Quarantine (CAQSIQ); this agency is responsible for implementation of the "Cross-Border Health Quarantine Law" and "Import and Export of Animal and Plant Quarantine Law"; 5, Fisheries Bureau, Ministry of Agriculture; the bureau is responsible for protection of environment of fishing grounds and aquatic wild animals and plants; safeguarding the fishing rights of the nation; drafting/preparation of laws and regulations of animal and plant epidemic prevention and quarantine, etc.

National legislation specifically addressing marine invasive alien species has not been established yet in China, however, most relevant law and regulations for management/control

of the MIS are “Entry and Exit Animal and Plant Quarantine Law of the PRC”, “Chartered Management Measures of Aquatic Wildlife Utilization”, “Regulations on Prevention of Ships Pollution and Sea Management”, “Management Measures on Entry-Exit Inspection and Quarantine of International Voyages” and “Frontier Health Quarantine Law of the PRC”.

Japan. National legislation includes the IAS Act (“Invasive Alien Species” Act). Under the International Convention for the Control and Management of Ship’s Ballast Water and Sediments, MLIT (Ministry of Land, Infrastructure and Transport) facilitates development of ballast water treatment system. Ministry of the Environment has started monitoring research on biodiversity, species compositions and abundances, in the local biotic community at selected 1000 monitoring sites (Monitoring Sites 1000) in terrestrial and aquatic environments in Japan (http://www.biodic.go.jp/moni1000/index.html).

Korea. No special legislation for the protection of marine biodiversity and marine bioinvasions has been established yet. The most relevant regulations and laws include: 1, legislation (No. 8045) to prevent marine ecosystem damages and marine biota decreases caused by indiscreet development activities and overfishing of marine organisms; 2, Provisional Regulation of Type Approval of Ballast Water Management System, the Act of Ministry of Maritime Affairs and Fisheries (MOMAF); 3, Law of Ballast Water Management (Law No. 8852) (to prepare integrated national strategies for the IMO Ballast Water Convention).

The Marine Ecology Division of the Ministry of Land, Transport and Maritime Affairs of Korea (MLTM) is in charge of the preservation and restoration of marine ecosystems,preservation of marine biological diversity, the security of marine biological resources and the safe management to threatening factors of marine ecosystem. The Maritime Technology Division of MLTM is in charge of the national strategies for ballast water management.

Russia. Russia has a large body of laws regulating biodiversity use and conservation. However, many of them are frame documents laying emphasis on natural resources and have to be realized through the introduction of additional legislative acts. Russian basic legislative acts and their by-laws are enumerated below and described in detail in the national report:

The federal law of the Russian Federation “On the Conservation of the Environment” N 7-FZ;

The federal law of the Russian Federation “On Specifically Protected Natural Territories” N 33-FZ;

The federal law of the Russian Federation “On the Animal World” N 52- FZ;

The federal law of the Russian Federation “On Fishery and Conservation of Water Biological Resources” N 166-FZ;

The federal law of the Russian Federation “On Ecological Expertise” N 174- FZ;

The federal law of the Russian Federation “On Government Regulation in the field of Gene and Engineered Activity” N 86-FZ;

The federal law of the Russian Federation “On Hunting and Conservation of Game Resources and on Amending Specified Legislative Acts of the Russian Federation” N 209-FZ;

Water Code of the Russian Federation N?74-FZ;

The federal law of the Russian Federation "On the Internal Waters, Territorial Sea, and Contiguous Zone of the Russian Federation" N 155-FZ;

The federal law of the Russian Federation "On the Continental Shelf of the Russian Federation" N 187-FZ;

The federal law of the Russian Federation "On the Exclusive Economic Zone of the Russian Federation" N 191-FZ;

Decree of the President of the Russian Federation "On State Strategy of the Russian Federation on the Environmental Protection andSustainable Development" N 236;

Decree of the President of the Russian Federation N 440 "On Concept of Transition of the Russian Federation to sustainable use";

"The Regulations on State Control ofEnvironmental Protection(The State Ecological Control)" approved by Resolution of the Government of the Russian Federation N 53;

"The Regulations of Impact Assessment of Projected Economic and Other Activity on the Environment in the Russian Federation", approved by Order of the State Committee of the Russian Federation on Environmental Protection N 372;

"The Regulations of Formation of Fisheries Protected Areas" approved by Resolution of the Government of the Russian Federation N 603;

"The Regulations of Determination of Fisheries Conservation Areas" approved by Resolution of the Government of the Russian Federation N 743;

"The Order of Recognition of Territories under Special Use Conditions as the Fisheries Conservation Areas and Fisheries Protected Areas" approved by Order of the Federal Agency for Fishery of the Russian Federation N 86.

In the Russian Federation, the following federal executive bodies perform functions on ensuring the sustainable nature management and conserving and rehabilitating the nature and natural biological diversity: 1, the Ministry of Natural Resources and Environmental Protection of the Russian Federation; it is basic federal executive body performing the functions on drafting the state policy and normative and legal regulation in the sphere of the environmental protection and conservation including the specifically protected natural areas as well as in the sphere of study, use, regeneration, and conservation of wildlife resources and their habitat; 2, the Federal Supervisory Natural Resources Management Service; a federal executive body performing control and supervision functions in the sphere of nature management; 3, The Federal Agency for Fishery of the Russian Federation; it is a federal body of executive authority performing functions on draft and exercise of state policy and legal regulation in the sphere of protection, rational use, research, preservation, and reproduction of marine living resources and their habitat, excluding marine resources in specifically protected natural territories of federal importance and listed in the Red Book of the Russian Federation.

There are no the specific acts of legislation aimed at solving the issues of invasion of alien species. A national strategy for alien species is not developed.? However, at least, eight laws and regulations among enumerated above mention the alien invasive species problem and management. Moreover, The Environmental Doctrine of the Russian Federation considers the control of use and distribution of alien species and genetically modified organisms as

one of the priority directions of activity in providing the environmental safety of Russia, and The Strategy for Conservation of Rare and Endangered Species of Animals, Plants, and Fungi determines the development and realization of measures for prevention of uncontrolled distribution of alien invasive species andelimination of the invasion consequences as well as for prevention of penetration of living genetically modified organisms in natural environment and their further hybridization with populations conserved as the main means of conservation of rare and endangered species in natural habitats at a population level.

9. Recommendations for decision–makers in terms of priority national actions, services and products

China. Chinese experts propose the following recommendations and actions with regard to MIS problem in the NOWPAP region: 1, to establish the special laws and regulations of MIS as soon as possible, realize the legal management of MIS; to establish the special regulations for the management of MIS, and define rights and responsibilities clearly; 2, to strengthen institution-building, research capacity building and to improve the multi-sectoral coordination and management mechanisms; to establish an inter-departmental leading group for MIS management, to coordinate the joint work of various departments/agencies, and to improve the management efficiency; 3, to strengthen the building of management system for MIS; to establish the scientific risk assessment system and implementation procedures; 4, to carry on appropriate measures of prevention, elimination, control and restoration for introduction of MIS; to take effective control measures in ports, strengthen the quarantine and inspection to the harmful marine alien species; rapid response, combination of methods of mechanical eradication, chemical control, and biological control are much in need; 5, to carry on scientific research, and provide a scientific basis for the management of MIS; to strengthen the research on MIS biology, ecology, and control measures, to establish invasive species databases; 6, to develop education and training programs to raise the public awareness; to promote public propaganda and education to raise public awareness of ecological protection.

Japan. According to Japanese experts, effective measures against MIS at the national level should include: 1, decrease of import of living marine animals from foreign countries; 2, quick eradication of the exotic species at the initial site before they may establish a core population should be planned to prevent spread of MIS to other Japanese waters; 3, detection of the occurrence of new exotic species in the early stage after the introduction is very important; 4, monitoring surveys to find MIS in international ports and aquaculture sites should be regarded as essential to prevent further introduction.

Korea. Korean experts propose the following actions with regard to MIS management: 1, establishment of special laws and regulations for effective management of MIS including establishment of MIS management system and step-by-step management procedures, ecological risk assessment of alien species; establishment of national MIS management database and network, and organization of national MIS management committee (council); 2, promotion of MIS research projects with emphasis to MIS status, monitoring, preparation

of list of species, understanding the pathways of introduction, MIS eradication, prevention of spreading, control-related studies and studies on the standards and ways for selecting MIS; 3, enhance national education, public outreach and raising awareness of MIS including a) study, education and distribution of knowledge for MIS prevention; b) to educate people and make available basic information/rules on alien species and pathways of introduction due to increased international exchange; c) to raise awareness of ecosystems changes conservation in connection with MIS management and control; d) to provide knowledge for general public on consequences of the MIS mismanagement and poor control; 4, establishment of a MIS-related international cooperative system that allows NOWPAP countries to exchange information and share their research findings and management experience; a close cooperation with international organizations and programs (e.g., Global Invasive Species Information Network, IUCN, CBD) should be developed.

Russia. Recommendations and actions on MIS problems for decision-makers can be summarized as follows: 1, improvement of legislation for conservation and management of natural environment; it includes the elimination of contradictions between the legislation for natural resources and conservation, and also between legislation regulations in other fields; adjusting the legislation of the Russian Federation on environmental protection in accordance with international conventions and international treaties; there is an urgent need for enacting the federal law "On Aquaculture" including the regulations for artificial reproduction of water biological resources and their acclimatization; 2, ratification of the International Convention for the Control and Management of Ships' Ballast Water and Sediments; it is necessary to develop the system of control and management of ballast water at the legislative level (development of the control system to manage the ballast water aboard the ship; organization of the system to control and manage ballast water in the ports; monitoring of the marine environment over the ballast's discharge and exchange areas). At large, the legislation should be developed on the basis of the ecosystem approach and biological principles of biodiversity conservation; 3, to improve work of authorized agencies for conservation, monitoring and management of natural resources, ecological expertise, environmental protection, and other governmental bodies (customs, public prosecution, internal affairs, and security agencies) directly responsible for biodiversity conservation as they act inefficiently and in an uncoordinated manner; 4, to develop integrated organizational, technical, economical, and ideological support of the unavoidability of punishment for breaking the environmental laws and injuring the damage to nature; 5, to establish and develop inter-agency cooperation between ministries, Russian Academy of Sciences, regional bodies and applied research institutions; 6, strengthening international cooperation, development of joint programs and projects; 7, improvement of capacity building and training of students and young scientists in taxonomy of marine organisms at all levels (universities, academic, funding agencies); 8, public awareness raising on MIS problem, ballast water management, biofouling; publication and distribution of posters, booklets and popular biodiversity guide-books.

10. Conclusions and general recommendations for future NOWPAP activities

The present overview shows that the problems related to the MIS in the NOWPAP region are ones of the most important issues with regard to biodiversity changes and management. MIS appearance, establishment and expansion impact ecosystems, economy and public health. There is insufficient information about MIS at both national and international levels, and there is no international coordination in research and management of the MIS in the NOWPAP region. Legislation system often does not deal directly with marine alien species although there is a number of laws and regulations on biodiversity management touching this issue to some degree, especially in China and Russia. There is still no comprehensive database on the MIS in the North-West Pacific area. The present regional overview and four national reports are the first efforts to describe and summarize MIS issues in a complex manner in the NOWPAP region. However, future activities of the NOWPAP are recommended as desirable.

1. There is a strong need to organize a joint China-Japan-Russia-Korea workshop or conferenceon MIS problems under auspice of the NOWPAP RCU and to share available information and to discuss future activities of the NOWPAP in this field.
2. Training course and on-site field observations on MIS with involvement of young scientists may be held as one of the NOWPAP actions in one of the members countries.
3. Preparation of flyers, posters, and booklets in Chinese, Japanese, Korean and Russian languages for general public are of crucial importance in terms of public outreach and education.
4. Bibliographic database with full bibliographic descriptions, in a most complete and full manner, including abstracts is proposed to be constructed. It would be an extremely useful tool for scientists, decision-makers and even general public. Moreover, the database should include (whenever possible according to international copyright) pdf copies of papers thus representing a first collection of pdf copies of papers on MIS in the region and serves as an electronic library resource for future work. This activity would complement the PICES database.
5. A book or atlas containing data/information, images and other relevant information on the MIS may be prepared by joint efforts of the member countries in four languages. It may summarize major species and basic information. A series of such atlases was published, for instance, for the Mediterranean basin.

11. References

Note: Main sources of the overview are: National Reports on Marine Invasive Species (MIS) in the NOWPAP Region (China, Japan, Korea and Russia), websites of related agencies, institutions and organizations, published literature information. References cited in the overview are enumerated below in alphabetical order.

Carlton J.T. 1985. Transoceanic and interoceanic despersal of coastal marine organisms: the biology of ballast water. Oceanography and Marine Biology: An Annual Review. V. 23. P. 313-371.

Carlton J.T. 1992. Introduced marine and estuarine mollusks of North America: an end-of-the-20th-century perspective. Journal of Shellfish Research. V. 11, N 2. P. 489-505.

Carlton J.T. 1996. Marine bioinvasions: the alteration of marine ecosystems by nonindigenous species. Oceanography. V. 9, N 1. P. 36-43.

Fukuda H. 2004. Alien species and the labyrinths hindering their identification. Japanese Journal of Benthology. N 59. P. 68-73.

Hobbs R.J., Arico S., Aronson J. et al. 2006. Novel ecosystems: theoretical and management aspects of the new ecological world order. Global Ecology and Biogeography. V. 15. P. 1-7.

Inoue K., Odo S., Noda T., Nakao S., Takeyama S., Yamaha E., Yamazaki F., Harayama S. 1997. A possible hybrid zone in the Mytilus edulis complex in Japan revealed by PCR markers. Marine Biology. V. 128. P. 91-95.

Ivanova M.B., Lutaenko K.A. 1998. On the distribution of Mytilus galloprovincialis Lamarck, 1819 (Bivalvia, Mytilidae) in Russian Far Eastern seas. Bulletin of the Institute of Malacology, Tokyo. V. 3, N 5. P. 67-71.

Iwasaki K. 2005. Impacts of introduced marine organisms on native ecosystems, fisheries and other industries in Japanese waters. Journal of Japan Society on Water Environment. V. 28. P.598-602.

Iwasaki K. 2006. Exotic sessile animals and Invasive Alien Species Act. Sessile Organisms. V. 23. P. 13-24.

Iwasaki K. 2007. Non-indigenous organisms introduced in Japanese waters and theirimpact on native ecosystems and industries. Nippon Suisan Gakkaishi. V. 73. P. 1121-1124.

Kharin V.E. 2008. Reptilians. In: A.V. Adrianov (Ed.). Biota of the Russian Waters of the Sea of Japan. Vol. 7. Vladivostok: Dalnauka. 169 p.

Occhipinti-Ambrogi A., Savini D. 2003. Biological invasions as a component of global change in stressed marine ecosystems. Marine Pollution Bulletin. V. 46. P. 542-551.

Okoshi K. 2004. Alien species introduced with imported clams: the clam eating moon snail Euspira fortunei and other unintentionally introduced species. Japanese Journal of Benthology. N 59. P. 74-82.

Okoshi K. 2007. Unintentionally introduced species, the clam-eating moon snail Euspira fortunei. Nippon Suisan Gakkaishi. V. 73. P. 1129-1132.

Orlova T.Yu., Stonik I.V., Shevchenko O.G. 2009. Flora of planktonic microalgae of Amursky Bay, Sea of Japan. Russian Journal of Marine Biology. V. 35, N 1. P. 60-78.

Otani M. 2004. Introduced marine organisms in Japanese coastal waters, and the process involved in their entry. Japanese Journal of Benthology. N 59. P. 45-57.

Ovsyannikova I.I. 2008. Barnacles in benthic communities of the inner part of Amursky Bay (Sea of Japan). In: K.A. Lutaenko and M.A. Vaschenko (Eds.). Ecological Studies and the State of the Ecosystem of Amursky Bay and the Estuarine Zone of the Razdolnaya River (Sea of Japan). Vladivostok: Dalnauka. P. 207-222.

Seo K.S., Lee Y. 2009. A first assessment of invasive marine species on Chinese and Korean coasts. In: G. Rilov and J.A. Crooks (Eds.). Biological Invasions in Marine Ecosystems. Ecological Studies 204. Berlin, etc.: Springer. P. 577-585.

Sokolovsky A.S., Sokolovskaya T.G., Epur I.V., Azarova I.A. 2004. Centennial changes in composition and abundance of ichtyofauna of the northwestern Japan Sea. Izvestiya (Bulletin of) TINRO. V. 136. P. 41-57.

Uzaki N., Kai M., Aoyama H., Suzuki T. 2003. Changes in mortality rate and glycogen content of the Manila clam Ruditapes philippinarun during the development of oxygene-deficient waters. Fisheries Science. V. 69. P. 936-943.

Zvyagintsev A.Yu. 2003. Introduction of species into the northwestern Sea of Japan and the problem of marine fouling. Russian Journal of Marine Biology. V. 29, Suppl. 1. P. S10-S21.

Zvyagintsev A.Yu. 2005. Marine Fouling in the North-West Part of Pacific Ocean. Vladivostok: Dalnauka. 431 p.

Zvyagintsev A.Yu. 2007. The role of bionvasions in the dynamics of anthropogenic and natural ecosystems and formation of biological resources in the Far-Eastern seas of Russia. In: V.G. Tarasov (Ed.). Dynamics of Marine Ecosystems and Modern Problems of Conservation of Biological Resources of the Russian Seas. Vladivostok: Dalnauka. P. 195-222.

Zvyagintsev A.Yu., Ivin V.V., Kashin I.A. 2009. The Methodical Advisories to Research of Ship Ballast Waters during Realization of Marine Bioinvasions Monitoring. Vladivostok: Dalnauka. 123 p.

National Report of China on Marine Invasive Species in the NOWPAP Region

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1. Introduction: marine invasive species (MIS) in China

China is a big coastal country, which has 18,000km mainland coastline ,more than 65000 islands the area of which beyond 500m^2, and about 30,000,000km^2 sea area under the jurisdiction. China marine area crosses 38 latitudes and 3 temperature zones, which makes the rich and unique marine ecosystems diversity of the country. At the same time, such features make the country more vulnerable to invasive species, because many alien species all around the world are likely to find their suitable habitat in China. In the past decades, the rapid development of China's economy has brought the great development of trade and transport system, as well as the increase of people's entering and leaving the country, which exacerbated the introduction of alien species. In recent years, the spread of alien species are accelerated because of multiple factors such as large scale mariculture, the fish flow as fresh product in the world, ornamental fish in the aquarium husbandry, extensive exchanges of invertebrates and algae, shipping (especially the ship ballast water) and so on.

Northwest Pacific region refers to the marine region surrounded by many countries such as China, Korea, Japan and Russia which belongs to the temperate climate, while with a heavy shipping and traffic situation every year. According to statistics, in recent years, there are about 30 major marine invasive species(hereinafter with MIS) recorded in the Northwest Pacific region, and China's marine ecosystem located in the Northwest Pacific coast are also effected by biological invasion.

2. Current status of the MIS in China (within the NOWPAP region)

2.1. Pathways (vectors and routes) of introduction of MIS to China

2.1.1 Shipping and ballast waters

The most common medium of the MIS is shipping and the ship's ballast water. According to the recent research: there are about 10 billion tons of ballast water onboard emissions every year in the word and more than 500 kinds of species living with ballast water around the world are confirmed. Some experts believe that once the MIS come to a new suitable water environment, the loss control of reproduction would occur, and that may result in the large-scale spread of harmful parasites and pathogens, which will endanger the native species.

In addition, the red tide organisms brought by ballast water can trigger the occurrence of red tide, because these algae have a huge amount of population and a strong reproductive ability, once the environmental conditions are right, they will grow and even breed a large number of individuals, then cause red tide. In April 2005, several important red-tide algae were detected in two samples of ballast water sediment by Xiamen Inspection and Quarantine Bureau (Guandong, China), which confirmed the speculation

that the occurrence of red tide has a relationship with the foreign planktonic algae carried by ballast water.

2.1.2 Intentional introductions

Intentional introduction is one of the main channels of invasive alien species. People usually introduce the alien species into the country for economical or ornamental purposes such as the introduction of domestic species, but due to mismanagement or lack of prior risk assessment, these alien species can easily become over-breeding and out of control, which will cause great harm to the marine ecosystems and habitat biodiversity. In the1980's, in order to protect beach berm, promote deposition, and open sea ranch, China introduced the English cordgrass (Spartina anglica C.E. Hubb) from Denmark, Netherlands and the United Kingdom to retaining solid-shore beaches. But in recent years due to mismanagement, the English cordgrass have spread out of the original introduction sites, formed their dominant community in wild and supplant other local plants, which became a threat to local biodiversity. In 1979, Smooth cordgrass (Spartina alterniflora Loisel) which originated in southeast coast of USA was introduced into China for retaining solid shore beaches and achieved a certain economic benefits at first .However, in recent years Smooth cordgrass has gradually evolved into the main MIS to the China's coastal belt, because this Smooth cordgrass with a huge amount can threaten the coastal ecosystem, destroy the coastal habitat, effect mariculture, plug the channel, result in deterioration of water quality and induce red tide which prevents the departure of vessels.

2.1.3 Aquaculture

Aquaculture is an important way leading to the invasive of alien species. As a breeding species escape to the natural environment because of the absence of effective management or introduction fails, will do harm to the local biota species and further have a negative effect on the local agricultural economy. So far, China has introduced at least ten species of fish, two kinds of shrimp, nine kinds of shellfish, one species of echinoderms, four kinds of algae in mariculture, but few breeding species can form the industrialization of mariculture and bring enormous economic benefits, however the failed introduction of alien marine organisms could be potential dangers to the marine environment of China. For example, one kind of urchin used to be introduced from Japan into northern China, then escaped from breeding cage into the natural marine environment and became a huge threat, because this alien species can not only bit the root of the algae and destroy the submarine seaweed beds, but also compete with the local S. nudus (Stronglocentrotus nudu) for food and space, and endanger the survival of indigenous urchin.

2.2. List of the MIS in China (with brief notes on local distribution)

2.1.1. Planktonic

NO.	English Name	Latin Name	Distribution
1	Red ormer	(Haliotis rufescens)	Coastal waters near Shandong and Liaoning Province
2	Big oyster	Crasostrea gigas	Most of the nation's coastal areas, Guangdong and Fujian Prov. are more.
3	Bbarnacles	B. eburneus	Most of the nation's coastal areas
4	Bbarnacles	B. improvisus	Most of the nation's coastal areas
5	Bbarnacles	B .amphitrite	Most of the nation's coastal areas
6	Ciona intestinalis	Ciona intestinalis	Most of the nation's coastal areas
7	Molgula manhattensis	Molgula manhattensis	Most of the nation's coastal areas
8	Styela canopus	Styela canopus	Most of the nation's coastal areas the south part has a larger volume
9	Barnacles	Balanus spp.	Most of the nation's coastal areas
10	Barnacles	Balanus spp.	Most of the nation's coastal areas
11	Barnacles	Balanus spp.	Most of the nation's coastal areas
12	Bryozoan	Bryozoan	Most of the nation's coastal areas
13	Sea squirt	Ciona intestinalis	Most of the nation's coastal areas
14	tunicate	Molgula manhattensis	Most of the nation's coastal areas

2.1.2 benthic

NO.	English Name	Latin Name	Distribution
1	Diatoms	Chaetoceros concavicornis,	Most of the nation's coastal areas
2	Diatoms	Cyclindrotheca closterium,	Most of the nation's coastal areas
3	Diatoms	Melosiar cancellate,	Most of the nation's coastal areas
4	Diatoms	Nitzschia deicatissima,	Most of the nation's coastal areas
5	Diatoms	Pinnularia viridis	Most of the nation's coastal areas
6	Dinoflagellates	Dinoflagellates spp.	Most of the nation's coastal areas

7	Dinoflagellates	Prorocentrum minimum	Most of the nation's coastal areas
8	Dinoflagellates	P. sigmoides	Most of the nation's coastal areas
9	Dinoflagellates	Perocentrum balticum,	Most of the nation's coastal areas
10	Dinoflagellates	Alexandrum catenclla,	Most of the nation's coastal areas
11	Dinoflagellates	Scrippsiella trochoidea,	Most of the nation's coastal areas
12	Dinoflagellates	Peridinium perardiforme)	Most of the nation's coastal areas
13	tubeworm	Hydroides elegans	Along the coast of China, appears the largest amount at the Hypersaline harbor in the southern marine area.

2.1.3 Others species

NO.	English Name	Latin Name	Distribution
1	Common Cordgrass	Spartina anglica C.E. Hubb	From Jinxi(Liaoning Prov.) to Hepu (Guangxi prov.), distribute on the coastal shoals of than 100 cities and counties as well as the Yellow River Delta, Bohai Bay, etc.
2	Smooth cordgrass	Spartina alterniflora Loisel.	Wildly distribute on the coastal areas of Fuji an,Zhejiang,Shanghai,Jiangsu,Shandong,Tia njin,Liaoning Prov.

3. Threats and impact of the MIS to native communities and ecosystems

3.1. Ecosystem Changes

3.1.1 Destroy ecological security and threaten biodiversity

MIS always seriously disturb or destroy the structure, function and biodiversity of the marine ecosystem. The invasion of alien marine organisms can not only reduce the region's biological uniqueness but also break the geographical isolation which is maintaining the global biodiversity. While the MIS invade the new environment successfully, they will destroy the structure of original ecosystem, break the food chains and change the ecological balance of the habitat sites. After the amount of native species is reduced by MIS with their biological advantage, the situation will turn worse, which further leads to the loss of ecosystem structure, finally results in the loss of biodiversity in the whole ecosystem.

3.1.2 Cause genetic diversity damage and contamination

Due to the development of human society and the growing strength of utilization of marine resources, the genetic diversity of China's marine organisms is facing various threats. Based

on the former research, except for the habitat destruction, MIS is the biggest threat to the genetic diversity, because these alien organisms can easily move to the new environment through many channels, such as attaching themselves to the bottom of ships, ship ballast water, the introduction of alien species and so on. The MIS can hybridize with local species and compete with them, which will affect or change the genetic diversity of the original ecosystems. In recent years, China has introduced many kinds of alien species for aquaculture, such as prawn, turbot (Scophthalmus maximus), scallop(Argopectens irradias) (Patinopecten (Mizuhopecten) yessoensis Jay), and also carried out some cross-breeding experiments in different degree and extent, which might make genetic diversity of marine organisms at risk. It is worth mentioning that, since the nektonic organisms such as fish and shrimp have a strong mobility comparatively, once they escape into the new environment because of mismanagement or some other reasons, it would be easily for them to enter the wild nature population, which may had adverse effects on the genetic structure and genetic diversity.

3.2. Economic impacts

MIS may cause many adverse effects, such as native species reduction, landscape loss, breeding degradation, economic biological diseases, frequent red tides, etc, which would not only result in the economic loss on marine based industry directly, such as fishing, aquaculture, tourism, transport etc , but also trigger a series of social problems indirectly such as labor and employment, insurance benefits etc.

Since 1993, shrimp virus disease started to spread on a large-scale in China's aquaculture, one major reason of which is the large-scale death of Chlamys farreri introduced from Taiwan Pro. In addition, MIS can also affect international trade, cause trade frictions between countries and become an excuse for trade sanctions, which hinders the smooth development of trade in agricultural products and brings direct economic losses to the parties States.

3.3. Public and health impact

Many MIS themselves are human pathogen or the mass media of pathogen. The success of their invasion may lead to epidemics, which seriously affect human's health. Some pathogenic microorganisms are small, that makes them can easily invade and spread through many channels but difficult to detect and block by the current quarantine inspection measures. These MIS may become serious threats human's health, economic development and even the social stability. Up to now, no systematic health risk assessment research of MIS is carried out in China.

4. Prevention, detection and management of MIS

4.1 National/local authorities dealing with MIS monitoring

The prevention ,detection and management of MIS are primarily took in charge by the State Oceanic Administration, at the same time Ministry of Agriculture, Ministry of Transport Maritime Bureau, State General Administration of Quality Supervision and other departments have also participated.

4.1.1 State Oceanic Administration

Develop the plans and standards of marine environmental protection and remediation; develop standards and norms to control the total amount of sea- system pollutant emission. In accordance with the national standards, supervise the land-based pollutants Emissions into the ocean, take charge of the prevention of marine oil exploration and recover the damage caused by marine pollution; Manage theinvestigation, monitoring, surveillance and evaluation of the marine environment, Monitor the marine biodiversity and marine ecological environmental protection, Supervise and manage nature reserves areas and special protective marine areas. Confirm the environmental impact report of new construction, reconstruction, expansion of coastal and marine engineering projects.

4.1.2 Ministry of Agriculture

Protect the ecological environment of fishing waters and the aquatic wild animals and plants; Safeguard the fishing rights of the nation. Exercise the rights of fishing vessels and fishery inspection. Draft laws and regulations of animal and plant epidemic prevention and quarantine. Sign the intergovernmental agreements and develop relevant standards. Organize the domestic animals and plants quarantine, publish the epidemic information and organize the work to fight against the epidemic.

4.1.3 Ministry of Transport Maritime Bureau

Develop, organize and implement the national guidelines, policies, regulations and technical norms and standards of many aspects such as the national water safety, prevention of ship pollution, inspections of ships and marine facilities, and maritime security. Supervise and manage the safety production conditions of the ship owners and water enterprise security management system. Investigate and process water traffic accidents, shipping accidents and water pollution cases.

4.1.4 State General Administration of Quality Supervision

Organize and implement the supervision of entry-exit health quarantine and infectious disease surveillance. Collect, analyze and sort the information of foreign epidemic situation and provide guiding information and advisory services. Implement the supervision and management of the

entry-exit animal and plant quarantine. According to the law, take charge of the inspection and quarantine work for immigration of genetically modified organisms and their products.

4.2. Existing control and preventive measures including status and risk assessment

4.2.1 Pest Risk Analysis (PRA)

Pest Risk Analysis is a process of investigation, evaluation of information and decision making with respect to a certain pest. With identification, determination and evaluation done, the process culminates with decision making to avoid or reduce the probability of entrance or establishment of the pest into the country. It includes three aspects: Pest Risk analysis for start-up; Pest Risk assessment; Pest Risk Management.

In 1990, the concept of PRA was formally introduced into China, after ten years, China's first PRA institutions ,the "PRA office" was formally established by the plant and animal laboratory approved by State Administration of Quality Supervision, Inspection and Quarantine, which is the central of China’s PRA work. Since the foundation of "PRA office", PRA working group formed by experts on insects, fungi, bacteria, nematodes, viruses, and computer has developed the PRA workflow and PRA procedures, proposed some revisions on PRA international standards which are being developed by FAO / IPPC and assisted State Administration of Quality Supervision, Inspection and Quarantine by holding fruitful PRA trainings. In recent years, the Ministry of Agriculture and some agricultural colleges and universities have begun to work in PRA. PRA has become the backbone of China's animal and plant quarantine policy, every one of which need the support of the relevant PRA report.

4.2.2 Risk Assessment of China Global Ballast Water Management Project

In September 2002, as a specific activity of the world's ballast water management project, ballast water risk assessment activities were carried out in the Dalian port, China. Risk Assessment Implementation Team was formed by the experts from Liaoning Maritime Bureau, Dalian Maritime University and Institute of Marine Environmental Protection. Through the simulation analysis of multi-environmental variables and the study of ship’s loading and discharge mode of ballast water, the risk assessment team judged the risk of MIS through ballast water. In these assessment activities, the team not only mastered the input of "ship's ballast water statements" and the database creation methods, but also successfully established the simulation analysis of environment and biological parameters of the port, and built up the regional geographic information systems. At present, similar risk assessments of ballast water have been launched in many ports of China.

4.2.3 Establish the "red tide" Information Publishing System for ships

The State Oceanic Administration of China steadily increases its efforts to monitor red tide. Up to now, 33 red tide monitoring zones have been established in the national key areas, 11 of which are at North Sea, 13 at East China Sea, and 9 at South China Sea. In order to supervise and control red tide of these areas, the relevant departments have set up the National Red Tide Monitoring Network combining national and local governments, professional people

and the masses and carried out some high-frequency and high density monitoring activities. In order to grasp the dynamic information of red tide in the areas with frequent occurrence, the government also carried out continuous monitoring of the occurrence of red tide by using some advanced technology and equipments, such as ocean satellites, maritime surveillance aircrafts, ships and shore-based stations.

4.3. Existing databases used for monitoring, control and prevention

In the past several decades, the Chinese government has made many efforts to support the MIS research and established a number of databases for the control and management of MIS.

1. China Invasive Species Database

Website: http://www.biodiv.org.cn/ias/index.htm

China Invasive Species Database was established by Nanjing Institute of Environmental Science, National Environmental Protection Ministry, which records the details of all the alien species discovered in China's land territory and marine area so far. The database information includes the Latin name, Chinese name, taxonomic status, geographical distribution, origin, habitat type and other basic data.

2. The basis information database of China alien marine species

Website: http://bioinvasion.fio.org.cn

This database consists of two basic databases: alien marine species database and alien marine invasive species database. According to the domestic and foreign-related information and evaluation, the basis information database includes the information of: breeding bio-, intertidal organisms, plankton, epiphytic bio-, pathogen bio- and aquarium bio-, which provides the basic data for risk analysis and early warning of MIS.

4.4. Future plans on monitoring, control and prevention

Towards the plans on monitoring, control and prevention of MIS, the government needs to achieve such flowing aspects:

1). Establish the rules and regulation of the implementation on MIS management system

2). Strengthen the management of introduction of marine plants and animals

3).Strengthen animal and plant quarantine

4).Take measures to eradicate pests which have already been admitted

5).Establish the eco-environmental impact assessment procedures of MIS

6).Make the Management institutions of MIS clear, and establish appropriate advisory institutions

7). Establish the risk assessment and risk management technology system on MIS

8). Establish the MIS information systems

9). Strengthen scientific research on management and monitoring of MIS

10). Strengthen the education of MIS prevention, and raise public enthusiasm

11). Carry out more extensive international cooperation on biological invasion

5. Current research projects and other initiatives on the MIS in the country

5.1. Priority research fields on the MIS

5.1.1 MIS–related laws and regulations

China lacks the specific laws or regulations on MIS management. At present, agriculture, forestry, environmental protection, quality inspection and other relevant departments are organizing experts to draft laws and regulations in the management of MIS, and will improve the relevant MIS regulations such as: proof and approval system of introduction, ballast water management systems, risk analysis system, full control system, cooperative system.

5.1.2 Research on MIS invasion mechanism

Since the 1990s, mathematical models, quantitative experiments, bio-technology and other means of research have been introduced into the study area of MIS, and people's understanding of MIS has been greatly improved, thus biological invasion has became a research focus in fields ofecology and biodiversity. The study of MIS mechanisms in China seems closer to the production and daily life, which focus on pest prevention.

In recent years, research on MIS mechanisms is gradually concerned, which focus on: the characteristics of MIS; the relationship between alien species and local species, as well as the relationship between their communities; the impact of habitat changes to invasion, and so on.

5.1.3 Studies on the invasion risk assessment and economic loss assessment of MIS

The alien species risk assessment started earlier in China, because since 1980s, the AQSIQ started to carry out the plans of Pest Risk Analysis (PRA), the plant PRA work of which is on the leading level in the global phytosanitary fields. Apart from AQSIQ, Ministry of Environmental Protection and the Ministry of Agriculture also organized the relevant research institutions and universities to carry out risk analysis projects research to establish China's own risk assessment system of alien species.

At the same time, the Ministry of Environmental Protection and many experts on MIS summed up and concluded the economic losses and control costs of harmful diatoms and alien fish in China, which included both overall national research and regional case studies.

5.1.4 Study of ballast water treatment technology

Chinese government always pays a great attention to the alien species invasion caused by ballast water, and supports the research on such issues of the relevant domestic institutions. These researches mainly focus on: treatment technology research of ballast water, dynamic testing system of ballast water exchange, ballast water testing standards and operating mechanism, mechanisms of aquatic organisms causing red tide carried by ballast water.

5.1.5 Research on strategies for monitoring the marine environment

China started to establish a "national marine environment monitoring network," since the 1980s. So far, in addition to the State Oceanic Administration, the environmental protection, water conservancy, agriculture, scientific research, the Navy, transportation, meteorology, marine oil and other departments have also established a number of their own research institutions to carry out some ocean-related research activities.

5.2 Brief summary of research/project/initiative

5.2.1Census of Marine Life (CoML)

Project	Census of Marine Life 2000
Department in charge	Institute of Oceanology C A S; Sloan Foundation
Methods and contents	Program will last for 10 years (2000-2010). The object is to assess and explain the diversity, distribution and abundance of the ever-changing marine species, understand marine life's past and present, and predict its future trends
Main results	In April 2004, the Institute of Oceanology CAS hosted the China Symposium of CoML in Qingdao for the first time, and set up the Academic Committee of CoML China. In December 2005, CoML China Committee held its second meeting, in which they determined the direction of China's CoML work, and established China Ocean Biogeographic Information System (http://www.iobis.org.cn)

5.2.2 The ship ballast water management work

Project	The ship ballast water management work 2000
Department in charge	Maritime Administration of Ministry of Transportation
Methods and contents	Carry out preventive measures activities and the relevant ballast water management plan carry out professional training to the laws enforcement person carry out relevant research activities, including ballast water risk assessment, port-based biological survey, ballast water treatment systems , etc
Main results	Set up the national implementation team of ballast water project. Completed some projects, including security study, port biological baseline survey.

5.2.3. Ballast water risk assessment of China

Project	Ballast water risk assessment of China 2002
Department in charge	Ministry of Transport Maritime Bureau Liaoning Maritime Bureau
Methods and contents	Track the whole process of risk assessment activities. Using the pre-collected-to-port ballast water statements, local bio-informatics, and dozens of key environmental parameters from the world's major ports generates the final Comparison coefficient between Dalian Port and other major ports.
Main results	Determined the possible risk of the species introduction Took appropriate measures to reduce the risk of Realize the localization of risk assessment Did the preparatory work for the entry into force and implementation of the International Convention for the Control and Management of Ship s Ballast Water and Sediments

5.2.4. Strong Ionization Discharge method for ballast water treatment

Project	Strong Ionization Discharge method for ballast water treatment 2003
Department in charge	Institute of Environmental Engineering, Dalian Maritime University
Methods and contents	A physical method is studied in which the electrons are accelerated and the gas molecules are aroused using a strong dielectric barrier discharge. Hydroxyl radicals that kill the introduced micro2organisms are associated with a dissociative radical reaction with a high reaction rate, and have a broad2spectrum deadly characteristic1After 20 minutes, the hydroxyl radical is decomposed into H2O and O¬¬2, which a “green” medicament without any toxin and residues1Therefore, this method is effective with a low cost for the treatment of ship’s ballast water.
Main results	Bai,mindong etc.2003.Hydroxyl radical ballast water treatment research, Outstanding Paper Award of the Seminar of High-Tech Ship Pollution Prevention and Regional Cooperation Bai,mindong. 2003. The killing of microorganisms in ship’s ballast water using hydroxyl radicals. Oceanologia et Limnologia sinica.34(5).p.484-489

5.2.5 The impact of MIS, risk assessment and application

Project	The impact of MIS risk assessment and application 2004
Department in charge	Science and Technology Ministry , First Oceanography Institute of State Oceanic Administration
Methods and contents	Risk assessment of MIS and its effect to social development of the coastal region ; A biological impact assessment of typical MIS; Genetic pollution assessment Of economic alien marine species; Evaluation of pathogenic micro-organisms carried by MIS
Main results	The initial establishment of some databases alien marine species database, laws and regulations, research papers database, dynamic database of science and technology, foreign language research papers database Shi,hongjing, Jiangwei, Yidan. 2005. The research progress of MIS risk assessment. China Society of Oceanography Marine Biology Engineering Committee ,Annual Meeting Proceedings

5.2.6.The National Biological Species Resources Survey Project

Project	The National Biological Species Resources Survey Project 2006
Department in charge	Ministry of Environment Protection
Methods and contents	Carry out field investigation of the typical nature reserves to identify the invasive status of them. Based on the scientific analysis of the findings, propose special policy and proposals for the effective prevention of invasive species and the protection of biology resources.
Main results	The spatial distribution of some vicious invasive species in the typical nature reserves. The spatial difference of the impact of 27typical nature reserves List of invasive species in China. Plate of 45 vicious invasive species in nature reserves.

5.3 National taxonomy initiatives

《Inventory Invasive Species in China》

This book describes the classification and distribution information of China's invasive alien species from the terrestrial, freshwater aquatic and marine ecosystems, including alien micro-organisms, invertebrates, amphibians, reptiles, fish, birds, mammals, weeds,

trees in detail. The information refers to the economic and ecological impact of the introduction, first found location and time, the path of introduction, invasion pathway, habitat types, life history, control measures, etc. and there are62 pictures of alien invasive species equipped .

This book can not only serve as the reference book to the professional universities and research institutes, but also be a guide book for the management of biological diversity conservation, plant protection, quarantine, agriculture, forestry, marine and so on, as well as the reference for the public's awareness of invasive alien species in China.

5.4. National databases or Internet sources on MIS

1. China Invasive Species Database

Website: http://www.biodiv.org.cn/ias/index.htm

China Invasive Species Database was established by Nanjing Institute of Environmental Science, National Environmental Protection Ministry, which records the details of all the alien species discovered in China's land territory and marine area so far. The database information includes the Latin name, Chinese name, taxonomic status, geographical distribution, origin, habitat type and other basic data.

2. The basis information database of China alien marine species

Website: http://bioinvasion.fio.org.cn

This database consists of two basic databases: alien marine species database and alien marine invasive species database. According to the domestic and foreign-related information and evaluation, the basis information database includes the information of: breeding bio-, intertidal organisms, plankton, epiphytic bio-, pathogen bio- and aquarium bio-, which provides the basic data for risk analysis and early warning of MIS

3. China Species Information System (CSIS)

Website: http://monkey.ioz.ac.cn/bwg–cciced/index.htm

CSIS comes from the expansion of the China Endangered Species Information System (CESIS) d and consists of nearly ten thousand species and subspecies information including: 513 kinds of mammals, 1329 kinds of birds, 390 kinds of reptiles, 260 kinds of amphibians, 3720 species of fish, as well as more than 800 kinds of trees. CSIS also includes the information of33 provinces, 1770 rivers, 780 mountains ,more than 1000 nature reserves , 210,000 historical records of the counties, 1300 photos and distribution maps (ARC / INFO format) of mammals, birds and reptiles ,the associated literatures and more than 40,000 records of the rivers with freshwater fish. Using GIS technology, the spatial distribution information of all species can be converted to points, lines and other vector data, which can be queried on the national or sub-provincial scale.

6. Existing gaps in relation to the global and regional developments dealing with marine and coastal biodiversity, including invasive alien species

6.1. Compliance with relevant global conventions and agreements (e.g. CBD, BWC, etc.) and with other FAO and IMO regulations

6.1.1 The implementation of "Convention on Biological Diversity" (CBD) Progress in China

In 1990s, China has participated in the work of drafting, revision and negotiation of CBD actively, which was the one of the prior countries signing the convention.

Since the implementation of CBD entered into force in 1993, Chinese government have made great efforts to implement the convention, and carried out a series of fruitful work for marine biodiversity conservation, which not only promoted the sustainable development of economy and society effectively but also made an important contribution to the protection of the unique ecosystems, species system and genetic resources of China's marine for the world.

For the implementation of CBD, China carried out a series of work mainly in the following aspects:

1) Develop national strategies

Following the requirements of the Convention, China has constituted the "Agenda 21" and "Ocean Agenda 21", while made marine biodiversity conservation as an essential component of them. Together with State Oceanic Administration and other departments, Ministry of Environmental Protection has developed some action plans for the protection of marine biodiversity, wetlands biodiversity, and special germplasm resources. In terms of the policy of "equal emphasis on pollution prevention and ecological protection," and "equal emphasis on ecological protection and construction", China has protected the marine biodiversity resources at the policy level effectively.

2) Strengthen the investigation of marine biodiversity, emphasize publicity and education

The Chinese government has always attached great importance to the census of marine life species. The past 60 years, China has carried out the Bohai Sea and northern Yellow Sea marine survey (1957-1958), the National Integrated Marine Survey (1958-1960), the National Integrated island resources Survey (1989-1993), which greatly enriched the records of marine biodiversity, and laid the foundation for the research activities.

Every year a series of publicity and education activities on biodiversity conservation and convention implantation are organized to recognize good people and expose the illegal activities in these fields by the Chinese government. These education activities not only enhanced the communication and popularization of biodiversity science, but also raised public initiative of awareness and participation in biodiversity conservation.

3) Establish nature reserve

So far, the Ministry of Environmental Protection, State Oceanic Administration, Ministry

of Agriculture and local governments have established 72marine nature reserves along the coast, including 22 national nature reserves, 16 provincial nature reserves and 14county level nature reserves. In order to protect the juvenile large yellow croakers (Pseudosciaena crocea), the State Department has also set up the relevant protected areas on Yellow Sea and East China Sea. The State Forestry Department has started the coastal shelterbelt system, and created a long coastal belt with 1.5 million km shelterbelts and 1.4 million hectares planted. The government also encourages large farms to build their own sea creatures breeding centers and use artificial conditions to cultivate a large number of offspring to make up the lack of seeds resources in natural water. Till now, there have been more than 50 aquariums established in china.

4) Carry out information technology exchange and international cooperation.

The Chinese marine management departments at all levels have carried out a wide range international cooperation within the field of marine biodiversity conservation. For example, in recent years China has carried out a number of multilateral cooperation with many international organizations like UNDP, UNEP, EAO, DNESCO, the World Bank and GEF, and some countries.

6.1.2 Implementation the International Convention for the Control and Management of Ship s Ballast Water and Sediments in China.

As a big navigation country and the A-class members of IMO, China possesses 3.4% of the world's total tonnage. From 2000, China started to participate in the projects of ballast water and sediments management. As the lead agency for the project, China Maritime Safety Administration set up a national project implementation team and completed a number of ballast water management projects in Dalian port, including security studies, the Port biological baseline surveys. In particularly, the risk assessment of ballast water project was carried out in the six demonstration countries in 2002, while China's activities were mainly carried out in Dalian port. In this activity, risk assessment team formed by the experts from Dalian marine university tracked the whole process of risk assessment activities. Using the pre-collected-to-port ballast water statements, local bio-informatics, and dozens of key environmental parameters from the world's major ports, the team generated the final comparisoncoefficient between Dalian Port and other major ports, then determined the possible risk of the species introduction.

6.2. Future needs in capacity building, public awareness raising

1. Improve laws and regulations of alien invasive species

At present, the lack of a special law of alien invasive species requires that environmental protection, agriculture, forestry, quality control, marine and other departments together in consultation, and develops the relevant laws and regulations as soon as possible.

2. Establish the risk assessment system of MIS

The environmental protection, agriculture, forestry, quality control, marine and other departments should join together to establish a relevant examination and approval system,

improve the ecological risk assessment of marine alien species, the technical standards and related technology systems, and strengthen the introduction of alien species, strengthen the supervision of ecological risk assessment, and gradually establish the monitoring, early warning and rapid response system of MIS.

3. Establish the early warning and rapid response system of MIS

China should strengthen the monitoring and survey of MIS, and carry out regular survey of MIS to understand their situation. It is particularly important for the government to strengthen the monitoring of the alien species which have been confirmed as invasive species, or the ones with a high invasive risk but still be introduced. Once the phenomenon of expansion or re-invasion happen, it is necessary to take timely measures to control it.

In order to establish the early warning system, the government should use a variety of technical means to provide the information on MIS, assess their risk, predict the potential impacts and provide management recommendations. For the new record of alien species, an unobstructed channel for timely reporting to the appropriate department is also very important.

4. Carry out scientific research on MIS

The following research aspects should be focused on in the future:

A comprehensive analysis of the distribution and the role of alien species; From the different stages of alien invasive species such as induction, escape, population establishment and hazards, research the mechanisms of invasive process and the law of the occurrence, development, and the outbreak of their harm on the level of gene, individual, and ecosystem; Build different risk assessment and management technology systems toward different medias, approaches and levels of risk degree of the alien invasive species; Establish the quarantine inspection system and the technology platform for environmental monitoring and prediction of the alien species.

7. Legislation, programmes and responsible organizations related to marine and coastal biodiversity, including invasive alien species

7.1. National legislation related to marine and coastal biodiversity issues (the full names of laws, policies and regulations)

1.The current legislations for the management of species in China are mainly one-way laws, regulations or implementation details, which can be divided into two categories as follows:

One category is the inspection and quarantine laws, including: " Entry and Exit Animal and Plant Quarantine Law of the PRC" " Frontier Health and Quarantine Law of the PRC " and " Animal Epidemic Prevention of the PRC ", " Entry and Exit Animal and Plant Quarantine Law Regulations of the PRC "" Health and Quarantine Law of the implementation details of the PRC ""Regulations on Plant Quarantine of the PRC ""Implementation details of plant quarantine regulations, "" Regulations on Disease Prevention of livestock and poultry" and so on.

The other category is the industry-oriented laws and regulations for management and

hazard prevention and control, including: "Animal Husbandry Law of the PRC," " Fisheries Law of the PRC," " Grassland Law of PRC," "Seed Law of the PRC " "Marine Environmental Protection Law of the PRC " "Rules for the Implementation of terrestrial wildlife conservation" "Forest Pest Prevention Act of the PRC "" Nature Reserves Ordinance of the PRC " and so on.

2. Brief introduction of laws and regulations:

Name	The main principles and policies
Entry and Exit Animal and Plant Quarantine Law of the PRC	Prevent the spread of animal diseases, parasitic diseases and plant diseases, insects, weeds; protect the production of agriculture, forestry, animal husbandry and fishery and human health; promote the development of foreign economic and trade.
Frontier Health Quarantine Law of the PRC	Prevent the spread of diseases imported from abroad or by domestic, carry out the implementation of frontier health and quarantine, and protect human health.
Animal Epidemic Prevention Law of the PRC	Manage, prevent, control and fight against animal diseases, promote the development of aquaculture, and safeguard public health and safety
Entry and Exit Animal and Plant Quarantine Regulations of the PRC	Carry out the inspection and quarantine of specific animals and plants, protect the public health and safety
Rules for the Implementation of Health and Quarantine Law of the PRC	Monitor the spread of infectious diseases, implement health quarantine in public places and border areas, implement health surveillance, and protect people's health.
Plant Quarantine Regulations of the PRC	prevent the damage diseases from plants, insects, and weeds, protect of agricultural and forestry production safety
Disease Prevention Ordinance of Livestock and Poultry	Prevent and eradicate of infectious diseases (including parasitic diseases) of livestock and poultry, protect livestock production and people's health
Implementation Details of Disease Prevention Ordinance of Livestock and Poultry	Prevent and fight against infectious diseases of livestock and poultry, carry out the supervision and management work , protect animal husbandry production and people's health
Animal Husbandry Law of the PRC	Regulate the behavior of livestock production, Protect the quality and safety of livestock products, Protect and rationally use animal genetic resources; safeguard the legitimate rights and interests of livestock production; promote sustained and healthy development of animal livestock production.

Fisheries Law of the PRC	Protect fisheries resources, develop artificial breeding, protect the legitimate interests of fish producers and promote the development of fishery production
Seed Law of the PRC	Protect the rational utilization of germplasm resources, regulate the management of breeding and seed production, safeguard the legitimate rights of breeding operators and seed producers, and promote the development of farming and forestry
Marine Environmental Protection Law of the PRC	Protection of the marine environment and marine resources, prevent pollution damage, maintain ecological balance, safeguard human health and promote economic and social sustainable development
Chartered Management Measures of Aquatic Wildlife Utilization	Protect, develop and rational use the aquatic wildlife resources, strengthen the protection of aquatic wildlife, regulate the issuance and use of standardized documents.
Regulations on Prevention of Ships Pollution and Sea Management	Monitor the use and disposal of tanker ballast water, prevent of marine pollution, protect the coastal biodiversity
Management Measures on Entry-Exit Inspection and Quarantine of international voyages	Carry out the management and supervision of entry-exit inspection and quarantine for international ships, t facilitate international ships entering and leaving China Port

7.2 Leading authorities (e.g. ministry, agency) to implement national legislation related to marine biodiversity issues

1. Ministry of Environmental Protection of the PRC

Ministry of Environmental Protection is the government agencies of national environmental protection and pollution control under the State Department, Which is mainly responsible for land-based pollution and coastal pollution prevention projects. Based on the "Marine Environmental Protection Law", the Ministry of Environmental Protection coordinate, supervise and guide the work of marine environmental protection, with affiliates in all the provinces, autonomous regions and municipalities.

The Ministry of Environmental Protection is also responsible for the implementation of the Convention on Biodiversity, including: coordinate the implementation of the Convention on biodiversity; monitor biodiversity conservation; develop action plans; investigate and deal with the damage and impact of the biodiversity of events.

2. Ministry of Transport Maritime Bureau

Develop, organize and implement the national guidelines, policies, regulations and technical norms and standards to supervise and manage the national water safety, prevention

of ship pollution, inspections of ships and marine facilities, and maritime security. Supervise and manage the safety production conditions of the ship owners and water enterprise security management system. Investigate and process water traffic accidents, shipping accidents and water pollution cases

Ministry of Transport Maritime Bureau has 24 direct province bureaus, 1180 branches, 25,000 law enforcement persons, and 1,300 patrol vessels. The Ministry of Transport Maritime Bureau Administration attend t most of the meetings of IMO.

3. State Oceanic Administration

The main responsibilities of State Oceanic Administration are explained as follows:

Develop the plans and standards of marine environmental protection and remediation; Develop standards and norms to control the total amount of sea- system pollutant emission. In accordance with the national standards, supervise the land-based pollutants emissions into the ocean, take charge of the prevention of marine oil exploration and recover the damage caused by marine pollution; Manage the investigation, monitoring, surveillance and evaluation of the marine environment, Monitor the marine biodiversity and marine ecological environmental protection, Supervise and manage nature reserves and the special protective marine areas. The State Oceanic Administration has established an Environment Monitoring Center in Dalian, information center in Tianjin, research center in Qingdao, and a number of institutes in the South. The State Oceanic Administration equipped with monitor aircrafts and boats.

4. Central Administration of Quality Supervision, Inspection and Quarantine (CAQSIQ).

CAQSIQ is the government agency which is responsible for the implementation of the Cross-border Health Quarantine Law and import and Export of Animal and Plant Quarantine Law under the State Department. CAQSIQ's major function is the quarantine of product quality, people's health and goods.

According to the National Health and Quarantine Law, ship's ballast water from infected areas which have been set out by the World Health Organization (WHO) and the government requires disinfection before discharge. CAQSIQ has branches at all the opening ports, which are responsible for the quarantine of health, as well as the ship carrying species, people and goods.

5. Fisheries Bureau, Ministry of Agricultural

The main responsibilities of State Oceanic Administration are explained as follows:

Protect the ecological environment of fishing waters and the aquatic wild animals and plants; Safeguard the fishing rights of the nation. Exercise the rights of fishing vessels and fishery inspection. Draft laws and regulations of animal and plant epidemic prevention and quarantine. Sign the intergovernmental agreements and develop relevant standards. Organize the domestic animals and plants quarantine, publish the epidemic information and organize the work to fight against the epidemic. Fisheries Bureau has branches at all the fishing ports in China.

7.3. National legislation specifically addressing marine and coastal invasive alien species (including the full name of laws, policies and regulations with a short summary)

In China, marine bio-invasion-related rules and regulations are scattered among the many laws, but for the protection of marine biodiversity and marine bio-invasion no special legislation has been established yet. The brief introduction of the relevant regulations and laws as follows.

1. Entry and Exit Animal and Plant Quarantine Law of the PRC

Prevent the spread of animal diseases, parasitic diseases and plant diseases, insects, weeds; protect the production of agriculture, forestry, animal husbandry and fishery and human health; promote the development of foreign economic and trade.

2. Chartered Management Measures of Aquatic Wildlife Utilization

Protect, develop and rational use the aquatic wildlife resources, strengthen the protection of aquatic wildlife, regulate the issuance and use of standardized documents.

3. Regulations on Prevention of Ships Pollution and Sea Management

Monitor the use and disposal of tanker ballast water, prevent of marine pollution, and protect the coastal biodiversity.

4. Management Measures on Entry-Exit Inspection and Quarantine of international voyages

Carry out the management and supervision of entry-exit inspection and quarantine for international ships, t facilitate international ships entering and leaving China port.

5. Frontier Health Quarantine Law of the PRC

Prevent the spread of diseases imported from abroad or by domestic, carry out the implementation of frontier health and quarantine, and protect human health.

The above-mentioned laws and regulations are the legal basis of China's control of MIS, and the relevant policies have also provided supports to the supervision and management of MIS to a certain degree for all departments.

However, there is no doubt that, many problems still exist in the management of marine alien species, such as, incomplete legal system, the disorder of expression, the biased guiding ideology of legislation, lack of special legislation, the lack of coordination mechanisms and inter-departmental cooperation mechanism, the lack of policy and economic incentives, the lack of control mechanism, the lack of risk assessment and emergency warning systems, the weak ecological awareness and public participation, no smooth exchange of information ,the ineffective supervision an lax law enforcement and so on. In view of this, based on the purpose of re-establishing the legislative, we must clean up and revise the relevant laws and regulations, enact specific legislation, finally improve the legal system for the prevention and control of MIS.

8. Recommendation for decision–makers in terms of priority national actions, services and products

As a global problem, MIS has caused lots of attentions from many countries as well a number of international organizations. In order to strengthen the management of MIS, many countries including the USA, Australia and New Zealand, have developed their strategies for the management of MIS, and also established a variety of guidelines, technical guidelines, and corresponding legislations. The WCU, IMO and other international organizations have also developed some conventions and some other guiding technical documents for the introduction, prevention, elimination, control and recovery of MIS.

Reference to the international advanced experience, the Chinese Government should achieve the following aspects in the future.

1. Establish the special laws and regulations of MIS as soon as possible, realize the legal management of MIS

Establish the special regulations for the management of MIS, and define the object management content, rights and responsibilities clearly; In particular, strengthen the legislation of the alien species introduced intently to meet the needs of the agriculture, aquaculture and other production. Make clear provisions for the control actions of those who have been confirmed as MIS, ensure that the relevant provisions and the corresponding international conventions, agreements are consistent, and thus full realize the regulation of the marine invasive species by law.

2. Strengthen institution-building, improve the multi-sectoral coordination and management mechanism

Because the management MIS is a long-term task, so we should establish the multi-sectoral coordination and management mechanism, which involves multiple departments. In the request of the relevant laws and regulations, achieve the common effective management of MIS, with the division of labor by departments. We suggest that, based on the collaborative groups of MIS prevention and control that have already been established, the government should the establish an inter-departmental leading group for MIS management, so to coordinate the work of various departments, enhance the coherence of the MIS management and improve the management efficiency.

3. Strengthen the building of management system for MIS.

Establish the scientific risk assessment system and make sure the strict implementation of it. This system should include the risk assessment of intentional introduction of MIS, as well as the risk assessment of trade, tourism, transportation, entertainment and other activities, which could lead to the unintentional introduction or transfer of MIS. Especially in some large-scale construction projects, it is necessary to introduce the content of risk assessment of introduction and transfer of the MIS into the environmental impact assessment report, ensure the risk caused by that these activities is minimum. In order to eliminate the illegal introduction of MIS we should improve and strictly implement the introduction

system, establish the introduction filing system, and strengthen the management of foreign introduction.

4. Carry out appropriate measures of prevention, elimination, control and restoration for the introduction of MIS.

Take effective control measures in ports, strengthen the quarantine and inspection to the harmful marine alien species, and build the first line of defense to prevent harmful MIS, and these are the most important aspects to reduce the risk of unintentional introduction of MIS, which is more effective than any other economic measures taken after the invasion. While facing the outbreaks of invasive species, the government should make rapid response, combine the methods of mechanical eradication, chemical control, and biological control, and carry out comprehensive prevention and control measures to reduce the impact of MIS to a minimum. It is also necessary to carry out research activities and establish some new eradication and control methods at the same time.

5. Carry out scientific research, and provide a scientific basis for the management of MIS

Strengthen the research on MIS biology, invasion ecology, and control measures, establish invasive species databases, and format information sharing mechanism of MIS, so that it can provide a scientific basis for policy formulation, and also improve the timeliness and rationality of policy-making and the management effectiveness of the government.

6. Develop education and training programs to raise the public awareness

We should strengthen job of education and training for the relevant staff to enhance their identification, analysis and detection capabilities to MIS. The government should promote the public propaganda and education to raise public awareness of ecological protection, make them resist the MIS consciously, reduce their intentional or unintentional introduction or transfer of MIS in travel, trade, transportation and other activities, and encourage them to participate into the control and eradication of MIS.

9. References

Yubo Liang, Bin Wang .2007. China's foreign marine organisms and its impacts. Biological Diversity .9 (4). P.458-465

Xiaochun Liu, Jie Bai .2006. Situation and Countermeasures of China's biological invasions. Environmental Science and Management .31 (2). P.80-82

Haigen Xu .2004. The distribution of alien invasive species and the analysis of incoming path. Biological Diversity.12 (6). P.626-638

Qiyan Hong .2004. China ecological distribution of biological invasion. Eco-Environment .13 (3). P.414-416

Qingguang Lu .1994. Biological invasion risks. World Agriculture .4. P.38-39

JianQing Ding .2002. Alien bio-invasion mechanisms and their impact on the ecological security. Review of China Agricultural Science and Technology.4. P.16-20

Zhujian Geng, Luli Zhang.2009. Marine invasive species and ballast water management in China. Ecological Layout and Management.12. P.306-310

Lei Du, Chengxiang Qian, Xiujuan Guo 2009. The Introduction "Ships Ballast Water Management Convention and national responses. China Water Transport .9 (5). P.98-100 Zunde Cai 2008. Ship ballast water management and security assessment. Seamanship .5. P.25-28

Cheng Li .2009. The countermeasures and suggestions to ballast water management deal of IMO. Journal of Dalian Maritime University.35. P. 43-45

Chen Yu, Xingqi Wang. 2005. Analysis to" Convention of the International Ship Ballast Water and Sediments, control and management." World Shipping. P. 43-47

Xiaoman Xu. 2007. The significance of Global Ballast Water Management project risk assessment and carried out in China. Outstanding proceedings of China Institute of Navigation academic exchange meeting in 2007. P.39-44

Zhaofang Min, Ying Liu, Shen Li .2009. The status and countermeasures of ship's ballast water management in China. China Water Transport. P.1-5

Hong Chen. 2007. Control of ship's ballast water pollution measures. Environment and Sustainable Development .6. P.24-27

Qibo Zheng. 2009. The performance of ballast water management and China's response. Tianjin Navigation .6. P.29-31

Mingjie Liu, Zhisheng Li, Jian Yu, Hongwei Zhang, Jun Gu, Shizheng Jia. 2007. Improve the ship's ballast water control and management. Chinese Frontier Health Quarantine .30 (04). P.112-114

Dong Wang, Dongrong Xiao, Haitao Zhi, Mingjun Li.2003. The red tide monitoring network database and the implementation of modeling system. Marine forecast.20 (03). P.40-46 Weigen Huang, Xianmou Mao, Hongxiang Zhang, Aiqin Shi. 1998. The satellite remote sensing monitoring and real-time forecasting of red tide. Marine forecast .15 (03). P.110-115

ShiYong Wen, Dongzhi Zhao, Fengshou Zhang, Xiaofeng Ma, Fan Yang. 2009. The

methodology of red tide disaster risk assessment. Journal of Natural Disasters.18 (01). P.106-111

Zhongfeng Qiu. 2006. high incidence of red tide in ocean Donghai Ocean Color Remote Sensing Algorithms and Red Tides Detection in the High Frequency Red Tides Areas of the East China Sea. Chinese Academy of Sciences Graduate School PhD thesis. P.18-22

Hongjun Chen, Xiaohong Fan, WeiMin LI.2002. The history and current status of China's pest risk analysis (PRA). Plant Quarantine.16 (1). P.28-32

Kuoliang Zhou, Weimin LI, Limin Yin, Yajun Huang, Wei Jing Zhu, Zhigang Xu. 2006. pest risk analysis research development. Plant Quarantine.20 (3). P.162-164

Xiaofan Chen, Hongling Zhang, ZijuanLuo, Rirong He, Mutao Wu.2005. The invasion of exotic pest plant quarantine and control measures. Plant Quarantine.19 (2). P.87-90 Xianpu Wang, Ke Guo.2006. China's implementation of the Convention on Biological Diversity, the achievements and prospects. Guihaia. 26 (3): 249 - 256

General Group of China Biodiversity Conservation Action Plan Report. 1994. China Biodiversity Conservation Action Plan. China Environmental Science Press. P.120-126

Dehui Wang .2003. China's implementation of "Convention on Biological Diversity,". Environmental Progress .2003. P.5-10

Ministry of Environmental Protection .2005. The third national report of implementation of "Convention on Biological Diversity" of China. P.35-40

Wanling Lin. 2008. Legal Problems of MIS. Xiamen University, a master's degree thesis P.43-46

Hongyan Xie, Jiapu Zuo. 2005. Review of Chinese alien species of plants. Journal of Nanhua University (Science and Technology) .19 (3). P.47-51

Chengyuan Xu, Ju Zhang, Baorong Lu, Jiakuan Chen. 2001. Mechanisms of biological invasion .Biodiversity Science. 9 (4). P.430-438

Shi Qi, Jiang Wei, Yi Dan. 2005. Risk assessment research on alien marine species. Advances In Marine Science.23. P.127-131

Gaoguo Wei, Ninghui Li, Wen Yu.2007.The economic loss assessment research of biological invasion alien. Environment and Sustainable Development.3. P.1-6

Yan Zhu .2006. Research on Establishment and Management of Marine Protected Areas in China, Xiamen University, a master's degree thesis. P.48-53

Xiaolei Yi. 2003. Countermeasures of China's marine Environmental Monitoring Development. Qingdao Ocean University, a master's degree thesis. P.17-32

Runzhi Zhang, Le Kang. 2003. Early warning and legislative management for alien invasive species. Bulletin of the Chinese Academy of Sciences.6.P.413-415

Gen Xu, Sheng Qiang. 2004. Invasive Alien Species in China. China Environmental Science Press. P.46-47,259-279

The National Report of Japan on Marine Invasive Species in the NOWPAP Region

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1. Introduction: marine invasive species (MIS) in Japan

Japan has about 30,000 km of the shore line, and main urban and industrial areas are locating along the shore. After the last quarter of the 20th century, introduction of marine non-indigenous species into Japanese coastal waters, from Hokkaido to Okinawa archipelago, became large concern for marine scientists and industrial fields. The term of introduced or non-indigenous species, however, had not been clearly defined. Iwasaki et al. (2006a) classified these introduced species into three categories based on range of native distribution and Japanese border: 1, introduction from abroad; 2, introduction from abroad but the same specie lives in Japan; and 3, domestic introduction. In this report, a term of "exotic species" is used as the same mean of non-indigenous or introduced species that is involved in categories 1 and 2 in Iwasaki (2006a).

In 2002, the Ecological Society of Japan edited a handbook for exotic species in terrestrial and fresh/marine waters in Japan (Ecological Society of Japan 2002). Taxonomical and ecological information of 15 common exotic marine/brackish water species were described in the handbook.

In the same year, the Japanese Association of Benthology held a symposium titled "Marine Introduced Species in Japan and Associated Environmental Problems". Proceedings of the symposium have been published on "Japanese Journal of Benthology vol. 29 (2004)". The committee for the preservation of the natural environment, the Japanese Association of Benthology, cautiously evaluated information of non-indigenous marine and brackish water species, through three aspects that are; the original habitat of the species, when and where it was found in Japan, and possible vector of the introduction, then identified 25 non-indigenous (=exotic) species (24 zoobenthos and 1 macroalgal species) that have populated in the Japanese waters (Iwasaki et al. 2004).

In 2006, the Plankton Society of Japan also held a symposium titled "Ballast Water and Introduction of Plankton, Current Conditions and Future Measures", in which Iwataki and Matsuoka (2007) concluded that a dinoflagellate species may be recently introduced. Other topics were represented in the proceedings of the symposium in "Bulletin of the Plankton Society of Japan Vol. 54(1) (2007)".

The Japan Wildlife Research Center (2008) edited a guidebook for exotic species in terrestrial and aquatic habitats. Fifteen common marine/brackish water exotic species are elucidated with photographs, with an appendix for a list of exotic species in Japan. The Japanese Fishery Science Association published special issue for "Fishery Industry and Exotic Species" in 2009 (Nippon Suisan Gakkaishi, Vol.76 No.6). In this issue, Iwasaki (2009) listed 49 exotic marine species (but the brackish water bivalve Corbicua may contain several species) that have been possibly introduced in Japan, and 23 species including Corbicula spp. have been found in the Japanese coastal waters. Among 49 exotic species listed, 22 species have been populated in the Japanese waters. After he discussed about the impact of the exotic species on natural ecosystems, fishery and other industrial fields, he strongly mentioned that

it is very important to prevent introduction of marine organisms under the precautionary principle, since once the exotic species populated, it is impossible to eradicate established exotic populations.

The Plankton Society of Japan and the Japanese Association of Benthology collaboratively edited a book that describes characteristics of biology, ecology, fisheries and social problems relating to marine and fresh water exotic species (Plankton Society of Japan and Japanese Association of Benthology 2009). In this book, they recommended that quick actions to prevent the marine invasion should be done, with establishment of new monitoring systems for future invasions and process of spread of the exotic species that have populated in the Japanese coastal waters.

By referring the results of such activities and with other scientific reports, 24 zoobenthos, 5 macrophyte, 1 phytoplankton, 1 fish and 2 parasite species are recognized as marine exotic species that those exotic populations have established in the Japanese waters (see Table 1).

On a basis of the Article 8(h) of Convention on Biological Diversity, the government of Japan has enforced a new act "Invasive Alien Species Act (IAS Act)" in 2005 with the aim of preventing the adverse effects on ecosystem, human safety, agriculture, forestry or fisheries by Invasive Alien Species, that have populated terrestrial, freshwater, brackish and marine water habitats in Japan. Under the act, one family, 15 genera, and 81 species are registered as harmful exotic species or taxa, known as "Invasive Alien Species". Importing, raising, planting, storing or carrying of these registered organisms are prohibited under the act. Marine organisms, however, have not been included in the registered species in the act. This is because the information for the effects of most alien marine species to ecosystems and human society has been relatively restricted in comparison of that of terrestrial species. To date, there is no legal regulation for marine exotic organisms. Furthermore, monitoring system to observe new marine invasion and spread of the exotic species in the Japanese waters has not been established yet.

2. Current status of the MIS in Japan

2.1. Pathways (vectors and routes) of introduction of MIS to Japan

Iwasaki et al. (2004) estimated possible vectors of marine invasion into the Japanese coastal waters. They classified the vectors into 3 main categories: 1, fisheries; 2, shipping; and 3, aquarium. Results of the analysis indicated that the fisheries and shipping had almost the same responsibility for the vectors during the 20th century, but aquarium may have small responsibility (Fig. 1).

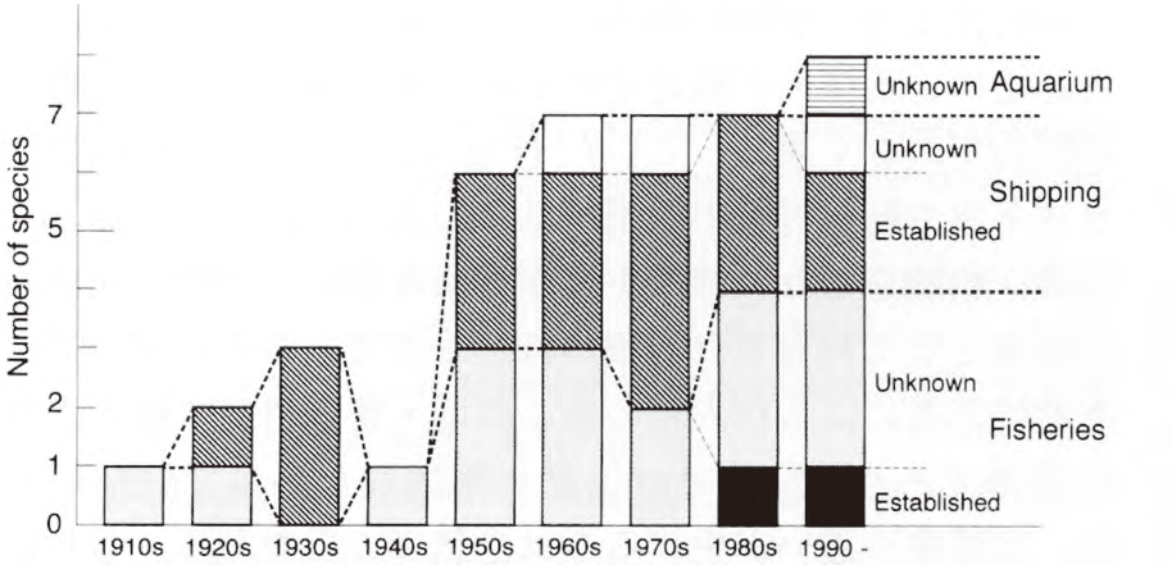

Fig. 1 Number of the first recorded non-indigenous species introduced into Japan every decade after 1910, with possible vectors of the introduction. Status of population establishment is shown whether established or unknown (Iwasaki et al. 2004).

2.1.1. Shipping and ballast waters

Otani (2004) reported that rich marine invasive species were found on ship hull and in sea chests. He estimated that about 44% of exotic marine species in Japan were brought with hull fouling. He also stated increase of importance of sea chests in human mediated trans-oceans of marine organisms rather than of ballast water, since inside of the sea chest is more stable than on ship hull or in ballast water. Even free living exotic

Fig.2 Pyromaia tuberculata

animals which are not be able to cling to the hull, such as the spider crab, Pyromaia tuberculata (Fig. 2), the Mediterranean green crab Cercinus asetuarii (Fig. 3) and the hard clam Mercenaria mercenaria (Fig. 4) may survive in the sea chest after trapped in the sea chest at the departure port (Otani 2004).

Fig.3 Cercinus asetuarii

Fig.4 Mercenaria mercenaria

2.1.2. Intentional introductions

Since most Japanese people prefer to eat fresh raw seafood, such as Sushi or Sashimi, many species of marine organisms commercially available have been imported under living condition. Some of these organisms were released to natural habitat for future utilization. Iwasaki (2007) reported that 21 exotic species among 49 marine and brackish water animal species or higher taxa that had brought into the Japanese waters were introduced intentionally for commercial selling or fishery studies and 3 species were unintentionally released with other commercial animals. The brackish water bivalve Corbicula spp. and the continental bass Lateolabrax sp. (Fig. 5) have established exotic populations in the Japanese waters.

Fig. 5 Lateolabrax sp.

The killer algae Caulerpa taxifolia was introduced to Japan for aquarium decoration, but there is no evidence of the establishment of its exotic population in the Japanese waters (Kawai 2009).

2.1.3. Aquaculture

Since young living fishes and shellfishes have been introduced to Japan from foreign countries, especially from China, Taiwan and Korea, to cultivate in aquaculture systems constructed in the natural marine environment along the Japanese coasts, many exotic species may have escaped into natural marine environment. Furthermore, some species have been unintentionally released with such commercial animals. Okoshi (2004, 2007) listed 22 animal species found in sacks of imported manila clams Rudtapes philippinarum which were released to tidal flats in northern Honshu. The moon snail Euspira fortunei (Fig. 6), which is one of these unintentionally released species and preys on the manila clam, have populated a lagoon in northern Honshu, and the moon snail caused critical damage of manila clam local fisheries. To date, the moon snail is establishing new local populations near the first populated site.

Fig.6 Euspira fortunei

Some of unintentionally introduced species brought by contamination with the aquaculture animals are the same species that is native to Japan. Genetic disturbance in Japanese population with abroad population of the same species should be concerned (Okoshi 2004, 2007).

2.1.4. Other

No special issue.

2.2. List of the MIS in Japan

See Table 1.

2.2.1. Benthic

Twenty nine species of exotic benthic animals and plants that have populated in the Japanese waters were listed in Table 1. Among them, 19 species are sessile, suggesting that these species were introduced with ships. The striped barnacle, Amphibalanus amphitrite (Fig. 7), and the Mediterranean blue mussel Mytilus galloprovincialis (Fig. 8) was introduced before the second war. Most of other sessile species were introduced after 1960s when cross-ocean trade largely increased, suggesting increase of ship arrival from foreign countries largely contributed introduction of the exotic species.

Fig.7 Amphibalanus amphitrite

Fig.8 Mytilus galloprovincialis

Table 1 List of exotic marine species that have populated in Japanese waters (1)

ZOOBENTHOS							
Species	Group	1st record	Location of 1st record	References	Possible vector	Current distribution	Native range
Balanus glandula Darwin	Barnacle	2000	Iwate Pref.	Kado (2003)	Ship hull-fouling	Pacific ocean in Western Hokkaido to Miyagi Pref.	Northeast Pacific
Amphibalanus improvisus Darwin	Barnacle	1952	Ago Bay, Mie Pref.	Kosaka (1985)	Ship hull-fouling	Honshu, Sikoku, Kyushu	Northeast Pacific
Amphibalanus eburneus Gould	Barnacle	1950	Yokosuka, Kanagawa Pref.	Henry and McLaughlin (1975)	Ship hull-fouling	Yamagata (Japan Sea) or Miyagi (Pacific) Prefs. to Kyushu	West Atlantic
Amphibalanus amphitrite Darwin	Barnacle	1935	Sagami Bay	Henry and McLaughlin (1975)	Ship hull-fouling, ballast-water	Entire Japanese coasts, except around Okinawa	Unknown
Amphibalanus zhujiangensis (Ren)	Barnacle	1998	Gushi Rv., Okinawa Pref.	Japanes Association of Benthology (2009)	Ship hull-fouling?	Okinawa Main Island, Indonasia, Australia	China
Megabalanus coccopoma (Darwin)	Barnacle	2005	Chigasaki, Kanagawa Pref.	Henry and McLaughlin (1986)	Ship hull-fouling?	Boso peninsula, Tokyo Bay, Sagami Bay, Izu peninsula, Kii peninsula, Seto Inland Sea	Tropical East Pacific
Paracerceis sculpta (Holmes)	Isopod	1986	Uwajima, Ehime Pref.	Ariyama and Otani (2004)	Ship hull-fouling	Ehime Pref., Osaka Bay	East Pacific
Pyromaia tuberculata (Lockington)	Crab	1970	Miura Peninsula	Iwasaki et al. (2004)	Ship hull-fouling	Pacific coast from Sendai Bay to Ise Bay, Seto Inland Sea, Ariake Sea	East Pacific
Rhithropanopeus harrisi (Gould)	Crab	2006	Ise Bay (Port of Nagoya)	Iseda et al. (2007)	Ship hull-fouling	Ise Bay, Osaka Bay, Tokyo Bay	West Atlantic
Carcinus aestuarii Nardo	Crab	1984	Tokyo Bay	Watanabe (1995)	Ship hull-fouling	Pacific coast from Sendai Bay to Ise Bay, Seto Inland Sea, Dokai Bay	Mediterranean, Black Sea
Crepidula onyx Sowerby	Gastropod	1968	Miura peninsula	Egawa (1985)	Ship hull-fouling	Hokkaido, Miyagi, Fukusima, Pacific coast from Chiba prefecture to Shikoku, Seto Inland Sea, Northern Kyusyu, Ariake Inland Sea	East Pacific
Nassarius sinarus (Philippi)	Gastropod	2000	Ariake Inlet	Tamaki et al. (2002)	Fisheries	Ariake Inland Sea, Seto Inland Sea	China
Euspira fortunei (Reeve)	Gastropod	Later 1980's	Shizuoka Pref.	Okoshi (2004)	Fisheries	Pacific coast from Iwate Pref. to Shizuoka Pref.	Sea, Mikawa Bay, China, Korean peninsula
Mytilus galloprovincialis Lamarck	Bivalve	1932	Osaka Bay (Port of Kobe)	Uchihashi (1939)	Ship hull-fouling	All Japanese coast	Mediterranean, East Pacific
Perna viridis (Linnaeus)	Bivalve	1967	Okitsu Osaka Bay, Hyogo Pref.	Ueda (2001)	Ship hull-fouling	Pacific coast from Chiba to Kagoshima Prefs.	Indian Ocean, Southeast Asia
Xenostrobus securis (Linnaeus)	Bivalve	1972	Lake Kojima, Seto Inland Sea, Okayama Pref.	Kimura et al. (1999)	Ship hull-fouling	Kanto and southward	Oceania
Mytilopsis sallei (Recluz)	Bivalve	1974	Port of Shimizu, Suruga Bay	Nabeshima (2002)	Ship hull-fouling, cargo fouling	Kanto and southward	Caribbean Sea
Mercenaria mercenaria Linnaeus	Bivalve	1998	Chiba City, Tokyo Bay	Nishimura (2003)	Unknown	Tokyo Bay, Osaka Bay	West Atlantic
Petricola sp. cf. *lithophaga*	Bivalve	1985	Sano, Osaka Bay	Kojima and Nishikawa (1995)	Ship hull-fouling	Osaka Bay, Tokyo Bay, Sagami Bay, Mikawa Bay	Unknown
Ficopomatus enigmaticus (Fauvel)	Polycoate	1966	Lake Kojima, Seto Inland Sea, Okayama Pref.	Arakawa (1980)	Ship hull-fouling	Pacific coast Miyagi Pref. and southward, Northern Kyushu	Unknown
Hydroides elegans (Haswel)	Polycoate	1928	Wakayama Pref. Lake Kojima, Okayama Pref.	Iwasaki et al. (2004)	Ship hull-fouling	Pacific coast of Honshu and Shikoku, Northern Kushu	Unknown
Hydroides dianthus (Verrill)	Polycoate	1997	Osaka Bay	Obani and Yamanishi (2007) Link et al. (2009)	Ship hull-fouling	Osaka Bay, Tokyo Bay	East coast of North America
Molgula manhattensis (De Kay)	Ascidian	1972	Takeoka, Seto Inland Sea, Hirosima Pref.	Iwasaki et al. (2004)	Ship hull-fouling	Pacific coast from Tokyo Bay and southward, Northern Kyushu	Northeast amd Northwest Atlantic
Polyandrocarpa zorritensis (van Name)	Ascidian	1991	Usa, Tosa Bay	Nishikawa et al. (1993)	Ship hull-fouling	Toyama Bay, Dokai Bay, Izu peninsula, Osaka Bay, Shikoku	Unknown

Table 1 List of exotic marine species that have populated in Japanese waters (2)

PHYTOBENTHOS							
Species	**Group**	**1st record**	**Location of 1st record**	**References**	**Possible vector**	**Current distribution**	**Native range**
Cutleria multifida (Turner) Greville	Brown algae	1957	Sasebo Bay	Migita and Ichiki (1962)	ship hull-fouling	Kyusyu, Ehime Pref., Hiroshima Pref., Mie Pref., Noto peninsula	Europe
Ulva fasciata Delile	Green algae	1970's	Seto Inland Sea , Ise Bay, Mikawa Bay	Arasaki (1984)	Ballast water	of Japan, Okinawa Archipelago	Mediterranean
Ulva armoricana Dion et al.	Green algae	2003	Mikawa Bay, Osaka Bay	Kawai et al. (2009)	Ballast water	Mikawa bay, Osaka bay	Northeast Atlantic
Ulva scandinavica Bliding	Green algae	2003	Mikawa Bay, Osaka Bay	Kawai et al. (2009)	Ballast water	Mikawa bay, Osaka bay	Northeast Atlantic
Ulva californica Wille	Green algae	2003	Mikawa Bay, Osaka Bay	Kawai et al. (2009)	Ballast water	Mikawa bay, Osaka bay, Pacific coast from Tohoku to Kanto	West coast of North America
PLANKTON							
Species	**Group**	**1st record**	**Location of 1st record**	**References**	**Possible vector**	**Current distribution**	**Native range**
Heterocapsa circularisquama	Dinoflagellata	1988	Western Japan	Iwataki and Matsuoka (2007)	Ballast water	Western Japan	Southwest Pacific?
FISH							
Species	**Group**	**1st record**	**Location of 1st record**	**References**	**Possible vector**	**Current distribution**	**Native range**
Lateolabrax sp.	Fish	1992	Shikoku	Konishi (1993)	Fisheries	Central to western Japan	China
PARASITE							
Species	**Group**	**1st record**	**Location of 1st record**	**References**	**Possible vector**	**Current distribution**	**Native range**
Neobenedenia girellae Hargis	Platyhermi nthes	1991	Western Japan	Ogawa et al. (1995)	Fisheries	Western Japan	Subtropical, Tropical
Neoheterobothrium hirame Ogawa	Platyhermi nthes	1993	Japan Sea	Ogawa (1999)	Fisheries	Entire Japanese coasts, except around Okinawa	Atlantic, Northamerica

Populations of these exotic species tended to be established in urban enclosed waters such as Tokyo bay and Osaka bay where had been developed for urban use in coastal areas, and bottom hypoxia is severe during summer due to eutrophication. Along the shores of these enclosed waters, tidal flats are natural coastal structure, but most of the tidal flats have been reclaimed to provide new urban and industrial areas and ports. Kimura (2000) suggested that construction of concrete hard-surfaces by the coastal development facilitated establishment of the exotic sessile species. Furota and Kinoshita (2004) suggested that deterioration of native benthos communities by seasonal bottom hypoxia provided temporal open habitats for exotic crabs that can quickly intrude into habitats where had recovered from summer hypoxia by life historical adaptability.

The hard clam Mercenaria mercenaria (Fig. 4) is one of recently introduced species in Tokyo bay. To date, this clam is very abundant in subtidal reduced soft-bottoms where most native benthic animals could not survive during summer hypoxia (Hiwatari and Kohata 2005). Higher tolerance of the hard clam to the hypoxia should be a reason to that the clam utilizes monopolistically such severe habitat environment.

2.2.2. Planktonic

The red tide dinoflagellate, Heterocapsa circularisquama, is considered to be exotic species, since it occurred after 1988 in western Japan, while it had been found in plankton samples collected in 1986 in Hong Kong water, China (Iwataki and Matsuoka 2007, 2009). Two red tide dinoflagellates species, Alexandrium tamarense and A. catanella, recently expanded their distribution range in Japan (Koike 2002), but it is not clear whether these species are exotic.

Since ballast waters usually contain rich plankton community including cysts of phytoplankton and resting eggs of zooplankton, many exotic plankton species should occasionally be released in the Japanese waters. However, there is very limited number of reports on the occurrence of the exotic plankton species in the Japanese coastal waters, probably due to taxonomical difficulties and scarcity of information on plankton communities in the past.

2.2.3. Nektonic and nektobenthic

Only the continental bass Lateolabrax sp. has been identified as an exotic nekton species by biochemical (Isozyme and DNA) and morphological analyses (Taniguchi 2009). During the early 1990s, the bass had been imported to western Japan from China for aquaculture. Some of the cultured bass escaped to natural waters, then they were fished by local amateur fishermen (Konishi 1993). Since the continental bass is genetically different from the native bass L. japonicus (Fig. 5), hybridization with the native bass may not be occurred (Taniguchi 2009).

2.3. Potential (expected) MIS in the NOWPAP Region

During the later half of the 20th century, 7 to 8 new exotic marine species have been recorded every decade in the Japanese coastal waters (Fig. 1) (Iwasaki et al. 2004). Since, to date, there is no legal regulation for both intentional and unintentional introduction of marine

abroad species into the Japanese waters, this trend may continue to future.

Fishery associated introduction of abroad marine species is an important vector for new introduction of the exotic species (Iwasaki 2004, 2007). Many living fishery animals, such as fishes, bivalves, gastropods and crabs, are imported from neighboring countries, such as China, Taiwan, South Korea and Russia. Some of these animals will be cultured not only in enclosed system but also in open habitat such as tidal flat. Furthermore, large number of marine species could be contaminated with living fishery animals (Okoshi 2004, 2007). If they were released into natural habitat with several individuals of the same species, they might be able to reproduce, and then some of them may succeed to establish new exotic populations.

3. Threats and impact of the MIS to native communities and ecosystems

3.1. Ecosystem changes (ecological)

Iwasaki (2006a, 2007) reviewed impact of the exotic marine species to the natural ecosystems in Japan, then he suggested that the exotic species have caused large disturbances in native benthos genes and communities. Hybridization occurred between Mediterranean Mytilus galloprovincialis and native M. trossrus mussels in northern Japan (Inoue et al. 1997, Rawson et al. 1999). Possibility of genetic disturbance through hybridization or introgression was pointed out in some genetically closed species; Chinese Eriocheir sinensis and native E. japonica mitten crabs (Kobayashi 2003), Chinese Meretrix petechialis and native M. rusoria hard clams (Kosuge 2002), Taiwanese Corbicula sp. and native C. japonica bivalves (Komaru 2002), and between Chinese and Japanese populations of the red ark shell Scapharce broughtonii (Yokogawa 1997).

Exclusion of native species by growth of the exotic species has been reported. The Mediterranean blue mussel Mytilus galloprovincialis covered on the native sessile species such as the small barnacle Chthamalus challengeri and the native oyster Crassostrea gigas, native mussel Septifer virgatus and brown alga Hizikia fusiforme, then the Mediterranean blue mussel occupied the space for such native species (Hoshiai 1958, 1960, 1961, 1964, 1965, Furuse and Furota 1985). Predominance of the exotic striped barnacle Amphibalanus amphitrite on intertidal hard bottom surfaces in enclosed waters may suggest that the exotic barnacle had decreased population density of the native barnacle Balanus reticulates (Yamaguchi 1989).

3.2. Economic impacts

Economic damage caused by out-break of exotic species population has been reviewed (Iwasaki 2006a,b). The Chinese snail, Nassarius sinarus (Fig. 9) has populated Ariake Inland Sea, Kyushu. They feed on gobies captured in fishery traps (Fukuda 2004).

Fig.9 Nassarius sinarus

Exotic sessile organisms such as mussels, M. galloporovincialis and Perna viridis (Fig. 10), calcareous tube building warms, Ficopomatus enigmaticus (Fig. 11) and Hydroides elegans, construct massive cluster on the hard substratum. They caused damage in the water pipes of electric generation plants and aquaculture nets (Iwasaki 2005, 2006a,b). An out-break growth of H. elegans caused economic damage in oyster culture in Hiroshima bay through fouling on oyster shells (Arakawa 1971).

Fig.10 Perna viridis

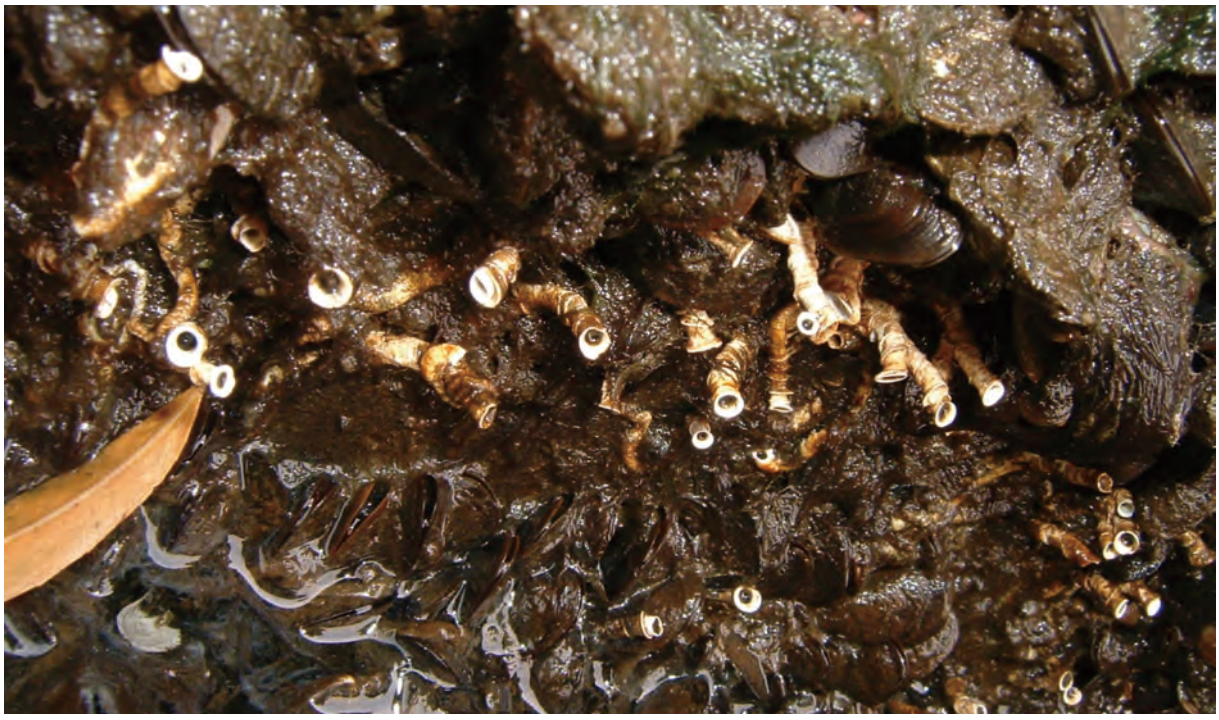

Fig.11 Ficopomatus enigmaticus

The moon snail, Euspira frotunei, was unintentionally introduced with manila clam Ruditapes pilippinarum imported from China, and was brought catastrophic damage in manila clam fisheries in Sendai bay, northern Honshu (Okoshi 2004, 2007). Though local fishermen are removing the snails and its egg collars from tidal flats, the damage is still critical.

3.3. Public health impacts

No evidence associated with public health caused by exotic marine species has been reported. However, Iwasaki (2007) stated that unintentional introduction of human-parasite trematode Paragnimus westernmanii with the intermediate host, the Chinese mitten crab Eriocheir sinensis, should be cautious, because the parasite may infect the native mitten crab E. japonica.

4. Prevention, detection and management of MIS

4.1. National/local authorities dealing with MIS monitoring

In the IAS Act, no marine exotic organism is included in the most severe criteria, known as “Invasive Alien Species” whose importing, raising and transferring within the country are prohibited. However, in order to strengthen the understanding and cooperation of individuals and businesses involved in the use of alien species to ensure proper handling, the “Alien Species Alert list” was published as a list of alien species that have no controls placed on their

handling such as raising based on the IAS Act, but have potential to cause adverse effects on ecosystems etc. As of April 2010, 12 invasive marine animals and one marine fish are listed on the Alien Species Alert list; Mytilus galloprovincialis, Perna viridis, Hydroides elegans, Ficopomatus enigmaticus, Amphibalanus amphitrite, Cercinus aestuarii, C. maenus, Nassarius sinarus, Xenostrobus secures (Fig. 12), Mytilopsis salei (Fig. 13), Corbicula spp.,Meretrix petechialis and Lateolabrax sp.

Fig.12 Xenostrobus secures

Fig.13 Mytilopsis salei

The government of Japan funded 925,000 Canadian $ for PICES to support establishment of global database system for marine invasive organisms. Under this financial support, PICES organized working group (WG 21) in 2006 for development of the template for the global database (Otani et al. 2009). The WG 21 carried out rapid assessments for marine invasive species in each PICES country to get basic data for the development of the effective template. In Japan, Furota et al. (2009) reported the result of a rapid assessment conducted in Tokyo bay.

To date, though there is no action for field survey on marine exotic species, associated with government support, the council of marine exotic species study (CMESS) in the Japanese coastal waters was organized in 2009 by three aquatic science associations, the Japanese Society of Phycology, the Plankton Society of Japan and the Japanese Association of Benthology. The group will report annually results of the analysis on the information of exotic marine species in the Japanese coastal waters.

4.2. Existing control and preventive measures, including status and risk assessments

The manila clam Ruditapes philippinarum is one of the most important commercial products in tidal flats around Japanese main islands. In Sendai bay, northeastern Honshu, local clam populations has been largely damaged by predation of the exotic moon snail Euspira frotunei that had been unintentionally introduced with the manila clams imported from China (Okoshi 2004, 2007). Local fisherman associations has been trying to eradicate the snails and deposited egg collars from the tidal flats, and they remove the contaminated animals other than the manila clam before they release the manila clams on tidal flats (Okoshi 2004, 2007). The local clam populations, however, have not been recovered yet.

Since there is not any law to request measures to reduce ecological and industrial damages caused by the exotic marine organisms, no governmental actions for the problem of the exotic marine species have been started.

4.3. Existing databases used for monitoring, control and prevention

There is no available database specialized for marine exotic species. Working group 21 (WG21) in PICES which was founded by the government of Japan has started to develop global database system for marine invasive organisms. Several scientific experts on the marine invasive organisms have participated in the WG21. Activities of the WG21 will end in 2012, but the database system will be established by 2011.

4.4. Future plans on monitoring, control and prevention

There is no plan on research and measure for the marine invasive organisms supported by the government of Japan. The council of marine exotic species study (CMESS) was established in 2009 for annual analysis of the information on the marine exotic species in the Japanese waters. Some members in the CMESS have started local monitoring for occurrence

of the invasive species in Tokyo bay, in which native species are also included to be observed due to some of such species are donor of invasive species for foreign ocean waters, such as the shore crab, Hemigrapsus sanguineus, and the sea star, Asterias amurensis.

5. Current research projects and other initiatives on the MIS in Japan

The CMESS will analyze annually information on the exotic species collected by members of each association and relating scientists. Its results will be published on a journal of one of the participated associations. Some members of the CMESS also have been worked as a member of WG 21 in PICES.

5.1. Priority research fields on the MIS

The exotic marine species tend to be more diverse and abundant in eutrophicated bays, such as Tokyo bay and Osaka bay whose waters are organically polluted and most shore lines have changed to hard substratum with concrete, while the exotic organisms are scarce in natural tidal flats in the bays or rocky shores in open coasts (Furota 2007). Bottom hypoxia in the eutrophicated bays destructs native populations, but some exotic species populated such severe habitat environment by higher physiological tolerance to the hypoxia ((in case of the hard clam Mercenaria mercenaria (Hiwatari and Kohata 2005)), by seasonal utilization by opportunistic recovery of local population ((in case of Pyromai tuberucalta (Furota and Kinoshita 2004)), or by seasonal migration ((in case of Cercinus aesturarii (Furota and Kinoshita 2004)). These suggest that deterioration of natural ecosystem and change of bottom structure could provide new open habitats for marine invasive species (Kimura 2000, Furota and Kinoshita 2004). Furota (2007) emphasized that recreation of natural and healthy habitats for marine organisms is necessary to recover the native community. Therefore, study on restoration of marine environment including shore structure and water quality is the basic measure for recovery of the native marine community.

Except for some species as mentioned above such as the Mediterranean blue mussel M. gallorovincialis, damages on ecosystems and native populations associating with establishment of exotic populations have not been clear, probably due to that such damage have been interested mainly in fishery field. Ecological studies on the effect of exotic species on native communities and ecosystems must be facilitated.

About 7 to 8 new exotic species were introduced into Japan every decade (Iwasaki et al. 2004) (Fig. 1). After the establishment of new exotic populations in a firstly populated water (core population), they spread to nearby other waters with rates of 10 to 25 km every year (Iwasaki et al. 2007). Quick action to eradicate the newly found core population must be fundamental measure to prevent establishment new exotic populations in the Japanese coastal waters, before it spreads to nearby waters (Iwasaki et al. 2007). Therefore, periodic monitoring on the occurrence of the exotic species at places where is potentially large chance to receive exotic species by cross-ocean ships or intentional

release of fishery species for aquaculture.

5.2. Brief summary of research/project/initiative

By Japanese members of WG 21 in PICES, rapid assessment for marine invasive species will be conducted in western Seto Inland Sea in June of 2010. Actions of the WG 21 will be closed next year. To date, there is no plan to establish next international actions for marine invasive species by the PICES.

The CMESS will analyze annually information and articles relating to marine exotic species in the Japanese waters. The CMESS will evaluate the information in the viewpoint of taxonomy and ecology, and then the results will be published on a Japanese journal published by one of the associations participated in the CMESS.

5.3. National taxonomy initiatives, including species inventory of alien species

After the end of WG 21 activity in PICES, there is no plan to initiate the taxonomical studies on the marine invasive species. Number of taxonomists for marine species is getting smaller, because professional positions for taxonomists are very limited in natural historical museum, universities, and marine institutes. Since taxonomy is not directly connected with commercial fields, job opportunities for the taxonomists and study condition should be improved under public support.

5.4. National databases or Internet sources on MIS

Though PICES WG 21 will establish a global database for MIS, such global system has not been available at present time.

Some Japanese marine biologists are working to establish global network (the Census of Marine Life: CoML) (http://www.comlsecretariat.org/) for marine biodiversity. The CoLM consists of four major component programs: the History of Marine Animal Populations (http://www.hmapcoml.org/), the Ocean Realm Field Project (http://www.coreocean.org/Dev2Go.web?id=254014), Future of Marine Animal Populations (http://news.coml.org/descrip/fmap.htm), and the database of the Ocean Biogeographic Information System (http://www.iobis.org/) (Fujikura et al. 2009).

6. Existing gaps in relation to the global and regional developments dealing with marine and coastal biodiversity, including invasive alien species

6.1. Compliance with relevant global conventions and agreements (e.g. CBD, BWC, etc.) and with other FAO and IMO regulations

According to the Article 8(h) of Convention on Biological Diversity, each contracting party shall, as far as possible and as appropriate, prevent the introduction of, control or eradicate those exotic species which threaten ecosystems, habitats or species. In response to this convention, as aforementioned, the IAS Act was established in Japan.Also, in order to comply with the necessary regulation relating to IMO, Act for the Prevention of Marine Pollution and Maritime Disasters was enacted in Japan. There are no acts containing regulations relating to BWC since BWC does not come into effect. However, Japan has been actively involved in the discussions at the IMO for developing the guidelines of the BWC.

6.2. Status of expertise and capacity building as related to MIS research; taxonomic ability to identify MIS in member countries

Since taxonomists of marine organisms are very limited, information of local marine fauna and flora are insufficient even in native species which include potential donor for future marine invasion around the world. Researches on the marine exotic species are basically conducted by personal or volunteer activities of marine taxonomists, ecologists and amateur naturalists. To date, there is no systematic contribution of the amateurs for research of the marine exotic species. The council for Marine Exotic Species Study (CMESS) will collect information from specialists and amateurs who are interesting in marine species, and then analyze the information.

Monitoring system for marine invasion must be established as soon as possible, because this monitoring system will contribute not only to get the newest occurrence of exotic species, but also to educate students and amateurs.

6.3. Future needs in capacity building (including training and equipment), public awareness raising, communication, compliance and enforcement

Since main vectors of marine invasions are associated with commercial activities; trading by ships and import of fishery species (Iwasaki 2004), those commercial fields must have the largest responsibility to prevent future invasion and to measure the marine exotic species populated in the Japanese waters. Establishment of new monitoring system by the government of Japan is required to understand current status not only of exotic marine species but also of native species, because many marine species native to Japan are potential donor for invasive

species in abroad waters (Carlton 1987).

Well-trained persons are necessary to identify marine species. If accuracy for the identification is not liable, the data and information of marine species will cause global confusion. Thus, experts for marine taxonomy must be well-trained to become professional taxonomists in universities, natural museum and institutes.

7. Legislation, programs and responsible organizations related to marine and coastal biodiversity, including invasive alien species

Ministry of the Environment has started monitoring research on biodiversity, species compositions and abundances, in the local biotic community at selected 1000 monitoring sites (Monitoring Sites 1000) in terrestrial and aquatic environments in Japan (http://www.biodic.go.jp/moni1000/index.html). The monitoring sites include 41 sandy shores, 6 rocky shores, 131 tidal flats, 6 eelgrass beds, 6 kelp beds, and 24 coral reefs. Special attention to find the exotic marine species should be paid in this monitoring survey. However, the selected sites are healthy natural environments as hot spots for conservation of biodiversity. In such healthy natural ecosystems, exotic species tend to be scarce or absent. Therefore, this monitoring survey is insufficient to find new introduction or expansion of the exotic marine species. As mentioned before, monitoring sites for marine invasion should be set in urbanized waters such as Tokyo bay and Osaka bay, and near aquaculture sites.

7.1. National legislation related to marine and coastal biodiversity issues (the full names of laws, policies and regulations)

The IAS Act.See 8.1.

7.2. Leading authorities (e.g. ministry, agency) to implement national legislation related to marine biodiversity issues

Biodiversity Research Center, Ministry of the Environment, The government of Japan: Conducting Monitoring sites 1000 in Japan. (See 7.)

http://www.biodic.go.jp/moni1000/monitoring/index.html

7.3. National legislation specifically addressing marine and coastal invasive alien species (including the full name of laws, policies and regulations with a short summary)

The IAS Act (Ministry of the Environment, Government of Japan, see Tanaka 2007 and http://www.env.go.jp/en/nature/as/040427.pdf) came into force by the government of Japan in 2004. However, marine exotic species, that culture and transport are prohibited, are not covered by the act as “Invasive Alien Species” whose importing, raising and

transferring within the country are prohibited. Other than this act, no legislation for the exotic marine organisms has not established by the national government in Japan. However, as aforementioned, thirteen exotic marine species are listed in the "Alien Species Alert list".

Under the so-called Ballast Water Management Convention (International Convention for the Control and Management of Ship's Ballast Water and Sediments, 2004), MLIT (Ministry of Land, Infrastructure and Transport, the Government of Japan) facilitates development of ballast water treatment system that is required to be cleared the standard of the Ballast Water Convention (Ministry of Land, Infrastructure and Transport, the Government of Japan 2007).

8. Recommendations for decision–makers in terms of priority national actions, services and products

To date, there is no action requested by Japanese laws to measure the exotic marine species that has been introduced or will be introduced into the Japanese coastal waters. Two vectors, trans-ocean ships and import of aquaculture animals, have been suggested to be major role of the marine invasion (Iwasaki 2004). In the case of the ship, the hull, especially niche areas such as seachests, and ballast water are temporal habitats during trans-ocean cruise. Therefore, to minimize the transfer of invasive aquatic species on the hull, biofouling management practices such as the use of anti-fouling system and in-water cleaning are discussed at some sub-committee of IMO. On the ballast water, some Japanese companies have developed ballast water treatment system that had final approval of the IMO.

Import of living marine animals for aquaculture is one of main vectors for introduction of invasive species (Iwasaki et al. 2004). Even import of the same species with Japanese natives, genetic disturbance, it must be concerned. Therefore, import of living marine animals from foreign countries must be decreased. Furthermore, when the imported animals are released in aquaculture system, careful attention to remove contaminated other animals and plants must be paid.

After an exotic species was introduced in a certain region, the exotic species may establish a core population in that regional water, and then starts to spread gradually to neighborhood waters by natural and human dispersal (Iwasaki et al. 2004b). Quick eradication of the exotic species at the initial site, before it established exotic core population in the initial site, may be most effective measure to prevent spread of exotic population to other Japanese waters (Iwasaki et al. 2004b). This suggests that detection of the occurrence of new exotic species in the early stage after the introduction is very important. Therefore, monitoring surveys to find exotic marine organisms at international ports and aquaculture sites where have large chance to receive exotic species are essential to prevent further introduction.

9. References

Arakawa K. 1971. Notes on a serious damage to cultured oyster crops in Hiroshima caused by a unique and unprecedented outbreak of a serpulid worm, Hydroides norvegica (Gunnerus) in 1969. Venus, 30: 75-81. (in Japanese with English abstract)

Arasaki S. 1984. A new aspect of Ulva vegetation along the Japanese coast. Hydrobiologia, 116/117: 229-232.

Ariyama H. and Otani M. 2004. Paracerceis sculpta (Crustacea: Isopoda: Sphaeromatidae), a newly introduced species into Osaka Bay, Central Japan. Benthos Research, 59: 53-59.

Carlton JT. 1987. Pattern of transoceanic marine biological invasions in the Pacific Ocean. Bulletin of Marine Science, 41: 452-465.

Ecological Society of Japan (ed.) 2002. Handbook of Alien Species in Japan. Tokyo: Chijinshokan, 390p. (in Japanese)

Egawa K. 1985. Distribution and Dispersion of Crepidula onyx in Japan. Chiribotan (Journal of Malacological Society of Japan), 16: 37-44. (in Japanese)

Fukuda H. 2004. Alien species and the labyrinths hindering their identification. Japanese Journal of Benthology, 59:68-73. (in Japanese with English abstract)

Furota T. (2007) Exotic benthic animals in Tokyo Bay. Aquabiology, 29:231-235. (inJapanese with English abstract)

Furota T. and Kinoshita K. 2004. Life histories of introduced crabs, the majid, Pyromaia tuberculata and the portunid, Cercinus aestuarii, in Tokyo Bay, and their adaptability to seasonal hypoxic environment caused by organic pollution. Japanese Journal of Benthology, 59: 96-104. (in Japanese with English abstract)

Furota T. Nakayama S. Taru M. Nishi E. Kurozumi T. Komai T. Nishikawa T. and Tomikawa K. 2008. A report for 2008 PICES WG 21 meeting in Dalian, results of rapid assessment for marine invasion in Tokyo Bay conducted in 2008. PICES (The North Pacific Marine Science Organization) 17th Annual Meeting Dalian, China. October 25, 2008.

Furuse K. and Furota T. 1985. An ecological study on the distribution of intertidal sessile animals in inner Tokyo Bay. Marine Fouling, 5: 1-6. (in Japanese with Einglish abstract)

Fujikura K. Nishida S. and Shirayama Y. 2009. Census of Marine Life. Bulletin of the Plankton Society of Japan, 56: 313-135. (in Japanese with English abstract)

Henry D. P. and McLaughlin P. A. 1975. The barnacles of the Balanus amphitrite complex (Cirripedia, Thoracica). Zoologische Verhandelingen, 141: 1-254.

Henry D. P. and McLaughlin P. A. 1986. The recent species of Megabalanus (Cirripedia: Balanomorpha) with special emphasis on Balanus tintinnabulum (Linnaeus) sensu lato. Zoologische verhandelingen, 235: 1-69.

Hiwatari T. and Kohata K. 2005. The large exotic bivalve Mercenaria mercenaia introduced in Tokyo Bay. Journal of Japan Society on Water Environment, 28: 614-617. (in Japanese)

Hoshiai T. 1958. Synecological study on intertidal communities. I. The zonation of intertidal animal community with special reference to the interspcific relation. Bulletin of the

Marine Biological Sation of Asamushi, 9: 27-33.

Hoshiai T. 1960. Synecological study on intertidal communities. III. An analysis of interrelation among sedentary organisms on the artificially denuded rock surface. Bulletin of the Marine Biological Sation of Asamushi, 10: 49-56.

Hoshiai T. 1961. Synecological study on intertidal communities. IV. An ecological investigation on the zonation in Matsusima Bay concerning the so-called covering phenomenon. Bulletin of the Marine Biological Sation of Asamushi, 10: 203-211.

Hoshiai T. 1964. Synecological study on intertidal communities. V. The interrelation between Septifer virgatus and Mytilus edulis. Bulletin of the Marine Biological Sation of Asamushi, 12: 37-41.

Hoshiai T. 1965. Synecological study on intertidal communities. VI. A synecological study on the intertidal zonation of the Asamushi coastal area with special reference to

its re-formation. Bulletin of the Marine Biological Sation of Asamushi, 12: 93-126.

Inoue K. Odo S. Noda T. Nakao S. Takeyama S. Yamaha E. Yamazaki F. and Harayama S. 1997. A possible hybrid zone in the Mytilus edulis complex in Japan revealed by PCR markers Marine Biology, 128: 91-95.

Iseda M. Otani M. and Kimura T. 2007. First record of an introduced crabs Rhithropanopeus harrisii (Crustacea: Brachyura: Panopeidae) in Japan. Japanese Journal of Benthology, 62: 39-44. (in Japanese with English abstract))

Iwasaki K. 2005. Impacts of introduced marine organisms on native ecosystems, fisheries and other industries in Japanese waters. Journal of Japan Society on Water Environment, 28: 598-602. (in Japanese)

Iwasaki K. 2006a. Human mediated introduction of marine organisms in Japan: a review. In: Koike F. Clout MN. Kawamichi M. De Poorter M. and Iwatsuki K. (eds.), Assessment and Control of Biological Invasion Risks. Tokyo: IUCN, Gland and Shokaboh Book Sellers, p.104-112.

Iwasaki K. 2006b. Exotic sessile animals and Invasive Alien Species Act. Sess Org,23:13-24.

Iwasaki K. 2007. Non-indigenous organisms introduced in Japanese waters and theirimpact on native ecosystems and industries. Nippon Suisan Gakkaishi, 73: 1121-1124.(in Japanese)

Iwasaki K. Kimura T. Kinoshita K. Yamaguchi T. Nishikawa T. Nishi E. Yamanishi R. Hayashi I. Okoshi K. Kosuge T. Suzuki T. Henmi Y. Furota T. and Mukai H. 2004a. Human-mediated Introduction and Dispersal of Marine Organisms in Japan: Results of a Questionnaire Survey by the Committee for the Preservation of the Natural Environment, the Japanese Association of Benthology, 59: 22-44. (in Japanese with English abstract)

Iwasaki K. Kinoshita K. and the committee for the preservation of the Japanese Association of Benthology 2004b. Renge expansion of non-indigenous marine benthos introduced into Japan through human activiteies. Bulletin of the Plankton Society of Japan, 51:132-144. (in Japanese with English abstract)

Iwataki M. and Matsuoka K. 2009. Transportation of harmful dinoflagellates.

In: The Plankton Society of Japan and the Japanese Association of Benthology (eds.), Marine Aliens Introduced by Human Activities and Their Impacts on Ecosystems and

Industries. Hatano: Tokai University Press. p.108-121. (in Japanese)

Japan Wildlife Research Center (ed.) 2008. A Photographic Guide to Invasive Alien Species in Japan. Tokyo: Heibonsha, 479p. (in Japanese)

Kado R. 2003. Invasion of Japanese shores by the NE Pacific Barnacle Balanus glandula and its ecological and biogeographical impact. Marine Ecology Progress Series, 249: 199-206.

Kawai H. 2009. Marine algae: Japanese algae that spread all over the world. In: Plankton

Society of Japan and Japanese Association of Benthology (eds.), Marine Aliens

Introduced by Human Activities and Their Impacts on Ecosystems and Industries. Hatano: Tokai University Press. p.138-150. (in Japanese)

Kawai H. Uwai S. Hanyuda T. Nakamura K. and Shimada S. 2009. Origin and dynamics of the introduced populations of Undaria pinnatifida (Phaeophyceae) and detection of introduced populations of Ulva spp. (Ulvophyceae) by the analyses using molecular markers. Japanese Journal of Ecology, 59:145-152. (in Japanese with English abstract)

Kimura T. 2000. Molluscs that are trifled by anthropogenic activities, endangered and exotic species in embayments. Kaiyo Monthly, Special Issue, (20): 66-73. (in Japanese)

Kimura T. Tabe M. and Shikano Y. 1999. Limnoperna fortunei kikuchiiHabe, 1981 (Bivalvia: Mytilidae) is a synonym of Xenostrobus securis (Lamarck, 1819): introduction into Japan from Australia and/or New Zealand. Venus, 58: 101–117.

Kobayashi S. 2003. Shanhai-gani ni tsuite (Chinese mitten crab). http://www.zpc.com/mokuzu/shanghai/index.htmi

Koike K. 2002. Toxic dinoflagellates. In: Hori T. Ohno M. and Horiguchi T. (eds.), Special Issue to Celebrate the 50th Anniversary of the Japanese Society of Phycology: Phycology in the early 21st century. Yamagata: JSP, p.67-70. (in Japanese)

Kojima T. and Nishikawa T. 1995. Occurrence of fossil shells in upthrusted bottom in inner bay (off Sakai). Kainakama (Newsletter of the Hansihin Shell Club), 29: 4-14. (in Japanese)

Konishi H. 1993. The third bass, spoted bass. Fishing Sunday (January 24th), 18: 63-70. (in Japanese)

Komaru A. 2002. Corbicula fluminea? In: Ecological Society of Japan (ed.). Handbook of Alien Species. Tokyo: Chijin-shokan, p.174. (in Japanese)

Kosaka A. 1985. Barnacles, competition for wharf surface. In: Okiyama M. and Suzuki K. (Eds.) Marine Organisms in Japan, Ecology of Invasion and Disturbance. Tokyo: Tokai University Press. p.61-68. (in Japanese)

Kosuge T. 2002. Meretrix petechialis. In: Ecological Society of Japan (ed.). Handbook of Alien Species. Tokyo: Chijin-shokan, p.190. (in Japanese)

Kyushu University, Faculty of Agricurture 1997. ?Development of technique and method for prevention of fishery damage (Fish and Shellfish kills) by red tides. Report on mesures against harmful algae in FY1996, p.1-4. (in Japanese)

Link H. Nishi E. Tanaka K. Bastida-Zavala R. Elena K. Kupriyanova E. K. and Yamakita T. 2009. Hydroides dianthus (Polychaeta: Serpulidae), an alien species introduced into Tokyo Bay, Japan. Marine Biodiversity Records, 2:e87.

Maritime Bureau, Ministry of Land, Infrastructure and Transport, the Government of Japan 2007. Policy of the MLIT on ballast water management convention issue. Nippon Suisan,

Gakkaishi, 73: 1150-1154. (in Japanese)

Migita S. and Ichiki A. 1962. Cutleria multifida in west coast of Kyushu. Japanese Journal of Phycology, 10: 77-81. (in Japanese)

Ministry of the Environment, the Government of Japan:
http://www.env.go.jp/en/nature/as/040427.pdf

Nabeshima Y. 2002. Mytilopsis sallei, Dreissenidae bivalve of Caribbean Sea origin. In: Ecological Society of Japan (ed.). Handbook of Alien Species. Tokyo: Chijin-shokan, p.189. (in Japanese)

Nishikawa T. Kajiwara K. and Kawamura K. 1993. Probable introduction of Polyandrocarpa zorritensis (van Name) to Kitakyusyu and Kochi, Japan. Zoological Science, 10:176.

Nishimura K. 2003. The introduced clam Mercenaria mercenaria in inner Tokyo Bay. Hitachiobi (The Reports of the Tokyo Malacological Society), 94: 13-17. (in Japanese)

Ogawa K. 1999. Neoheterobothrium hirame sp. Nov. (Monogenea: Diclildoporidae) form the buccal cavity wall of Japanese flounder Paralichthys olivadeus. Fish Pathology, 34:195-201.

Ogawa K. Bondad-Reantaso M.G. Fukudome M. and Wakabayashi H. 1995. Neobenenia grellae (Hargis, 1955) Yamaguchi, 1963 (Monogenea: Capsakudae) form cultured marine fishes of Japan. Journal of Parasitology, 81:223-227.

Okoshi K. 2004. Alien species introduced with imported clams: the Clams: the clam eating moon snail Euspira fortunei and other unintentionally introduced species. Japanese Journarl of Benthology, 59: 74-82. (in Japanese with English abstract)

Okoshi K. 2007. Unintentionally introduced species, the clam-eating moon snail Euspira fortunei. Nippon Suisan Gakkaishi, 73: 1129-1132. (in Japanese)

Otani M. 2004 Introduced marine organisms in Japanese coastal waters, and the process involved in their entry. Japanese Journal of Benthology, 59: 45-57. (in Japanese with English abstract)

Otani M. Furota T. Yokoyama H. and Katoh M. (2009) Development of database for marine non-indigenous species by PICES. Bulletin of the Plankton Society of Japan, 56: 182-189. (in Japanese with English abstract)

Otani M. and Yamanishi R. 2007. Two newly recorded alien species Rhithropanopeus harrisii (Crustacea; Panopeidae) and Hydroides dianthus (Polychaeta; Serpulidae). Proceedings of the Annual Meeting of the Japanese Society of Sessile Organisms, 2007, 9. (in Japanese)

Plankton Society of Japan and Japanese Association of Benthology (eds.) 2009.

Marine Aliens Introduced by Human Activities and Their Impacts on Ecosystems and Industries. Hatano: Tokai University Press, 298 p. (in Japanese)

Rawson PO. Agrawal V. and Hilbish TJ. 1999 Hybridization between the blue mussels Mytilus galloprovincialis and M. trossulus along the Pacific coast of North America: evidence from limited introgression. Marine Biology, 134: 201-211.

Tamaki A. Mahori N. Ishibashi T. and Fukuda H. 2002. Invasion of two marine alien gastropods Stenothyra sp. and Nassarius (Zeuxis) sinarus (Caenogastropoda) into the Ariake

Inland Sea, Kyushu, Japan. Yuriyagai (Journal of t
he Malocozoological Association of Yamaguchi), 8: 63-81.

Tanaka E. 2007. Effort of the Minstry of the Environment on measures against alien aquatic species. Nippon Suisan Gakkaishi, 73: 1147-1149. (in Japanese)

Taniguchi N. 2009. Present condition of exotic fish introduction and risk management. In: Plankton Society of Japan and Japanese Association of Benthology (eds.), Marine Aliens Introduced by Human Activities and Their Impacts on Ecosystems and Industries. p.177-192. (in Japanese)

Uchihashi K. 1939. New distribution of the blue mussel (Mytilus edulis Linné) in Japanese Archipelago. Bulletin of the Fisheries Experiment Station of Hyogo-ken, 1: 5-8. (in Japanese)

Ueda I. 2001. Sedentariness of the green mussel in Japan. In: Kajiwara T. and Okutani T. (Eds). Kuroshozoku no Shinnyusha (Invaders Dressed with Black Cloths). Tokyo: Kouseisha Kouseikaku, p. 27-45. (in Japanese)

Watanabe S. 1995. The massive appearance of the Mediterranean green crab, Carcinus medittarraneus, in Tokyo Bay. Cancer, 4: 9-10. (in Japanese)

Yamaguchi T. 1989. Foreign barnacles immigrated to Japan, with special reference to the changes in geographic distribution and ecology. Kanagawa Shizen-shi Siryou, 10: 17-32. (in Japanese)

Yokogawa K. 1997. Morphological and genetic differences between Japanese and Chinese red ark shell Scapharca broughtonii. Fisheries Science, 63: 332-337.

National Report of Republic of Korea on Marine Invasive Species in the NOWPAP Region

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1. Introduction: Marine invasive species (MIS) in Korea

Korea is a peninsula state surrounded by water on three sides. Although the area of the state is small, there are many ports on the coastline. The indented coastline creates semi-closed topography with possibility for exotic species flowing into to the sea 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-raising and transplant (Park et al., 2005). In fact, according to the report from National Institute of Environmental Research (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).

Today, most of export and import cargoes are transported via ocean, and in 2005, the amount of ocean trade reached 375 billion dollars occupying 69% of the total amount of trade. In particular, Busan port, being fifth in the world container traffic rankings is serving as a gate for Asia linking the Pacific and Eurasia (KCTA, 2006). Also, Korea is one of the major shipbuilding countries in the world, and its CGT (Compensated Gross Tonnage) will reach 8.5 million by October, 2006. Korea is also a major fishing industrial country exporting 1,139 million dollars and importing 2,233 million dollars in 2004 (OECD, 2006; KFA, 2007).

Therefore, the extent of potential damage for Korea due to the inflow and spread of marine alien species is expected to be greater comparing to any other countries.

Every year harmful algal blooms or harmful organisms such as jellyfish appear near Korea, Japan and China located in the Pacific Northwest 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.

2.Current status of MIS in Korea (within the NOWPAP region)

2.1. Pathways (vectors and routes) of introduction of MIS to Korea

2.1.1. Shipping and ballast waters

For the risk assessment of ballast water among the ports, it is necessary to understand the amount and frequency of discharge and intake of ship ballast water as well as environmental similarity and risk species threat. In case of Korea, however, the ballast reporting form is not required by law. Korea port state cannot directly estimate the amount of discharge or intake of water in their ports.

The amount of discharge was calculated by multiplying the ratio by the amount of net loading by which the amount of unloading is subtracted from the amount of loading. Over

160,000 of data regarding the amount of loading and unloading for 2007 was provided by SP-IDC (Shipping and Port-Internet Data Center).

The amount of ballast water discharge in all of ports in Korea in terms of ship departures from various foreign ports was calculated. As an example, Tables 2.2.1.1 to 2.2.1.3 show the discharge of ballast water at the port of Busan from China, Japan and Russian Federation, respectively.

Table 2.2.1.1. Prediction of Discharge of Ballast Water at the Port of Busan from China, 2007

Port	Ship Type	Freq	Cargo Loading	Cargo Unloading	Total Cargo	Net Loading Cargo	Variation Ratio (Table 1)	Estimated DBW	DBW/ Total Cargo
SHANGHAI	Ro-Ro Ship	3	4,000	12,000	16,000	3,000	4%	120	0.8%
	Container ship	774	8,439,235	5,470,873	13,910,108	3,587,426	8%	286,994	2.1%
	General cargo ship	23	328,424	714,265	1,042,689	57,288	33%	18,905	1.8%
	Bulk carrier	3	9,044	8,247	17,291	6,149	35%	2,152	12.4%
	Subtotal	803	8,780,703	6,205,385	14,986,088	3,653,863	-	308,171	2.1%
NINGBO	Container ship	279	3,725,891	1,747,410	5,473,301	2,157,793	8%	172,623	3.2%
	General cargo ship	5	11,155	22,961	34,116	9,405	33%	3,104	9.1%
	Subtotal	284	3,737,046	1,770,371	5,507,417	2,167,198	-	175,727	3.2%
QINGTAO	Ro-Ro Ship	1	73	5,959	6,032	50	4%	2	0.0%
	Container ship	311	5,342,043	5,877,638	11,219,681	1,026,289	8%	82,103	0.7%
	General cargo ship	15	194,034	455,161	649,195	28,182	33%	9,300	1.4%
	Bulk carrier	2	3,619	4,971	8,590	3,480	35%	1,218	14.2%
	Subtotal	329	5,539,769	6,343,729	11,883,498	1,058,001	-	92,623	0.8%
CHIWAN	Container ship	56	1,214,765	474,682	1,689,447	784,568	8%	62,765	3.7%
	Subtotal	56	1,214,765	474,682	1,689,447	784,568	-	62,765	3.7%
YANTIAN	Container ship	62	821,143	636,732	1,457,875	325,459	8%	26,037	1.8%
	Subtotal	62	821,143	636,732	1,457,875	325,459	-	26,037	1.8%
DALIAN	Ro-Ro Ship	19	1,333	2,351	3,684	967	4%	39	1.1%
	Container ship	40	1,258,096	2,462,583	3,720,679	38,285	8%	3,063	0.1%
	General cargo ship	12	116,286	534,472	650,758	25,120	33%	8,290	1.3%

	Bulk carrier	1	2,800	35,900	38,700	2,800	35%	980	2.5%
	Subtotal	72	1,378,515	3,035,306	4,413,821	67,172	-	12,372	0.3%

Table 2.2.1.2. Prediction of Discharge of Ballast Water at the Port of Busan from Japan, 2007

Port	Ship Type	Freq	Cargo Loading	Cargo Unloading	Total Cargo	Net Loading Cargo	Variation Ratio (Table 1)	Estimated DBW	DBW/ Total Cargo
HAKATA, FUKUOKA	Container ship	243	1,952,878	1,919,916	3,872,794	283,759	8%	22,701	0.6%
	General cargo ship	299	476,379	122,931	599,310	383,959	33%	126,706	21.1%
	Subtotal	542	2,429,257	2,042,847	4,472,104	667,718	-	149,407	21.7%
MOJI, FUKUOKA	Container ship	192	1532690	985887	2,518,577	633,779	8%	50,702	2.0%
	General cargo ship	2	114706	112300	227,006	3,306	33%	1,091	0.5%
	Subtotal	194	1,647,396	1,098,187	2,745,583	637,085	-	51,793	2.5%
OSAKA, OSAKA	Ro-Ro Ship	3	297,300	296,100	593,400	2,200	4%	88	0.0%
	Container ship	156	1,343,057	1,459,045	2,802,102	383,130	8%	30,650	1.1%
	General cargo ship	12	81,389	152,483	233,872	40,885	33%	13,492	5.8%
	Subtotal	171	1,721,746	1,907,628	3,629,374	426,215	-	44,230	6.9%
YOKOHAMA, KANAGAWA	Ro-Ro Ship	2	700	190	890	700	4%	28	3.1%
	Container ship	97	970,557	987,041	1,957,598	263,577	8%	21,086	1.1%
	General cargo ship	2	45,175	85,179	130,354	10,817	33%	3,570	2.7%
	Bulk carrier	1	12,326	45,991	58,317	3,126	35%	1,094	1.9%
	Subtotal	102	1,028,758	1,118,401	2,147,159	278,220	-	25,778	8.8%
NAGOYA, AICHI	Ro-Ro Ship	2	3,500	2,000	5,500	1,500	4%	60	1.1%
	Container ship	107	645,764	553,350	1,199,114	178,737	8%	14,299	1.2%
	General cargo ship	4	54,319	98,132	152,451	15,618	33%	5,154	3.4%
	Bulk carrier	1	8,523	41,617	50,140	230	35%	81	0.2%
	Subtotal	114	712,106	695,099	1,407,205	196,085	-	19,594	5.8%
SHIMONOSEKI, YAMAGUC	Ro-Ro Ship	90	82,793	120,567	203,360	8,837	4%	353	0.2%
	Container ship	12	41,988	40,895	82,883	5,293	8%	423	0.5%
	Subtotal	102	124,781	161,462	286,243	14,130	-	776	0.7%

Table 2.2.1.3. Prediction of Discharge of Ballast Water at the Port of Busan from Russian Federation, 2007

(unit: ton)

Port	Ship Type	Freq	Cargo Loading	Cargo Unloading	Total Cargo	Net Loading Cargo	Variation Ratio (Table 1)	Estimated DBW	DBW/ Total Cargo
VLADIV OSTOK	Ro-Ro Ship	46	15,450	858	16,308	15,000	4%	600	3.7%
	Container ship	125	669,534	311,525	981,059	385,458	8%	30,837	3.1%
	General cargo ship	18	44,553	45,096	89,649	39,241	33%	12,950	14.4%
	Subtotal	189	729,537	357,479	1,087,016	439,699	-	44,387	21.3%
VOSTOCH NIY,PORT	Container ship	100	649036	461441	1,110,477	233,985	8%	18,719	1.7%
	General cargo ship	12	34,486	12,524	47,010	27,655	33%	9,126	19.4%
	Subtotal	112	683,522	473,965	1,157,487	261,640	-	27,845	21.1%
NAKHOD KA	Ro-Ro Ship	9	1,166	0	1,166	1,166	4%	47	4.0%
	Container ship	48	118,361	42,428	160,789	84,197	8%	6,736	4.2%
	General cargo ship	16	24,747	144,657	169,404	15,935	33%	5,259	3.1%
	Oil tanker ship	2	4,650	13,567	18,217	4,650	50%	2,325	12.8%
	Subtotal	75	148,924	200,652	349,576	105,948	-	14,367	24.1%
KORSAKOV	Ro-Ro Ship	4	490	205	695	426	4%	17	2.4%
	Container ship	1	344	1,407	1,751	10	8%	1	0.1%
	General cargo ship	34	47,275	15,081	62,356	34,435	33%	11,364	18.2%
	Bulk carrier	1	100	0	100	100	35%	35	35.0%
	Subtotal	40	48,209	16,693	64,902	34,971	_	11,417	55.7%
VANINO	General cargo ship	19	45,900	41,883	87,783	34,848	33%	11,500	13.1%
	Subtotal	19	45,900	41,883	87,783	34,848	-	11,500	13.1%
KHOLMSK	General cargo ship	13	38,100	11,875	49,975	26,225	33%	8,654	17.3%
	Subtotal	13	38,100	11,875	49,975	26,225	-	8,654	17.3%

2.1.2. Intentional introduction

Normally, alien species are intentionally brought in for the purposes of exporting and importing fisheries product, procuring fishery recourse, cultivating target species, aquarium

fish and leisure (Campbell and Hewitt, 1999). Intentional or deliberate introduction for increasing resources and fish-raising usually means discharging single species. Intentional introduction for cultivating target species caused the secondary species to migrate and spread. The unexpected spread of these target species tends to have bad influence to ecology such as extinction of native species and changes in inhabiting environment.

2.1.3. Unintentional introduction

Unintentional introduction takes place when human as a vector transports species. Transportation of species via ship ballast water and ship (or hull) bio-fouling is known as one of the most important vectors today. There are more than 200 alien species introduced to San Francisco Bay via those routes. Also, organisms from any adjacent countries travel into the waters of another country and all kinds of organisms attached to drifted materials are introduced through ocean current. Moreover, the introduced alien species can escape and spread out (usually for raised fish and aquarium fish), and there are pathogens attached to the introduced species.

2.2. List of MIS in Korea (with brief notes on local distribution)

There are a few published reports on the extent of marine invasive species in the NOWPAP region (Seo and Lee 2008). However, a lot of marine invasive species have already invaded the region. Here, we need to briefly summarize the current information on MIS in Korea. There are 41 species suspected to be invaders in Korean coastal water (Kim 1992; Gong and Seo 2004; Lee and Kim 2006; Seo and Lee 2009). These species belong to seven classifications, namely bivalves, echinoderms, barnacles, tunicates, bryozoans, phytoplankton and fishes.

2.2.1. Benthic

The list of benthic invasive species in Korean waters is described in Table 2.2.2.1. A total of 22 benthic species are known as MIS in Korean coastal water. Among them, invasive bryozoan species such as Bugula neritina, Tricellaria occidentilis and Watersipora sutorquata are the most abundant species (Gong and Seo 2004; Hur et al. 1986). In China and Korea regions, 13 invasive bryozoans are reported (Seo and Lee 2009).

Table.2.2.2.1. List of marine benthic organisms considered as invasive species in Korea.

Classification	Species name	Distribution
Bivalves	Mytilus galloprovincialis (M. edulis)	Southern Europe, Mediterranean Sea
	Chlamys senatoris nobilis	West Pacific, China, Japan
Echinoderms	Asterias amurensis	

Barnacles	Balanus amphitrite	Indian, South Pacific
	Balanus eburneus	Caribbean Sea, Atlantic coast of North America
	Balanus improvisus	
	Balanus perfortatus	
Tunicates	Ciona intestinalis	
	Styela plicata	
Bryozoans	Amathia distans	Australia, Brazil, East Indies, Japan
	Electra tenella	California Bay, Florida, Brazil, Colombia, Japan, Caribbean Sea
	Bugula californica	Hong Kong, Mexico, Brazil, Japan
	Bugula neritina	Hong Kong, Hawaii, New Zealand, California coast, Japan, Pacific, Indian, Atlantic
	Tricellaria occidentilis	Hong Kong, New Zealand, Japan, Pacific
	Eurystomella bilabiata	California, England, Vancouver, Mexico, Japan
	Escharoides excavate	California, Australia, New Zealand, Galapagos Islands
	Celleporaria aperta	Japan
	Watersipora sutorquata	Brazil, West India, New Zealand, Japan, Burmud Islands, Cabo Verde Islands
	Schizoporella unicornis	China sea, Hong Kong, Hawaii, Japan, Pacific, Atlantic, Mediterranean, Indian
	Mucronella perforate	Japan
	Fenstrulina malusii	West Africa, Mediterranean, North Sea, Japan
	Celleporina geminate	Japan

2.2.2. Planktonic

The list of planktonic organisms considered as invasive species in Korean waters is shown in Table 2.2.2.2. These species might have originated from tropical waters, which is caused by the Kuroshio Current. Recently, the occurrences of tropical species such as fishes, invertebrates, and macro algae have been commonly observed in the southern coastal area of Korea (Lee and Kim 2006; Kim et al. 2008). The presence of tropical phytoplankton species could be attributed to recent changes in strength and direction the Kuroshio Current moving warmer southern waters close to the shores of Northeast Asia. Therefore, these species have been recently considered as invasive species. However, the intrinsic ability of these invasive species introduced via this water current was not examined. In addition, ship ballast water is considered to be the influential vector for introducing organisms outside of their bioregions (Carlton and Geller 1993). Until recently,

the impact of introducing organisms via ship ballast water has not been tried in Korea (MOMAF 2004). Thus, MIS from ship ballast water is not well understood.

Table 2.2.2.2. List of marine planktonic organisms considered as invasive species in Korea.

Classification	Species name	Distribution
Phytoplankton	Ceratium geniculatum	Atlantic, Indian, Pacific
	Ceratium lamellicorne	Tropical area, Atlantic, Indian, Pacific, Japan
	Ceratium praelongum	Atlantic, Indian, Pacific, Coasts attached to the main stream of the Kuroshio Current
	Dinophysis diegens	Tropical side of American Pacific ocean, Japan
	Dinophysis shuttii	Tropical ocean, Japan
	Histioneis highlei	Main stream of the Kuroshio Current
	Ornithocerus calolinae	Tropical area of American Pacific
	Ornithocerus serratus	Tropical area
	Oxytoxum reticulatum	Mediterranean, South Pacific, Japan
	Phalacroma cuneus	Main stream of Kuroshio Current
	Podolampas palmipes	Tropical area, South Pacific, Atlantic, Mediterranean, Southern Japan
	Pyrocystis hamulus	Japanese side of the Kuroshio Current
	Pyrocystis lunula	Japanese side of the Kuroshio Current

2.2.3. Nektonic and nektobenthic

Although much freshwater invasive fishes were reported, marine invasive nektonic organisms are relatively low (Seo and Lee 2009). Until now, a total of 6 nektonic and nektobenthic species are considered to be invasive species in Korean coastal waters. The current information on the six marine species is also limited.

Table 2.2.2.3. List of marine nektonic organism considered as invasive species in Korea.

Classification	Species name	Distribution
Fishes	Scophthalmus maximus (Pleuronectes maximus)	North Atlantic, Mediterranean, European coast, Black Sea
	Lateolabrax maculates(Holocentrum maculatum, Lateolabrax japonicus)	China, Japan
	Morone saxatilis(Perca saxatilis)	Canada, North America

	Pseudocaranx dentex(Caronx delicatissimus, Scomber dentex, Caranx dentex, Longirostrum delicatissimus)	Atlantic, Pacific
	Sciaenops ocellatus(Perca ocellata)	West Atlantic, Florida Bay, Maxico bay
	Salmo salar(Salmo brevipes)	West Atlantic, Canada, Portugal

2.3. Potential (expected) MIS in the NOWPAP Region

Studies on non-native marine species in the NOWPAP Region is relatively few compared to other areas such as North America, Europe and Mediterranean and Australia. However, many marine invasive species have already invaded the region. According to the Seo and Lee (2009), there are 136 species suspected to be invaders in Chinese and Korean coastal waters. These include a wide variety of taxa (Kim 1992; Gong and Seo 2004; Lee and Kim 2006). In case of Japan (Otani 2004), over 40 marine invasive species have been recognized. Therefore, more than 180 species may have been expected as MIS in the NOWPAP region.

3. Threats and impact of MIS to native communities and ecosystems

3.1. Ecosystem changes (ecological)

In ecosystems, the amount of available resources and the extent to which those resources are utilized by organisms determine the effects of introduced or invaded species on the ecosystem. In stable ecosystems, equilibrium exists in the utilization of available resources. When changes occur in an ecosystem, like marine habitat destructions in an area and marine pollution, normal succession would favor certain native species. However, with the introduction of species that can multiply and spread faster than the native species, the balance is changed and the resources that would have been used by the native species are now utilized by invaders. This impacts the ecosystem and changes its composition of organisms and their use of available resources. Until recently, ecosystem-based impact of marine bioinvasion on the ecosystem has not been tried in Korea. Instead, basic port surveys have been carried out for the integration of biological and environmental factors to develop the ballast water management program. Thus, more consistent investigation should be continued to understand what kinds of changes go on in the ecosystems of interest in Korea.

3.2. Economic impacts

The Mediterranean mussel Mytilus galloprovincialis was introduced to Korean shores by an ocean-going ship during the 1950s. It has since spread along the shores of Korea and has become dominant over the endemic species M. coruscus. Most power plants in Korea are located along seashores. This regional merit gives opportunity to easily cool down the heat

exchangers of power plants. However, massive fouling by the species throughout the inlet pipe to draw sea water makes the operation of power plant periodically stop to eradicate heavily fouled mussel. This process causes a lot of losses in terms of unnecessary labour and money. Until now, efficient eradication methods of the species on the artificial surfaces have not been developed.

3.3. Public health impacts

In Korea, mariculture can serve as a vector for transfer of alien pathogens. Indigenous shrimp culture farming has been seriously damaged by the White-Spot Syndrome Virus (WSSV) by 28.4% of shrimp farms in Korea during 2004. Without any strategic approach to eradicate such imported marine pests as soon as they are found, damage to the fishery industry could potentially spread along the entire coast. Similarly, human paillomavirus (HPV) was recently found in 76% of shrimp farms, and is spreading gradually around the world. Other agents of disease have affected other fishery species. Indigenous turbot (Scophthalmus maximus), a typical mariculture species in Korea, has suffered from a mortality of 15% due to invasive viral diseases. Other fishes, such as Pagrus major and Sebastes inermis, had their population affected by the infections of iridovirus and viral nervous necrosis (VNN). It is assumed that the financial damage to mariculture by viruses or bacteria reaches about 250 million (US) dollars per year in Korea.

4. Prevention, detection and management of MIS

4.1. National/local authorities dealing with MIS monitoring

4.1.1. Korea Ocean Research & Development Institute (KORDI)

As part of the project “Development of port environmental risk assessment technology”, ecological risk assessment is aimed through consistent monitoring of the port environment, ecosystem and foreign species. Port ecological risk assessment program has been developed based on the set-up of the port’s environmental and biological database, inbound and outbound ship's information. This project consists of environmental and biological monitoring of the port and ballast water, set-up of environmental and biological parameter's database of port and ballast water, establishment of information for a ship's voyage and ballast water and set-up of integrated management for risk analysis. From the results of this project, risk management techniques will be established for port risk assessment. Then, port-to-port risk assessment techniques will be established as guidelines for risk assessment (G7) and additional measures regarding ballast water management (G13) under the BWM Conservation.

4.1.2. Ministry of Land, Transport and Maritime Affairs (MLTM)

This project (Study on the management of marine invasive species) aims to set-up integrated management method of marine invasive species for the conservation of marine

diversity from disturbance by foreign species. Thus, major contents of this project consist of field investigation of foreign species and suggestions of guidelines for global cooperation, effective field investigation and management implementation. Investigations to find out the current status of foreign species have been carried out in the coastal ports and trading ports adjacent to industrial complexes, and Jeju Island. Potential foreign species were listed through a taxonomical analysis of 10 major ports. Hull bio-fouling organisms were analyzed three times from ship's hulls at the ports of Ulsan, Busan and Incheon. Macro invertebrate was investigated from the three points around Jeju Island. On the other hand, international cooperation research program and plan were designed to enhance our governmental ability to manage marine invasive species.

4.2. Existing control and preventive measures, including status and risk assessments

In Korea, a prototype program of ballast water risk assessment was first made by Korea Ocean Research & Development Institute (hereinafter referred as "KORDI") in 2009. The program was established based on the GloBallast program initiated by International Maritime Organization and conducted by relative overall risk assessment. The calculation of ballast water risk assessment is based on four factors (C1, C2, C3, C4). C1 is the proportional 'inoculation' frequency. C2 is the proportional 'inoculation' size. C3 is the relative similarity of the source port/demonstration site's environmental conditions, and the relative level threat posed by the status of species assigned to the source port's bioregion (C4). Furthermore, Korea also consider the species-specific risk assessment, environmental matching risk assessment and species' biogeographically risk assessment which were outlined in G7 for assessing the risks in relation to granting an exemption in accordance with regulation A-4 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.

4.3. Existing databases used for monitoring, control and prevention

Currently, KORDI is building a MIS related database as a part of their research called Development of Port Environmental Risk Assessment Technology. Also, Ministry of Land, Transport and Maritime Affairs (hereinafter referred as "MLTM") 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

4.4. Future plans on monitoring, control and prevention

The government needs to achieve the following aspects for the plans on monitoring, control and prevention.

- Establishment of law, regulation and guideline for the implementation of MIS management system
- Establishment of infrastructure (manpower, equipment, among others) for the monitoring, prevention and control of MIS
- Strengthen the port baseline surveys (environmental factors, pathogenic bacteria, plankton, benthic and sessile animals)
- Strengthen the management of introduced marine organisms
- Strengthen the marine organism quarantine
- Strengthen the management and selection of target species of MIS which have already been admitted
- Establishment the eco-environmental risk assessment procedures and database of MIS
- Development of the detection and spreading prevention techniques of MIS
- Development of rapid detection technology of harmful MIS by controllable inflow source (ballast water, ship bio-fouling, among others)
- Strengthen R&D on management and monitoring of MIS
- Establishment of the alarm system for emergency situations (increase of pathogenic bacteria, harmful (or toxic) organisms, among others) related to MIS
- Development of the general public education and information program of MIS
- Establishment of MIS information system and network service

5. Current research projects and other initiatives on MIS in Korea

5.1. Priority research fields on MIS

-Port baseline surveys (environmental factors, plankton, benthic and sessile animals etc.)
-Ship ballast water surveys (foreign invasive species, resting cells and eggs)
-Aquaculture organisms
-Ship (or hull) bio-fouling organisms
-Eco-environmental risk assessment of MIS

5.2. Brief summary of research/project/initiative

Development of port environmental risk assessment technology (Korea Ocean Research & Development Institute)

- Objectives, methods and outcomes

As concern about biological invasions via ballast water grows, project PERAT (Port

Environmental Risk Assessment Technology) began as a government program in 2007. The project was designed to develop the ballast water management program which controls the discharge of ballast water of ships entering the harbors of Korea. Risk assessment of ballast water is inevitable when considering discharge of ballast water beyond bioregion.

For the implementation of risk assessment defined by the G7 guidelines under the Convention, port baseline surveys, survival tests, and vector analysis are inevitable fundamental stages in the viewpoint of a whole-of-port approach. However, until recently, despite growing concern about biological invasions via discharged ballast water at major ports, no attempt has been made to discern introduced or invasive species from the native communities in Korea. Thus, as part of project PERAT, this project has conducted port baseline surveys seasonally at major ports (Incheon, Gwangyang, Busan and Ulsan) and has listed the species composition and abundance of planktonic and benthic community since 2007. Concurrently, to investigate biological and environmental information inside ballast water with a variety of ballasting source, ships of opportunity were visited and investigated. By investigating the commercial ships anchoring at the ports, their particulars and information of intake and discharge of ballast water were also summarized as a basis for consideration of risk assessment for exemption. By putting the abovementioned information together through the database system, ballast water management program suitable for our nation is under development. In addition, the diverse investigation for risk assessment is being carried out as part of a currently ongoing project in Korea.

Coastal Marine Biodiversity and Conservation (IOC/WESTPAC)

In contributions to the High Level Objective of IOC/UNESCO (2008-2013) on "safeguarding the health of marine ecosystem", the Seventh Session of the IOC/WESTPAC unanimously approved one regionally rooted project on the "Coastal Marine Biodiversity and Conservation", taking into account broad interests received from its member states. Great attention is paid to marine invasive species amongst other issues on biodiversity and its conservations. In recent years, the introduction of non-indigenous species into the coastal waters in many countries poses serious environmental and economic threats. There are many examples of disastrous invasions by such species that resulted in the loss of native species, changes in community structure and function, and damages to the fisheries and aquaculture. To better understand the current status, the impact of marine invasive species, and develop effective prevention and monitoring measures or plan, the first IOC/WESTPAC workshop on marine invasive species and management was held during June 4-5, 2009. The objectives of the workshop are:

i. To review the regional status on marine invasive species and increase the knowledge and the awareness of the threats of marine invasive species on marine biodiversity in the Western Pacific region.
ii. To provide scientific basis for marine invasive species management plan and to establish the research priority and direction in the Western Pacific region.
iii. To share experiences and knowledge related to marine invasive species issues and to

establish collaborative research among scientists in the Western Pacific region and outside the region.

In addition, Term of References (TOR) of the sub-project on marine invasive species, which is under the project "Coastal Marine Biodiversity and Conservation", was approved. The details of the TOR are:

1. Asses the status of non-indigenous species in the WESTPAC region by
   a. combining an inventory of currently reported estuarine and non-indigenous marine species in WESTPAC member countries
   b. compiling definitions of term and making recommendations on use of terms
   c. summarize the impact of bio-invaders in the Western Pacific region
2. Share information on accidental release cases and their ecological and economical consequence
3. Compile a list of expertise and programs related to non-indigenous marine species, vectors etc.
4. Develop a comprehensive Non-Indigenous Marine Species Database.
5. Plan alien species alert report
6. Develop risk assessment guideline
7. Promote the collaboration among WESTPAC member countries and between ICES, PICES, NaGISA, and other organizations/programs
8. Promote public awareness and education

PICES WG 21 Rapid Assessment Surveys (RAS)

Since its onset in 2006, PICES Working Group on Non-indigenous Aquatic Species (WG 21) has been advancing the understanding of non-indigenous marine species in the North Pacific Ocean. Two specific initiatives have been identified within the non-indigenous marine species. The first is the development of a comprehensive database for non-indigenous species and taxonomy initiative. The taxonomy initiative will focus on the rapid assessment surveys for native and non-native species in a variety of habitats in commercial ports of PICES member countries, and on a collector survey to characterize the distribution of fouling organisms at a number of locations in each PICES member country. As ports have a greater probability of containing non-indigenous species, commercial ports in PICES member countries have been elected. These locations serve as a recipient environment for organisms transported by commercial shipping. They also tend to be more disturbed than natural environments, a factor that could enhance invasion success. From all habitat types within a port, the survey focuses on major ecosystem components such as intertidal and sub tidal habitats. PICES WG 21 first RAS was conducted in October 2008 in China and second RAS was in October 2009 in Korea. The study sites in China were two commercial ports, Dalian on the Yellow Sea and Bayu Quan on the Bohai Sea. The study sites in Korea were Seogwipo port and Seongsan sand beach in Jeju Island.

5.3. National taxonomy initiatives, including inventory of alien species

To assess an invasive species initiative, an initial step towards a national strategy should be to identify a cross-spectral group including the ecological interactions between native species and invasive species. Also, it is required to have the preparation of an inventory of existing invasive species problems and an assessment of the current situation. Ballast water can spread many non-indigenous planktonic organisms from diverse taxonomic groups originating from various bio-geographic regions (Carlton and Geller 1993; Ruiz et al. 2000). In Korea, the first national project to study ballast water risk assessments was initiated in 2003 (MOMAF 2004). Since then, port surveys and ballast water sampling have been carried out to gain the information for alien species as a part of the KORDI project "Development of Port Environmental Risk Assessment Technology". More marine planktonic species were introduced in the ballast water originating from the other country such as New Zealand, Hong, Singapore, China and Japan. Among the plankton observed in the ballast water, several non-native species were identified (Yoo et al. 2006). However, they did not examine to identify a cross-spectral group. Due to this reason, introducing non-indigenous planktonic organisms from ship ballast water could not be assessed. Therefore, additional research needs to investigate whether or not several species can inhabit in Korean coastal waters in further study.

5.4. National databases or Internet sources on MIS

There are no national databases or Internet sources on MIS now. It will be expected to establish a national database in the near future based on KORDI's integrated management system of port risk assessment. This integrated management system of port risk assessment was designed and constructed by KORDI from 2007. The database system was also integrated and constructed for the integrated management system of port risk assessment.

The database consisted of shipping records, ballast water discharge records, port environmental parameters, risk species taxonomic and distribution data and Geographic Data as shown in Table 2.5.4.1.

Table 2.5.4.1 Tables of the integrated database

No.	Data	No.	Data
1	Information of biological classification code	20	Bacterial information of BW
2	Information of species image	21	Information of surveyed marine environment
3	Information of measured phytoplankton	22	Information of surveyed station

4	Information of measured zooplankton	23	Marine environmental data by reference
5	Information of measured benthos	24	Meta information by reference
6	Information of measured protozoan	25	Station information by reference
7	Phytoplankton information by reference	26	Nation coastal stationary data
8	Zooplankton information by reference	27	Information of nation coastal stationary observation
9	Benthos information by reference	28	National rainfall data
10	Protozoan information by reference	29	Data of national marine environmental survey
11	Species information of port	30	Station of national marine environmental survey
12	Threat level of species	31	Initial input of port environmental similarity
13	Risk species coefficient C4	32	Port-to-port environmental similarity, C3
14	Ship information of BW	33	Parameter information to port environmental similarity
15	Phytoplankton information of BW	34	Information of Ports
16	Zooplankton information of BW	35	Information of Ships
17	Benthos information of BW	36	Information of Shipping
18	Protozoan information of BW	37	Information of Ballast water
19	Environmental information of BW	38	BWRA C1, C2

6. Existing gaps in relation to global and regional developments dealing with marine and coastal biodiversity, including invasive alien species

6.1. Compliance with relevant global conventions and agreements (e.g. CBD, BWC, etc.) and with other FAO and IMO regulations

After the mid 20th century, there was a growing recognition that biological diversity was being threatened by human engaging in excessive socioeconomic activities precluding sustainable development of human race. This eventually led the international society to adopt Ramsar Convention and Convention on Biological Diversity (CBD). Korea ratified CBD in 1994 and joined Ramsar Convention in 1997.

Now, various projects for biological diversity and resources conservation are being carried out mainly by Ministry of Education, Science and Technology, Ministry for Food, Agriculture, Forestry and Fisheries, Ministry of Environment and etc. However, most of those efforts are

being made for land organisms, and there are very few specific action plans for conserving diversity of marine organisms and for continuously using them. In particular, the marine organism specimens, DNAs and seeds owned by certain institutes are simply not enough to grasp the taxonomical facts of Korean marine biota, and because they are limited to certain classification groups, there is hardly any information for the rest.

As of 2006, the responsibility for managing Korean marine biota was transferred from Law for Protection of Wild Animal and Plant of Ministry of Environment to Law for Management and Preservation of Marine Ecosystem of MLTM. Before 2006, the projects for conserving diversity of marine biota and marine biological resources in Korea were limited to certain investigation projects such as Study on Inventories of Tidal Flats in Korea. After 2006, the general investigation of marine ecosystem was conducted. Also, for establishing policies to manage marine ecosystem, various projects were carried out namely, Study on Conservation and Management of Biological Diversity, Study on Management of Invasive Species in Marine Ecosystem, Research of Ballast Water, Making a List of Marine Biota (invasive and native species), Establishment of Information System of Biological Diversity and Notification for Exports and Imports of LMO (Living Genetically Modified Organism) of Marine Fishery.

The International Convention for the Control and Management of Ships Ballast Water & Sediments was adopted by consensus at a diplomatic conference of IMO in 2004. Following the Convention, fourteen guidelines have been developed by IMO as follows:

Guidelines for sediments reception facilities (G1)
Guidelines for Ballast Water Sampling (G2)
Guidelines for BWM equivalent compliance (G3)
Guidelines for BWM and Development of BWM Plans (G4)
Guidelines for Ballast Water reception facilities (G5)
Guidelines for Ballast Water Exchange (G6)
Guidelines for Risk Assessment under Regulation A-4 (G 7)
Guidelines for approval of BWM Systems (G8)
Guidelines for approval of BWM systems that make use of active substances (G9)
Guidelines for approval and oversight of prototype ballast water treatment technology programs (G10)
Guidelines for Ballast Water Exchange Design and Construction Standards (G11)
Guidelines for sediment control on ships (G12)
Guidelines for additional measures including emergency situations (G13)
Guidelines on designation of areas for ballast water exchange (G14)

The objective of these guidelines is to assist governments and other authorities, ship masters, operators and owners, and port authorities in minimizing the risk of introducing harmful aquatic organisms and pathogens from ship's ballast water and associated sediments while protecting ships' safety.

The Convention will be enforced 12 months after its ratification by 30 states, representing 35 percent of the world's merchant shipping tonnage. It has been ratified by 22 countries

representing 22.65 percent of the gross tonnage of the world's merchant shipping until end of 2009. The Republic of Korea deposited of ratification the Convention at 10th December 2009.

6.2 Status of expertise and capacity building as related to MIS research;taxonomic ability to identify MIS in member countries

With support from MLTM, Korea is conducting preliminary studies for Management of Invasive Species in Marine Ecosystem, Study on MIS Control and Management of Ship Ballast Water in order to vitalize MIS studies. Based on these studies, Korea is planning to select MIS to be managed by the country to focus on studying the ways for monitoring, spread prevention and elimination. Also, Korea is going to operate a specialized research institute to control the introduction of harmful underwater organisms via ship ballast water. The institute will conduct the following researches and studies.

- Status of underwater organisms in Korean ports and the nearby waters
- Designation of waters where ship ballast water injection is prohibited
- Prevention of introduction of harmful underwater organisms due to ship ballast water
- Support for technology development of ship ballast water management
- Support for related international convention

The Korean government is constructing National Institute of Marine Biological Resources and the construction is going to be completed by 2013. Also, KORDI is constructing Library for Marine Samples which is to be completed by 2012. In order to maintain the facility, marine organism classification experts are absolutely needed. It is expected that the importance of MIS related studies and facility expansion will increase the demand for the marine organism classification experts.

6.3. Future needs in capacity building (including training and equipment), public awareness raising, communication, compliance and enforcement

-Establishment by law about management and control of marine invasive species
-Early warning system and rapid detection of marine invasive species, and development of action plans
-Construction of risk assessment system against marine invasive species
→ Ecological risk assessment
→ Risk assessment of marine resources
→ Risk assessment after human exposure
- Distribution of brochure including information about marine invasive species, action plans, and caution
- Construction of research activity for surveillance and management of invasive species

7. Legislation, programmes and responsible organizations related to marine and coastal biodiversity, including invasive alien species

7.1. National legislation related to marine biodiversity issues and invasive alien species (the full names of laws, policies and regulations)

In Korea, no special legislation for the protection of marine biodiversity and marine bio-invasion has been established yet. The brief introduction of the most relevant regulation and laws is as follows.

In 2006, the Korean government established legislation (No. 8045) to prevent marine ecosystem damages and marine biota decreases caused by indiscreet development activities and overfishing of marine organisms. The legislation includes the following details.

- Establishment of preservation plan and definition of marine protected organism
- Establishment of general plan for marine ecosystem management and preservation
- Implementation of the general investigation of marine ecosystems
- Designation and management of Marine Protected Areas
- Support of the residents in Marine Protected Areas
- Levy and collection of cooperative fund for marine ecosystem preservation

Also, the Korean Government has prepared for the implementation of the IMO Convention. To prepare the tasks regarding the type approval of management system, the Korean Government notified the Provisional Regulation of Type Approval of Ballast Water Management System on the Act of Ministry of Maritime Affairs & Fisheries (MOMAF) in November 2006 (Notification No. 2006-77). Since then, the bill of Law of Ballast Water Management was legislated and enacted on December 2007 (Law No. 8852) to prepare integrated national strategies for the IMO Ballast Water Management Convention (Kim 2007).

In Korea, KORDI started the research on Ballast Water Management at an earlier state as a government research institute. KORDI has been developing various fundamental technologies for national strategy such as biological survey, type approval procedure and technical information for the formulation of regulations through a project of the Ministry of Maritime Affairs & Fisheries (Kim 2008). From this year, KORDI also started to develop the risk assessment technology of Ballast Water as a new government project. There have been many developments for ballast water treatment system through commercial project by several companies.

The South Sea Institute of KORDI is the designated organization for land-based and shipboard testing for the type approval of ballast water management systems in the Republic of Korea. When the testing body and developers reviewed the various possibilities for the construction of a land-based test site, it was found that it was not easy and very costly to pump seawater or fresh water containing high density of micro-organisms to an in-land test site. Therefore, it was decided to build a test barge dedicated for land-based tests. The barge was designed very similarly to an actual ship with ballast tanks and its circulation method (Republic

of Korea, 2007).

Surveys on biological and environmental parameters have been seasonally conducted to establish the risk assessment system for ballast water. Furthermore, sample surveys of ballast water discharge have also been conducted because it was not mandatory to submit the ballast water reporting form to port states and there were no statistics for ballast water discharge in Korea.

7.2.Leading authorities (e.g. ministry, agency) to implement national legislation related to marine biodiversity issues

The MLTM aims to construct transport and logistics network that advances into the world and opens a brighter future for Korea. The Marine Ecology Division of the MLTM is in charge of the preservation and restoration of marine ecosystem (including the wetlands), the preservation of marine biological diversity, the security of marine biological resources and the safe management to threatening factors of marine ecosystem. Also, the Maritime Technology Division of this Ministry is in charge of the national strategies for ballast water management.

8.Recommendations for decision–makers in terms of priority national actions, services and products

Due to the expansion of personal and material exchange between countries in line with globalization and upswing in trade activities, the alien species which threaten ecosystem are being introduced resulting in damages to ecological stability and economic loss which are now serious problems globally. The spread of alien species is a global phenomenon and it has become one of the most important issues of the world. Invasion or spread of land alien species can be easily observed by scholars or even ordinary people but not for marine alien species, and Korea is highly exposed to the invasion of alien species.

International Union for Conservation of Nature and Natural Resources (IUCN) has once reported that the global economic losses from damages in ecosystem due to alien species count up to hundreds of billions of dollars per year. International codes for efficiently controlling alien species which threaten ecosystems are being established mainly by IUCN, Convention on Biological Diversity and IMO Ballast Water Management Convention.

After all, the studies on the invasion and spread of alien species are required not only in academic aspect but also in social, economic and diplomatic aspects. Some countries are already discussing the problem of alien species and providing institutional means and strategies required for preventing it beforehand.

The Korean government should consider the following by referring to the international advance technologies.

Establishment of the special laws and regulations for effective management of MIS

The special laws and regulations for management of MIS should include the following

major items.

- Establishment of MIS management system and step-by-step management procedures
- Ecological Risk Assessment of Alien Species
- Establishment of national MIS management database and network
- Organization of national MIS management committee

Promotion of MIS Research Project

MIS research project must be promoted in order to establish fundamental infrastructure for MIS management. This research project should consist of MIS status research, monitoring, making the list of species, understanding the path ways of introduction, MIS fundamental R&D, MIS eradication, prevention of spreading, control-related studies and studies on the standards and ways for selecting MIS.

National Education, Publicity and Raising Awareness of Alien Species

MIS eradication or control can be successful by providing accurate information to the people on the background, purpose, objectives, expected results and national cooperation. The national publicity and education should include the following principles; 1) Positively study, educate and publicize the things that the people need to know for prevention. 2) Educate and publicize basic information/rules on alien species that must be understood and abide by the people as the frequency of international exchange is increasing. 3) Advance people's understanding of pathways of introduction of MIS. 4) Raise people's overall awareness of ecosystem and let them know that MIS management and control is one of the many ways to conserve ecosystem. 5) Analyze the cause of ecosystem damage and extinction of native species. 6) Educate and publicize various aspects that can be caused by MIS.

Establishment of MIS–Related International Cooperative System

The seriousness of MIS problems in Japan and China having the form of trade, geographical and ecological features similar to Korea, should not be treated only as a problem of a country but as a mutual problem that must be dealt jointly by the region or the world. Therefore, establishment of international cooperative system is required where the adjacent countries must exchange related information and share their experiences or research results. A close cooperative system for information, academic and research exchanges must be established and international organizations and conventions namely, Global Invasive Species Information Network and IUCN need to come up with alien species programs such as Global Invasive Species Program of Convention on Biological Diversity (CBD).

9. References

Campbell, M.L., C.L. Hewitt. 1999. Vectors, shipping and trade. In: C. L. Hewitt, M. L. Campbell, R. E. Thresher and R. B. Martin, (eds). Marine Biological Invasions of Port Phillip Bay, Victoria. CRIMP Technical Report No. 20. CSIRO Marine Research, Hobart. P. 45-60

Carlton, JT, Geller JB. 1993. Ecological roulette: the global transport of nonindienous marine organisms. Science 261. P. 78-82.

Eun-Chan Kim et al. 2008. Development of Technique preparing for International Conventions on Ballast Water Management, KORDI Report

Eun-Chan Kim. 2007. Development of technologies preparing for the IMO Convention on BWM in Korea, International Workshop on the Ballast Water Risk Management in the Northwest Pacific Region, KORDI.

Gong, YH, Seo J. 2004. A taxonomic study on fouling Bryozoans from Korea. Underwater Sci Technol 5(1). P. 11-16 (Korean)

Hur, SB, Chun, SC, Kim, HS. 1986. Chemical treatment of fouling organisms on fishing nets. Bull Korean Fish Soc 19. P. 241-248 (Korean)

KCTA. 2006. website (http://portal.kca.or.kr/bbs?id=contstatisbbs &flag=det&seq=15002). Korea Container Terminal Authority. (Korean)

KFA. 2007. Korean fisheries yearbook. Korea Fisheries Association. P. 428 (in Korean)

Kim, HS, Jung, MM, Lee, JB. 2008. The Korean Peninsula warming based on appearance trend of tropical dinoflagellate species, genus Ornithocercus. J Kor Soc Oceanogr 13. P.303-307

Kim, IH. 1992. Invasion of foreign barnacles into Korean waters. Korean J Syst Zool 8. P.163-176 (Korean)

Lee, JB, Kim HS. 2006. Occurrence of tropic marine flagellates introduced from Kuroshio Current in the adjacent waters of Jeju Island. The 1st International Symposium on the Bio-invasion of Non-indigenous Species. Bukyung National University, July 31, 2006. (Korean)

MOMAF. 2004. Research of response technique development discharge regulation ship ballast water (I).Ministry Maritime Affairs and Fisheries (Korean)

NIER. 1996. Ecological assessment of established species (Ⅱ). NIER report 18. P. 1-117. (Korean)

OECD. 2006. Korean shipbuilding policy overview C/WP6/(2006)32, website (http://www.oecd.org/dataoecd/17/40/37882612.pdf). Organisation for Economic Co-operation and Development.

Otani, M. 2004. Introduced marine organism in Japanese coastal waters, and the processes involved in their entry. Jpn J Benthol 59. P. 45-57

Park, K.S. Min and H.G. Lim. 2005. Colonization and ecology of exotic aquaculture organisms. National Fisheries and Development Institute. P.329 (Korean)

Republic of Korea. 2007. Information on land-based testing facility and the availability of testing slots, IMO, BLG 11/4/8

Ruiz, GM, Rawlings, TK, Dobbs, FC, Drake, LA, Mullady, T, Huq, A., Colwell, RR. 2000.

Global spread of microorganism by ship. Nature 408. P. 49-50

Seo. KS, Lee, Y. 2009. A first assessment of invasive marine species on Chinese and Korea Coasts. In Biological Invasions in Marine Ecosystems: Rilov, G, Crooks, JA.

Yoo, JK, Song, TY, Hong, HP, Jeong, KM, Myung, CS. 2006. Marine plankton in ballast water of ship entering Korea. Ocean Polar Res. 28. P. 57-65 (Korean)

National Report of the Russian Federation on Marine Invasive Species in the NOWPAP Region

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1. Introduction: marine invasive species (MIS) in Russia (within the NOWPAP region)

Biological invasions in marine environment represent a serious ecological and economic menace leading to biodiversity loss, ecosystem unbalancing, fishery and tourism impairment; they are lesser known aspect of global change (Occhipinti-Ambrogi, Savini, 2003). We are witnessing rapidly growing interest in the phenomenon of biological invasions as a result of an increasing number of unintentional invasions of marine organisms due to the release of ballast water through international shipping activities, and of increasing aquaculture purposes and for open sea fisheries enhancement (Carlton, 1992). Bioinvasions create so-called "novel" (or "emerging") 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. Novel ecosystems increase in importance but are relatively little studied (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 speces, 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). At that time, the Chinese diatom Biddulphia sinensis was discovered in Europe, and the Chinese mitten crab Eriocheir appeared in German rivers: these were first signalsof a new era of intensive bioinvasions and novel ecosystems (l.c.).

Ballast water, carried on empty ships to provide balance and stability, is discharged when loading cargo, often introducing alien species from the port of origin. The International Maritime Organisation (IMO) estimates that the 3.4 billion tonnes of ballast water that are used annually may move some 7,000 species around the planet at any one time.

Eradication has been largely unsuccessful to date, but might be feasible if an introduction is identified early enough and is limited in distribution. It is thus essential to have an effective monitoring and early warning system. Programmes to assess and monitor alien species, are being set up in several countries, including the USA, Australia and Seychelles, however, there are few efforts of such kind in Russia. The GEF/UNDP/IMO Global Ballast Water Management Programme (GloBallast) is an important step towards monitoring and management of the MIS. The recently adopted global convention on the regulation of ballast water movement may help to reduce the threat by promoting better practices.

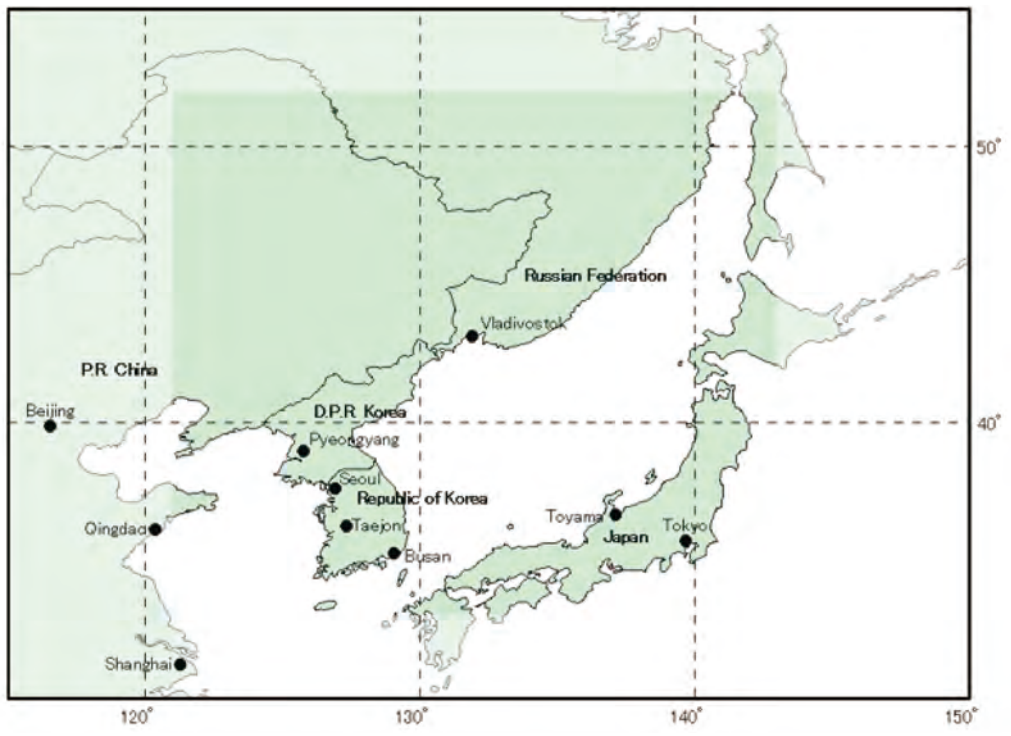

Fig. 1. NOWPAP Region (http://cearac.nowpap.org/nowpap/coverage.html).

Despite the widely acknowledged threat posed by invasive species in coastal waters, there are substantial gaps at the intersection of science and policy that are impeding invasive species management (Williams, Grosholz, 2008).

Prevention is the key to successful management of marine alien invasive species but again Russian Federation does not develop at the moment a system of preventive measures and monitoring except for some initiatives of institutions of the Russian Academy of Sciences.

Many Marine and Coastal Protected areas (MCPAs) are located adjacent to ports and shipping lanes, or to sites that will eventually be developed as ports. MCPAs are also at risk from species carried on the hulls of yachts and fishing boats. There is frequently aquaculture in or in the vicinity of MCPAs. A study by the IUCN Global Marine Programme found that a quarter of MCPAs have aquaculture within the MCPA, and half within 100 km of the MCPA, in many cases culturing exotic species. This means that, outside ports, MCPAs are often the first point of MIS outbreak, and 33% of MCPAs surveyed already have invasive species. Far East Marine Biosphere Reserve, largest marine reserve in Russia, is an example of the close proximity of ports and intensive shipping lanes to a protected area.

In the Russian part of the NOWPAP Region (Fig. 1), Peter the Great Bay (southern Primorye) is the most studied area with respect to marine invasive species (Zvyagintsev, 2003; 2005; Zvyagintsev et al., 2009). As for the middle and northern Primorye coast and Sakhalin, scarce data are available on biological invasions, their taxonomic composition and scale. However, southern Primorye is characterized by highest intensity of the maritime traffic, availability of harbors for successful colonization, and numerous cabotage vessels operating in the area. For that reason, in this National Report we review and summarize mostly information

from Peter the Great Bay.

Definitions. Terminology used for invasive species is different among managers, law makers and researchers. For the purposes of this National Report, we use hereafter the following terms as clarified below.

Native species: a species living within its natural range including the area which it can reach and occupy using natural dispersal out of its natural range even if it is seldom found there.

Alien species: a species introduced outside its normal past or present distribution; the synonyms are "invasive", "intoduced", "non-native", "non-indigenous", or "exotic" species.

Introduction: the movement, by human agency, of a species outside its natural range.

Intentional introduction: the purposful movement by humans of a species outside ots natural range and dispersal potential (for aquaculture, fishing, etc.).

Unintentional introduction: an introduction of a species outside its natural range introduced "unwittingly" by humans or human delivery system (in ballast water, as a parasite of an intentionally introduced species, etc.).

Invasive alien species: an alien species whose establishment and/or spread threaten ecosystems, habitats or species with economic or environmental harm. In legal practice, the meaning of this term may be different.

Ballast water: any water and associated sediment used to manipulate the trim and stability of any vessel (including modern ocean racing yachts).

Biofouling: growth of sessile algae and animals on submerged structures, especially vessel hulls, artificial underwater structures, and water intake pipes.

Pathway: the mechanism, purpose or activity that facilitates the entry or spread of a pest; for example, shipping, travel, trade.

Vectors: the physical means, agent or carrier - living or non-living - carrier that transfers organisms or their propagules intentionally or unintentionally from one place to another. For example, ship's hulls, ballast water, fishing equipment, etc.

2. Current status of the MIS in Russia (within the NOWPAP region)

2.1. Pathways (vectors and routes) of introduction of MIS to Russia

2.1.1 Shipping and ballast waters

Shipping and ballast water release are the most important ways of introduction of marine organisms into the Russian waters of the NOWPAP region. The rate of species distribution by means of vessels with different regimes of exploitation depends primarily on the intensity of the maritime traffic and the availability of harbors appropriate for colonization (Zvyagintsev, 2003, 2005). Later, as the available harbors are colonized, the rate of species distribution increases due to cabotage vessels. In Peter the Great Bay, about 16000 ships enter ports and harbors 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 favours introductions of alien species through fouling communities

and release of ballast waters. It is believed that more than 1 million tons of ballast waters release into Peter the Great Bay every year (l.c.). There are two major vectors of introductions of differents taxonomic groups of organisms into the Russian NOWPAP waters – Asian (Fig. 1) and Trans-Pacific (Fig. 2).

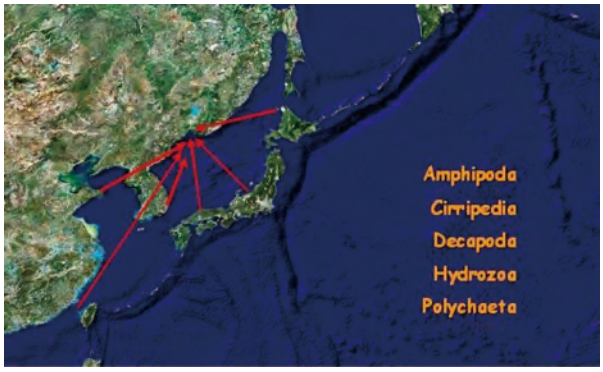

Fig. 2. Asian vectors of introductions of MIS into the Russian part of the NOWPAP region (http://www.imb.dvo.ru/files/ballast.pps).

Fig. 3. Trans-Pacific vectors of introductions of MIS into the Russian part of the NOWPAP region (http://www.imb.dvo.ru/files/ballast.pps).

2.1.2 Intentional introductions

Intentional releases of non-native species to enhance local fisheries or start new aquaculture are widely known. In Russia, there are many examples of such kind referring to southern (Caspian and Azov seas) or northern seas (e.g., intentional introduction of the king crab Paralithodes kamchaticus into Barents Sea). In Primorye, we are aware only of intentional introductions of freshwater fishes into the basin of Razdolnaya River (Kolpakov et al., 2008). No intentional introductions of marine species in the Russian part of the NOWPAP Region are known.

2.1.3 Aquaculture

All aquaculture practices in the Russian NOWPAP Region are based on local species, and there are no evidences of intentional/unintentional (e.g., as fouling of shellfish, seed material, etc.) introductions of marine organisms in aquculture operations.

2.1.4 Other

Climatic changes leading to intensification of warm currents are most important factor in the penetration of marine invasive species to the coast of the Russian part of the NOWPAP Region. It is shown that warm subtropical waters regularly penetrate into the south-western part of Peter the Great Bay bringing subtropical animals (Nikitin et al., 2002). The general regional trend of temperature fluctuations in north-western Sea of Japan/East Sea for last 100 years is an increase of air temperature by 1.74? C (latitute of Vladivostok) and sea surface temperature – by 0.64? (Gayko, 2005). Numerous examples of migrations of warm-water species of fish, reptilians and phytoplankton from southern regions to Peter the Great Bay are given below (Chapter 5.2).

2.2. List of the MIS in Russia (with notes on local distribution and ecology)

2.2.1. Benthic organisms

Cirriped crustaceans (Cirripedia)

Amphibalanus improvisus. This species was recorded for the first time in the fouling of hydrotechnical constructions (HTC) of Peter the Great Bay in 1969 (Zevina, Gorin, 1971). Zvyagintsev (2003; 2005) found this species in the fouling of all active vessels of cabotage and harbor navigation examined in the bay in late July, i.e., in the beginning of the period when the young of A. impovisus begin settling. At present, A. improvisus has become a common species in the fouling of vessels of cabotage and harbor navigation in Peter the Great Bay (Fig. 4). In the fouling of HTC of this bay, A. improvisus has been registered in almost all examined objects as a characteristic species in fouling communities of HTC in Amursky Bay and Zolotoy Rog Bay. Great ecological plasticity and the ability to withstand almost complete desalination allowed this species to occupy a free ecological niche and to naturalize in Amursky Bay (Zvyagintsev, 2003). An analysis of several specimens of this species from the upper subtidal area showed that some animals comprised larvae at the last stage prior to hatching, while other animals had already relea-sed the larvae (Zvyagint-sev, 2005). It is evident that in Peter the Great Bay a local population of A. im-provisus has developed, capable of reproduction and inhabiting not only artificial substrates, but also became a component of benthic communities (Ovsyannikova, 2008; Fig. 5).

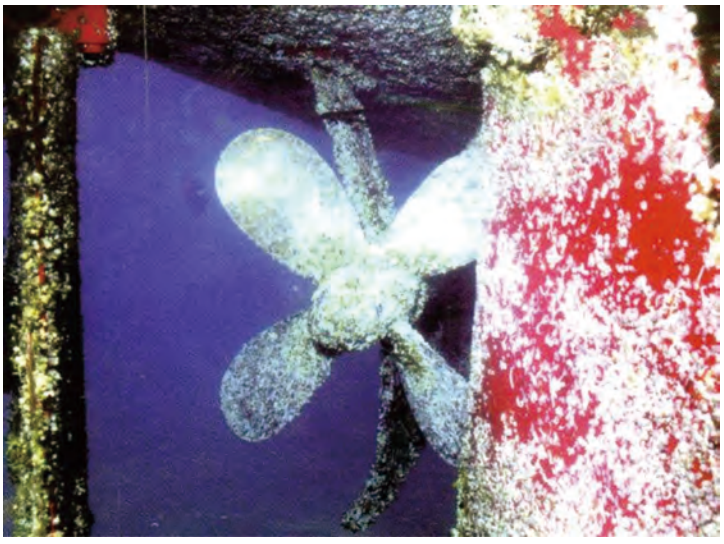

Fig. 4. Community of Amphibalanus improvisus in fouling of ships in Peter the Great Bay (after: Zvyagintsev et al., 2009).

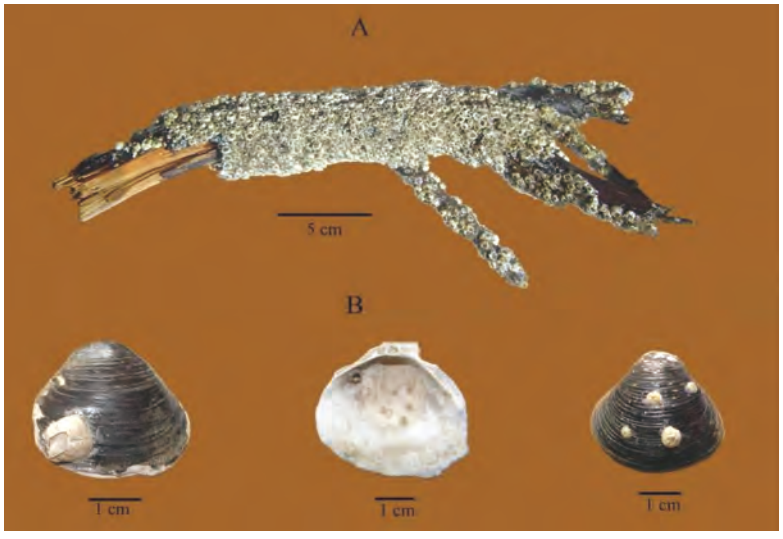

Fig. 5. The appearance of Amphibalanus improvisus attached to a tree branch (A) and shells of the bivalve mollusk Corbicula japonica in Amursky Bay (after: Ovsyannikova, 2008).

Balanus amphitrite is a subtidal widely distributed tropical-subtropical species. According to Zevina and Gorin (1975), this species occurred in the fouling of buoys in Nakhodka, Strelok, and Amursky bays only in warm years. In Peter the Great Bay, Zvyagintsev (2003) found B. amphitrite in the fouling of 46% of the examined active vessels except ships that spent no less than 20% of time in Zolotoy Rog Bay where this species has been registered on all examined objects. However, in the fouling of vessels of cabotage and harbor navigation in this bay, B. amphitrite occurs every year and not only in warm years (l.c.). Certain specimens could survive wintering, however on most examined vessels this species was not recorded after winter exploitation. Zvyagintsev (2003) did not find B. amphitrite on examined vessels of harbor navigation in the harbors of the Sea of Japan located to the north of Cape Povorotny (i.e., north of Peter the Great Bay); however, it is common on cabotage vessels running on the route Vlavivostok–Svetlaya (northern Primorye). It is shown that reproduction in this species and settling of the larvae take place from August to October under a wide temperature range, from +13 to +22.5°C. In Peter the Great Bay, in the warm period of the year there is a dependent population of B. amphitrite inhabiting only anthropogenic substrates. Adult specimens introduced into the bay with foreign-going vessels in the season favorable for the life of the species produce larvae that have enough time to settle and grow up.

Balanus eburneus is a tropical-subtropical subtidal species, very vulnerable to low temperatures. It was found for the first time in the fouling of small well warmed-up bights (Zevina, Gorin, 1975). B. eburneus might appear again later on, especially in warm years; however, it could never acclimatized in Peter the Great Bay. This species has never been found in benthos communities.

Balanus trigonus is a tropical-subtropical widely distributed species which is common in the warm waters of Japan. In 1970, it was found on buoys in Nakhodka Bay (Zevina, Gorin, 1975). Zvyagintsev (2003) found only a few dead specimens of this species on the tanker Molodechno that arrived from India and operated for one navigation in the outer harbor of Vladivostok. Evidently, this species not acclimatized in Peter the Great Bay.

Fistulobalanus albicostatus. This species was found in fouling of experimental plates, hydrotechnical facilities and ships (Zvyagintsev et al., 2009). This barnacle is originally known from Japan, Korea, China, and California.

Megabalanus rosa. In Peter the Great Bay, it is known only in biofouling of ocean-going ships; it is distributed in Japan and Taiwan (Zvyagintsev et al., 2009).

Megabalanus tintinnabulum. This circumtropical barnacle is a seasonal migrant species in Peter the Great Bay (Zvyagintsev et al., 2009).

Conchoderma auritium. This species was found in fouling of ocean-going ships (Zvyagitsev etal., 2009).

Lepas anatifera. This species inhabits ship hulls, buoys, drifting litter, hydrotechnical structures.

Amphipods (Amphipoda)

Corophium acherusicum. This species has been found in Peter the Great Bay only as a

component of fouling communities (Zevina, Gorin, 1975; Kudryashov, Zvyagintsev, 1981). It has been supposed that this species is transferred with A. improvisus and B. eburneus settling in the shells of dead barnacles. The geographical ranges of these tropical-subtropical species are very similar. Recently, this species was recorded in benthic communities in southwestern Peter the Great Bay and around the mouth of the Tumen River (Budnikova, 2001). Moreover, C. acherusicum was found in the fouling of the water cooling system on Heat and Power Station No. 2 of Vladivostok (Zvyagintsev, Budnikova, 2003). This proves naturalization of C. acherusicum in Peter the Great Bay.

Isopods (Isopoda)

Sphaeromatiidae gen sp. An unidentified to species level sphaeromatiid was found in biofouling comminities of a ship and was supposed to be an alien species originated from Australia or Singapore (Rostomov, 1981).

Crabs and hermit crabs (Decapoda)

Planes marinus. This crab was found on a drifting buoy in Peter the Great Bay (Sea of Japan). The species probably arrived in the bay with subtropical waters penetrating into this area during the summer period (Kepel et al., 2002).

Portunus sanguinolentus. This crab was found in Peter the Great Bay on a drifting buoy (Fig. 6); it was suggested that occurrence of the members of tropical fauna along the coast of Primorye was related to the enlargement of the amount of marine litter transported with sea currents that serves as a substrate for settlement of different marine organisms (Kepel, Tsareva, 2005).

Fig. 6. Crab Portunus sanguinolentus found in Peter the Great Bay (after: Kepel, Tsareva, 2005).

Plagusia depressa tuberculata. This crab was found in Peter the Great Bay on a drifting buoy (Fig. 7); as for the previous species, it was suggested that occurrence of the members of tropical fauna along the coast of Primorye was related to the enlargement of the amount of marine litter transported with sea currents that serves as a substrate for settlement of different marine organisms (Kepel, Tsareva, 2005).

Fig. 7. Crab Plagusia depressa tuberculata found in Peter the Great Bay (after: Tsareva, Kepel, 2005).

Diogenes nitidimanus. This hermit crab settlement was found n August–Sep-tember 2002 in the estu-arine part of Vostok Bay (Peter the Great Bay, Sea of Japan) on a silty bottom at a depth of 2–3 m; the her-mit crabs inhabited shells of the gastropod mollusks Batillaria cumingii, Linatia pallida, Littorina squalida, and Umbonium costatum (Korn et al., 2007). Later, the larva of the hermit crab was found in the ballast waters of the tanker Minotaur that arrived from the Chinese port of Laizhou (Bohai Bay, Yellow Sea) (Zvyagintsev, Kornienko, 2008; Figs. 8, 9). The finding of its larva in ballast waters of a ship on the Russia–China route confirms the introduction of this species into Peter the Great Bay.

Fig. 8. Hermit Diogenes nitidimanus found in Vostok Bay (after: http://www.imb.dvo.ru/files/ballast.pps).

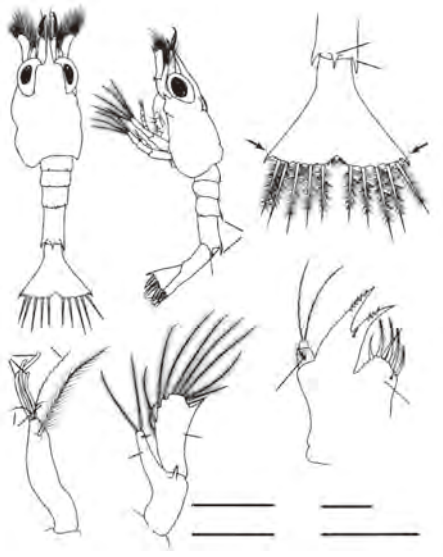

Fig. 9. The first zoea of a decapod crab found in the sample of ballast waters (after: Zvyagintsev, Kornienko, 2008).

Hydroids (Hydroidea)

Gonothyrea loveni. This hydroid species known from the Northern Atlantic was recorded for the first time in fouling of vessels from Tatarsky Strait and then on other substrata (Chaplygina, 1980; Zvyagintsev, 2003). Later on, Zvyagintsev (2003) found this species in the fouling of vessels from Tatarsky Strait, the harbor fleets of Kholmsk and Nevel'sk towns, and Aniva Bay. It seems that G. loveni is at the first stage of acclimation because it is not registered in the composition of the benthos communities.

Campanularia johnstoni. This species is widely distributed in both hemispheres. According to Chaplyugina (1980), in the northwestern Sea of Japan C. johnstoni has been found on almost all types of anthropogenic substrates except vessels. However, Zvyagintsev (2003) found that in the fouling of vessels, C. johnstoni was common. According to Bagaveeva et al.(1984), this species naturalized in bottom communities of the northwestern Sea of Japan.

Laomedea flexuosa. This species is widely distributed in waters of the Northern Atlantic as well as in the White and Barents Seas. In Peter the Great Bay, it was found for the first time on the hull of a foreigngoing vessel arriving from the Atlantic. Later on, it was also found on cabotage vessels and in northern Primorye. In the 1990s, it was registered everywhere in the fouling of piers and mooring facilities in Peter the Great Bay, in the village of Plastun, and on southwestern Sakhalin (Zvyagintsev, 2003).

Laomedea calceolifera. During the last two decades, L. calceolifera was found in Peter the Great Bay on the same substrates as the closely related L. flexuosa, however, in smaller numbers (Zvyagintsev, 2003).Both L. flexuosa and L. calceoliferaare new invaders into the Sea of Japan; the former species is also new for the fauna of the Pacific in general. However, it is not clear if they naturalized as they are recorded on anthropogenic substrates only.

A hydroid medusae Aequorea coerulescens was recorded for the first time in Russian waters of the NOWPAP Region (along the middle Primorye) in 1995 (Pogodin, Yakovlev, 1999) but

it is unclear if this species an invasive one or it is merely a first finding of the medusae in a poorly studied area. A. coerulescens is known in Japan including northern coast of Hokkaido.

Polychaetes (Polychaeta)

Polydora limicola. This species is characterized by significant ecological plasticity and withstands desalination down to 6‰ and significant oil pollution. Bagaveeva and Zvyagintsev (2000) and Zvyagintsev (2003) reported P. limicola in the fouling of HTC in Vladivostok, Nakhodka, Nevelsk, Kholmsk, Korsakov, and Uglegorsk, but it was not found in benthic communities. It is evident that in the northwestern Sea of Japan this species is at the first stage of acclimation.

Hydroides elegans. This is an eurybiontic species that undergoes significant fluctuations in salinity and rather strong pollution. H. elegans has been found in the fouling of experimental plates installed in Zolotoy Rog Bay (Gorin, 1975). Bagaveeva and Zvyagintsev (2000) and Zvyagintsev (2003) found H. elegans on most of the vessels examined in Peter the Great Bay. A necessary requirement of the presence of this species in the fouling of vessels is entries and, at least, short stays in Zolotoy Rog Bay. This species dominates the fouling in the bay, and its biomass increases toward the innermost part of the bay. It is possible to conclude that H. elegans in Zolotoy Rog Bay is now at the stage of "ecological explosion" (Zvyagintsev, 2003).

Pseudopotamilla occelata. P. occelata inhabits intertidal and subtidal areas in Alaska, Oregon, California, and Japan. In the northwestern Sea of Japan, it found P. occelata for the first time in 1980 in the fouling of hydrotechnical installations of several harbors and anchorages (Zvyagintsev, 2003). The greatest quantitative indices for the population density of this species were registered in the fouling in western Sakhalin; it was found also along the coasts of Primorye and the southern Kurile Islands on rocky surf capes (Bagaveeva, Zvyagintsev, 2000; Fig. 10). The process of naturalization of this species is described in details by Zvyagintsev and Bagaveeva (1998). Its naturalization in Peter the Great Bay resulted in significant changes in the composition of the upper subtidal benthic communities.

Fig. 10. Pseudopotamilla occelata found in Peter the Great Bay (after: Zvyagintsev et al., 2009).

Perinereis aibuhitensis. This species as an introduced polychaete is mentioned in presentation of the Center for Monitoring of Marine Bioinvasions and Ballast Waters (http://www.imb.dvo.ru/files/ballast.pps) (Fig. 11).

Fig. 11. Perinereis aibuhitensis in Peter the Great Bay (after: (http://www.imb.dvo.ru/files/ballast.pps).

Bivalve mollusks (Bivalvia)

Mytilus galloprovinciallis. This species was first recorded from Possjet Bay (south-western part of Peter the Great Bay) attached to anthropogenic substrates (drifted raft) at the beginning of the 1980s and was identified as "Mytilus edulis diegensis". Further studies revealed that it is M. galloprovincialis (Fig. 12) and this species became established in several areas of Peter the Great Bay and then was found also in Vladimir Bay, Moneron Isl. and Kunasir Isl (Ivanova, Lutaenko, 1998; Fig. 13). However, it was shown later that only 2% specimens from local populations studied mostly from experimental cultivation farms can be regarded as true Mediterannean mussel, and about 70% are morphologically hybrids between M. galloprovincialis and M. trossulus (Ivanova, Lutaenko, 1998). This was recently confirmed by genetic analysis (Skurikhina et al., 2001).

Fig. 12. Mediterranean mussel Mytilus galloprovinciallis from Peter the Great Bay (after: Ivanova, Lutaenko, 1998).

When Mediterranean mussel first appeared in Peter the Great Bay is not clear. In Japan, this species first settled in the 1920s

(Wilkins et al., 1983); it is known for certain in northern China since 1950s (Tchang et al., 1955); but when it reached Korea is not clear (Je et al., 1990).

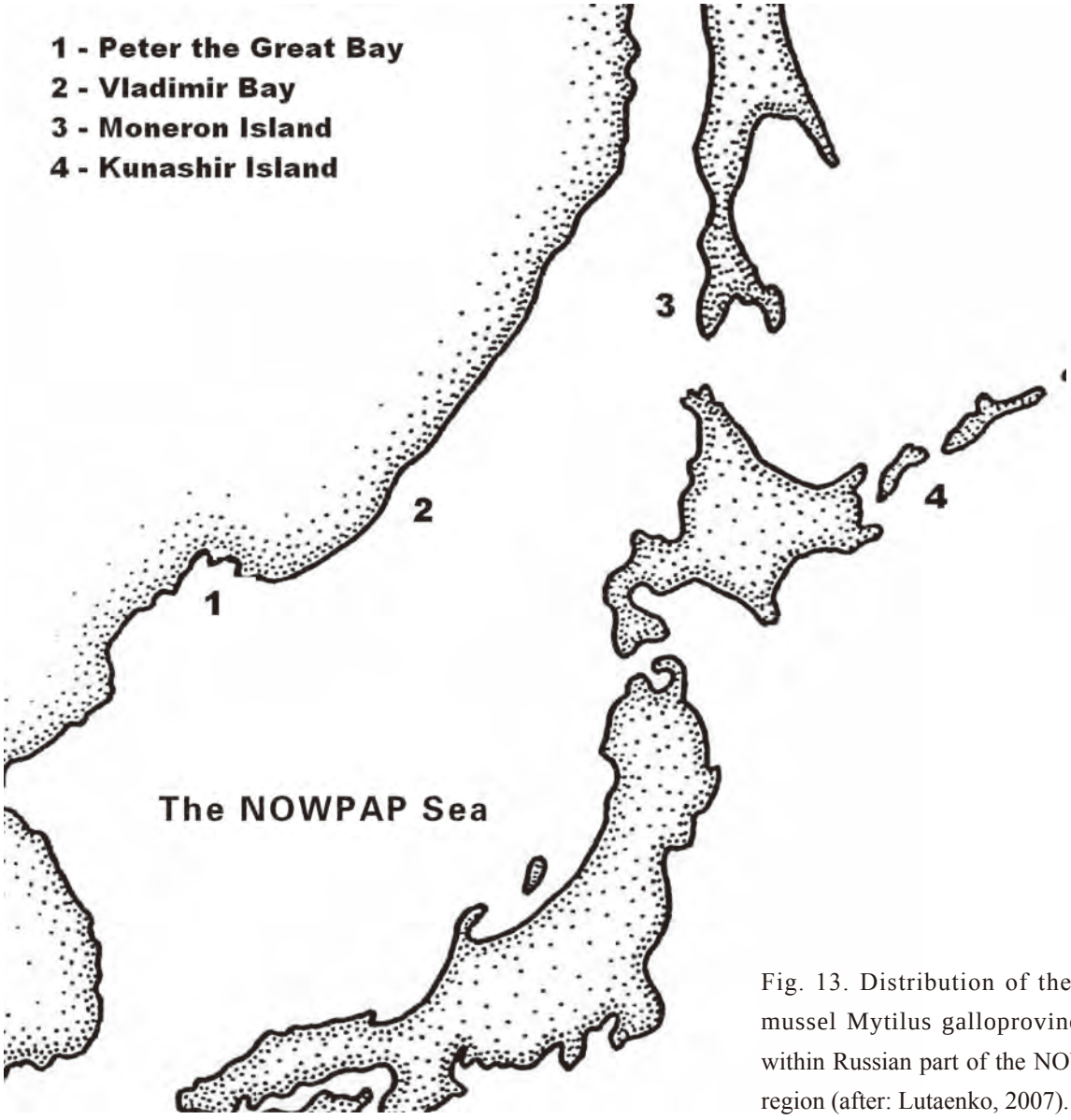

Fig. 13. Distribution of the alien mussel Mytilus galloprovinciallis within Russian part of the NOWPAP region (after: Lutaenko, 2007).

Gomphina aequilatera. This species was first found as abundant empty shells in beach drift near the Russian-Korean border (south-western part of Peter the Great Bay) in 1997 (Lutaenko, Yakovlev, 1999; Lutaenko, 2007). All findings were represented by empty shells collected as a beach drift (Fig. 14) but based on taphonomic features (good shell preservation, presence of coloration pattern and ligament), it was suggested that a living population of the species has been established in this area in the early 1990s which was confirmed later by finding shells with soft parts on the beach. The distribution of G. aequilatera is limited by the South China Sea in the south and by Hokkaido and North Korea in the north (subtropical in zonal-geographical terminology), and this species has never been recorded in well-studied shallow waters of Peter the Great Bay.

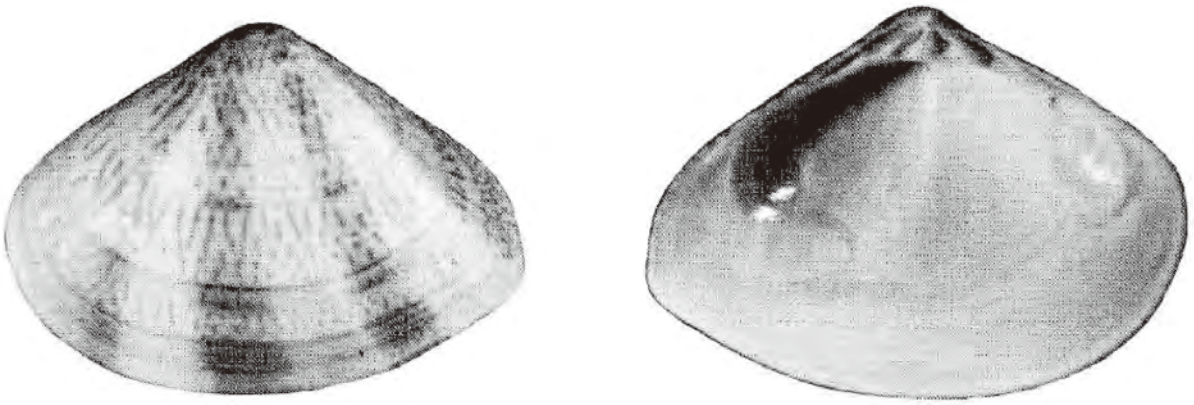

Fig. 14. Bivalve Gomphina aequilatera from Peter the Great Bay (after: Lutaenko, 2007).

Gastropods (Gastropoda)

Haliotis discus. This species has never been recorded from Peter the Great Bay despite the long history of zoological and hydrobiological researches in this area but it was found on rocks near the Russian-Korean border in 2002 at a depth of 13 m (Rakov, Arhipov, 2004). In Russian waters, it is known also from Moneron Island near the southern Sakhalin Island. The finding can be related to coastal water warming during last decades (Fig. 15).

Fig. 15. Abalone Haliotis discus found in Peter the Great Bay (after: Rakov, Arhipov, 2004).

Aplysia parvula. This species of the "sea hare", a probable invasive gastropod, was found for the first time off Furugelm Island (Peter the Great Bay) in 2005 (Chernyshev et al., 2006; Fig. 16). The authors (l.c.) explained the finding by migration of larvae with warm currents.

Fig. 16. "Sea hare" Aplysia parvula found in Peter the Great Bay (after: Chernyshev et al., 2006).

Cellana toreuma. This subtropical species of limpet was found as a single specimen in beach drift in Furugelm Island (Peter the Great Bay) (Chernyshev, Chernova, 2003). It can be regarded as a possible invasive species.

Alderia modesta. The ascoglossan mollusk Alderia modesta was found upon Vaucheria algal mats in an artificial semi-enclosed lagoon of Amursky Bay (Peter the Great Bay); in late May and early June the density of settlements of A. modesta was up to 2000 specimens/m? (Chernyshev, Chaban, 2005). This might be a new invader into Russian waters of the NOWPAP region.

Bryozoans (Bryozoa)

Bugula californica. Zvyagintsev (2003) found this species in the fouling of cabotage vessels in the northwestern Sea of Japan. B. californica was encountered on 41% of vessels examined in Peter the Great Bay and on 83% of vessels examined in Zolotoy Rog Bay, in the community of the polychate Hydroides elegans. In the communities of mussels and oysters, B. californica has been encountered on 69 and 50% of vessels examined, respectively. This species has not been registered on vessels operating to the north of Povorotny Cape. This species is still only at the first stage of acclimation (Zvyagintsev, 2003).

Conopeum seurati. This species is common on the Atlantic coast of Europe, from the British Islands to the Mediterranean and Black seas. C. seurati was found in bottom communities of Possjet and Vostok bays, on experimental plates installed in Zolotoy Rog Bay and on a buoy on Cape Uliss, all localities are within Peter the Great Bay (Zevina, Gorin, 1975). C. seurati is very common in the fouling of vessels examined from Peter the Great Bay; the greatest biomass of this species (12 g/m?) was registered on vessels that were staying or operating in Zolotoy Rog Bay (Zvyagintsev, 2003). Beyond Cape Povorotny, this species was found as single specimens on vessels in the harbors of Rudnaya Pristan and Preobrazhenye. The introduction of this species into Peter the Great Bay may be considered as a classical example of introduction with the following acclimation and naturalization (l.c.).

Schizoporella unicornis. This species is a member of fouling communities of Possjet Bay and is widely distributed in the benthos of the upper subtidal zone of Possjet and Vostok bays (Zevina et al., 1975). It is found on 25% of vessels examined in Peter the Great Bay showing an insignificant biomass and an occurrence frequency in samples of only 6% (Zvyagintsev, 2003). S. unicornis is absent on vessels from Sakhalin; on the coast of Primorye beyond the Povorotny Cape it was found only in the harbor of Preobrazhenye (l.c.).

Bowerbankia gracilis. Bagaveeva et al. (1984) believe that this species was introduced through autotransplantation and then naturalized in Peter the Great Bay. Zvyagintsev (2003) registered B. gracilis only on one of 245 cabotage vessels operating along the western coast of Sakhalin. It is possible that this is an indigenous species of the northwestern Sea of Japan, which, however, could hardly survive environmental conditions in harbor waters (l.c.).

Ascidians (Tunicata)

Molgula manhattensis. The fact of introduction of a solitary ascidian Molgula manhattensis was registered for the first time in the fouling community of experimental plates in Zolotoy

Fig. 17. Ascidian Ciona savignyi from Peter the Great Bay (http://www.imb.dvo.ru/files/ballast.pps).

Rog Bay and Rynda Bay (Russky Island), Peter the Great Bay in 1999 (Zvyagintsev, 2003). The geographical range of M. manhattensis lies in the Atlantic coast of North America and extends from Maine to Louisiana. However, this species is rapidly being distributed throughout the world. In the 1950s it was found in great quantities on the Pacific coast of North America, in San Francisco Bay (l.c.). This is one of a few species of ascidians that could easily adapt to low salinity.

Ciona savignyi. The occurrence of this solitary ascidian in Vostok Bay (Peter the Great Bay) was first documented in 2004 (Fig. 17). Adult specimens occurred in fouling communities of floating docks in Gaydamak Bay and on different anthropogenic substrates. The introduction of this ascidian into Vostok Bay is attributable to fishing ships which regularly frequent ports of Japan and to favorable environmental conditions (temperature and salinity of seawater) (Zvyagintsev et al., 2007).

Botrylloides diegense. This species was first found in Peter the Great Bay in 1969 and was introduced into this area from southern part of California (Beniaminsin, 1981).

Botryllus tuberatus. This species was found only once in Possjet Bay in bottom comminities in a depth range of 1.5 – 11 m (Beniaminson, 1981). Its native range lies in Japan, Yellow Sea, Palau and Gilber islands, and Banda Sea.

2.2.2. Planktonic organisms

In Amursky Bay, long-term studies of the species composition of phytoplankton carried out during the period from 1991 to 2006 revealed a total of 357 species of planktonic microalgae from eight divisions: Cyanophyta (8 species), Chrysophyta (8), Bacillariophyta (157), Cryptophyta (5), Dinophyta (143), Raphidophyta (3), Euglenophyta (11), and Chlorophyta (22 species); some of them can be invasive species but it is diffucult 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 Possjet 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).

Zvyagintsev et al. (2009) and Zvyagintsev and Selifonova (2008) noted the copepod crustacean, Pseudocalanus inopinus in ballast waters of the Timber Star motorship (Russia-

Japan shipping lines) which is rare or occasional component of plankton communuties of Peter the Great Bay and a marker of the arrival of tropical warm waters.

Larvae of polychaete Polydora sp. found in ballast waters has a morphology different from species known in Peter the Great Bay and can be introduced from coastal waters of Japan (Zvyagintsev et al., 2009).

2.2.3. Nektonic and nektobenthic

Jellyfish (Scyphozoa)

Rhopilema esculentum. This jellyfish was first recorded along the coast of Primorye in 1999 and became an object of commercial harvesting in 2001 (Borodin et al., 2003). Its natural distributional range is located in tropical and subtropical waters – South China, Yellow and East China seas. Borodin et al. (2003) explain its appearance in Peter the Great Bay by intensification of warm Tsushima and East Korean currents.

Fishes (Pisces)

Dynamics of fish composition and abundance largely depends on climatic fluctuations, current system changes (e.g., intensification of warm currents) and a number of other factors. There are many data and evidences around the world support the opinion about increase of distributional ranges of warm-water – tropical-subtropical and subtropical – fishes and their northward migrations. These migrants should be regarded as invasive species as they are non-native and existing (even temporarily) outside their normal past or present distribution. Sokolovsky et al. (2004) described in details centennial dynamics of fish species migrated from southern areas into the north-western Sea of Japan/East Sea (Russian part of the NOWPAP Region) based on numerous observations and literature sources. These authors (l.c.) found that in total, 100 species of "southern" fish were recorded in the time span between 1901 and 2003. For comparison, a total of 365 species of fish are known up to date in Russian waters of the Sea of Japan/East Sea (Sokolovsky et al., 2007), and 312 species are recorded in Peter the Great Bay (Sokolovsky et al., 2009). For last twenty years (since 1991), Sokolovsky et al. (2004) enumerated 55 fish species occurred in the Russian part of the NOWPAP Region and regarded as "southern migrants" in 1991-2003. Below is given a list of these species (Table 1).

Table 1. A list of southern migrants – fishes in Peter the Great Bay during the 1991 – 2003 (after: Sokolovsky et al., 2004)

SPECIES	1991 – 2000	2000 – 2003
Isurus oxyrinchus	+	
Carcharhinus brachiurus	+	
Prionace glauca	+	
Sphyrna zнgaena	+	
Dasyatis matsubarai	+	+

Etrumeus teres	+	
Sardinella zunasi	+	
Sardinops melanostictus	+	+
Konosirus punctatus	+	+
Engraulis japonicus	+	+
Cypselurus h. doderleini	+	
Hyporhamphus sajori	+	+
Strongylura anastomella	+	+
Cololabis saira	+	+
Mugil cephalus	+	+
Sphyraena pinquis	+	+
Lateolabrax japonicus	+	+
Seriola quinqueradiata	+	+
Seriola lalandi	+	
Seriola dumerili		+
Trachurus japonicus	+	
Alectris ciliaris	+	+
Coryphaena hippurus	+	
Coryphaena equisetis	+	+
Brama japonica	+	
Lobotes surinamiensis	+	
Acanthopagrus schlegeli	+	+
Upeneus bensasi		+
Parupeneus spilurus		+
Microcanthus strigatus	+	
Girella punctata	+	+
Scatophagus argus	+	
Oplegnathus fasciatus	+	+
Pictiblennius jatabei	+	
Chirolophis saitone	+	+
Eleutherochir mirabilis	+	
Thunnus t. orientalis	+	

Sarda orientalis		+
Scomber japonicus	+	+
Istiophorus platipterus	+	
Hyperogliphe japonica	+	+
Pampus argenteus	+	+
Pampus echinogaster	+	+
Cheilodonichthys spinosus		+
Hexagrammos agrammus	+	+
Hexagrammos otakii	+	+
Liparis punctulatus	+	+
Liparis tanakae	+	
Thamnaconus modestus	+	+
Stephanolepis cirrhifer		+
Diodon holocanthus		+
Takifugu rubripes	+	+
Takifugu niphobles	+	+
Takifugu xanthopterus	+	+
Histrio histrio		+

Sea reptiles (Chelonia and Serpentes)

Sea reptiles (turtles ans sea snakes) have been recorded from the Russian waters of the Sea of Japan/East Sea since the late 19th century; they are yellowbelly sea snake Pelamis platura (records in 1873, 2007) (Fig. 20), Chinese sea snake Pseodolaticauda semifasciata (1978), leatherback turtle Dermochelys coriacea (1936, 1972, 1979, 1984) (Fig. 18), and loggerhead turtle Caretta caretta (1940) (Fig. 19) (Kharin, 2008). The reason for migration of these reptiles to the Russian waters of the NOWPAP Region is coastal warming and intensification of warm currents (l.c.).

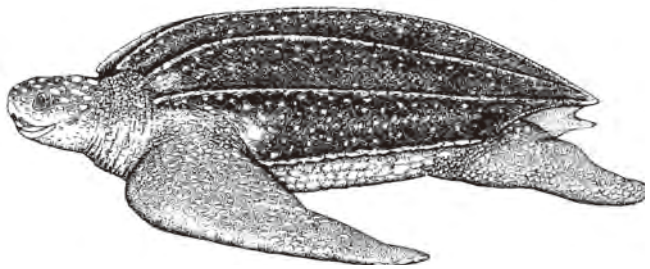

Fig. 18. Sea turtle Dermochelys coriacea found in Russian part of the NOWPAP region as a seasonal migrant (after: Kharin, 2008).

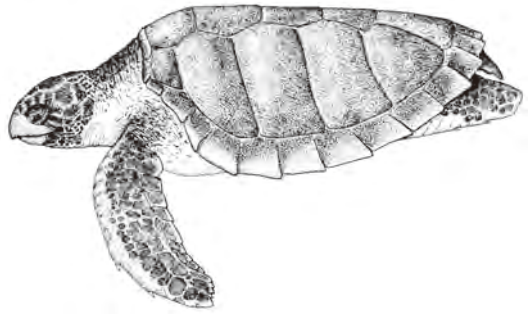

Fig. 19. Sea turtle Caretta caretta found in Russian part of the NOWPAP region as a seasonal migrant (after: Kharin, 2008).

Fig. 20. Sea snake Pelamis platura found in Possjet Bay (after: Kharin, 2008).

Overall, 100 species suspected to be invaders in Russian waters of the NOWPAP region resulting from either northward shifts in distributional ranges or anthropogenic introductions. For comparison, 136 of marine invasive species are known collectively from Korean and Chinese coastal waters (Seo, Lee, 2009).

2.2.3. Potential (expected) MIS in the NOWPAP Region

According to Orlova et al. (2009), the increase of phytoplankton species diversity in Amursky Bay compared with the data of the late 1960s and early 1970s was due, first of all, to personal human factors: new taxa were described and taxonomic revisions of certain groups of microalgae were done; also, the overall number of floristic studies on phytoplankton in this area using modern techniques increased significantly. However, these authors should not rule out the possibility that in the recent decades the phytoplankton species diversity in Amursky Bay could also have increased due to objective factors, in particular, at the expense of increasing water eutrophication in the bay and introduction of species (Orlova et al., 2009). This shows the future possible appearance of new invasive phytoplankton species.

Sokolovsky et al. (2004) predict appearance of more subtropical fish species in Peter the Great Bay with global warming and intensification of warm currunts in the Sea of Japan/East Sea.

Zvyagintsev et al. (2009; Zvyagintsev, Guk, 2006) 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. These

species were introduced into the coastal waters of Japan (Otani, 2004), and taking into account intensive shipping between Russia and Japan, this vector of introduction of the MIS is hihgly possible.

Zvyagintsev (2003) regarded as potential invaders species that are in the first stage of introduction and small-scaled development. He referred to this group of potential invasive species above-mentioned in the list of MIS G. loveni, L. flexuosa, L. calceolifera, P. limicola, and B. californica. They show great ecological plasticity and relatively frequently occur in the fouling of harbor fleet vessels and HTC in the northwestern Sea of Japan/East Sea; however, they usually do not develop mass settlements and are absent in the benthos. 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. It is still not known what species of this group could naturalize in the Sea of Japan/East Sea.

Another group of potential invasive species are related to migrations induced by global warming and current system modifications. A model of future (expected) faunal changes based on a detailed study and reconstruction of the Holocene molluscan migrations in the Sea of Japan/East Sea was proposed by Lutaenko (1999). In this respect, especially important was a period of so-called climatic optimum of the Holocene (ca. 5000 – 6000 years BP) which can be regarded as an analogue of recent global warming. Based on the data on species composition andchronology of mollusks, one can predict expected changes in the fauna, i.e., appearance/disapperance of abundant species which became regionally extinct during the second half of the Holocene due to a series of coolings (Lutaenko, 1993; Taira, Lutaenko, 1993; Lutaenko et al., 2007; Table 2). This reconstruction may be very important in terms of future dramatic impacts of new invaders on ecosystems. Coastal warming and introduction of new species may also favour aquaculture and fisheries.

Table 2. Possible new inhabitants (invasive species) – bivalve mollusks in different parts of the Sea of Japan in course of global warming (after Lutaenko, 1999; with corrections)

Species	Southern Sakhalin	Peter the Great Bay	Middle Primorye
A. brougthonii	+	*	+
A. inaequivalvis	+	+	-
A. kagoshimensis	?	+	-
Trapezium liratum	+	*	-
Meretrix lusoria	-	+	-

Note: "+" – immigration is expected; "?" – immigration is not expected; "*" – the species inhabits this area at present.

Kharin (2008) believes that one more species of sea turtle and seven more species of sea snakes may appear in the Russian part of the NOWPAP Region due to global warming.

3. Threats and impact of the MIS to native communities and ecosystems

a. Ecosystem changes (ecological impacts)

Biological invasions are a great threat to the integrity of natural communities of plants and animals and to preservation of endangered species (Carlton, Geller, 1993). Marine and coastal ecosystems are not immune to invasions and can be readily impacted as illustrated by predominance of some "aggressive" MIS. The ecological roles and impacts of invading species can only be partially predicted from knowledge of their biology and ecology, and for that reason bays, estuaries and shallow waters may be among the most threatened ecosystem on the planet (Carlton, Geller, 1993). Ecological impacts have become a major focus of invasion research in coastal areas, and most studies have focused on interactions between the introduced species and its immediate competitors, predators, and prey; studies on impacts across multiple trophic levels demonstrates that two functional groups in particular, ecosystem engineers and filter feeders, are the predominant groups responsible for impacts across trophic levels; ecosystem engineers and filter feeders are also likely to have disproportionately strong impacts on system-wide biodiversity and ecosystem function (Williams, Grosholz, 2008).

One of the important consequences of the natiralization of invasive species in Peter the Great Bay is predominanance of new inhabitants over native species which lead to alterations in the ecosystem structure and trophic relationships and occasionally to unbalancing of coastal ecosystems. Ovsyannikova (2008) clearly showed that a successful naturalization of the invasive barnacle Amphibalanus improvisus led to displacement of indigenous cirripeds from dominating macrobenthic species of the local fauna. As we mentioned earlier, this species has become widespread via ship fouling and was first recorded in the fouling of the hydrotechnical facilities in Peter the Great Bay in 1969, and then became a common component of fouling of ship hulls, a mass species on aquaculture installations and other anthropogenic substrata. In Amursky Bay, A. improvisus was recorded in eleven intertidal communities of the inner part (Ivanova et al., 2008). Near Cape Rechnoy, this species formed a monodominant community in the middle horizon of the stony intertidal zone with polpulation density of 900 individuals/ m? and biomass of 6.8 g/m?; in other sites, its population density reached as high as 17000 individuals/ m? and 157g/ m? (Ovsyannikova, 2008).

Non-indigenous bivalve mollusks are known as ecosystem engineers – they have the capacities to directly or indirectly affect the availability of resources to other species by physically modifying the environment; a variety of mechanisms via which they modify, maintain and create habitats include changes in sediment chemistry, grain size, and organic matter content via bioturbation, increased light penetration into the water column due to filter feeding, changes in near bed flow and shear stress due to presence of shells, and provision of colonisable substrate and refuges by shells (Sousa et al., 2009). Numerous settlements of the Meditteranean mussel Mytilus galloprinciallis with high population density in Peter the Great

Bay provides an example of ecosystem alerations 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. However, in the case of possible competition, we cannot measure all the resources that a particular species is using and may be competed for by an invader (Rilov, 2009).

In case of microalgae blooms caused by possible invasive phytoplankton species, the effect of oxygen-defficient water and eutrophication may lead to mass mortality of benthic animals and fishes. Large quantities of decomposing phytoplankton biomass are harmful for ecosystem stability especially in semi-enclosed bays and estuaries. It appears that many ecosystems that are now severely stressed by hypoxia may be near or at a threshold of change or collapse (loss of fisheries, loss of biodiversity, alteration of food webs) (Diaz, 2001). Development and prevalence of oxygene-deficient waters have been reported in most bays of Japan (Uzaki et al., 2003) and occassionaly take place in Amursky and Ussuriysky bays in the Russian part of the NOWPAP region.

One possible negative effect of the invasive species may be introduction of parasites not native to the organisms.

In many cases, biodiversity (at least in terms of species richness) regionally increases by invasions because we are not aware of any marine example of species that went globally extinct due to an invasion (Rilov, 2009).

b. Economic impacts

Red tides have frequently resulted in large mortality of fishery resources and huge economic losses to fisheries in the NOWPAP Region. However, there are no clear evidences that invasive species of phytoplankton were responsible for massive algal blooms in the Russian part of the NOWPAP region.

Biofouling of ships, piers, buoys and other hydrotechical structures consisting partly of invasive species has an important economic impact. The cost of cleaning ship hulls is very high.

Sokolovsky and Sokolovskaya (2005) showed that maximum species diversity of fishes was observed in the end of 20th and beginning of 21st centuries which is explained by global warming and intensification of warm currents in the Sea of Japan/East Sea. “Southern migrants” appeared in Peter the Great Bay play an important role in local fishing. It is obviously a positive economic effect of introduction of non-native species. However, man-made environmental changes (i.e, pollution of coastal waters and overfishing) negatively influence state of fisheries in the Russian NOWPAP Region (Sokolovsky, Sokolovskaya, 2005). Moreover, periods of anomalous increase of abunbance of warm-water, subtropical and tropical-subtropical, species of fishes are not always closely correlated with warmings and often unpredictable.

Mussel Mytilus galloprovinciallis which became an abundant component of biofouling in Peter the Great Bay (Ivanova, Lutaenko, 1998) as well barnacles may damage aquaculture installations. Form the other side, this mussel and its hybrids with local allied species Mytilus

trossulus are perspective object of aquaculture.

Conditionally pathogenic and toxinogenic mycelial fungi which are able to induce mycoses and mycotoxicoses of invertebrates and fishes were isolated from ballast waters of ships in Vladivostok Port (Zvyagintsev et al., 2009).

c. Public health impacts

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 (Orlova et al., 2009). 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). Shellfish poisoning is a common threat in the NOWPAP region. 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 (Integrated Report…, 2005). Some invasive shrimps in China and/or Korea contain pathogens such as human papilloma virus (Seo, Lee, 2009).

4. Prevention, detection and management of MIS

4.1. National/local authorities dealing with MIS monitoring

In contrast to other countries, in the Russian Federation, the federal government has not created a centralized agency that has had the necessary resources or the authority for nimble management of introduced species. There are no regional authorities in Primorsky and Khabarovsky Territories or in the Far Eastern Federal District dealing with MIS monitoring at present. The only research lab, Center for Monitoring of Marine Bioinvasions and Ballast Waters belonging to the A.V. Zhirmunsky Institute of Marine Biology FEB RAS is responsible for MIS monitoring in the NOWPAP Region.

4.2. Existing control and preventive measures, including status and risk assessments

There are no special control and prevention at present with regard to MIS in the Russian part of NOWPAP region. International Convention for the Control and Management of Ships' Ballast Water and Sediments was not ratified by Russian Federation (http://www.imo.org/, Status of Conventions by Country). However, Zvyagintsev et al. (2009) mentioned that Administration of the Vladivostok Port under the auspice of Federal Agency of Marine and River Transportation started recently to collect and analyze data on ballast waters of ships enterering the port.

4.3. Existing databases used for monitoring, control and prevention

The local database on the MIS in the Russian Far Eastern seas is currently under construction in the Institute of Marine Biology FEB RAS (Vladivostok) as an initiative of Center for Monitoring of Marine Bioinvasions and Ballast Waters but it is not available in the Internet yet.

There are four databases on invasive plants, insects, fishes and mammals managed as a part of the national project "Alien Species on the Terrotory of Russia" (http://www.sevin.ru/invasive/dbases.html#) but they do not include marine species at present.

4.4. Future plans on monitoring, control and prevention

UNEP Regional Seas recommends the following actions on control and prevention:

Pre-border interventions to prevent the introduction of invasive species include Environmental Impact Assessments (EIAs) prior to importation of alien species, permit systems for trade or movement of listed species, and appropriate ballast water management;

Border controls are designed to stop potentially invasive species at the point of entry, with officials responsible for inspecting cargo, checking compliance with permit systems, and imposing quarantine periods or treatment regimes;

Post-border interventions occur once the potentially invasive species is present in the area, and include early detection and rapid response, eradication, and control and mitigation.

Reballasting at sea helps to reduce the transfer of alien species, but has safety implications for ships and is not 100% effective. Alternatives include filtration or treatment by thermal, chemical or radiation means, but these technologies are still being developed. The IMO provides voluntary guidelines to minimise the transfer of harmful organisms through ships' ballast water, and the International Chamber of Shipping has developed a Model Ballast Water Management Plan that is being adapted for national use by some countries. Globallast is promoting good practices through a series of demonstration sites.

Zvyagintsev et al. (2009) suggested a number of practical measures for the Vladivostok Port to be implemented with regard to monitoring of invasive specieas and treatment of ballast waters.

UNEP Regional Seas proposed a list of activities that could be incorporated into the regional Action Plans and could be implemented in the Russian part of the NOWPAP Region:

- Baseline assessments of invasive species – as part of biodiversity surveys
- Analysis of risks/ pathways
- Training
- Awareness-raising
- Development and implementation of management strategies for priority invasive species.

5.Current research projects and other initiatives on the MIS in Russia

5.1. Priority research fields on the MIS

Priority research fields on marine invasive species in Russia include study on species composition, ecology and distribution of biofouling and countermeasures against ship fouling; taxonomic position of new invaders; ecological and environmental impacts of MIS; study on ballast waters, vectors of introduction of MIS; economic impacts.

5.2. Brief summary of research/project/initiative and national databases or Internet sources on MIS

A number of research institutions currently involved in the studies on MIS and biodiversity in the NOWPAP Region. They conduct annual field-works, collecting and biological observations including biodiversity, ecosystem and environmental monitoring. Several institutions manage museum/research collections which form a basis for a long-term monitoring and taxonomic databases. The potential and taxonomic expertise of the institutions and specialists are very high in Russian Fedetation which is manifested in numerous publications and biodiversity projects. The history of biodiversity researches in the Russian part of the NOWPAP Region goes back to the mid-19th century (see for review: Lutaenko, 2009). Below is given information about these institutions with brief description of their biodiversity/taxonomic activities including MIS. This information was partly summarized in a previous DINRAC NOWPAP report (Regional and National Reports…, 2007).

A.V. Zhirmunsky Institute of Marine Biology (IMB), Far East Branch, Russian Academy of Sciences (FEB RAS): 17 Palchevskogo Street, Vladivostok, 690041, Russia; e-mail: inmarbio@mail.primorye.ru; website: http://www.imb.dvo.ru.

Main activity in BD research: studies of flora and fauna, ecology and bioproductivity of shelf of the Russian Far Eastern seas and other areas of the World Ocean; development of scientific bases of protection, reproduction and rational use ofbioresources. The IMB manages three coastal biological stations located in the eastern area of the NOWPAP region, and the Institute Museum with biggest in the Far East marine biological collections. In 2008, the Institute established the only in the Russian Far East Center for Monitoring of Marine Bioinvasions and Ballast Waters (contact: Dr. A.Yu. Zvyagintsev, ayzvyagin@gmail.com). The Center aims to collect, process and analyze the information on marine invasive species and to transfer these data to the PICES NISIS database. Currently, several specialists of the IMB are involved in studies on MIS and potential invaders (A.Yu. Zvyagintsev, V.V. Ivin, A.V. Chernyshev, V.I. Radashevsky, M.S. Selina, T.V. Morozova, A.A. Begun, I.V. Stonik, A.S. Sokolovsky, V.E. Kharin, K.A. Lutaenko, and others). During the last decade, the staff members of the IMB ublished two important books on marine fouling and bionvasions:

Zvyagintsev A.Yu. 2005. Marine Fouling in the North-West Part of Pacific Ocean.

Vladivostok: Dalnauka. 431 p.

Zvyagintsev A.Yu., Ivin V.V., Kashin I.A. 2009. The Methodical Advisories to Research of Ship Ballast Waters during Realization of Marine Bioinvasions Monitoring. Vladivostok: Dalnauka. 123 p.

A project supported by the APN (Asia-Pacific Network for Global Change Research) under the title Marine Biodiversity of the Coastal Zones in the NW Pacific: Status, Regional Threats, Expected Changes and Conservation (ARCP2008-05CMY) with participation of three countries (Russia, China and Republic of Korea) was implemented by the IMB and included a significant portion on the MIS (website of the project: http://www.imb.dvo.ru/misc/apn/bio/index.htm). In frames of the project, two workshops on biodiversity were held in China and Korea: the workshop Biodiversity of the Marginal Seas of the Northwestern Pacific Ocean was held on November 21-23, 2007, in the Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China, with participation of more than 20 scientists, and proceedings containing full-length papers were published (available online: http://www.imb.dvo.ru/misc/apn/bio/e_b001.htm); the workshop Marine Biodiversity and Bioresources of the North-Eastern Asia was held in Cheju National University, Jeju, October 21-22, 2008 and full-length papers were published (available online: http://www.imb.dvo.ru/misc/apn/bio/e_b001.htm).

V.I. Il'ichev Pacific Oceanological Institute (POI), Far East Branch, Russian Academy of Sciences (FEB RAS): 43 Baltiyskaya Street, Vladivostok, 690041, Russian Federation; website: http://www.poi.dvo.ru.

Main activity in BD research: POI was established in 1973. POI is a multipurpose scientific institutesolving the most complicated problems of the ocean study and exploration. In the disposal of the institute there are two coastal experimental stations located in the eastern sector of NOWPAP region. The institute has an opportunity to conduct studies in cruises on board the research vessels of the FEB RAS. There are several specialists studying mollusks, zooplankton and some other groups.

Pacific Research Fisheries Center (TINRO-Center), Federal Agency of Fisheries: 4 Shevchenko Alley, Vladivostok, 690950, Russian Federation; e-mail: tinro@tinro.ru; website: http://www.tinro-center.ru.

Main activity in BD research: The Institute primarily was established in 1925 as the Pacific Research Fisheries Station (TONS) and later was renamed into TINRO-Center. Investigations of TINRO-Center include a wide range of scientific disciplines and are supported by large volume of monitoring information about the state and dynamics of marine ecosystems, climatic processes, and anthropogenic impact on marine bioresources. Research integration has been carried out on the basis of complex bioresources research programs of the Far Eastern Seas and Pacific open-water for many years. Programs purposefulness are keys for understanding complicated physical and biological processes, which take place in marine ecosystems, for correct forecasting their consequences as well as the effect of these processes on the resource stock dynamics and mariculture development. TINRO-Center carries on large-scale fisheries research including monitoring of fish migrations which is relevant to climatically-induced appearance of MIS. Benthic surveys regularly conducted by this institution provide an important information on ecology and distributions of marine organisms

and state of environment.

Far Eastern Regional Hydrometeorological Research Institute (FERHRI), Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet): 24 Fontannaya Street, Vladivostok, 690091, Russian Federation; e-mail: hydromet@ferhri.ru; website: http://rus.ferhri.ru.

Main activity in BD research: FERHRI was established in 1950. The Institute carries out extensive researches on meteorology, oceanography, land hydrology, climate and ecology (including measurements of the pollutant content in the sea water and bottom sediments, plankton and benthos characteristics) of the Russian Far East, Northwest Pacific Ocean and its marginal seas. The scientific fleet of FERHRI includes the research vessels of different class. The Institute has taken part in numerous national and international research programs. They provide recommendations to fisheries, maritime transportation and engineering organizations. Regular benthic surveys conducted by the FERHRI provide an necessary information on the state of communities including MIS. Staff members of the institute participated in APN projects on biodiversity in coooperation with the IMB.

Far Eastern National University (FENU), Ministry of Science and Education,8 Sukhanova Street, Vladivostok, 690950, Russian Federation; e-mail: rectorat@dvgu.ru; website: http://www.dvgu.ru.

Main activity in BD research: taxonomy and biodiversity of marine organisms mostly in the Sea of Japan/East Sea; publication of catalogues of museum collections. The FENU has the Zoological Museum established in 1958 which is an important regional depository of biodiversity collections and data.

A number of other organizations such as All-Russian Research Institute of Fisheries and Oceanography (VNIRO, Moscow), Zoological Institute, Russian Academy of Sciences (St.-Petersburg), Far East Technical Fisheries University (Vladivostok), Maritime State University (Vladivostok), P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences (Moscow),Institute of Problems of Ecology and Evolution, Russian Academy of Sciences (Moscow) and Sakhalin Research Fisheries and Oceanography Institute (Yuzhno-Sakhalinsk) carry on research on biodiversity of the Russian Far Eastern seas which occassionaly includes MIS problem.

In recent years, Russian national periodicals devoted to problems of bioinvasions started. They contain valuable papers dealing with new invasive species records, biological invasions of alien species in both terrestrial and aquatic ecosystems. Russian Journal of Biological Invasions (ISSN 1996–1499, Russian version) started in 2008 with free download of papers (http://www.sevin.ru/invasjour/index_eng.html); Editor-in-Chief, Academician D.S. Pavlov, Deputy Editor-in-Chief, Corresponding Member Yu.Yu. Dgebuadze. English version of this journal is published by Springer under the title Russian Journal of Biological Invasions (ISSN: 2075-1117, print version; ISSN: 2075-1125, electronic version).

National Projects

There are several national projects related to biodiversity and partly to invasive species.

Project “Alien Species on the Territory of Russia” (http://www.sevin.ru/invasive/, only in

Russian) is implemented by the Institute of Problems of Ecology and Evolution RAS with support of the Ministry of Education and Science of the Russian Federation. The project aimed at public awareness raising, informing legislative organs and scientific community on the problems related to invasive species; coordination of the activities of specialists and relevant organizations in the invasive species; creation of the databases.

Project "Biota of the Russian Waters of the Sea of Japan". This project is implemented since 2004 by the A.V. Zhirmunsky Institute of Marine Biology FEB RAS (leader – Prof., Academician A.V. Adrianov) and aims in publication of about 40 volumes of guide-books on the biota of the Russian waters of the Sea of Japan/East Sea. The important advantage of the project is publication of both Russian and English versions of books. The website of the project is under construction. 15 staff members of the IMB and 12 staff members of other institutions (Zoological Institute, Russian Academy of Sciences (St.-Petersburg), Institute of Problems of Ecology and Evolution, RAS (Moscow), P.P. Shirshov Institute of Oceanology, RAS (Moscow), Institute of Biology of Inland Waters, RAS (Borok), Institute of Biology of Southern Seas, National Academy of Sciences of Ukraine (Sevastopol), Pacific Institute of Bioorganic Chemistry, FEB RAS (Vladivostok), Moscow State University (Moscow), Kazan State University (Kazan), Kharkov National University (Kharkov, Ukraine) participate in the project at present. Seven volumes were published until 2009:

Vol. 1: Crustacea (Cladocera, Leptostraca, Mysidacea, Euphausiacea) andPycnogonida

Vol. 2: Prokaryota

Vol. 3: Brachiopoda and Phoronida

Vol. 4: Amphipoda – Caprellidea

Vol. 5: Crustacea (Thoracica and Facetotecta)

Vol. 6: Polyclad Turbellarians, Leeches, Oligochaetes, Echiurans

Vol. 7: Reptilians.

Project of the information system "Biodiversity in Russia" (http://www.zin.ru/biodiv/index_e.html). Since January 2002, the Zoological Institute (ZIN) of the Russian Academy of Sciences (St.-Petersburg) has been fulfilling the scientific program "Information System on Biodiversity of Russia" supported by the Ministry of Industry, Science and Technologies (now Ministry of Education and Science) of the Russian Federation. Preceding this work was thirty year history of computerization of the ZIN. The Institute of Problems of Ecology and Evolution, Russian Academy of Sciences (IPEE), the Botanical Institute, Russian Academy of Sciences (BIN) and the Institute of Cytology and Genetics, Siberian Branch of the Russian Academy of Sciences (ICG) are participants in this project.

Objective and tasks of the project. The major objective of the project "Information System

on Biodiversity" (ISBD) is creating a complex of software and databases (DB) for working on classification of animals and plants which would serve as a basis of information retrieval system (IRS) on the biodiversity of Russia, supporting heterogeneous collections of dispersed information resources containing systematic, collection and ecological information.The main tasks of ISBD are the development of standards, formats and methodology of creating a conjoint national distributed ISBD within the framework of the Russian segment of the global Internet and building a pilot information network on species diversity of Russia, combining DB supported by the participant institutes on species composition of all taxa (microorganisms, plants and animals) and data on collections kept at these institutes. The initial data for the work are the results of research conducted by subdivisions of ZIN, BIN, IPEE and ICG in the field of biology including the already created and partly published scientific products in the field of systematics of animals and plants.

Importance of the project. The objects of the research are prokaryotes, protists, fungi, plants, and animals inhabiting Russia and neighbouring territories. Of particular importance is the study of Antarctic animals and plants which adds to the value of the contribution of the Russian scientists in the study of biodiversity of the Earth. The project includes fundamental research, applied programs development, databases construction, and Internet access to different taxonomic groups of living organisms. The information systems will be beneficial for the resolution of different tasks: fundamental, applied, educational, and nature conservational.

Participation in international projects/initiatives

Project REABIC. The Regional Euro-Asian Biological Invasions Centre (REABIC, http://www.reabic.net) is a largely virtual institute providing on-line information services in the area of biological invasions and biodiversity research and management. Facilitation of international cooperation on the invasive species related issues, linking international research community and general public, managers and decision-makers as well as other interested stakeholders are among the main REABIC objectives. The REABIC is started in 2001 as a web portal, providing access to the global, regional, sub-regional and national Internet resources on biological invasions (the Regional Biological Invasions Centre project, RBIC). At present REABIC is serving as an independent virtual data centre for applied biodiversity research and management focusing on the Euro-Asian region and providing online services for interested stakeholders around a World. Since 2006 REABIC is serving also as an official publisher of Aquatic Invasions, (http://www.aquaticinvasions.net), an international journal on applied research on biological invasions in aquatic ecosystems (Managing Editor: Dr. Vadim E. Panov, Regional Euro-Asian Biological Invasions Centre, Finland, and St.-Petersburg State University, Russian Federation).

PICES projects. PICES has the Working Group on Non-Indigenous Aquatic Species (hereafter WG 21) which regularly holds meetings and also aims in creating a database on MIS. From Russian Federation, there are two members of the WG 21 (Dr. Evgenyi I. Barabanshchikov and Dr. Vasily I. Radashevsky as Co-Chairman). A 2008/2009 workplan of the PICES WG 21 for database and taxonomy initiatives of a marine non-indigenous species (MNIS) project funded by a voluntary contribution from Japan included 1, Database

development (a template for standards and elements of relevant scientific data (scientific and common names, native range distribution and invasion range distribution(s), life histories, habitat requirements, ecological roles, impacts of invasions, and management and mitigation measures undertaken in invaded countries) is to be developed and documented, based on the United States Environmental Protection Agency (EPA) and the United States Geological Survey (USGS) "Pacific Coast Ecosystem Information System" (PCEIS) spatial database; 2, Beta testing of the database (focus is to be on entry of data for a pilot NIS taxon (bivalves) by all PICES member countries; potential limitations identified through this exercise are to be discussed at the proposed inter-sessional meeting; 3, Meeting to obtain consensus on database format, standards and elements to be held.

6. Existing gaps in relation to the global and regional developments dealing with marine and coastal biodiversity, including invasive alien species

6.1. Compliance with relevant global conventions, agreements and other international regulations in the field of marine and coastal biodiversity

The Convention on Biological Diversity (CBD) aimed at preserving biological diversity on genetic, specific, and ecosystem levels was ratified by the Russian Federation in 1995. In accordance with its duties within the scope of the Convention, the National Strategy of Biodiversity Conservation in Russia has been elaborated. It was presented on Conference of the Parties to the Convention on Biological Diversity (Hague, 2002).

Within the plans of development and realization of National Strategy of Biodiversity Conservation in Russia, the federal laws "On Specifically Protected Natural Territories", "On the Animal World", "On Fishery and Conservation of Water Biological Resources" and others were enacted. The law "On aquaculture" is on the project stage. The law "On the Plant World" and other regulating the issues of biodiversity are being developed.

Russian Federation is not a party to the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004. The systems of ballast water management are not developed in the Russian seaports located in the north-west part of Pacific Ocean. There are also no any procedures to inform touching at a port ship about the requirements regarding the management of ship water ballast, the areas and terms for exchanging the ballast are not determined.

There is no monitoring in the ports for early detection of alien species brought with the ships' ballast water and for detection and estimation any negative consequences of such organisms. At the same time, the effective planning and securing measures can be based only on results of long-term regular standard observations of biological contamination which are made as a part of special monitoring of biological contamination.

The Russian Federation is also not a member of International Theoretical and Practical Program "The Elimination of Barriers on the Way of Effective Realization of the Measures to Control and Manage Ballast Water in Developing Countries" (GloBallast Program), founded

in 1999 with the participation of Global Ecological Fund, United Nations Development Program andInternational Maritime Organization. One of the main directions of this program which is realized in 6 demonstration centers in different countries is the estimation of the level and types of ecological dangers arising in global shipping intensification. There are no similar demonstration centers in Russia, although by present time there is an urgent necessity to improve state standards of shipping safety, to implement the international environmental standards in the practical activity of the Russian ships and coastal enterprises of marine transport of Russia.

6.2. Status of expertise and capacity building as related to MIS research; taxonomic ability to identify MIS in member country (Russia)

Knowledge of species taxonomy and natural geographic distributions are of paramount importance for interpreting patterns in ecology, biogeography and biodiversity including MIS (Carlton, Geller, 1993). Systematics of many marine organisms are far from complete, and many introduced species may be cryptic, having invaded and gone unrecognized or been mistaken as native species (l.c.). In this respect, status of biodiversity expertise and taxonomic ability to identify and recognize MIS in the NOWPAP Region are of critical importance. As was shown in chapter 8, there are many research institutions and specialists in the Russian Federation currently conducting studies on the BD as well as participating in international projects. Traditionally, BD researches have strong development in Russia. Numerous publications and launch of new periodicals directly related to invasive species make it easier to exchange information, building databases and international involvement.

6.3. Future needs in capacity building (including training and equipment), public awareness raising, communication, compliance and enforcement

COBSEA Secretariat identified several needs with regard to MIS problem (Report…, 2009):

- Limited and incomplete information on the presence, impacts and pathways of marine invasive species;
- A shortage of adequately trained personnel (managers, scientists, taxonomists, technical experts and enforcement officers) and facilities;
- A lack of awareness of marine invasive species and their impacts;
- Where policies and legislation do exist, they tend to be focused on terrestrial and freshwater invasive species rather than marine and in general institutional arrangements do not facilitate the management of MIS.

Same problems and needs in capacity building, manafement and public awareness raising exist in the Russian part of the NOWPAP Region. Moreover, there is no international coordination in the research and management of the MIS in the NOWPAP region. There is a strong need to conduct a joint Russian-Korea-Japan-China workshop on MIS problems and to share available information. It would be desirable to create a database in frames of NOWPAP DINRAC in coordination with similar efforts of PICES.

7. Legislation, programs and responsible organizations related to marine and coastal biodiversity, including invasive alien species

7.1. National legislation related to marine and coastal biodiversity issues

A basis for current Russian environmental legislation is provided by the Constitution of the Russian Federation. There is a well-developed system of legislative institutions, rules, and prescriptions concerned with biodiversity conservation. The federal law "On the Conservation of the Environment" is of crucial importance. The federal laws "On the Animal World", "On Specifically Protected Natural Territories", Water Code and other normative and legal documents are also of great importance of biodiversity conservation. The Presidential and Governmental decrees and other by-laws are also directed at maintenance and use of natural resources as well as environmental protection. Russia is a party to many International Conventions on conservation and sustainable use of biodiversity and its components which are the part of national legal system.

On the whole, Russia has rather a large body of laws regulating biodiversity use and conservation. However, many of them are frame documents laying emphasis on natural resources and have to be realized through the introduction of additional legislative acts. Hence, controversies and conflicting situations dictating the necessity of changes, amendments, and further target-oriented work of making new laws in the areas covered by the Convention on Biological Diversity, and other international conventions and agreements.

The Russian legislative acts aimed at ensuring the biodiversity conservation with short summaries are listed below.

The federal law of the Russian Federation "On the Conservation of the Environment" № 7-FZ, dated January 10, 2002	It is legally concerned with the state environmental policy on ensuring the maintenance of favorable environment state, biological diversity, and natural resources to meet the demands of recent and future generations, strengthen the law and order on environmental protecting and ensuring of ecological safety
The federal law of the Russian Federation " On Specifically Protected Natural Territories" № 33-FZ, dated March14, 1995	It regulates relations in the field of organization, protection and use of specifically protected natural territories to conserve unique and representative natural complexes and objects, notable natural formations, objects of the vegetable and animal worlds and their gene pool as well as to research natural biospherical processes and control its changes of state

The federal law of the Russian Federation "On the Animal World" № 52- FZ, dated April 24, 1995	It regulates the relations in the field of protection and use of animal world as well as of conservation and rehabilitation of its natural habitat to maintain biological diversity, sustainably use all its components, provide conditions for sustainable animal world existence, conserve gene pool of wild animals and protect the animal world being as integral part of nature
The federal law of the Russian Federation "On Fishery and Conservation of Water Biological Resources" № 166-FZ, dated December 20, 2004	It directed to preserve the water biological resources viz. to maintain or restore the water biological resources to a such level when their maximal stable catch and biological diversity can be ensure by means of scientifically substantiated implementation of measures on research, protection, reproduction and rational use of water biological resources as well as protection of their habitat
The federal law of the Russian Federation "On Ecological Expertise" № 174- FZ, dated November 23, 1995	It directed to prevention of negative environmental impact of economic activity including that which assumed to realize on specifically protected natural territories
The federal law of the Russian Federation "On Government Regulation in the field of Gene and Engineered Activity" № 86-FZ, dated July 5, 1996	It determines the environment protection and restoration and biodiversity conservation as one of the guidelines for the government regulation on gene and engineered activity
The federal law of the Russian Federation "On Hunting and Conservation of Game Resources and on Amending Specified Legislative Acts of the Russian Federation" № 209-FZ, dated July 24, 2009	It directed at ensuring the sustainable existence and use of game resources as well as their biodiversity conservation
Water Code of the Russian Federation № 74-FZ, dated June 3, 2006	It directed at habitat conservation of water biological resources and other objects of the world and vegetable worlds
Decree of the President of the Russian Federation "On State Strategy of the Russian Federation on the Environmental Protection and Sustainable Development" № 236, dated February 4, 1994	It determines biodiversity conservation, development and improvement of specifically protected natural territories system as one of the guidelines for the Russia activities on participation in solution of global environmental problems

Decree of the President of the Russian Federation № 440 "On Concept of Transition of the Russian Federation to sustainable use", dated April 1, 1996	It determines the biodiversity conservation, development and improvement of specifically protected natural territories system as one of the guidelines for the Russia international activities on environmental protection
"The Regulations on State Control of Environmental Protection (The State Ecological Control)" approved by Resolution of the Government of the Russian Federation № 53, dated January 27, 2009	It lays down an order of exercising the state control of environment protection (the state ecological control), which carries out to execution of environmental legislation and observe demands on environmental protection as well as ensure the ecological safety by public authorities of the Russian Federation and subjects of the Federation as well as local bodies, artificial and natural persons
«The Regulations on Impact Assessment of Projected Economic and Other Activity on Environment in the Russian Federation", approved by Decree of the State Committee of the Russian Federation on Environmental Protection № 372, dated May 16, 2000	It regulates procedure of impact assessment of projected economic and another activity on environment to prevent or minimize the unfavorable impacts of economic activity to environment including biodiversity conservation and social, economic and other consequences concerned

To promote a fulfillment of the Russian Federation's commitments as a member of the Convention on Biological Diversity and to purpose of its biological diversity conservation The National Strategy of Biodiversity Conservation in Russia was approved at the National Forum on the Wildlife Conservation (Moscow, 2001). The National Strategy is a document of long-term planning concerning environmental protection and sustainable use of the country. The National Strategy determines principles, priorities and main trends of the Russia policy related to the biodiversity conservation, main lines of elaboration of legislative and normative legal acts, a system of organizational, administrative, financial, and economic mechanisms to ensure conservation and sustainable use of biodiversity. It is a basis of elaboration of strategies of biodiversity conservation of regional importance, conservation strategies for particular species and ecosystems as well as action plans and strategies of governmental, public and commercial institutions to the same effect.

The Strategy expresses common aspirations of the Russian society to safeguard biodiversity thus opening the possibility for active participation of all interested parties.

The Action Plan, a system of concrete measures and actions aimed at biodiversity conservation, was worked out on the basis of National Strategy. It was elaborated according to the rules and procedures recommended by the Russian Government for the preparation of draft Federal Targeted Programs. The Action Plan represents a portfolio of project proposals to be implemented by the Government of the Russian Federation, subjects of the Federation,

and various agencies for preparation of different appropriate programs and specialized environmental action plans.

The Environmental Doctrine of the Russian Federation approved by Prescription of the Government of the Russian Federation № 1225-r, dated August 31, 2002 is based on provisions of the National Strategy. The Environmental Doctrine determines the main trends of the state environmental policy, of them conservation of natural systems and maintenance of their continuity and life-supporting functions for developing the sustainable society and securing the country's ecological safety are of great importance. Conservation and rehabilitation of natural systems, their biological diversity, and self-regulation ability as an indispensable condition of human society existence is one of important issues aimed at the goal achievement. The following steps should be initiated for the fulfillment of this task:

- to conserve diversity of using biological resources, their internal structure, and ability to self-regulation and self-reproduction;
- to conserve and rehabilitate the complex of terrestrial, fresh-water, and marine natural systems optimal for sustainable development of the country and its regions;
- to conserve and rehabilitate rare and vanishing species in natural environment, captivity, and genetic banks;
- to organize and develop the specifically protected areas of different levels and regimes, and to form on their basis the natural and reserved fund of Russia as an integral component of the country and regions development;
- to conserve and rehabilitate the natural biological diversity and landscapes on urbanized territories and areas under economic activity.

7.2. Leading authorities to implement national legislation related to marine biodiversity issues

In the Russian Federation, a number of federal executive bodies perform functions on ensuring the sustainable nature management and conserving and rehabilitating the nature and natural biological diversity.

The Ministry of Natural Resources and Environmental Protection of the Russian Federation [www.mnr.gov.ru] is a basic federal executive body performing the functions on drafting the state policy and normative and legal regulation in the sphere of the environmental protection and conservation including the specifically protected natural areas as well as in the sphere of study, use, regeneration, and conservation of wildlife resources and their habitat. The Ministry acts on the basis of "The regulations on the Ministry of Natural Resources and Environmental Protection of the Russian Federation" approved by Resolution of the Government of the Russian Federation № 404, dated May 29, 2008. The Government of the Russian Federation is at the head of the Ministry.

The Federal Supervisory Natural Resources Management Service [http://rpn.gov.ru] is under the authority of the Ministry of Natural Resources and Environmental Protection of the Russian Federation. The Federal Supervisory Natural Resources Management?Service is a

federal executive body performing control and supervision functions in the sphere of nature management. It acts on the basis of "The Regulations on the Federal Supervisory Natural Resources?Management?Service" approved by Resolution of the Government of the Russian Federation № 400, dated July 30, 2004.

The Federal Supervisory Natural Resources Management Service exercises control and supervision in the field of preservation, use, and reproduction of wildlife and wildlife habitat; in the sphere of organization and functioning of specially protected natural territories of federal importance; of the observance of legislation of the Russian Federation and international rules and standards concerning the marine environment and natural resources of internal seas, the territorial sea, exclusive economic zone, and on the continental shelf.

The Federal Agency for Fishery of the Russian Federation [http://fish.gov.ru] is a federal body of executive authority performing functions on draft and exercise of state policy and legal regulation in the sphere of protection, rational use, research, preservation, and reproduction of marine biological resources and their habitat, excluding marine resources in specifically protected natural territories of federal importance and listed in the Red Book of the Russian Federation. The Federal Agency acts on the basis of "The Regulations on the Federal Agency for Fishery of the Russian Federation" approved by Resolution of the Government of the Russian Federation № 444, dated June 11, 2008. The Government of the Russian Federation is at the head of the Agency.

7.3. National legislation specifically addressing marine and coastal invasive alien species

In the Russian Federation, there are no the specific acts of legislation aimed at solving the issue of invasion of alien species including marine and coastal ones. A national strategy for alien species, brought to territory of Russia, is absent too.?The issues of species introduction are regulated by certain dispositions of some federal laws and governmental resolutions. A number of them are of either branch-wise or common type.?

The list of base legal acts of the Russian Federation, which regulate the issues of introduction, acclimatization, and migration of species in whole and applicable to marine andcoastal invasive species is given below.

The federal law of the Russian Federation "On the Conservation of the Environment" № 7-FZ, dated January 10, 2002	It prohibits production, raising and use of plants, animals and organisms, which are not peculiar to natural ecological systems or artificially made, without development of the effective measures for preventing their uncontrolled reproduction, positive decision of governmental ecological expertise, and permission of federal authorities performing functions in the sphere of the environmental protection

The federal law of the Russian Federation " On Specifically Protected Natural Territories" № 33-FZ, dated March14, 1995	It prohibits the introduction of living organisms for their acclimatization on the territory of the state wildlife reserved areas and national parks
The federal law of the Russian Federation "On the Animal World" № 52- FZ, dated April 24, 1995	It allows to acclimatize the objects of the fauna which are new to Russia's fauna, to move the objects of the fauna to new habitats, and to perform the hybridization of the animal world's objects only with the permission of special authorized governmental bodies in protecting, controlling, and regulating the use of objects of the animal world and habitats and in presence of resolution of competent scientific organization taking into consideration the requirements for environmental safety
The federal law of the Russian Federation "On Fishery and Conservation of Water Biological Resources" № 166-FZ, dated December 20, 2004	It determines the acclimatization of water biological resources as an activity on placement of water biological resources of valuable species into water bodies with fishery capabilities and in creation of stable populations of these species in the water bodies with fishery capabilities, which have not been inhabited before by these species or have lost its value. The order of measures for acclimatization of water biological resources is defined by the federal executive body in the field of fishery
The federal law of the Russian Federation "On Hunting and Conservation of Game Resources and on Amending Specified Legislative Acts of the Russian Federation" № 209-FZ, dated July 24, 2009	It allows the acclimatization, relocation, and hybridization of game resources to settle them in new habitat and provide the conservation their specific diversity only in presence of the permissions and on the base of scientifically substantiated recommendations
"The Regulations on the Federal Supervisory Natural Resources Management Service" approved by Resolution of the Government of the Russian Federation № 400, dated July 30, 2004	It includes into the list of powers of the Federal Supervisory Natural Resources Management Service the issuance of the license (permission) to acclimatize the objects of fauna which are new to the fauna of Russia, to relocate the objects of the animal world to new habitats, and to hybridize the objects of the animal world which are enlisted in the Red book of the Russian Federation

The Environmental Doctrine of the Russian Federation approved by Prescription of the Government of the Russian Federation № 1225-r, dated August 31, 2002 considers the control of use and distribution of alien species and genetically modified organisms as one of the priority directions of activity in providing the environmental safety of Russia. For organization and providing this control it is necessary to solve the following issues:

- to ensure the effective work ofquarantine services, to prevent the invasion and unauthorized import to the territory of the country of alien species and genetically modified organisms as well as pests, carriers, and agents of diseases;
- to perform the control of domestic acclimatization activities;
- to develop and fulfill the system of arrangements for prevention of uncontrolled distribution of alien species and genetically modified organisms in natural environment and for elimination of the consequences ofthese processes;
- to perform control and support of safe use of alien species and genetically modified organisms in economical turnover.

8. Recommendations for decision–makers in terms of priority national actions, services and products

One of the most important actions of Russia in the field of conservation of biodiversity and environmental safety of the State is the improvement of legislation for preservation of natural environment. It includes the elimination of all contradictions between the legislation in the fields of natural resource and natural preservation, and also between legislation regulations in other fields; support of realization of legislation acts by the enactment of the subordinate acts which are necessary for complete usage of the federal laws; adjusting the legislation of the Russian Federation in the field of environmental protection in accordance with international laws within the scope of Russia's duties under international treaties.

For the legal regulation of the issue of introduction of marine and coastal species it is necessary to develop the whole number of new normative and legal documents and to amend the existing ones. So, it is need for enacting urgently the federal law “On aquaculture” regulating the activity in the field of reproduction of water biological resources, including the work for artificial reproduction of water biological resources and their acclimatization; for enacting a law for the regulation of the turnover of rare and being under threat of extinction species of animals, plants and other organisms etc.

It is an imperative need for ratification by Russia of new international agreement which is aimed at avoiding, reducing and eliminating the alien species migration with ships’ ballast water., i.e. the International Convention for the Control and Management of Ships’ Ballast Water and Sediments, 2004. Before entering into force as well as ratification of Russia, the Convention can be used as the basis for measures implementing to reduce a risk of the transfer of harmful aquatic organisms and pathogens via ships’ ballast water. It is necessary to develop the system of control and management of ballast water at the legislative level. The main directions of law-making in this field are:

- development of the control system to manage the ballast water aboard the ship;
- organization of the system to control and manage ballast water in the ports;
- monitoring of the marine environment over the ballast's discharge and exchange areas. The Russian Federation should also elaborate the normative and legal act determining the recruitments on composition of ballast water and procedure of its analytic control as well as regulations of control by specialized executive bodies.

Current normative and legal documents of the Russian Federation should be added with the requirements of biodiversity conservation and inexhaustible use of its components. The methods of calculation of damage injured to the nature are to be developed to include not only separated kinds of resources but also the whole nature complexes and ecosystems. The requirements to conserve the biological diversity should be included into the procedure of ecological expertise. At large, the legislation is to be developed on the basis of the ecosystem approach and biological principles of biodiversity conservation.

The present situation in Russia is characterized by non-effective and unsatisfactory enforcement of current laws on biological diversity conservation. Specially authorized state agencies for conservation, monitoring and management of natural resources, ecological expertise, environmental protection, and other governmental bodies (customs, public prosecution, internal affairs, and security agencies) directly responsible for biodiversity conservation act inefficiently and actually in an uncoordinated manner. Coordination of their activities is needed to prevent and suppress illegal or abusive use biodiversity.

Against the background of common decrease of law execution the situation with the nature protection is more aggravated as among tasks which are carried out by law-enforcement and other agencies the issues of conserving of biodiversity are far from being major priority. In the field of law enforcement the main task is an integrated organizational, technical, economical, and ideological support of the unavoidability of punishment for breaking the environmentall laws and injuring the damage to nature.

9. References

Bagaveeva E.V., Kubanin A.A., Chaplygina S.F. 1984. Role of vessels in the introduction of hydroids, polychaetes and bryozoans into the Sea of Japan. Biologiya Morya (Marine Biology, Vladivostok). N 2. P. 19-26.

Bagaveeva E.V., Zvyagintsev A.Yu. 2000. The introduction of polychaetes Hydroides elegans (Haswell), Polydora limicola Annenkova, and Pseudopotamilla occelata Moore to the northwestern part of the East Sea. Ocean Research. V. 22, N 1. P. 25-36.

Beniaminson T.S. 1981. New for Peter the Great Bay colonial ascidians – Ascidiacea, Styelidae (Botryllinae). In: V.A. Kudryashov (Ed.). Organisms of Fouling of the Far Eastern Seas. Vladivostok: Far East Sci. Centre, USSR Acad. Sci. P. 94-98.

Borodin P.A., Osipov E.V., Yakovlev Yu.M. 2003. Paths of jellyfish Rhopilema esculentum penetration into Peter the Great Bay and its distribution. Izvestiya (Bulletin of) TINRO. V. 133. P. 236-239.

Budnikova L.L. 2001. Benthic amphipods (Crustacea: Amphipoda) in the southwestern part of Peter the Great Bay. In: V.L. Kasyanov, M.A. Vaschenko and D.L. Pitruk (Eds.).The State of Environment and Biota of the Southwestern Part of Peter the Great Bay and the Tumen River Mouth. Vladivostok: Dalnauka. V. 2. P. 98-109.

Carlton J.T. 1985. Transoceanic and interoceanic despersal of coastal marine organisms: the biology of ballast water. Oceanography and Marine Biology: An Annual Review. V. 23. P. 313-371.

Carlton J.T. 1992. Introduced marine and estuarine mollusks of North America: an end-of-the-20th-century perspective. Journal of Shellfish Research. V. 11, N 2. P. 489-505.

Carlton J.T. 1996. Marine bioinvasions: the alteration of marine ecosystems by nonindigenous species. Oceanography. V. 9, N 1. P. 36-43.

Carlton J.T., Geller J.B. 1993. Ecological roulette: the global transport of nonindigenous marine organisms. Science. V. 261. P. 78-82.

Chaplygina S.F. 1980. Hydroids in the fouling of the Northwestern Sea of Japan. In:Ecology of Fouling in the Northwestern Pacific. Vladivostok: Far East Sci. Centre, USSR Acad. Sci. P. 56-71.

Chernyshev A.V., Chaban E.M. 2005. The first findings of Alderia modesta (Lovén, 1844) (Opistobranchia, Ascoglossa) in the Sea of Japan. Ruthenica (Russian Malacological Journal). V. 14, N 2. P. 131-134.

Chernyshev A.V., Chernova T.V. 2003. The first finding of limpets Cellana toreuma (Reeve, 1855) (Gastropoda, Patelliformes) in the Peter the Great Bay (Japan Sea). Ruthenica (Russian Malacological Journal). V. 13, N 2. P. 101-102.

Chernyshev A.V., Ratnikov A.V., Chaban E.M. 2006. First findings of the "sea hare" Aplysia parvula (Gastropoda: Opisthobranchia) in Peter the Great Bay, Sea of Japan. Biologiya Morya (Marine Biology, Vladivostok). V. 32, N 6. P. 445-446.

Diaz R.J. 2001. Overview of hypoxia around the world. Journal of Environmental Quality. V.

30, N 2. P. 275-281.

Gayko L.A. 2005. Peculiarities of Hydrometeorological Regime of the Coastal Zone in the Peter the Great Bay (Sea of Japan). Vladivostok: Dalnauka. 150 p.

Gorin A.N. 1975. Seasonal settling dynamics of fouling organisms in northwestern Sea of Japan. In: G.B. Zevina (Ed.). Fouling in the Sea of Japan and Sea of Okhotsk. Vladivostok: Far East Sci. Center, USSR Academy of Sciences. P. 45-70.

Hobbs R.J., Arico S., Aronson J. et al. 2006. Novel ecosystems: theoretical and management aspects of the new ecological world order. Global Ecology and Biogeography. V. 15. P. 1-7.

Integrated Report on Harmful Algal Blooms (HABs) for the NOWPAP Region. 2005. Toyama: NOWPAP CEARAC. 64 p.

Ivanova M.B., Belogurova L.S., Tsurpalo A.P. 2008. The composition and distribution of intertidal biota in the estuarine zone of Amursky Bay (Peter the Great Bay, Sea of Japan). In: K.A. Lutaenko and M.A. Vaschenko (Eds.). Ecological Studies and the State of the Ecosystem of Amursky Bay and the Estuarine Zone of the Razdolnaya River (Sea of Japan). Vladivostok: Dalnauka. P. 92-142.

Ivanova M.B., Lutaenko K.A. 1998. On the distribution of Mytilus galloprovincialis Lamarck, 1819 (Bivalvia, Mytilidae) in Russian Far Eastern seas. Bulletin of the Institute of Malacology, Tokyo. V. 3, N 5. P. 67-71.

Je J.-G., Zhang C.I., Lee S.H. 1990. Characteristics of shell morphology and distribution of 3 species belonging to genus Mytilus (Mytilidae: Bivalvia) in Korea. Korean Journal of Malacology. V. 6, N 1. P. 22-32.

Kepel A.A., Spiridonov V.A., Tsareva L.A. 2002. Finding of the crab Planes marinus Rathbun, 1914 (Decapoda: Grapsidae) in Peter the Great Bay, Sea of Japan. Russian Journal of Marine Biology. V. 28, N 3. P. 206-207.

Kepel A.A., Tsareva L.A. 2005. First record of tropical crabs Portunus sanguinolentus (Herbst, 1783) and Plagusia depressa tuberculata Lamarck, 1818 in Peter the Great Bay, Sea of Japan. Russian Journal of Marine Biology. V. 31, N 2. P. 124-125.

Kharin V.E. 2008. Reptilians. In: A.V. Adrianov (Ed.). Biota of the Russian Waters of the Sea of Japan. Vol. 7. Vladivostok: Dalnauka. 169 p.

Kolpakov N.V., Barabanshikov E.I., Chepurnoi A.Yu. 2008. Species composition, distribution and biological condition of non-indigenous fishes in the estuary of the Razdolnaya River (Peter the Great Bay, the Sea of Japan/East Sea). Russian Journal of Biological Invasions. N 2. P. 47-55.

Korn O.M., Kornienko A.S., Zvyagintsev A.Yu. 2007. Naturalization of the hermit crab Diogenes nitidimanus Terao, 1913 (Decapoda: Anomura: Diogenidae) in Vostok Bay, Sea of Japan: hypothesis or reality? Izvestiya (Bulletin of)TINRO.V. 150. P. 291-297.

Kudryashov V.A., Zvyagintsev A.Yu. 1981. Amphipod crustaceans (Crustacea, Amphipoda) in ship fouling of the Far Eastern sea basin. In: V.A. Kudryashov (Ed.). Organisms of Fouling of the Far Eastern Seas. Vladivostok: Far East Sci. Centre, USSR Acad. Sci. P. 56-72.

Lutaenko K.A. 1993. Climatic optimum during the Holocene and the distribution of warm-

water mollusks in the Sea of Japan. Palaeogeography, Palaeoclimatology, Palaeoecology.V. 102, N 3-4. P. 273-281.

Lutaenko K.A. 1999. Expected faunal changes in the Sea of Japan: influence of climate and sea level on the distribution of bivalve mollusks. Bulletin of the Russian Far East Malacological Society. V. 3. P. 38-64.

Lutaenko K.A. 2007. New records of bivalve mollusks in Peter the Great Bay (Sea of Japan) during the last 20 years: consequences of coastal water warming? In: K.A. Lutaenko (Ed.). Biodiversity of the Marginal Seas of the Northwestern Pacific Ocean: Proceedings of the Workshop, Institute of Oceanology CAS, Qingdao, China, November 21-23, 2007. Qingdao: IOCAS. P. 29-31.

Lutaenko K.A. 2009. Biodiversity in the Sea of Japan: more than a century of Russian research. In: Proceedings of the First Marine Biodiversity Workshop in the Northwest Pacific Region, 16 September 2009, Toyama, Japan. Toyama: NPEC. P. 17-23.

Lutaenko K.A., Yakovlev Yu.M. 1999. Gomphina (Macridiscus) aequilatera (Sowerby, 1825) (Bivalvia, Veneridae), a new subtropical species in the Russian Far Eastern marine fauna. Ruthenica (Russian Malacological Journal). V. 9, N 2. P. 147-154.

Lutaenko K.A., Zhushchikhovskaya I.S., Mikishin Yu.A., Popov A.N. 2007. Mid-Holocene climatic changes and cultural dynamics in the basin of the Sea of Japan and adjacent areas. In: D.G. Anderson, K.A. Maasch and D.H. Sandweiss (Eds.). Climate Change and Cultural Dynamics: A Global Perspective on Mid-Holocene Transitions. Amsterdam, etc.: Elsevier Inc. P. 331-406.

Nikitin A.A., Lobanov V.B., Danchenkov M.A. 2002. Possible routes of warm subtropical water transport to the area of Far Eastern Marine Reserve. Izvestiya (Bulletin of) TINRO-Centre. V. 131. 41-53.

Occhipinti-Ambrogi A., Savini D. 2003. Biological invasions as a component of global change in stressed marine ecosystems. Marine Pollution Bulletin. V. 46. P. 542-551.

Orlova T.Yu., Selina M.S., Shevchenko O.G. 2003. Morphology of cysts and vegatative cells of Gyrodinium instriatum, a new species of dynoflagellate for Russian seas. Biologiya Morya (Marine Biology, Vladivostok). V. 29, N 2. P. 138-140.

Orlova T.Yu., Stonik I.V., Shevchenko O.G. 2009. Flora of planktonic microalgae of Amursky Bay, Sea of Japan. Russian Journal of Marine Biology. V. 35, N 1. P. 60-78.

Otani M. 2004. Introduced marine organisms in Japanese coastal waters, and the processes involved in their entry. Japanese Journal of Benthology. V. 59. P. 45-57.

Ovsyannikova I.I. 2008. Barnacles in benthic communities of the inner part of Amursky Bay (Sea of Japan). In: K.A. Lutaenko and M.A. Vaschenko (Eds.). Ecological Studies and the State of the Ecosystem of Amursky Bay and the Estuarine Zone of the Razdolnaya River (Sea of Japan). Vladivostok: Dalnauka. P. 207-222.

Pogodin A.G., Yakovlev Yu.M. 1999. First record of hydroid medusae of the genus Aequorea in Russian waters of the Sea of Japan. Russian Journal of Marine Biology. V. 25, N 5. P. 417-420.

Rakov V.A., Arhipov A.A. 2004. Finding of the abalone Haliotis (Nordotis) discus (Gastropoda, Haliotidae). Bulletin of the Russian Far East Malacological Society. V. 8. P.

130-131.

Regional and National Reports on Marine and Coastal Biodiversity Data and Information in the Northwest Pacific Region. 2007. UNEP/NOWPAP/DINRAC Publication No. 6. Beijing: DINRAC. 158 p.

Report of the Training and Review Workshop on the Management of Marine and Coastal Invasive Species in the COBSEA Region Bangkok, Thailand, 31st August – 4th September 2009. UNEP(DEPI)/MIS 1 WS. Bangkok: UNEP. 28 p.

Rilov G. 2009. The integration of invasive species into marine ecosystems. In: G. Rilov and J.A. Crooks (Eds.). Biological Invasions in Marine Ecosystems. Ecological Studies 204. Berlin, etc.: Springer. P. 241-244.

Rostomov S.A. 1981. Isopod crustaceans (Crustacea, Isopoda) in fouling of port, cabotage and ocean-going ships of the Far Eastern sea basin. In: V.A. Kudryashov (Ed.). Organisms of Fouling of the Far Eastern Seas. Vladivostok: Far East Sci. Centre, USSR Acad. Sci. P. 73-78.

Selina M.S., Morozova T.V., Begun A.A. 2009. Morphology of the dinoflagellate Oxyphysis oxytoxoides Kofoid and Scrippsiella spinifera Honsell et Cabrini (Dinophyta), new for Russian marine waters. Botanical Journal. V. 94, N 4. P. 42-46.

Seo K.S., Lee Y. 2009. A first assessment of invasive marine species on Chinese and Korean coasts. In: G. Rilov and J.A. Crooks (Eds.). Biological Invasions in Marine Ecosystems. Ecological Studies 204. Berlin, etc.: Springer. P. 577-585.

Skurikhina L.P., Kartavtsev Yu.F., Chichvarkhin A.Yu., Pan'kova M.V. 2001. Study of two species of mussels, Mytilus trossulus and Mytilus galloprovincialis (Bivalvia, Mytilidae), and their hybrids in Peter the Great Bay of the Sea of Japan with the use of PCR markers. Russian Journal of Genetics. V. 37, N 12. P. 1448-1451.

Sokolovsky A.S., Dudarev V.A., Sokolovskaya T.G., Solomatov S.F. 2007. Sea Fishes of the Russian Waters of the Sea of Japan (Annotated and Illustrated Catalogue). Vladivostok: Dalnauka. 199 p.

Sokolovsky A.S., Sokolovskaya T.G. 2005. Climate, fishery, and fish diversity dynamics in the Peter the Great Bay and their centennial changes. Bulletin of the Far Eastern Branch, Russian Academy of Sciences. N 1. P. 43-50.

Sokolovsky A.S., Sokolovskaya T.G., Epur I.V., Azarova I.A. 2004. Centennial changes in composition and abundance of ichtyofauna of the northwestern Japan Sea. Izvestiya (Bulletin of) TINRO. V. 136. P. 41-57.

Sokolovsky A.S., Sokolovskaya T.G., Yakovlev Yu.M. 2009. Fishes of the Peter the Great Bay. Vladivostok: Dalnauka. 376 p.

Sousa R., Gutiérrez J.L., Aldridge D.C. 2009. Non-indigenous invasive bivalves as ecosystem engineers. Biological Invasions. V. 11, N 10. P. 2367-2385.

Stonik I.V., Orlova T.Yu. 1998. New data on morphology and distribution of Cerataulina dentata (Bacillariophyta). Botanical Journal. V. 83, N 4. P. 65-68.

Taira K., Lutaenko K.A. 1993. Holocene palaeoceanographic changes in the Sea of Japan. Reports of the Taisetsuzan Institute of Science, Hokkaido University of Education. N 28. P. 65-70.

Tchang S., Tsi C.-Y., Li K.-M. 1955. Mollusques marins utiles et nuisible du Nord de la Chine. Beijing: Science Press. 98 p.

Uzaki N., Kai M., Aoyama H., Suzuki T. 2003. Changes in mortality rate and glycogen content of the Manila clam Ruditapes philippinarun during the development of oxygene-deficient waters. Fisheries Science. V. 69. P. 936-943.

Williams S.L., Grosholz E.D. 2008. The invasive species challenge in estuarine and coastal environments: marrying management and science. Estuaries and Coasts. V. 31. P. 3-20.

Wilkins N.P., Fujino K., Gosling E.M. 1997. The Mediterranean mussel Mytilus galloprovinciallis Lmk. in Japan. Biological Journal of the Linnean Society. V. 20. P. 365-374.

Zevina G.B., Gorin A.N. 1971. Introduction of Balanus improvisus and B. eburneus into the Sea of Japan. Zoologichesky Zhurnal (Zoological Journal, Moscow). V. 50, N 5. P. 771-773.

Zevina G.B., Gorin A.N. 1975. Fluctuation of cirripede barnacles in the fouling of buoys in Peter the Great Bay. In: G.B. Zevina (Ed.). Fouling in the Sea of Japan and Sea of Okhotsk. Vladivostok: Far East Sci. Center, USSR Academy of Sciences. P. 71-78.

Zevina G.B., Kamenskaya O.E., Kubanin A.A. 1975. Species-invaders in the fouling of the Sea of Japan. In: Integrated Studies of the Nature of the Ocean. Vol. 5. Moscow: Moscow State University. P. 240-249.

Zvyagintsev A.Yu. 2000. Fouling of ocean-going shipping and its role in the spread of exotic species in the seas of the Far East. Sessile Organisms. V. 17, N 1. P. 31-43.

Zvyagintsev A.Yu. 2003. Introduction of species into the northwestern Sea of Japan and the problem of marine fouling. Russian Journal of Marine Biology. V. 29, Suppl. 1. P. S10-S21.

Zvyagintsev A.Yu. 2005. Marine Fouling in the North-West Part of Pacific Ocean. Vladivostok: Dalnauka. 431 p.

Zvyagintsev A.Yu. 2007. The role of bionvasions in the dynamics of anthropogenic and natural ecosystems and formation of biological resources in the Far-Eastern seas of Russia. In: V.G. Tarasov (Ed.). Dynamics of Marine Ecosystems and Modern Problems of Conservation of Biological Resources of the Russian Seas. Vladivostok: Dalnauka. P. 195-222.

Zvyagintsev A.Yu., Bagaveeva E.V. 1998. Naturalization of a sabellid polychaete Pseudopotamilla occelata in Peter the Great Bay, Sea of Japan. Biologiya Morya (Marine Biology, Vladivostok). V. 24, N 3. P. 189-191.

Zvyagintsev A.Yu., Budnikova L.L. 2003. Amphipods (Amphipoda, Crustacea) in the fouling of water cooling system of Heat and Power Station No. 2 in Vladivostok. Izvestiya (Bulletin of) TINRO-Center. V. 132. P. 280-298.

Zvyagintsev A.Yu., Guk Yu.G. 2006. Estimation of ecological risks arising from bionvasion in marine coastal ecosystems of Primorye Region (with sea fouling and ballast waters as an example). Izvestiya (Bulletin of) TINRO. V. 145. P. 3-38.

Zvyagintsev A.Yu., Ivin V.V., Kashin I.A. 2009. The Methodical Advisories to Research of Ship Ballast Waters during Realization of Marine Bioinvasions Monitoring. Vladivostok:

Dalnauka. 123 p.

Zvyagintsev A.Yu., Kornienko E.S. 2008. Discovery of larvae of the hermit crab Diogenes nitidimanus Terao, 1913 (Decapoda: Diogenidae) in ship ballast waters: evidence in support of its introduction into Peter the Great Bay. Russian Journal of Marine Biology. V. 34, N 6. P. 403-406.

Zvyagintsev A.Yu., Sanamyan K.E., Kashenko S.D. 2007. On the introduction of the ascidian Ciona savignyi Herdman, 1882 into Peter the Great Bay, Sea of Japan. Russian Journal of Marine Biology. V. 33, N 2. P. 133-136.

Zvyagintsev A.Yu., Selifonova J.P. 2008. Study of the ballast waters of commercial ships in the sea ports of Russia. Russian Journal of Biological Invasions. N 2. P. 20-29.