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Regional report on pilot assessments of impacts of major threats on marine biodiversity in the NOWPAP region

CEARAC Report 2017

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Table of Contents

Preface

The tenth meeting of the Conference of the Parties to the Convention on Biological Diversity (CBD COP10), held in October 2010 in Nagoya, Japan, adopted a revised and updated Strategic Plan for Biodiversity, including the Aichi Biodiversity Targets, for the 2011-2020 period.

The Conference of the Parties decided that the fifth national reports should focus on the implementation of the 2011-2020 Strategic Plan and progress achieved towards the Aichi Biodiversity Targets. Based on the submitted fifth national reports from countries, the Global Biodiversity Outlook 4 (GBO4), which shows a mid-term assessment of progress towards the implementation of the Strategic Plan for Biodiversity 2011-2020, was published in 2014. In most cases, progress will not be sufficient to achieve the target set for 2020, and additional action is required to keep the Strategic Plan for Biodiversity 2011-2020 on course.

NOWPAP CEARAC started activities on marine biodiversity in 2012 in order to contribute to the conservation of marine biodiversity in the NOWPAP region. In 2013, CEARAC published “Monitoring and management of Marine Protected Areas in the NOWPAP region” to provide information on the current status of Marine Protected Areas (MPAs) in the NOWPAP region. This report introduces the definition of MPAs in each member state, and their monitoring and management status as well. Such information is a useful input for achieving the Aichi Biodiversity Target 11 in each member state, namely to design 10 percent of coastal and marine areas as MPAs.

In Aichi Biodiversity Target, Strategic Goal B aims to reduce the direct pressures on biodiversity and promote sustainable use. In the NOWPAP region, there are several pressures/threats on marine biodiversity. CEARAC selected three pressures/threats, eutrophication, non-indigenous species and habitat alteration, which are significant in the NOWPAP region and proposed to implement pilot assessments in order to understand the current status of them.

This regional report introduces the results of the pilot assessments. This report is the first step toward developing a new assessment methodology of the impact of pressures/threats to marine biodiversity in the NOWPAP region. Based on the available data in the pilot assessments, assessment indicators and methodology will be considered as a next step.

Finally, CEARAC would like to thank the national experts who implemented pilot assessments in each member state, and CEARAC Focal Points and NOWPAP National Focal Points for their contribution to this publication.

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Executive Summary

The Strategic Plan 2011-2020, including Aichi Biodiversity Targets were adopted at the tenth meeting of the Conference of the Parties to the Convention on Biological Diversity held in 2010. The mission of the new plan is to take effective and urgent actions to halt the loss of biodiversity by 2020 and the new plan consists of five strategic goals, including twenty Aichi Biodiversity Targets. To achieve these goals and targets, it is required to reduce pressures on biodiversity, restore ecosystems, sustainably use biological resources and more.

The NOWPAP region is one of the most biological diverse marine areas in the world. However, the area faces various threats due to rapid economic growth and concentration of population in the coastal area. In order to assess the impact of pressures/threats on marine biodiversity in the NOWPAP region, "Pilot assessment on the impacts of major threats to marine biodiversity in the NOWPAP region" was started in 2014 as the first step for assessment of the impacts. The objectives of this pilot assessment are to clarify available data on major threats in the NOWPAP region and understand the situation of the threats using available data. Each NOWPAP member state selected one or two target sea areas for the pilot assessment, and nominated experts collected available data and assessed the situation of the threats.

In China, a pilot assessment was undertaken in the coastal area of Changdao County, Yantai and the coastal area of Changhai County, Dalian. Both areas are significant sea areas for marine species and fishery is conducted very actively. Available data on eutrophication, non-indigenous species and habitat alteration shows that current situations are within the national standards and are not recognized as "potential risks" to marine biodiversity. However, due to active operation of aquaculture of non-indigenous species in recent years, there are potential threats on diffusion of non-indigenous species and its impacts to indigenous species in the assessed areas.

In Japan, two target sea areas were selected and many kinds of data on eutrophication, non-indigenous species and habitat alteration are available in both areas. Eutrophication is a threat in several sea areas in Japan. Nutrient condition is improved in the coastal areas compared with past years. However, nutrient concentration is still high and red tides occur frequently in several specific bays. Integrated management which covers management in land area needs to be enhanced. Non-indigenous species are found in north Kyushu sea area and coastal area of Hokuriku region. Serious impacts to local indigenous species are reported and continuing monitoring is necessary. In Japan, landfill is not active compared with the past. However, habitat loss is happening by coastal protection and dredging and collection of sea gravel.

In Korea, the pilot assessment focused on dike construction in Saemanguem. After the dike enclosure, marine environment inside of the dike changed. The environmental change caused the change of phytoplankton species and benthic species. This is obviously an impact to marine biodiversity, and collected data is useful information to understand the impact of habitat alteration on marine biodiversity. Unfortunately, data on non-indigenous species and other habitat alteration was not available in this pilot assessment, therefore it is expected to collect other relevant information in the future.

In Russia, the pilot assessment was undertaken in Peter the Great Bay. In the bay, several indicators on eutrophication have an increase trend in recent years. It is because of waste water output and storm water. Regarding non-indigenous species, not only artificial introduction but also influence of climate change is problematic. Through aquaculture and ship transportation, non-indigenous species appeared, and increase of the water temperature caused expansion of warm water species in Peter the Great Bay. Physical alteration is not a serious problem, but expansion of aquaculture activities caused biological alteration in Russia.

Through these pilot assessments, available data on major threats, namely eutrophication, non-indigenous species and habitat alteration in each member state was collected. However, available indicators common in the four member states are quite limited. Some lacking information can be available from and/or complemented by the outputs of other NOWPAP activities; however, it is expected to start monitoring of major indicators in each member state to accumulate more data.

Based on the results of these pilot assessments, potential assessment indicators and assessment methodologies will be discussed as the next step. CEARAC hopes our marine biodiversity activities contribute to conservation of marine biodiversity in the member states and NOWPAP region.

1. Introduction

Biodiversity and biogenic habitats in the world are being lost at a very fast pace. Thus, in 2002, countries adopted the 2010 Biodiversity Target to significantly reduce the rate of biodiversity loss by 2010. However, the target was missed due to increase in all major pressures/threats on biodiversity, namely i) loss, degradation, and fragmentation of natural habitats, ii) overexploitation of biological resources, iii) pollution, in particular the buildup of nutrients such as nitrogen and phosphorus in the environment, iv) negative impacts of invasive alien species on ecosystems and on the services those ecosystems provide to people, and v) climate change and acidification of the oceans, associated with the buildup of greenhouse gases in the atmosphere (CBD, 2010). Therefore, as a post-2010 Biodiversity Target, Strategic Plan 2011-2020 including "Aichi Biodiversity Targets" was adopted at the 10th Meeting of the Conference of the Parties to the Convention on Biological Diversity (CBD COP10) held in Nagoya, Japan. "Aichi Biodiversity Targets" have five strategic goals and 20 associated targets. One of the strategic goals, Strategic Goal B, aims to "reduce the direct pressures on biodiversity and promote sustainable use:

- The loss of all habitats is at least halved and where feasible brought close to zero (Target 5),
- All fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally, and by applying ecosystem-based approaches (Target 6)
- Area under aquaculture are managed sustainably, ensuring conservation of biodiversity (Target 7)
- Pollution from excess nutrients has been brought to levels that are not detrimental to ecosystem function and biodiversity (Target 8)
- Invasive alien species identified and prioritized (Target 9)
- Multiple anthropogenic pressures on other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning (Target 10)

Responding to the adoption of the Aichi Biodiversity Targets, some efforts have been made and are under way at regional and global levels. The United Nations conducted the World Ocean Assessment and published the report "The First Global Integrated Marine Assessment" in 2016 as the first cycle of the Regular Process for Global Reporting and Assessment of the State of the Marine Environment. This report provides an important scientific basis for the consideration of ocean issues by governments, intergovernmental processes, and all policy makers and others involved in ocean affairs.

The Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) plans to implement subregional, regional and global assessments of biodiversity and ecosystem services to strengthen the science-policy interface. The aim of assessments is to assess the status and trends of biodiversity and ecosystem services, the impacts of biodiversity and ecosystem services on human well-being, and the effectiveness of responses, including the Strategic Plan and its Aichi Biodiversity Targets and the national biodiversity strategies and action plans.

The Northwest Pacific (NOWPAP) region is one of the regions with rich biodiversity in the world. At the same time, it is one of the most populated and economically growing regions in the world. Anthropogenic impacts to marine biodiversity, such as discharge of chemical substances from land, coastal development and fishery activities, are serious issues in this region. The "Threats to Marine and Coastal Biodiversity in the NOWPAP Region" (NOWPAP, 2010) reports the current situation of fish catches, nutrient loading, shipping and sea surface temperature, and shows that these pressures/threats adversely influence marine biodiversity in the region. In order to achieve the Strategic Goal B of the Aichi Biodiversity Targets, it is necessary to understand the status and the causes of these pressures/threats and to reduce their impacts on the environment.

NOWPAP has experiences in understanding and assessment of impacts of pressures/threats. NOWPAP Special Monitoring and Coastal Environment Assessment Regional Activity Centre (CEARAC), one of the regional activity centres of NOWPAP, has developed a common procedure for the assessment of eutrophication status (NOWPAP CEARAC, 2009). This common procedure requires the collection of various kinds of data related to eutrophication, which indicates the degree of nutrient enrichment, direct effects of nutrient enrichment, indirect effects of nutrient enrichment and other possible effects. Sea areas in the NOWPAP region were assessed using this common procedure.

NOWPAP Data and Information Network Regional Activity Centre (DINRAC) has collected information on non-indigenous species in the NOWPAP region and published "Atlas of Marine Invasive Species" in 2013 (NOWPAP DINRAC, 2013). This report shows that there are 79 marine non-indigenous species with their distribution and vectors of introduction.

NOWPAP Pollution Monitoring Regional Activity Centre (POMRAC) published "Second State of Marine Environment Report" in 2014 (NOWPAP POMRAC, 2014). This report includes a holistic description, analysis and overview of the marine environment in the NOWPAP region. The status of several pressures/threats was also reported.

Such past NOWPAP activities can provide useful information on pressures/threats to marine biodiversity in our region, and it is important to assess the status of the marine environment regularly and improve the situation based on the assessment results. Thus, CEARAC proposed to develop a new assessment methodology to understand the status of impacts on major pressures/threats to marine biodiversity. However, in the NOWPAP member states, available data is limited and the monitoring framework is different by country. Therefore, as the first step for developing a new assessment methodology, pilot assessments focusing on three pressures/threats were implemented in the 2014-2015 biennium.

2. Pilot assessment on the impacts of major threats to marine biodiversity

The objectives of this pilot assessment are to clarify available data on major threats (eutrophication, non-indigenous species, and habitat alteration) to marine biodiversity in each NOWPAP member state and to understand the current situation of the marine environment using available data. Nominated experts collected available data and developed the data inventory, and implemented trial assessments of the current status of pressures/threats of the selected sea areas. This pilot assessment is the first step for developing a new assessment methodology to understand the impacts of major pressures/threats to marine biodiversity in the NOWPAP region. Through the pilot assessment, potential assessment indicators and applicable assessment methods will be considered. CEARAC expects this pilot assessment will contribute not only to the development of a new assessment methodology but also to current and future global and regional assessments which are implemented by other international organizations.

2.1 Potential threats to marine biodiversity

In recent years, many reports on marine biodiversity were published. In these reports, various kinds of pressures/threats on marine biodiversity were mentioned.

Global Biodiversity Outlook 3 lists five principal pressures on biodiversity. They are: 1) Habitat loss and degradation, 2) Climate change, 3) Excessive nutrient load and other forms of pollution, 4) Over-exploitation and unsustainable use, and 5) Invasive alien species. Habitat loss and degradation create the biggest single source of pressure on biodiversity worldwide. For terrestrial ecosystems, habitat loss is largely accounted for by conversion of wild lands to agricultural lands, which now accounts for some 30 percent of land globally. In some areas, the demand for biofuels increases the conversion of land. Climate change is already giving impacts on biodiversity and is projected to become a more significant threat in the coming decades. The related pressure/threat of ocean acidification, resulting from higher concentrations of carbon dioxide in the atmosphere, is also already being observed. Pollution from nutrients (nitrogen and phosphorous) and other sources are a continuing and growing threat to biodiversity in terrestrial, inland water and coastal ecosystems. Overexploitation and destructive harvesting practices are at the heart of pressures/threats being imposed on the world’s biodiversity and ecosystems, and there has not been a significant reduction in this pressure/threat. Changes to fisheries management in some areas are leading to more sustainable practices, but most stocks still require reduced pressure/threat for recovery. The State of World Fisheries and Aquaculture (2014) reported that 28.8 percent of fish stocks were estimated as at a biologically unsustainable level and 61.3 percent of fish stocks were fully fished stocks. Invasive alien species continue to be a major threat to all types of ecosystems and species. There are no signs of significant reduction of this pressure/threat on biodiversity to the countries, there are some indicators of increase. Intervention to control alien invasive species has been successful in particular cases, but it is outweighed by the pressure/threat to biodiversity from new invasion (Secretariat of the Convention on Biological Diversity (2010)).

In 2010, the UNEP Regional Sea Programme prepared “The Marine Biodiversity Assessment and Outlook Reports” in order to provide the first systematic overview at a sub-global scale of the state of knowledge of marine biodiversity, the pressures it currently faces and the management frameworks in place for addressing those pressures (UNEP Regional Sea Programme, 2010). In this report, four indicators, nutrient loading, port activity, climate change and fish landings, are selected as pressures/threats.

The First Global Integrated Marine Assessment, World Ocean Assessment I, was published in 2016 (UN, 2016). This assessment is a comprehensive assessment on marine environment, marine ecosystem services, marine biodiversity and human activities and so on. In this report, human impacts on the oceans are mentioned. The selected pressures and impacts of human activities are as follows;

(a) Climate change (and ocean acidification, including the resulting changes in salinity, sea level, ocean heat content and sea-ice coverage, reduction in oxygen content, changes in ultra-violet radiation);
(b) Human-induced mortality and physical disturbance of marine biota (such as capture fisheries, including by-catch), other forms of harvesting, accidental deaths such as through collisions and entanglement in discarded nets, disturbance of critical habitat, including breeding and nursery areas;
(c) Inputs to the ocean (these can be broken down according to the nature of their effects: toxic substance and endocrine disruptors, waterborne pathogens, radioactive substances, plastics, explosives, excessive nutrient loads, hydrocarbons);
(d) Demand for ocean space and alteration, or increase in use, of coasts and seabed (conflicting demands lead to both changes in human use of the ocean and changes to marine habitats);
(e) Underwater noise (from shipping, sonar and seismic surveys);
(f) Interference with migration from structures in the sea or other changes in routes along coasts or between parts of the sea and/or inland waters (for example, wind farms, causeways, barrages, major canals, coast reinforcement, etc.) and
(g) Introduction of non-native species

The NOWPAP region is one of the economically developing areas in the world. This economic development leads to the increase of population, industrial activities and coastal development. Due to the increase of population and industrial activities, nutrient input from sewages, factory wastage, and agriculture are becoming larger, and eutrophication caused by the excess input of nutrient is a serious problem in some sea areas. Since marine transportation is one of the vectors of movement of non-indigenous species through discharge of ballast water and ship hulls, an increase of such transportation by economic growth is causing another problem. Then, there are extensive aquaculture operations due to the increase in fish consumption. Several kinds of non-indigenous commercial fish and shellfish are cultured, and their introduction and distribution both in fish farms and the wild are becoming a serious concern. Another concern is coastal development such as land fill as well as coastal protection or bank protection which all decrease biological habitats in coastal areas. In some areas, seagrass/seaweed beds, tidal flats, and salt marshes, which are essential habitats for some marine organisms, have disappeared. Thus loss of habitats by alteration is also a serious pressure/threat in those regions.

By now, CEARAC has implemented eutrophication status assessments, and the member states have own monitoring surveys on direct and indirect indicators on eutrophication. In the 2014-2015 biennium, CEARAC started a new activity on seagrass mapping using remote sensing techniques, and information on seagrass beds in each country became available. NOWPAP DINRAC, one of the four Regional Activity Centres of NOWPAP, published “Atlas of Marine Invasive Species in the NOWPAP Region” in 2013. This atlas shows the existence and distribution of marine invasive species in the NOWPAP region. NOWPAP POMRAC published “State of the Marine Environment Report for the NOWPAP region (SOMER2)” in 2014, and the state of habitat transformation due to construction and urbanization in the NOWPAP region is introduced in the report. Such past outputs are useful knowledge/information to assess the pressures/threats on marine biodiversity. Based on such backgrounds, CEARAC has decided to assess the status of eutrophication, non-indigenous species and habitat alteration as target threats for the pilot assessment.

2.2 Implementation of pilot assessment

The final goal of the pilot assessment is to develop a new assessment methodology to understand the status of pressures/threats to marine biodiversity. However, it is not well known what kind of data is available and what indicators are appropriate for a new assessment methodology in the NOWPAP region. Therefore, as the first step, pilot assessments were planned to be implemented in order to clarify available indicators/data on three threats to marine biodiversity: eutrophication, non-indigenous species and habitat alteration in each NOWPAP member state. These assessments were done to understand the current situation of pressures/threats and to evaluate the status of them by using the available data.

To implement the pilot assessments, at first, the member states selected a target sea area and nominated an expert to implement the pilot assessment as follows.

Table 1 Sea areas for pilot assessments and experts who implement pilot assessment

	Selected sea areas	**Nominated experts**
China	Coastal area of Yantai and Dalian	Dr. Bei Huang
Japan	North Kyushu sea area and coastal area of Hokuriku region	Northwest Pacific Region Environmental Cooperation Center
Korea	Saemanguem	Dr. Young Nam Kim
Russia	The Peter the Great Bay	Dr. Tatiana Orlova

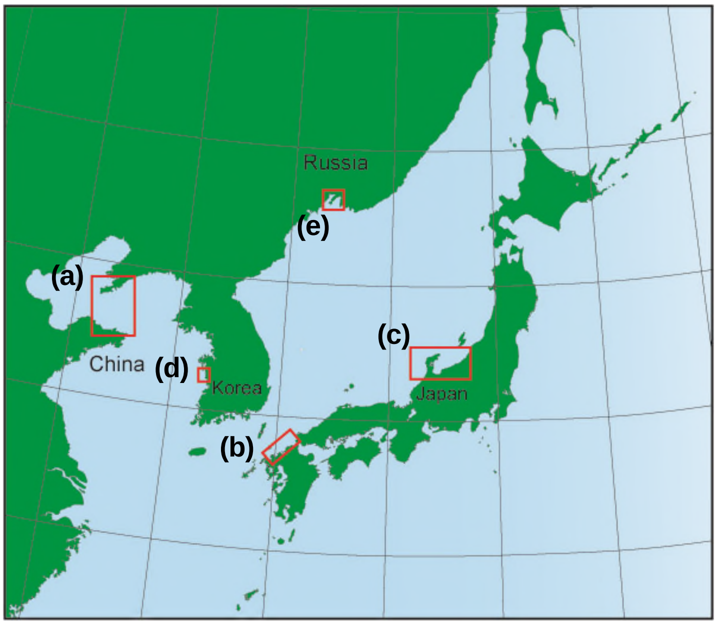


Figure 1 Location of selected sea areas (a: Coastal area of Yantai and Dalian, b: North Kyushu sea area, c: Coastal area of Hokuriku region, d: Seamanguem, e: Peter the Great Bay)

2.3 Target sea areas and their characteristics

(a) Coastal area of Yantai and Dalian in China

Map of coastal area of Yantai (A) and Dalian (B)

The coastal area of Changdao County, Yantai (Site A shown on the map) is located in the northeastern area of Shandong Province between the Shandong Peninsula and Liaodong Peninsula, at the border of the Yellow Sea and the Bohai Sea. The population of Changdao County is about 43,000, and there are two towns and eight villages. Changdao County is a natural marine garden where islands, land and sea water gather to develop a special natural and cultural scenic site. It has been listed as one of the National Parks of China. This area is also important as a migration area of marine species. 284 marine species, including 164 animals, 120 plants and 30 economically valuable fish and shrimp species are found in this area. Fisheries, marine aquaculture and the marine product processing industry are main industries. Scallop, sea cucumber, abalone, shrimp, blue mackerel, ribbonfish, small yellow croaker, flounder and flatfish are harvested and fished.

The coastal area of Changhai County, Dalian (Site B in the map) is located in the Northern Yellow Sea. The population of Changhai County is 73,000, and there are three towns and four villages. Changhai County consists of 112 islands and reefs, and the islands are characterized by high and precipitous mountains, irregular and twisting shoreline, and deep and meandrous valleys. There are a handful of strange reefs, beautiful bays, and natural bathing beaches with appealing landscape and scenery. For such characteristic land/seascape, Changhai County has been established as a National Forest Park and Liaoning Provincial Scenic and Historic Interest Area. This area is also a famous fishing ground in China, and shrimp, sea cucumber, abalone, scallop, ark clam, ark shell, oyster, sea urchin, globefish, flounder, shark, rock greenling, eel and *nori* (sea weed) are cultured.

(b) North Kyushu Sea Area in Japan

Map of north Kyushu sea area

The north Kyushu sea area is located in the southwestern part of Japan. Fukuoka Prefecture, Saga Prefecture and part of Nagasaki Prefecture are located in the area. Facing to the Tsushima Strait with the water depth of about 200m, this is a continental shelf area. In the offshore area of this region, the Tsushima Warm Current flows west to east. Due to the warm current, many kinds of southern species are observed in this area. This area is also the northern limit of coral reefs of the southwestern part of Japan. In Iki Island and Tsushima Island, several coral reefs are observed. This area is designated as Iki-Tsushima Quasi National Park and Genkai Quasi National Park, and both of them are Marine Protected Areas in Japan.

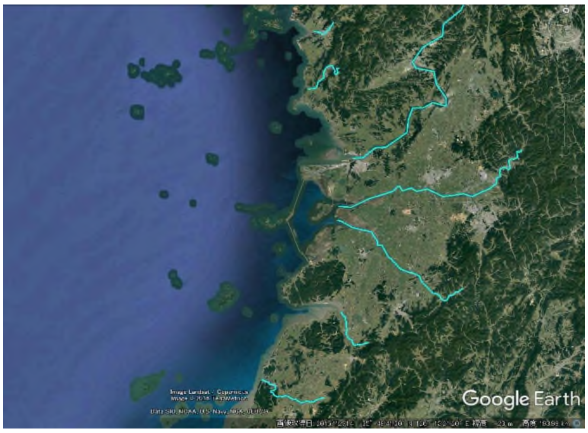
In the coastal area of this region there are big cities, such as Hakata and Kitakyushu, and the population in the basin reaches six million people. This area is one of the major economic regions in the northern coast of Japan. This area is also one of the industrial areas in Japan, and many factories are located there. Through big ports such as Hakata Port and Kanmon Port, many foreign ships enter this area for import and export. At the same time, this area is also important for fishery resources. The offshore area of this region is a major spawning ground of many fish species such as sardine and jack mackerel; therefore it is a rich fishery ground.

(c) Coastal area of Hokuriku region in Japan

Map of coastal area of Hokuriku region

The Hokuriku region is located in the middle of Japan and covers three prefectures: Niigata, Toyama, and Ishikawa. In this region, the Sado-Yahiko-Yoneyama Quasi National Park, the Noto Peninsula Quasi National Park, and the Echizen-Kaga Quasi National Park are located. Same as in the North Kyushu sea area, these Quasi National Parks are marine protected areas in Japan. Around Noto Peninsula, a huge area of seaweed/seagrass beds is formed, and the covered area is one of the biggest distributions in Japan. The density of the population and industries are smaller compared to the North Kyushu sea area; however, agricultural production such as rice is very active. In addition, in this area there are big rivers, and they supply rich nutrients from land. Such rich nutrient supply influence to primary production in the coastal area. Toyama Bay, which is located in the central part of the Hokuriku region, is very unique with the depth of 1,200m. There are many kinds of warm, cold and deep water species in the bay.

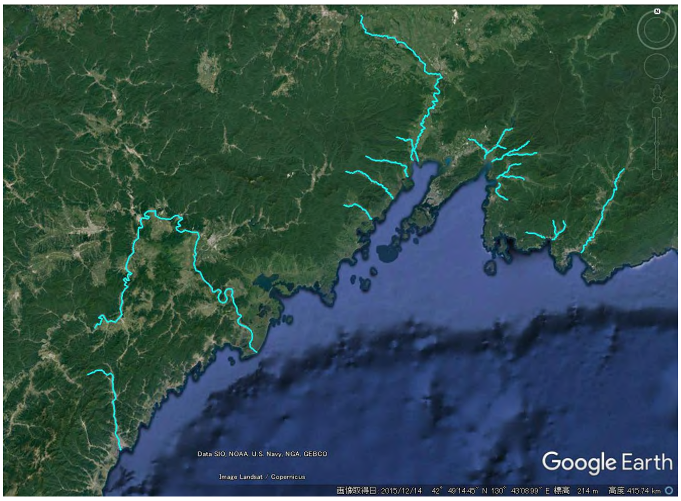
(d) Seamanguem in Korea



Map of Saemanguem

Saemanguem is a vast tidal flat area facing toward the Yellow Sea, and it is a famous habitat for migratory birds in East Asia. The government of Korea launched the Saemanguem Reclamation Project as a national project in 1991 to reclaim a large coastal area to obtain agricultural and industrial lands. The length of the dike is 34 km, and it has transformed the tidal flat into a lake and a land area of 401 km^2. The completion of this dike could be a major contributor to the decline of many species. Around 400,000 shorebirds including the two endangered waders, the Nordmann's greenshank and the spoon-billed sandpiper, were depended on the Saemanguem estuary as an important feeding ground in their 24,000-km migration between Asia and Alaska, Russia,. The number of surviving birds in each species is less than a thousand. An integrated coastal oceanographic study has been conducted since 2002 as a part of the Government Action Plan to monitor and assess changes in the marine environment. After the construction of the dike enclosure, the water quality within the dike did not improve as much as the developers expected, mainly due to the critical reduction of the hydrodynamic stirring power. Therefore, the original objectives of the Saemanguem Project were considered to be not fully satisfactory, and the project experienced various revisions from the original utilization plan to create an artificial lake.

(e) Peter the Great Bay in Russia



Map of Peter the Great Bay

Peter the Great Bay is located in the northwestern part of the NOWPAP region. It is a pretty big bay with the area more than 6,000 km^2 consisting of an open part and several smaller bays. Peter the Great Bay is characterized by high biodiversity due to a mix of northern and subtropical fauna. Common benthic fauna in this area includes various types of oysters and scallops. The area contains a vast distribution of *Laminaria* kelp, eelgrass, *Ahnfeltia*, and *Gracilaria*. Commercial fish stocks include Alaska pollock, groupers, and sardines. Commercial stocks of benthic invertebrates, such as Kamchatka craboid, snow crab, *Spisula* and *Mactra* are also represented, as are grey and black sea urchins and Red Listed gastropods. The marine area and islands are inhabited by more than 350 species of birds, 200 of which have links to the sea. The area is one of the main stop-over areas on the East Asian-Australasian flyway.

On the other hand, Peter the Great Bay watershed area is the most populated and developed part of the Primorsky Kray, and the Russian Far East as a whole. Therefore, anthropogenic impacts by agriculture and industry on the marine area are bigger than in other areas of the Russian Far East.

In this target area, the Far Eastern State Marine Nature Biospheric Reserve was established in 1978, and the State Marine Partial Reserve "Vostok Bay" was established in 1989.

2.4 Eutrophication

The available data on eutrophication in each member state is shown in Table 2 (direct indicators on eutrophication) and Table 3 (indirect indicators on eutrophication). The common available data among the four NOWPAP member states are dissolved inorganic nitrogen and dissolved inorganic phosphorus, and other indicators are available in some but not all member states. For indirect indicators, water quality is a common available data. However, the focus for water quality is different by country. China uses suspended substance (SS), dissolved oxygen (DO) and chemical oxygen demand (COD) as water quality indicators, while Japan uses transparency and DO. Korea uses SS and COD, and Russia uses biological oxygen demand (BOD).

Table 2 Data Inventory of available data on direct indicators of eutrophication

	China	**Japan**	**Korea**	**Russia**
Total nitrogen **Total phosphorus**	N	A	A	A
		sea surface Annual average (4-12 times/year)	2002-2009 3-4 times/year	2-8 times/year
Dissolved inorganic nitrogen **Dissolved inorganic phosphorus**	A	A	A	A
	*Once/year	sea surface 4-12 times/year	2002-2009 3-4 times/year	
River input of nutrient	N	A	N	A
		2-4 times/year		2-8 times/year COD, BOD, NH4+, NO3-, PO4
Chlorophyll a	N	A	A	N
		Only in Toyama Bay, Hakata Bay, Dokai Bay, Suo-Nada Sea, Karatsu Bay and Genkai Sea 2-4 times/year	2002-2009 3-4 times/year Monthly (April – October) 2 sites of inside of dike and 10 sites of outside of dike	
Total Volume of Industrial Waste Water Discharge	A	A	N	A
	Only coastal area of Dalian			

Table 3 Data Inventory of available data on indirect indicators of eutrophication

	China	Japan	Korea	Russia
Use of fertilizer	A	A	N	A
	Annual usage	Annual usage		Annual usage
Feeding of aquaculture	N	A	N	N
		Annual value		
Population	A	A	N	A
				2-8 times/year
Land use	N	A	N	A
		Only 1976, 1987, 1997, 1997 and 2006		
Water quality	A	A	A	A
	SS, DO, COD and oil	Transparency, DO	SS, COD, DO and hypoxia 2002-2009 3-4 times/year	
Bottom environment	N	A	A	N
		DO	Cu, Zn and Cd 2002-2009 3-4 times/year	
Red tide occurrence	N	A	A	N
		Hakata Bay, Karatsu Bay and Kariya Bay	2002-2009 3-4 times/year Monthly (April – October) 2 sites of inside of dike and 10 sites of outside of dike	

China

Dissolved inorganic nitrogen (DIN, which includes nitrate (NO_3^-), nitrite (NO_2^-) and ammonium (NH_4^+)) and active phosphate (AP) are available direct indicators for eutrophication assessment, and annual changes of concentration of DIN and AP are shown in Figure 2 and Figure 3 respectively. In the collected data, annual changes of DIN concentration in Changdao County and Changhai County continued rising from 2003 to 2013. DIN concentrations were lower than the Chinese national reference value in ‘National Sea Water Quality Standard of China’ (0.2 mg/L in Class I level and 0.5 mg/L in Class IV level). AP kept rising from 2003 to 2013 in Changhai County and no trend in Changdao County. The national reference values of AP were 0.015 mg/L in Class I and 0.045 mg/L in Class IV. Most of the observed AP concentration is lower than the national reference value; however, in the last two years, AP in Changhai is higher.

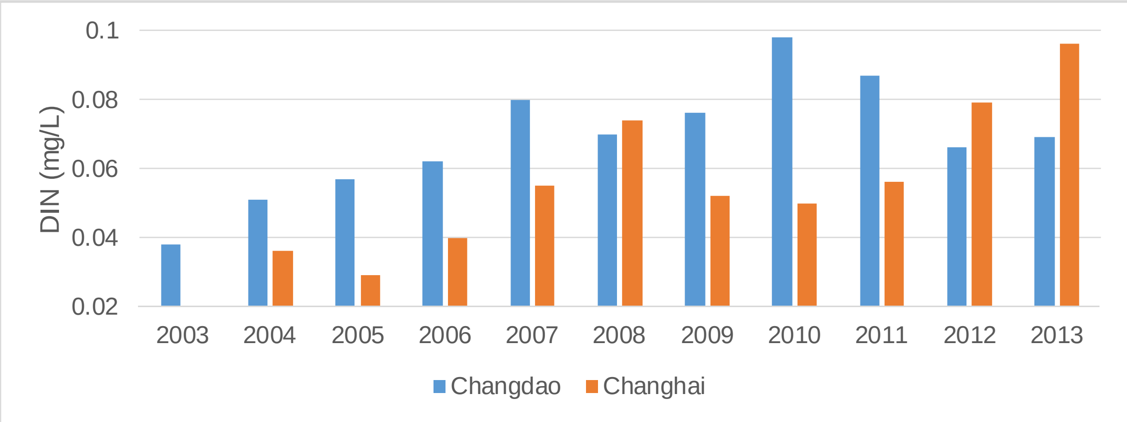


Figure 2. DIN in Changdao County and Changhai County

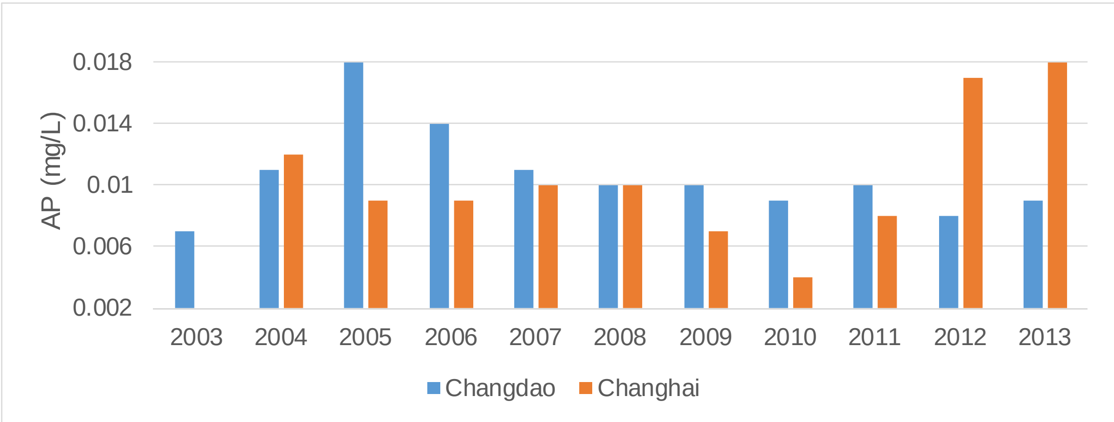


Figure 3. AP in Changdao County and Changhai County

Data on chemical oxygen demand (COD) was used as indirect indicators. COD (Figure 6) are available in both Changdao County and Changhai County. The national reference standards of COD is Class I < 2 mg/L. Water qualities in Changdao County and Changhai County reached the national standard references.

In addition to the direct and indirect indicators for eutrophication, indicators for water quality are useful parameters to understand the status of water pollution. In China, suspended solods (SS) (Figure 4) and dissolved oxygen (DO) (Figure 5) are available in both Changdao County and Changhai County. The national reference standards of SS and DO are; SS: Class I < 10 mg/L and Class IV > 150 mg/L, DO: Class I > 6 mg/L and Class IV < 3 mg/L. Most of the water qualities in Changdao County and Changhai County reached the national standard references; however, SS in Changhai County had an increasing trend and it was over the national reference standard in 2013.

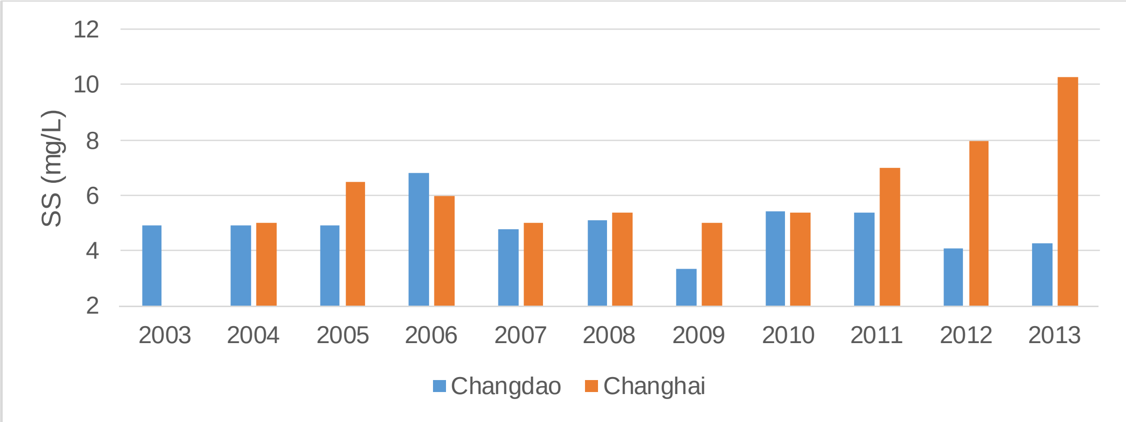


Figure 4. SS in Changdao County and Changhai County

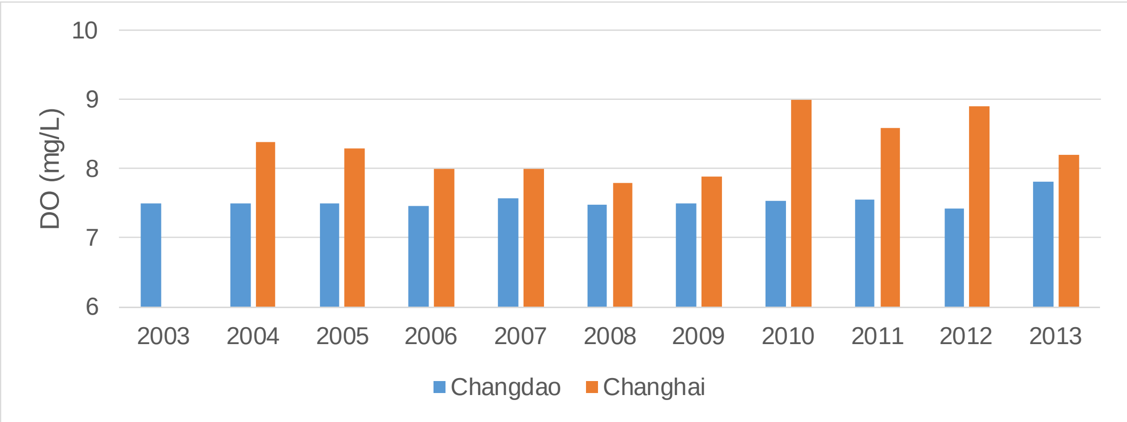


Figure 5. DO in Changdao County and Changhai County

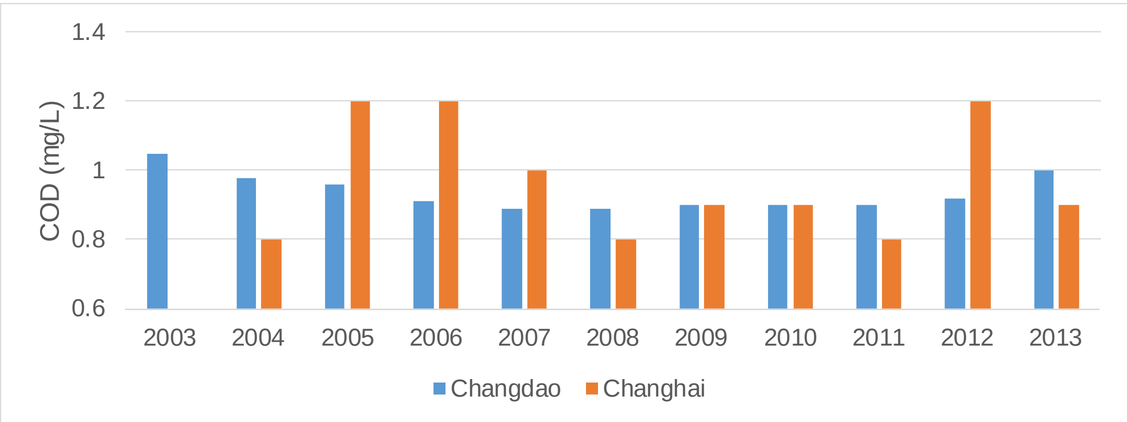


Figure 6. COD in Changdao County and Changhai County

Japan

In Japan, data on total nitrogen (TN) and phosphorus (TP), dissolved inorganic nitrogen (DIN), riverine input of TN and TP and chlorophyll-*a* are used as direct indicators. Fertilizer utilization, land area usage, aquaculture (feeding) and population density are available as indirect indicators.

Environmental standards of TN and TP are 0.3 mg/L and 0.03 mg/L respectively. In some monitoring sites of the north Kyushu sea area and Hokuriku region, concentrations of TN and TP are higher than their environmental standards (Figure 7). In sea areas, no environmental standard on dissolved nitrogen is set; however, there was an increasing trend in some sites in the north Kyushu sea area and the Hokuriku region in recent years (Figure 8).

The sites with a high concentration of these indicators are sea areas which are faced with strong anthropogenic impacts. In Niigata, one of the biggest rivers in Japan, the Shinano River flows into the ocean, and its annual river discharge is $17{,}322 \times 10^6$ m^3, which is much bigger than other rivers. Therefore, huge volumes of TN and TP are discharged into the ocean (Figure 9 and 10). The site where the concentration of TN has over 1.0 mg/L is located in the estuary area of the Shinano River.

High concentrations of TN and TP in Ishikawa were monitored during the last two decades at Kanazawa Port. Kanazawa Port is located next to Kanazawa City, prefectural capital of Ishikawa. Not only activities in port but also household wastewater influence the volumes of TN and TP.

In Saga Prefecture, high TN and TP were monitored in Imari Bay. Imari Bay is an enclosed bay and home to active aquaculture operations. Red tides occur frequently, and eutrophication is a concern in this bay.

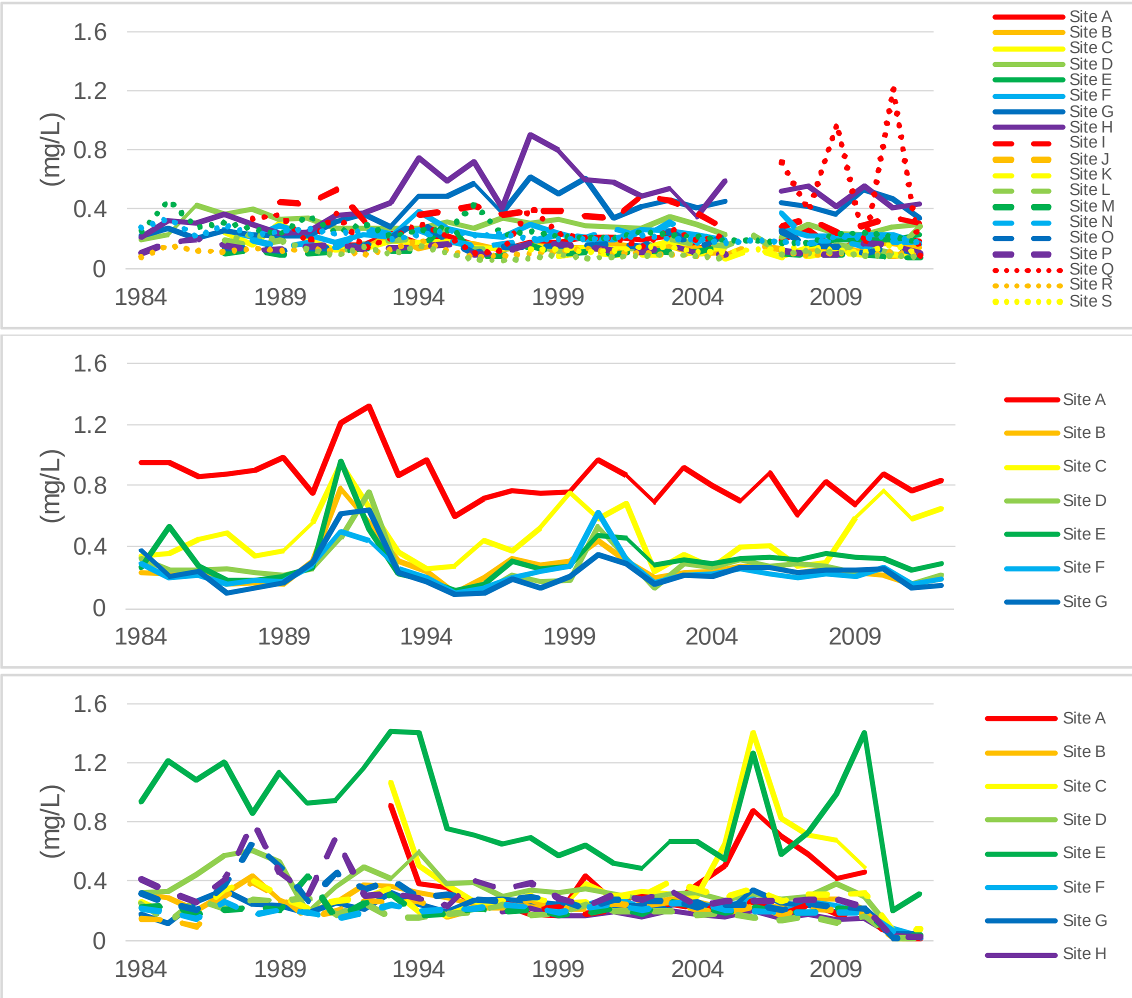


Figure 7. Total nitrogen in Niigata (upper), Ishikawa (middle) and Saga (bottom).

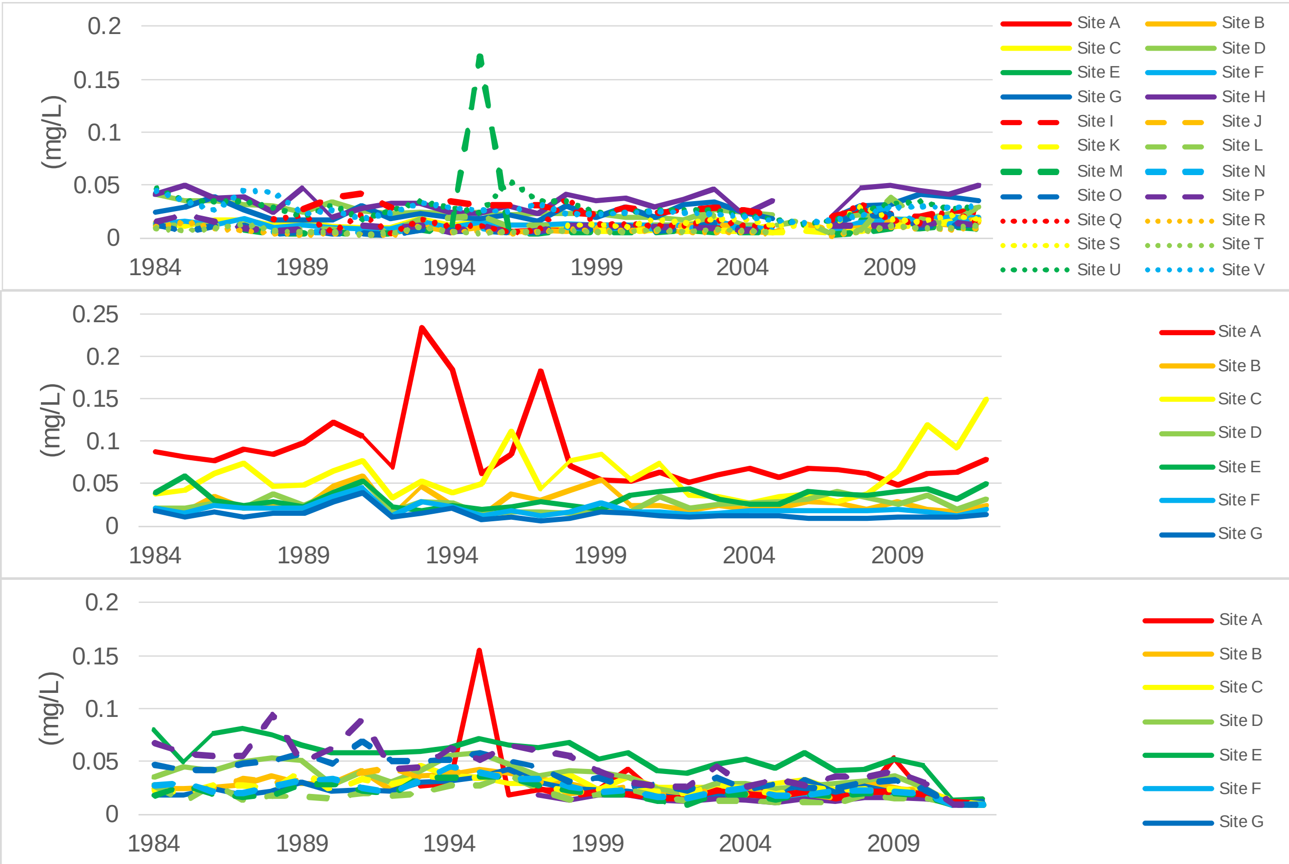


Figure 8. Total phosphorus in Niigata (upper), Ishikawa (middle) and Saga (bottom)

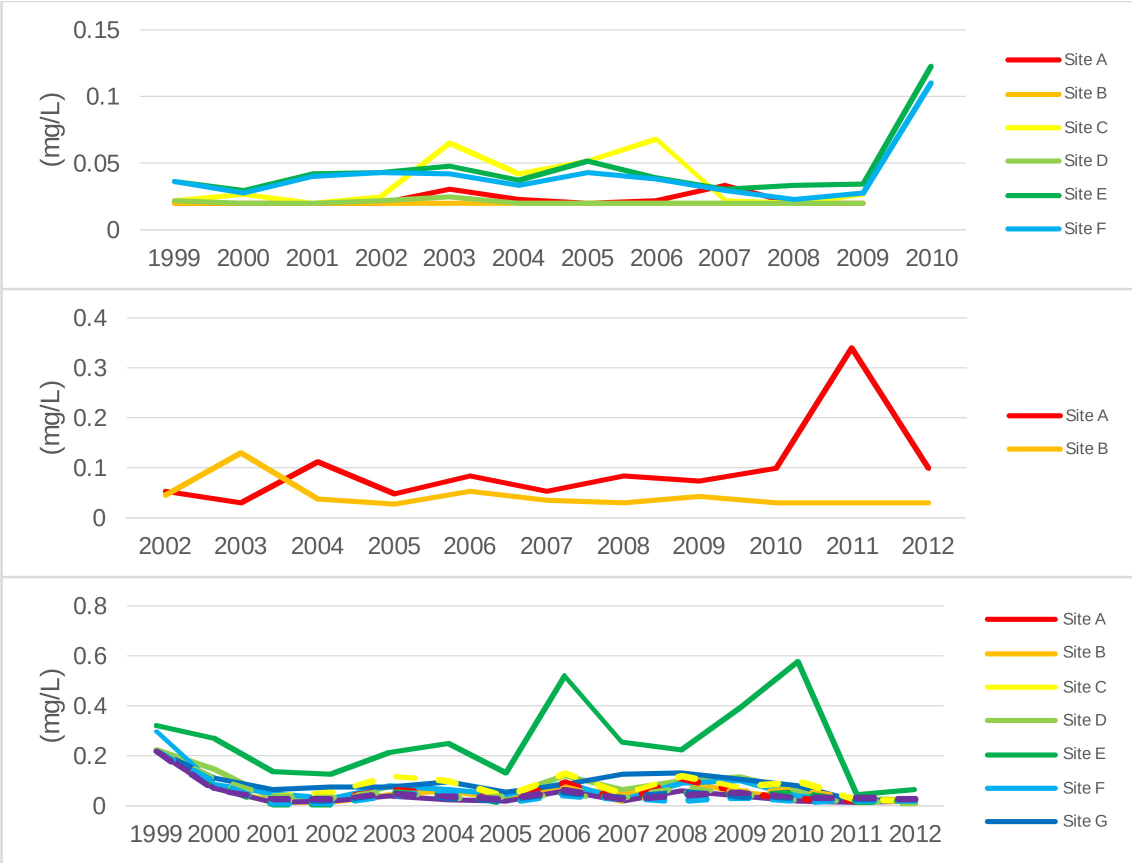


Figure 9. Dissolved inorganic nitrate (NO3+NO2) in Niigata (upper), Ishikawa (middle) and Saga (bottom)

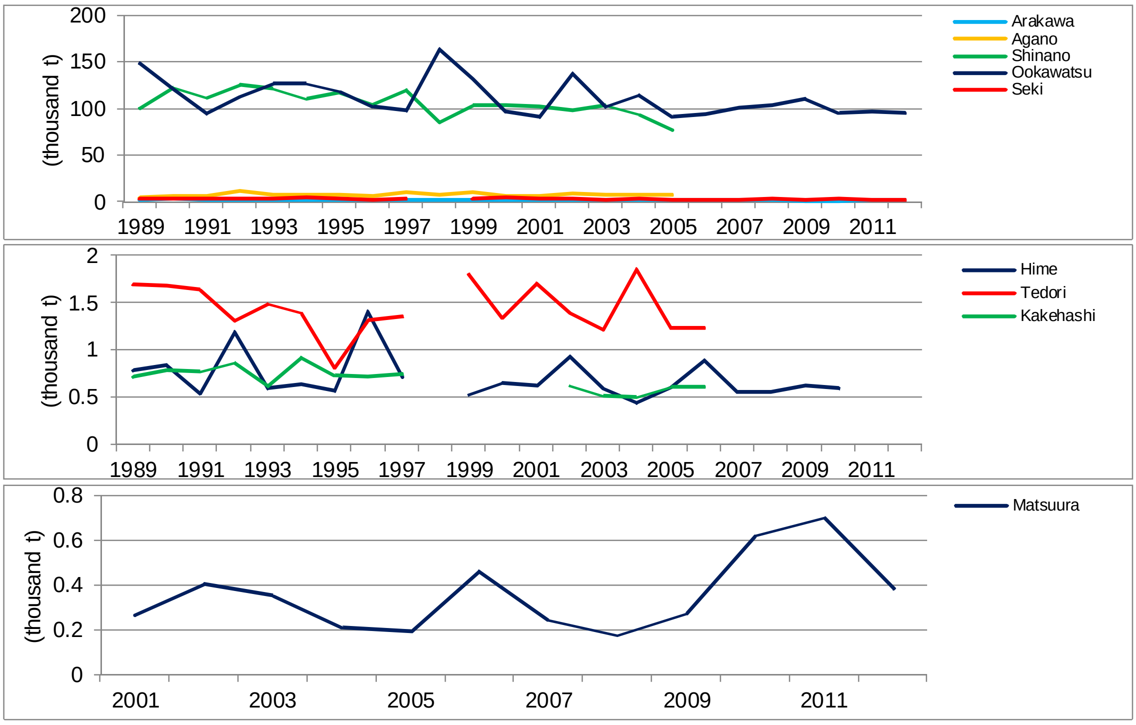


Figure 10. River input of TN in Niigata (upper), Ishikawa (middle) and Saga (bottom)

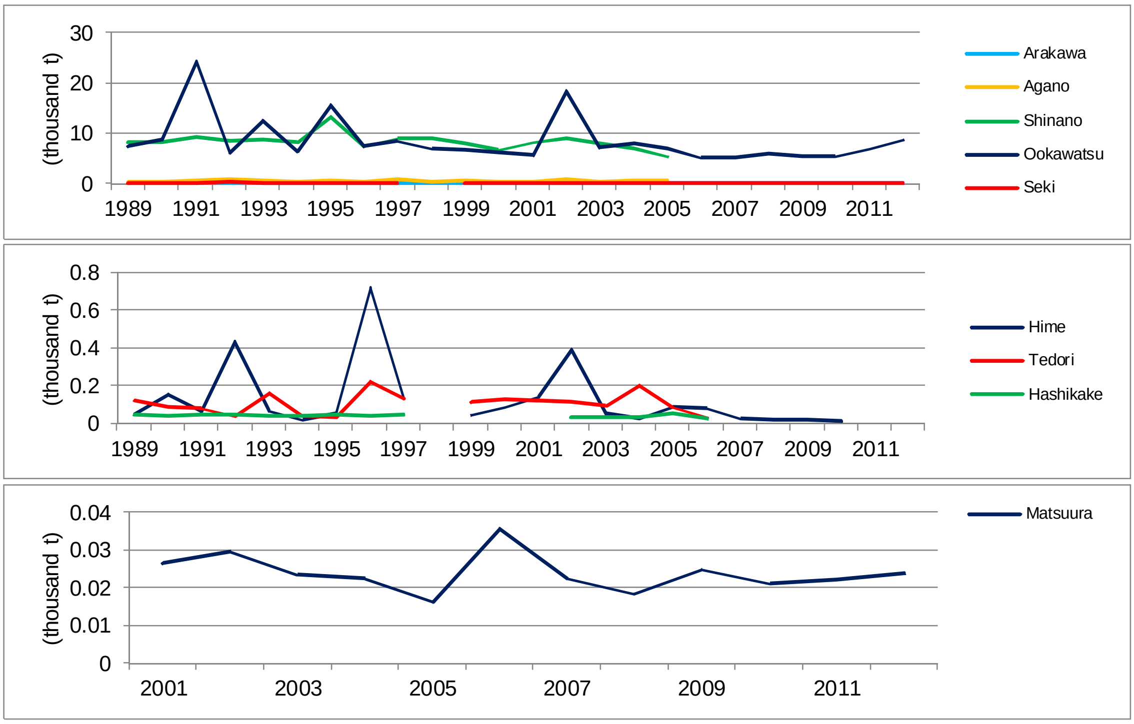


Figure 11. River input of TP in Niigata (upper), Ishikawa (middle) and Saga (bottom)

Chlorophyll-*a* concentration is available only in Saga (Figure 12). Chlorophyll-a concentration over 20 µg/L was observed in 2008, 2010 and 2011; however, a decreasing trend has been shown during the past six years. The sites with decreasing trend are situated in Karatsu Bay and Kariya Bay. Both bays are sea areas where red tides occurred frequently: Red tides by *Chattonella antiqua* in 2008, *Karenia mikimotoi* in 2010, and *Noctiluca scintillans* in 2011. High concentration of chlorophyll-*a* was related to these red tide events.

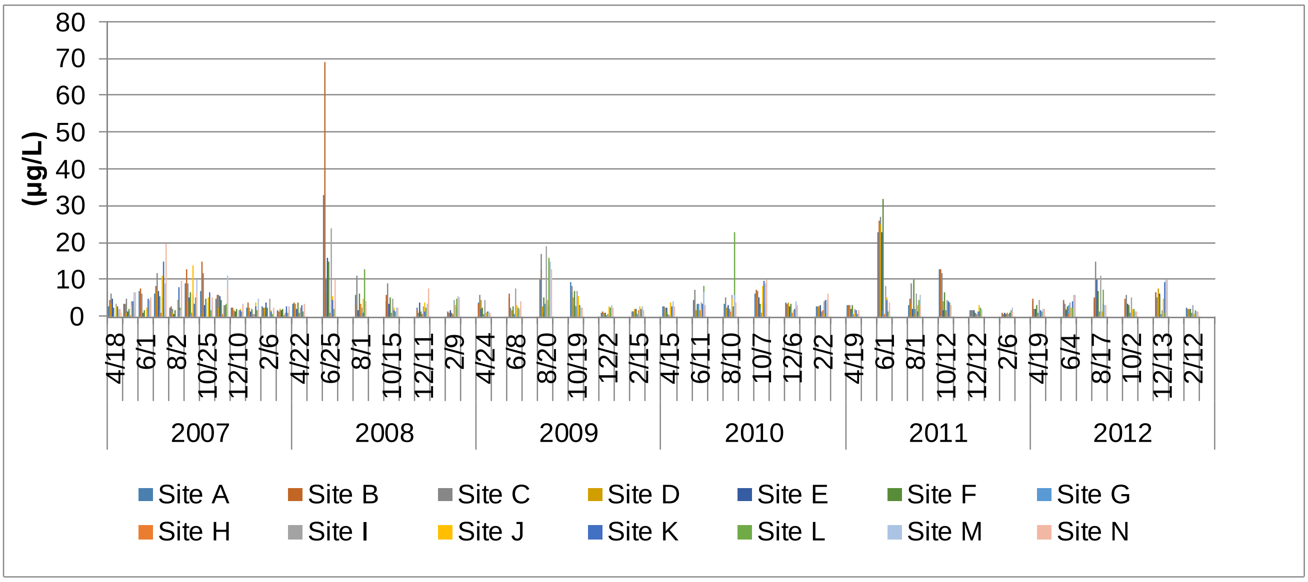


Figure 12. Chlorophyll-*a* concentration in Saga

As indirect indicators, data on fertilizer usage, land area usage, population density and feeding by aquaculture are available in Japan. In this pilot study, relationships between eutrophication and indirect indicators were not investigated, and these data were used as background information on eutrophication in target sea areas.

The excess use of fertilizer causes eutrophication in sea areas by its discharge via rivers. In both target sea areas, fertilizer utilization has a decreasing trend in recent years (Figure 13). As agriculture is a major industry in most of the prefectures in the target sea areas, it is natural that fertilizer is still used. In particular, chemical fertilizer, made from nitrate, phosphate, and kalium, has been used, however used amount is in the right amount.

Change of land use also influences eutrophication. Increase of farmland causes increase of nutrient input from plane source while industry and urban areas increase nutrient input from point sources. In all prefectures, forest areas haven't changed in the last 20 years (Figure 14). The change of land use indicates decrease of farmland and increase of city area. It may mean that sources of nutrient change from plane sources to point sources. In addition, fertilizer usage has also decreased, and it may be related to the decrease of farmland.

As for population density, big change did not happen in the last 20 years (Figure 15). Only in Fukuoka, population density has an increasing trend; however, total nitrogen and total phosphorus in the coastal area of Fukuoka have no and/or decreasing trend. It means waste water is treated adequately. Other prefectures have no trend or even a decreasing trend, and the volume of total nitrogen and total phosphorus are not problematic at present.

Leftover of feeding in aquaculture increases nutrient input to the ocean. Therefore, the volume of feeding in aquaculture is a useful information. Except for Toyama, where aquaculture is not active, shellfish and seaweed are main cultivated species in other four Prefectures (Figure 16). Therefore, total feeding is small.

Figure 13. Utilization of fertilizer in Niigata, Toyama, Ishikawa, Fukuoka and Saga (from top to bottom)

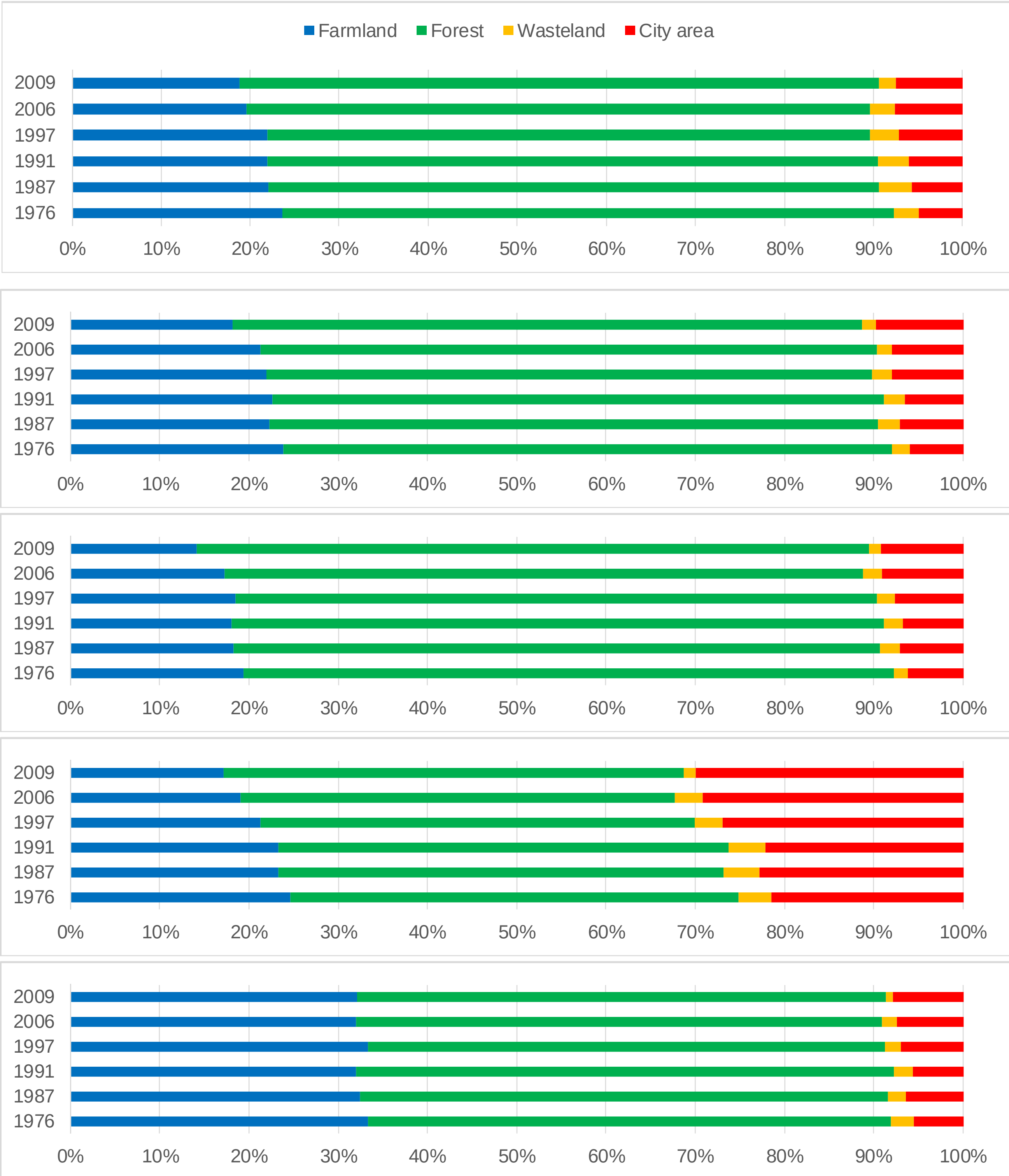


Figure 14. Land use in Niigata, Toyama, Ishikawa, Fukuoka and Saga

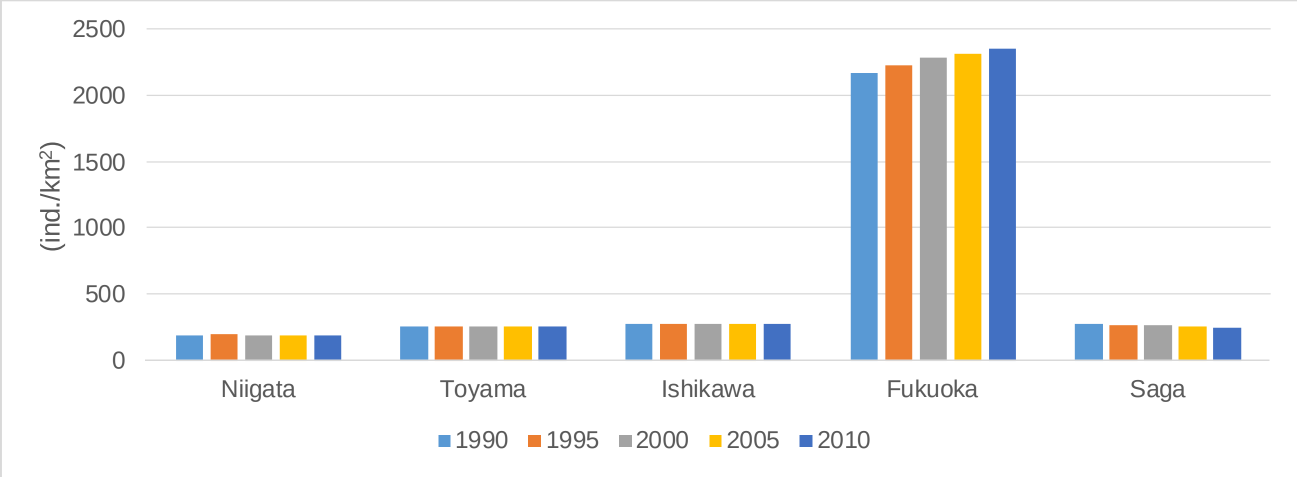


Figure 15. Change of population density in five prefectures.

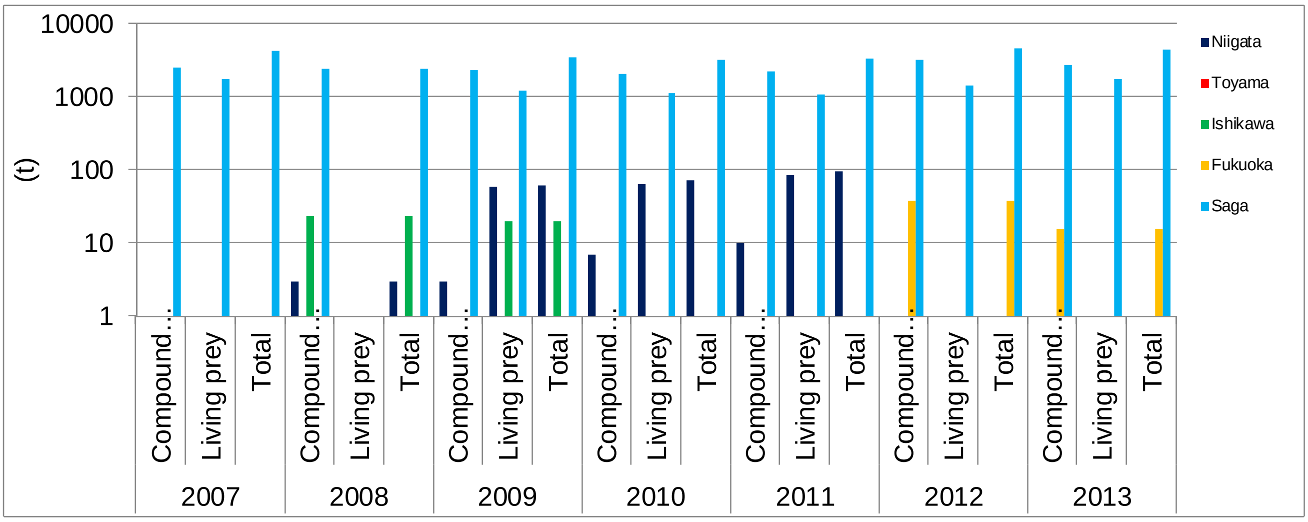


Figure 16. Feeding by aquaculture in target sea areas

Korea

The pilot study in Korea focused on the impacts of dike construction on the environment. An integrated oceanographic study has been conducted in 2002-2009 as a part of the Government Action Plan for Saemanguem to monitor and assess the changes in the marine environment. These monitoring results were used as available data in the pilot study, and the monitoring sites are shown in Figure 20. Dissolved Inorganic Nitrogen (DIN) is monitored as a direct indicator on eutrophication. Suspended substances by satellite observation and field monitoring, secchi depth, and Chemical Oxygen Demand (COD) are used as indirect indicators on eutrophication.

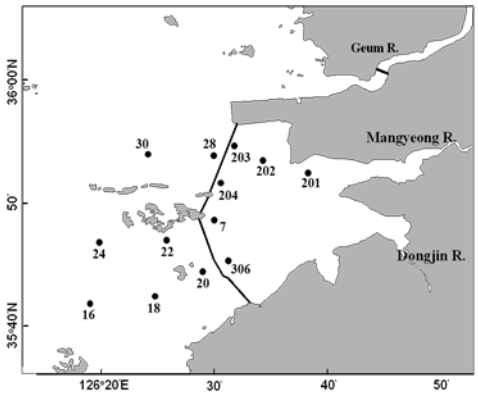


Figure 17. Monitoring sites of the Government Action Plan for Saemanguem

Average DIN (NO_3^-+NO_2^-+NH_4^+) concentrations in the sampling sites showed an increasing trend during the summer seasons with increased freshwater input from the river. However, outside the summer seasons, the values showed a decreasing trend (Figure 18). Average DIN concentrations in the sampling sites during 2002-2009 showed the highest concentrations at 201 μM near the Mankyeong River, and decreased further away from the river mouth (Figure 19). The increase in DIN during the summer seasons is related to the increase in river discharge. The average DIN concentration in the dike was 27.5±36.6 μM and the average DIN for the outer dike was 6.6±7.1 μM.

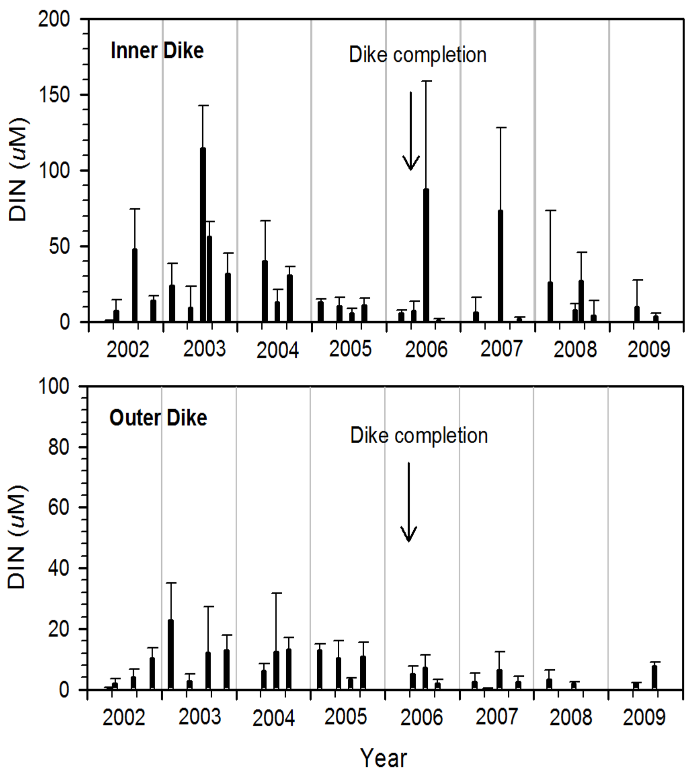


Figure 18. Variation of DIN concentration in 2002-2009 in the Saemanguem area. Upper is DIN in the inner dike and lower is the outer dike.

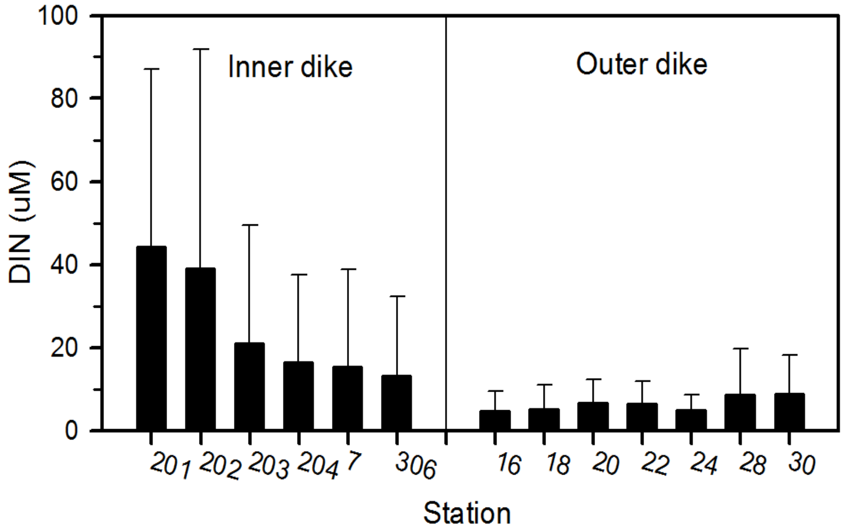


Figure 19. Averaged DIN concentration of each monitoring site in 2002-2009

Suspended substances observed by satellite shows a drastic increase in water transparencies and a decrease in suspended sediments/substances (SS). Water turbidity (Kd (490)) showed highs in winter and lows in summer both inside and outside areas of the dike before the dike enclosure (Figure 20). Before April 2006, the data showed significantly higher Kd (490) values inside the dike (mean 1.76/m) than outside (mean 0.92/m); however, after completion of dike the value decreased to 1.09/m and 0.77/m for both inside and outside, respectively. Similar patterns were observed for Kd (490), and significant reduction of MODIS-derived normalized water-leaving radiance images at wavelength 645, nLw (645) also occurred after construction of the dike enclosure. As shown in Figure 20(c), the nLw (645) values significantly declined after the dike enclosure compared with before the dike construction. Particularly in summer 2008, after the dike had been closed for more than two years, the nLw (645) values were almost the same between inside and outside areas of the dike.

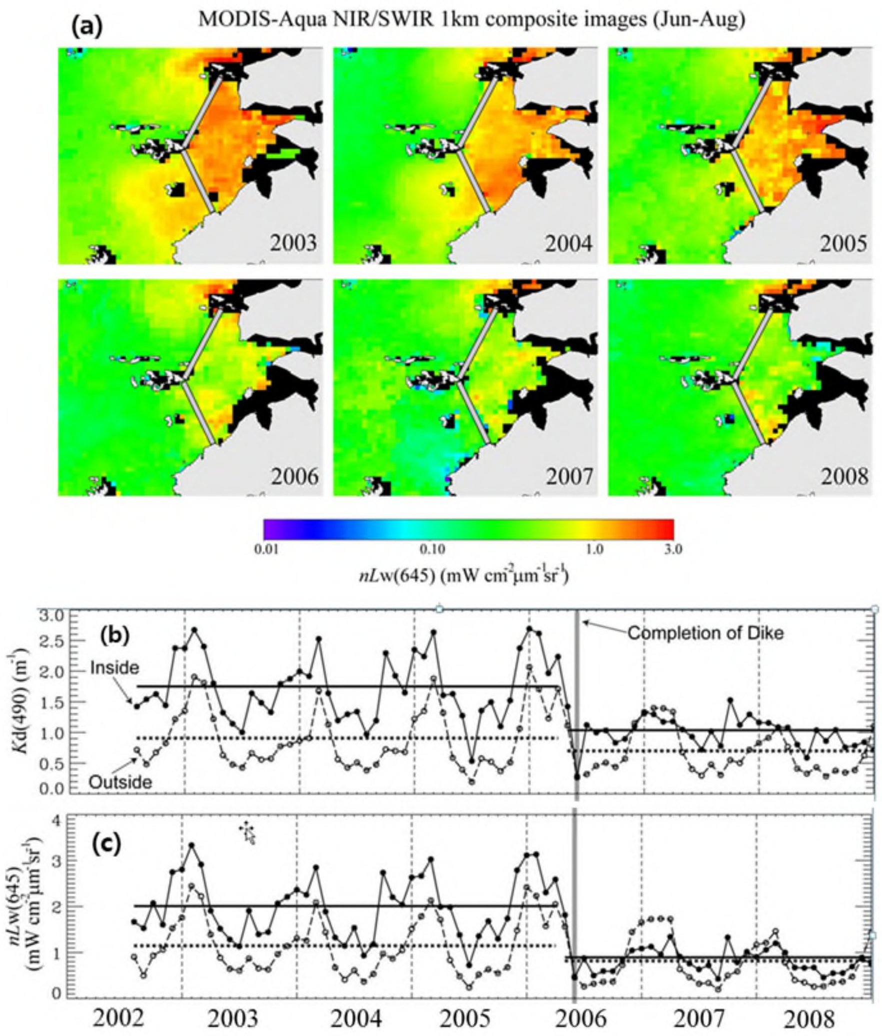


Figure 20. (a) MODIS-derived nLw (645) composite images in the region for the summers before and after the dike enclosure; (b) diffuse attenuation coefficient at a wavelength of 490nm; (c) total amount of SS in the coastal waters at a wavelength of 645nm.

Field monitoring of SS values also significantly declined after the completion of the dike, compared to the field monitoring before the dike's closure. The inner area of the dike showed high SS concentration of more than 100mg/L before the dike was constructed (Figure 21). However, the values decreased below 10mg/L in most sites after the completion of the dike.

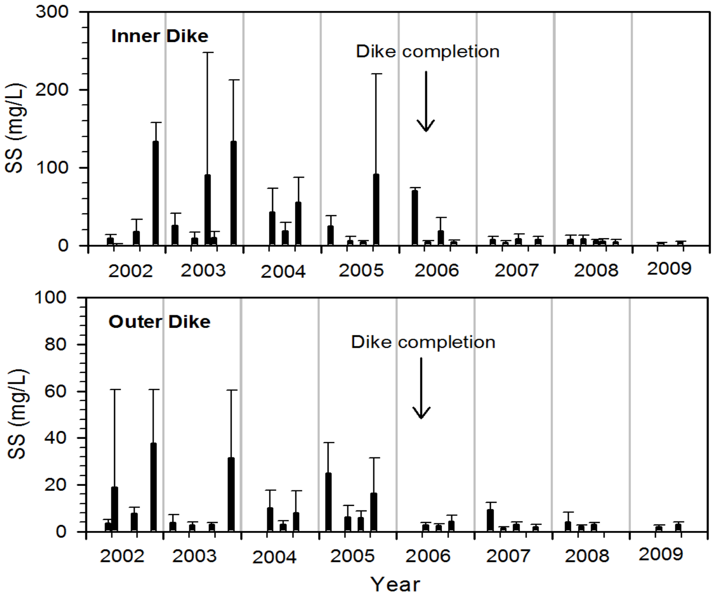


Figure 21. Variation of SS between 2002 and 2009 in the Saemanguem region. Upper is SS in the inner dike and lower figure is the outer dike.

Secchi depth also shows the decreasing trend of SS inside the dike (Figure 22).

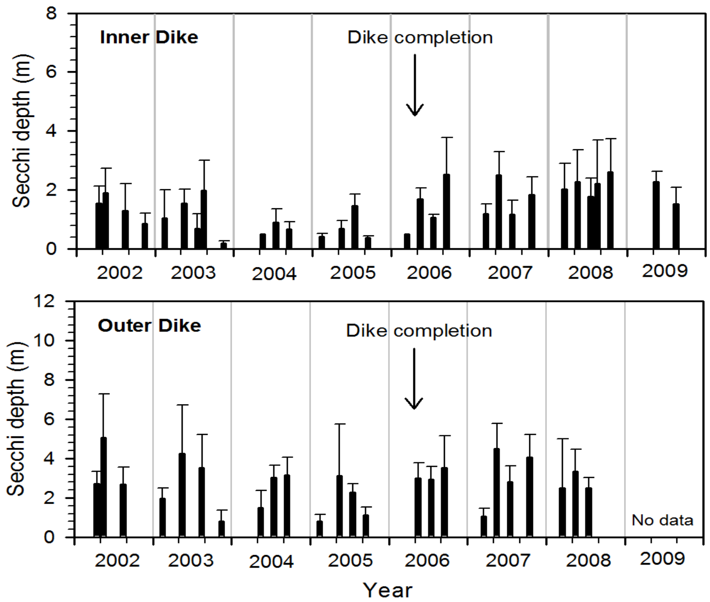


Figure 22. Variation of transparency between 2002 and 2009 in the Saemanguem region. Upper is Secchi depth in the inner dike and lower figure is the outer dike.

COD (Chemical Oxygen Demand) measured inside the dike showed an increasing trend as the dike construction progressed (Figure 23). The increasing trend accelerated when the water exchange became limited after the completion of the dike enclosure in 2006. COD measured outside of the dike seemed to maintain increased concentration since 2003; however, it was still lower than the inner dike area. An averaged spatial distribution of COD in the inner dike area was started to show a relatively sharp increase from June 2003 when the northern dike was closed. In 2002, the value was below 2mg/L; however, from the summer of 2003, the value was higher than 5mg/L in summer seasons. Particularly, the highest value of 7.7mg/L was observed in the autumn of 2008, one year after the construction of the final dike enclosure.

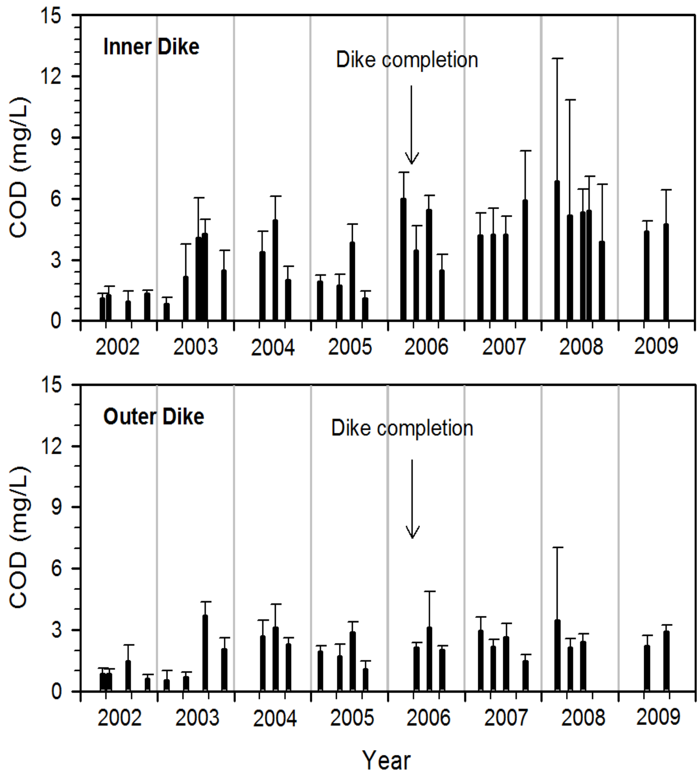


Figure 23. Variation of COD between 2002 and 2009 in the Saemanguem region.
Upper is COD in the inner dike and lower figure is the outer dike.

Russia

In the pilot study in Russia, total nitrogen (TN), total phosphorus (TP), nitrate (NO_3), Dissolved silica (DSi), and river and waste water input were used as direct indicators. The changes in averaged concentrations of these parameters are shown in Figure 24. The figures show concentration of TP, TN, NO_3 and DSi in each sub-area of Peter the Great Bay: Golden Horg Bight (ZR); Amursky Bay (AZ); Ussurisky Bay (UZ); Bosphprus Strait (BS); and Nakhodka Bight (Nah). There was a decreasing trend of DSi in Ussurisky Bay and most polluted Golden Horn Bight. Amursky Bay, with the averaged level of DSi due to the influence of the Razdolnaya River, did not demonstrate an unambiguous trend of inter-annual variability of DSi. Total nitrogen, despite significant inter-annual variability, showed some increasing trend almost in all areas of Peter the Great Bay. Nitrate and total phosphorus did not show any clear trends.

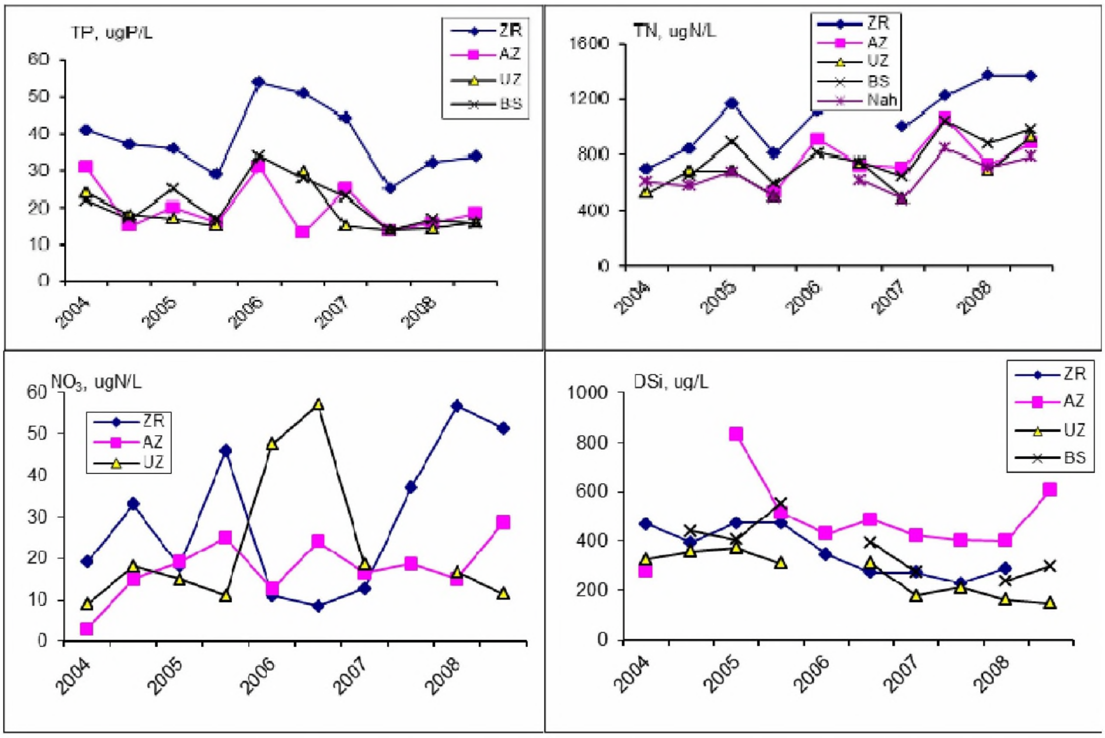


Figure 24. Trend of TP, TN, NO3 and DSi in Peter the Great Bay

The recent situation with chemical parameters reflecting nutrients and organic matter content in the river at Peter the Great Bay watershed is shown in Table 4. Chemical oxygen demand (COD) in many Russian rivers is significantly higher than that of Japan and Korea. Among Russian rivers, low COD is observed in most pristine, small mountainous streams of the southwestern subarea. High COD exceeding the maximum permissible concentration (MPC) was observed in the Razdolnaya River and severely polluted streams such as the Knevivhanka River. Biological oxygen demand (BOD) value exceeded MPC 2 mg/L in all rivers draining moderately populated and economically developed watersheds, namely in Razdolnaya and Knevichanka. The only exception was the downstream of the Tumen River with a rather low BOD but with elevated COD that exceeded MPC 15 mg/L. NH_4 and NO_2 as well as PO_4 in river water were equal or exceeded MPC in the Razdolnaya and Knevichanka rivers.

Interannual change of chemical composition of Russian rivers which flow into Peter the Great Bay is different by parameters (Figure 25). BOD showed a distinctive decreasing trend in the rather polluted Razdolnaya River, but in other polluted streams, such as the Knevichanka River, BOD increased 1.5 to 2 times during the last few years. In other less polluted rivers there was no clear trend shown. Annual means of phosphate showed an increasing trend during the last 5-6 years in the polluted rivers. The somewhat similar trend of rising is observed for the concentration of ammonia nitrogen and DIN in the contaminated Razdolnaya and Knevichanla rivers; however, there was stabilization or even decrease of DIN in other clean rivers.

Table 4. Some chemical characteristic (mg/L) of major rivers at Peter the Great Bay watershed (averaged data in 2001-2007)

River	COD	BOD	NH_4^+	NO_3^-	PO_4^{3-}
Tumen	18.8	1.93	0.24	0.63	0.017
Rivers of south-western part	.04	1.5	0.08	0.20	0.003
Razdolnaya	21.2	11.6	0.87	0.20	0.071
Knevichanka	26.1	6.1	2.25	0.22	0.24
Artemovka	10.7	2.14	0.14	0.09	0.010
Partizanskaya	10.8	2.53	0.05	0.12	0.009
Maximum Permissible Concentration	15.0	2.0	0.40	9.1	0.05

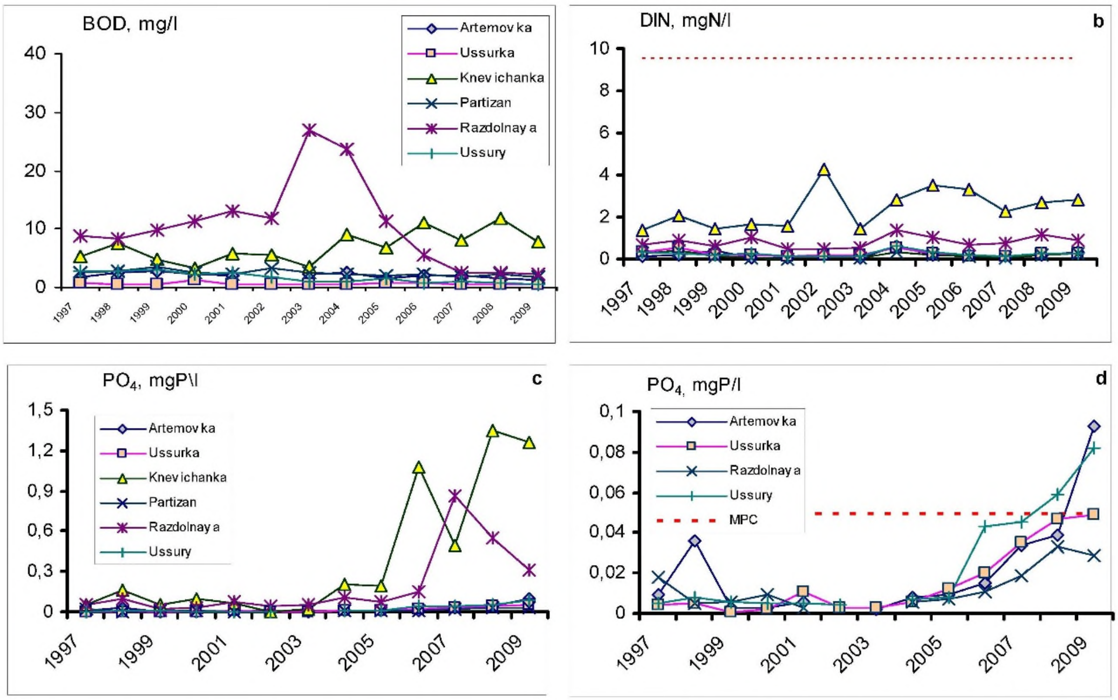


Figure 25. Annually averaged concentration of BOD, DIN, and phosphate in the Artemovka and Razdolnaya rivers of Peter the Great Bay basin, and in two big rivers of the Amur River basin: the Ussury and the Ussurka

The concentration of pollutants in the wastewater outputs and especially in the storm waters is very variable, and all assessments are inevitably rather approximate. Such estimates of chemical parameters, which are often used as water quality indices, for the Vladivostok area are shown in Table 5. The contribution of river, storm water and wastewater runoffs to the total input of water and some chemical substances to Peter the Great Bay is shown in Figure 26.

Table 5. Concentration (mg/L) of substances in the wastewaters and storm waters of Vladivostok (Gavaev et al. 1998)

	BOD	NH4	PO4	Surfactant	Petroleum hydrocarbon	Phenol	SS
Wastewater	32.6	4.2	1.9	0.11	0.92	0.015	39.2
Storm water	17.8	3.5	0.25	0.17	1.09	0.011	85.9

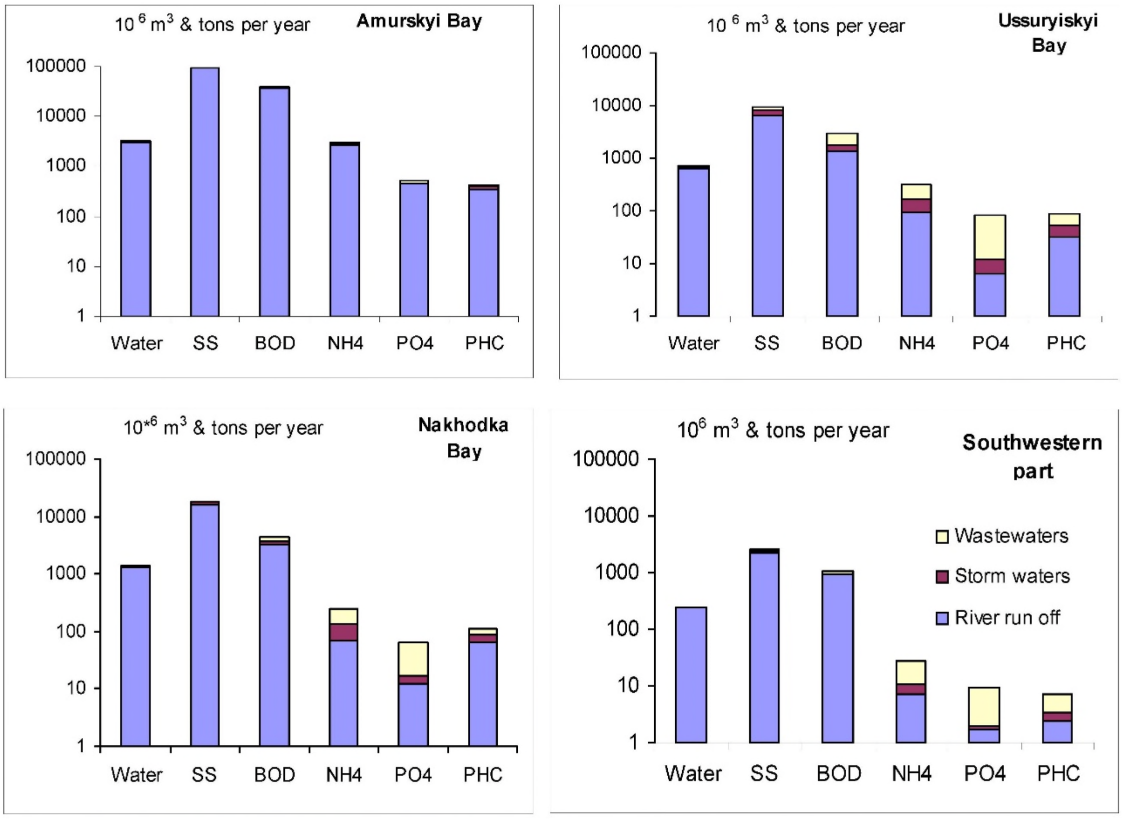


Figure 26. Contribution of river runoff (blue), storm waters (red), and wastewaters (yellow) to inputs of water, suspended solids (SS) and some chemical substances to the different sub-areas of Peter the Great Bay

2.5 Non-indigenous species

The available data on non-indigenous species (NIS) in each member state is shown in Table 6 and 7. Countries which has data on non-indigenous species are only Japan and Russia. Russia has regular monitoring on non-indigenous species, two to eight times per year. On the other hand, Japan does not implement regular monitoring. The data on NIS in Japan is collected from scientific reports and papers. In China, information on NIS is not available; however, information on protected species and aquaculture of NIS in target areas is available. The Korean pilot assessment focused on the impact of the dike, thus information on NIS is not available.

Table 6. Inventory of available data on direct indicators of non-indigenous species

	China	**Japan**	**Korea**	**Russia**
Number of NIS	N	A	N	A
		Niigata, Toyama, Ishikawa, Fukuoka		2-8 times/year
Distribution of NIS	N	N	N	N
Endangered species	N	A	N	N
		Red list published by each Prefectural government		
Protected species	A	A	N	N
	Spotted seal in coastal area of Yantai	List of protected species in National Park		

Korea focused on the impact of the dike construction. Therefore, data on non-indigenous species were not collected and not available in this pilot assessment.

Table 7. Inventory of available data on indirect indicators of non-indigenous species

	China	Japan	Korea	Russia
Aquaculture of NIS	A	A	N	N
Volume of discharged ballast water	N	A Number of foreign ships	N	N
Maritime passenger transport	A	N	N	N
Port cargo	A	A	N	A

Korea focused on the impact of the dike construction. Therefore, data on non-indigenous species were not collected and not available in this pilot assessment.

China

In China, data on the existence of NIS is not available. However, in the coastal areas of Changhai County and Changdao County, there are many aquaculture farms, and many kinds of NIS are cultured there (Figure 27). Bay scallop and Yesso scallop are cultured in Changhai County actively. In particular, production of NIS has dramatically increased in the past ten years in Changhai County. Escape of these cultured species has not been reported yet; however, there are potential threats of them to indigenous species.

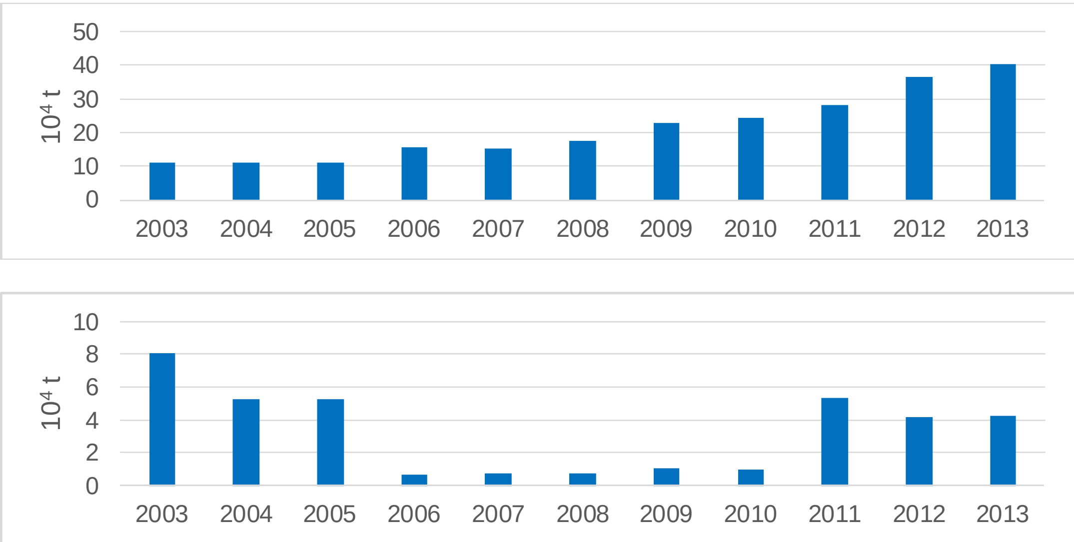


Figure 27. Production of NIS aquaculture (*Argopecten irradians*)
in Changhai County (up) and Changdao County (bottom)

In Changdao County, spotted seal (*Phoca largha*) uses coastal areas for breeding. Therefore, the Changdao Provincial Spotted Seal Nature Reserve was established in 2001, and the animal is protected now. The number of spotted seals has not changed in the recent ten years (Figure 28). Therefore, the impact of NIS to spotted seals has not been observed.

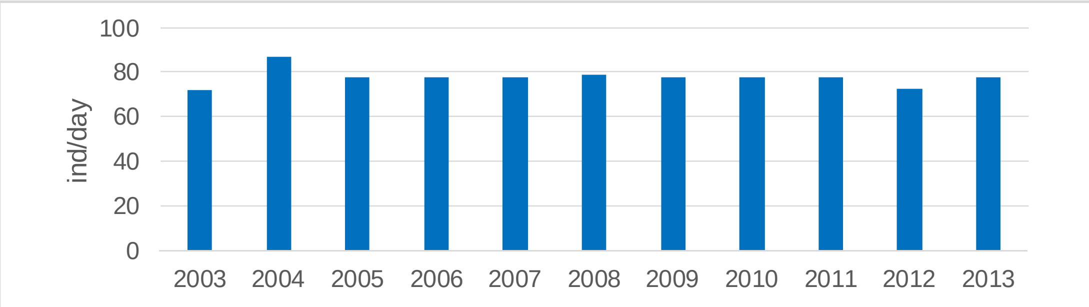


Figure 28. Number of spotted seals observed in Changdao County

Japan

Non-indigenous species found in Japan were reported by Iwasaki et al. (2004) and Iwasaki (2012). The list of NIS in the target sea areas is shown in Table 8. In this report, NIS in Saga Prefecture wasn't surveyed. NIS has already been introduced into the target sea areas, and 12 species were found in Fukuoka Prefecture.

Table 8. List of non-indigenous species in target sea areas

Name of NIS species	Niigata Prefecture	Toyama Prefecture	Ishikawa Prefecture	Fukuoka Prefecture	Saga Prefecture
Crepidula onyx		✔		✔	ND
Mytilus galloprovincialis	✔	✔	✔	✔	ND
Perna viridis				✔	ND
Xenostrobus securis		✔	✔	✔	ND
Mytilopsis sallei		✔		✔	ND
Ficopomatus enigmaticus				✔	ND
Balanus amphitrite	✔	✔	✔	✔	ND
Amphibalanus eburneus		✔	✔	✔	ND
Amphibalanus improvisus			✔	✔	ND
Pyromaia tuberculata				✔	ND
Polyandrocarpa zorritensis		✔		✔	ND
Molgula manhattensis				✔	ND
Cutleria multifida			✔		ND

Each prefecture published a red data book which covers marine organisms. However, the number of marine organisms is quite small compared with species on land. For example, in Fukuoka, *Sillago* *parvisquamis* (Category: IB), *Caretta caretta* (IB) and *Sinonovacula lamarcki* Huber (IA) are listed up as endangered species in the sea area. A total of 9 species in Ishikawa, 10 species in Fukuoka and 79 species in Saga are selected in their respective red data books (including near threatened and information shortage).

Protected species are listed up in marine protected areas as well. In Genkai Quasi National Park, located in the north Kyushu sea area, total 31 species (animals and plants), including *Lytocarpia Kirchenpauer and Aglaophenia whiteleggei,* are listed up as protected species. In Kanmurijima-Kutsujima National Wildlife Protection Area, located in the Hokuriku region, 5 species of seabirds are selected as protected species.

As an indirect indicator on NIS, the numbers on foreign ships and aquaculture operations of NIS are available. Two of the major ways of NIS introduction are ballast water and ship hulls of foreign ships. To investigate the number of foreign ships in major ports in target sea areas is useful for understanding the threat of NIS introduction. Figure 29 shows the change of the number of foreign ships entering ports. In Fukuoka, where Hakata Port and Kitakyushu Port are located, there is a predominantly high number of foreign ships. Except for Ishikawa, the number of foreign ships is decreasing.

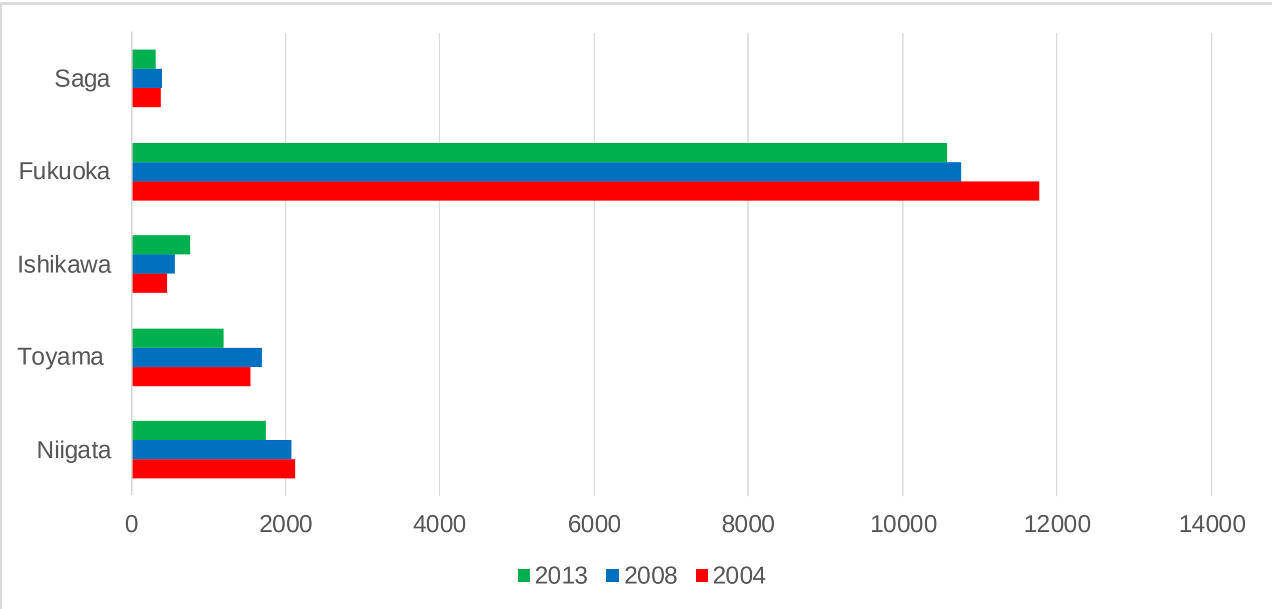


Figure 29. The number of foreign ships entering ports in five prefectures

Stocking of aquaculture species is another way of NIS introduction. Fortunately, in Japan, stocking of foreign species isn't implemented. However, non-native species are introduced to different regions in fisheries (Figure 30). For example, Ezo-abalone, *Haliotis discus hannai*, is a cold water species. However, its fishery value is very high and, it was introduced into the Hokuriku region.

In addition to artificial introduction, increase of the sea water temperature by climate change is problematic. *Aetobatus flagellum* and *Siganus fuscescens* which are warm water species, have extended their habitat range to northern area and damaged benthic species such as Manila clam and seagrass/seaweed. In the future, extended distribution of southern species may be a serious problem in Japan.

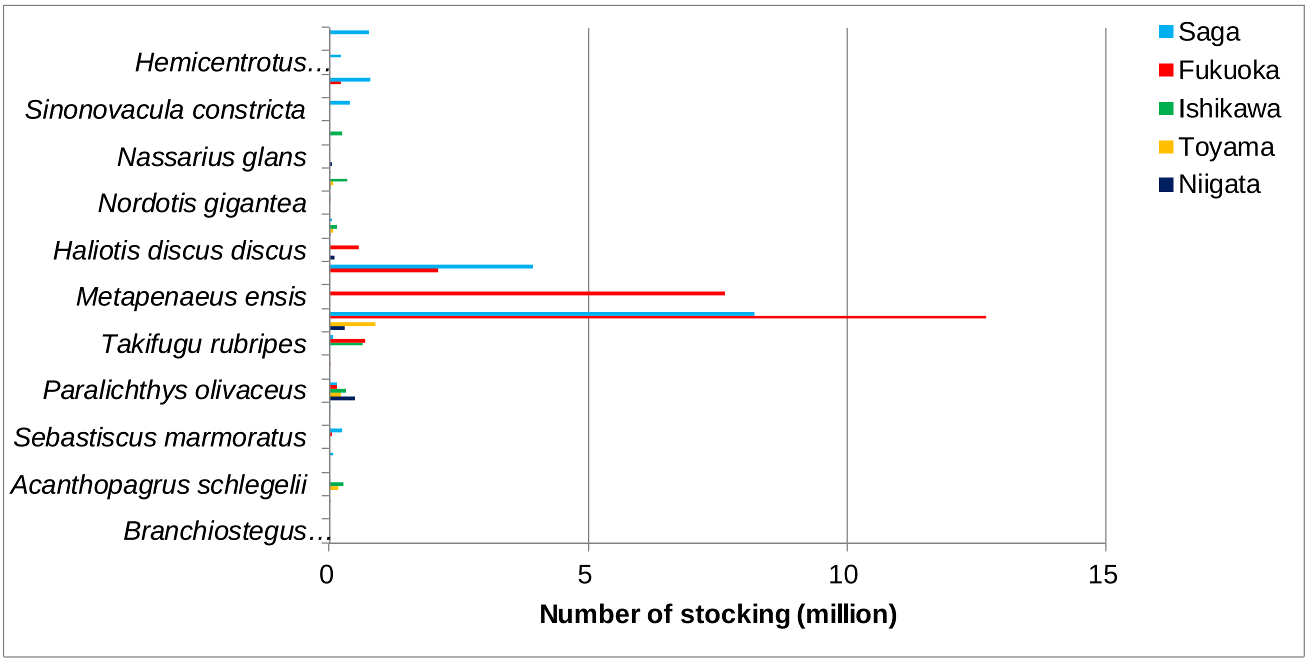


Figure 30. The number of breeder's stocks of fishery species in five prefectures

Korea

In Korea, the pilot assessment focused on dike construction and eutrophication. Therefore, information on NIS was not collected.

Russia

Since the beginning of this century, 19 new subtropical and tropical fish species have been registered in the water areas of southern Primorye. Currently, 110 of 316 species recorded for Peter the Great Bay are southern migrants (Sokolovsky et al., 2011). The process of warm-water species penetration into the Bay intensifies annually due to the warming of surface water and energization of western branches of the Tsushima Current (Sokolovsky and Sokolovskaya, 2005; Sokolovsky et al., 2009, 2011). It is important to note that many migrant species from southern regions both considerably extended their range to the north and significantly increased the period of stay in Russian water areas in the warm season. The species like the Pacific and Japanese needlefishes, dotted gizzard shad, Japanese anchovy, and striped mullet have become targets of commercial fisheries in recent years. It is shown that warm-water species sometimes introduce new parasites infecting native species.

Bio-invasions to Peter the Great Bay water is increasing through introductions of the fouling species from ships' hulls and ballast water of ocean-going ships (Figure 31). About 16,000 ships enter ports and harbors every year, and among them, about 8,000 ships operate on international lines. The total volume of cargo handled at seaports located in Peter the Great Bay is more than 80 million tons per year (Table

9). Such an intensive traffic favors introductions of alien species through fouling communities and release of ballast waters. In Peter the Great Bay, 56 marine invasive species were known by 2010.

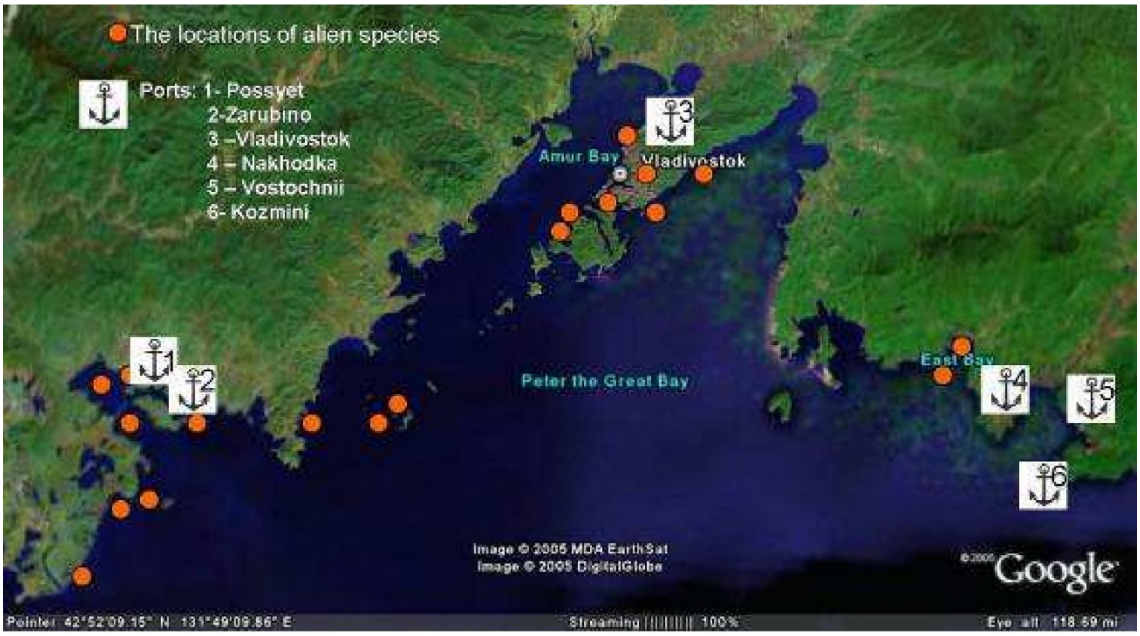


Figure 31. Main sea ports and the location of alien species in Peter the Great Bay

Table 9. Volume of cargo of the main ports located in Peter the Great Bay

Port	Conditions of navigation	Number of piers	Processed cargo
Vladivostok	Year-round navigation	16	Metal and metal product, timber, raw sugar, grain, containerized cargo, coke, ore
Nakhodka	Year-round navigation	23	Timber, lumber, metal and metal products, chemicals, pulp, cardboard, food, liquid cargo
Vostochnii	Year-round navigation	13	Coal, cement, timber, lumber, fertilizers, containerized cargo, bulk cargo
Kozmino	Year-round navigation	1	Crude oil
Zarubino	Year-round navigation	4	Metal, round wood and timber, general cargo, containerized cargo
Posyet	Year-round navigation	3	Coal

In Peter the Great Bay, naturalization of non-indigenous species such as *Amphibalanus improvises* and *Mytilus galloprinciallis* was reported. The predominance of these species may lead to suppression and displacement of other species. Increasing competition between native and alien species is an important ecological consequence of invasions.

Biofouling of ships, piers, buoys and other structures consisting partly of invasive species has an important economic impact. The mussel M. galloprovinciallis which became an abundant component of biofouling may damage aquaculture installations; however, at the same time, this mussel and its hybrids with local species Mytilus trossulus might be a prospective object of aquaculture.

The Far East Marine Biosphere Reserve, a marine protected area in Peter the Great Bay was chosen as a site in order to monitor already existing alien species in territories and waters. More than 5,100 species of terrestrial and marine species have been registered in the Far East Marine Biosphere Reserve, and a total of 499 new taxa have been found, including identified 131 species. The largest numbers of newly recorded species are planktonic microalgae (63 species) and diatom algae of periphyton (53 species). 7 non-indigenous benthic species, 5 insect species, 2 ichthyofaunas and 1 mesoplankton have been registered.

In the State Marine Partial Reserve “Vostok Bay”, rapid assessment survey on invasive species was performed in October 2011 by the North Pacific Marine Science Organization (PICES). Over 400 species of marine invertebrates and algae were collected, and 66 out of 103 species of crustacean amphipods found in 2011, which were not recorded in 1984, and 36 of 80 amphipod species described in 1984 were not found in 2011. Nearly all of the introduced species discovered in Peter the Great Bay since 2009 were previously known in Southeast Asian countries. The restricted ranges and summer occurrences for most of these species are consistent with expanding southern populations or northern migration.

2.6 Habitat alteration

The available data on habitat alteration in each member state is shown in Table 10. Habitat alteration is a serious issue in the NOWPAP region; however, the available data is quite limited. In such a situation, Korea focused on this threat in its pilot assessment.

Table 10. Inventory of available data on habitat alteration

	China	Japan	Korea	Russia
Natural coastlines	N	A	N	A
Landfills	N	A	A	N
Dredging/collection of sea gravel	N	A	N	N
Number of dams	N	A	N	N
Fixed asset investment	A	N	N	N

China

Changdao County is listed as one of the National Parks if China, and Changhai County has been established as a National Forest Park and Liaoning Provincial Scenic and Historic Interest Area. Habitat in both counties has been strictly protected in line with relevant regulations.

Japan

In Japan, natural coastlines, landfills, dredging/collection of sea gravel and the number of dams are available indicators. Coastlines are protected to prevent erosion by waves. Most of the coastal protection is done by concrete blocks. Such protection decreases habitat of species living in coastlines. In particular, natural coasts have been lost by coastal protection against winter ocean waves in the northern coast of Japan. There was no dramatical change between 1993 and 1999 except for Toyama (Figure 32). In Toyama, the percentage of artificial coast was 70 % in 1993; however, it increased to 90 % of the whole of coast line in 1999. 30 km of natural and semi-natural coastline was lost in 6 years, and habitat loss has been a concern.

Most of the landfills were created in the 1970s and 80s. In recent years, small scale development of landfills has been continued in some areas (Figure 33). Fukuoka is one of the regions where coastal development still continues. During the past 20 years, over 10 km^2 is reclaimed. The area is small compared with the area in past huge reclamations; however, seagrass/seaweed beds and other habitats in the sea have been lost.

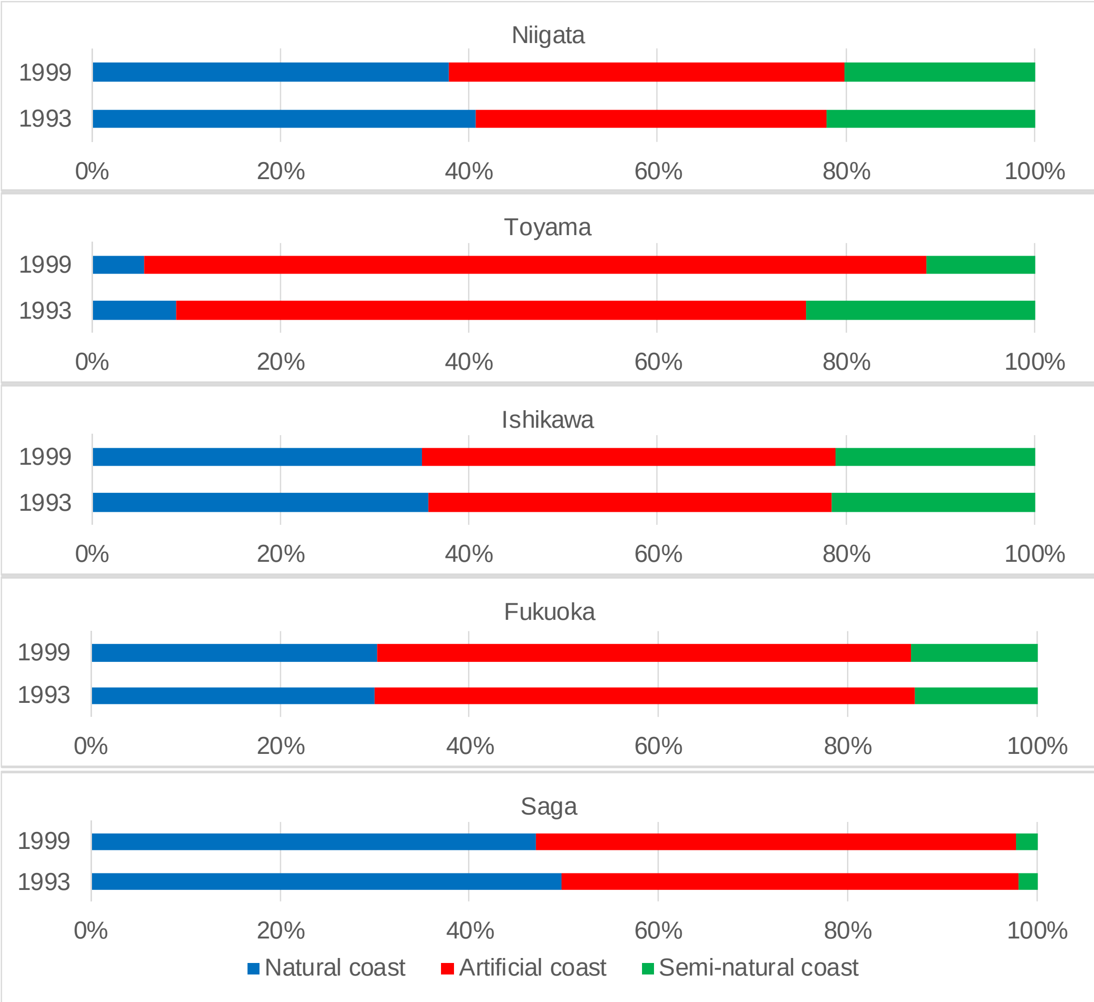


Figure 32. Percentage of natural, artificial and semi-natural coast in five prefectures

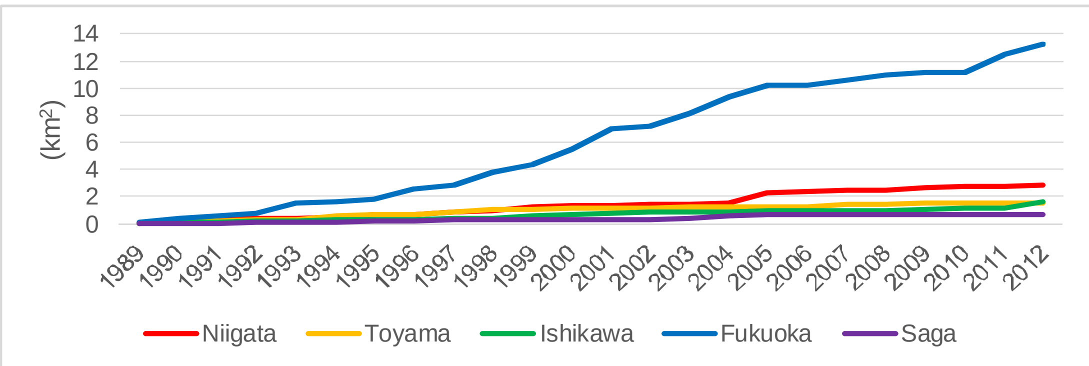


Figure 33. Accumulated area of landfills in five prefectures

Some fish and crustacean species use a sandy bottom as a hiding place. However, the collection of sea gravel causes the loss of such habitat. In addition, excess collection changes the bottom topography and it causes changes to the bottom environment such as hypoxia. Collection of sea gravel is one of the serious issues for habitat alteration (Figure 34). In the Hokuriku region, collection of sea gravel was prohibited in the 1990s. On the other hand, a huge volume of collection of sea gravel is continued in the north Kyushu sea area.

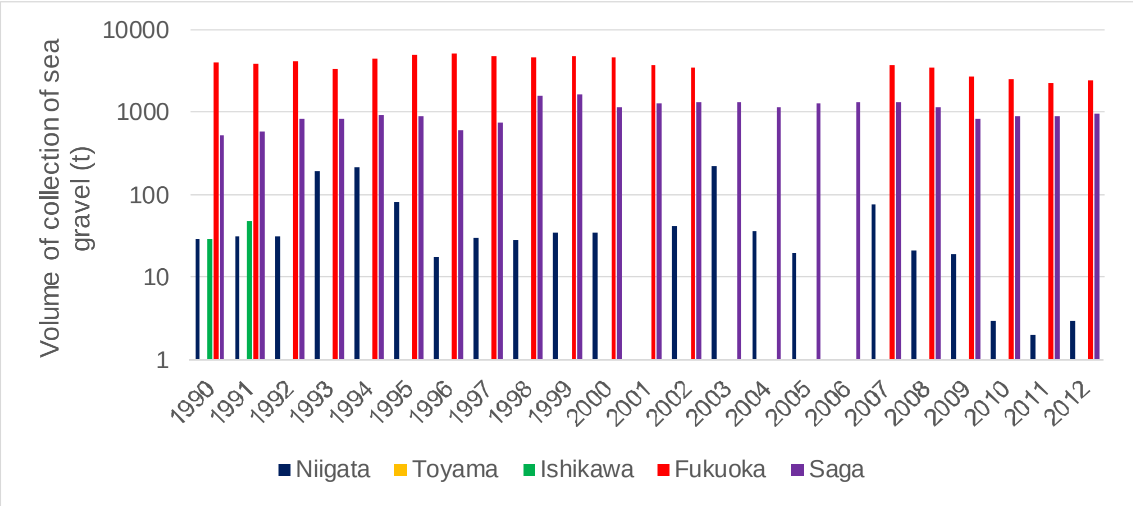


Figure 34. Collection of sea gravel in five prefectures

Korea

The pilot study of Korea focused on the impact of the dike construction in Saemanguem. The Saemanguem Reclamation Project was launched in 1991. In April 2006, a 33-km-long dike was enclosed and 401 km^2 of tidal flat was transformed into a lake and land.

Russia

There are three main issues of habitat alteration within Peter the Great Bay: 1) direct elimination; 2) local changes due to aquaculture activity; 3) more spatially wide changes in benthic habitats due to natural and anthropogenic reasons.

The significance at the regional scale of the habitat degradation due to anthropogenic influence is proportional to the population, and the Russian Far East has an average population density of 12 persons per square kilometers. The length of the port facilities within Peter the Great Bay does not exceed 16.6 km (6.2 km for Vladivostok, 5.8 km for Nakhodka, 3.5 km for Vostochny and 1.1 km for Posyet and Zarubino) - that is less than 0.01 % of the mainland shoreline.

The areas of aquaculture industries are prone to environmental changes affecting both benthic and pelagic organisms. The development of artificial fish farming started in 1972 in the southern part of Peter the Great Bay. In the mid-70s, the methods of artificial cultivation of clams, mussels, oysters and luminaria were taking into account the cultivating condition of the Far Eastern region with the help of Japanese and Korean experiences. Before 2000, there was a period of long stagnation in scallop farm production in the region, but after 2000 production has increased exponentially, more than 10 times in 5 years (Figure 35). The location of aquaculture facilities is changing from the South to the North of the region (Figure 36).

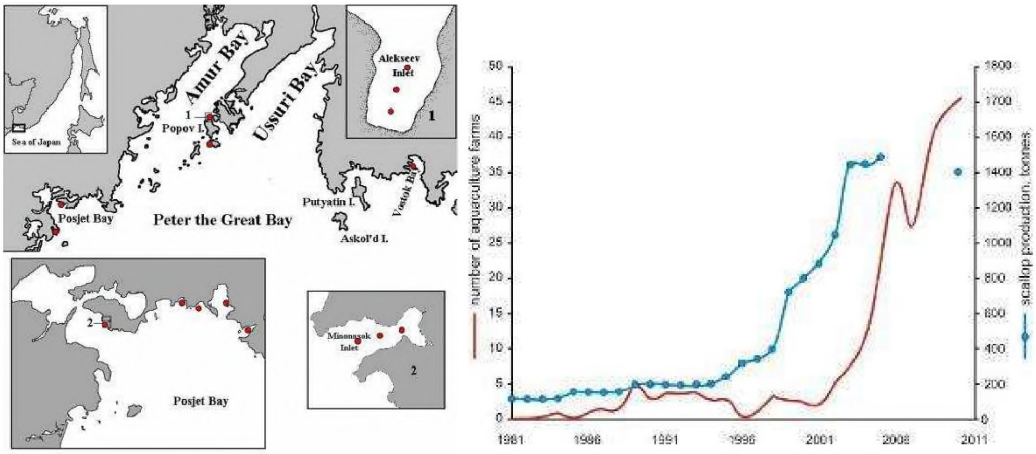


Figure 35. Data on aquaculture habitat alteration in Peter the Great Bay (left), and dynamics of scallop production for 30 years (right).

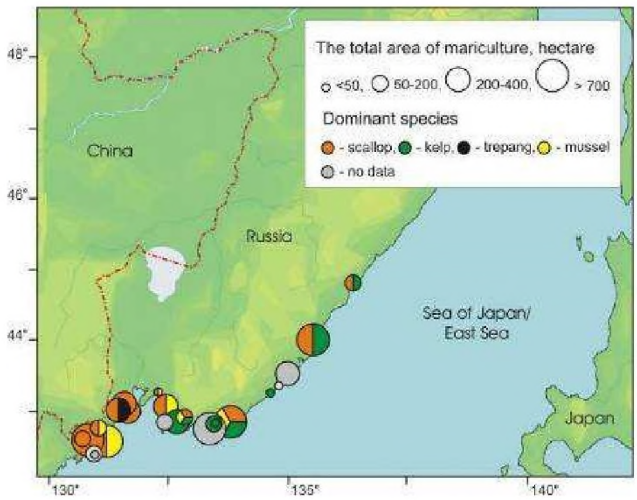


Figure 36. The map of aquaculture farms in Primorye

3 Evaluation of pilot assessment

One of the objectives of this pilot assessment is to clarify available data on major pressures/threats to marine biodiversity, namely eutrophication, non-indigenous species and habitat alteration in the NOWPAP member states. Through the pilot assessments, the gaps in data availability among the member states were identified. The common indicators which are available in all of the four member states are only dissolved inorganic nitrogen and phosphorus on eutrophication, but no common indicators are available everywhere on non-indigenous species or habitat alteration. This pilot assessment found a lack of many key indicators in the member states.

[Eutrophication]

In China, eutrophication status was assessed using DIN and active phosphate (AP). In both target sea areas (Site A and B), the concentration of DIN and AP were close to the values in the national standards, and there is no clear signal in water quality (suspended solids, dissolved oxygen, and chemical oxygen demand). The sea water quality in Changhai and Changdao County is good, and there is no potential risk of eutrophication. In recent years, however, DIN and AP both have an increasing trend in Changhai County, and continual monitoring and assessment are necessary. Both counties are located near big cities, Dalian and Qingdao. The influence from these big cities would be considered for understanding the impact of eutrophication on the sea areas in the future.

In Japan, eutrophication status was assessed using indicators of TN, TP, DIN, riverine input of nutrient and chlorophyll-a. In several sea areas located near river mouths and big cities, the values of indicators are high and the areas are identified as eutrophic. It is shown that some indicators had an increasing trend in the last seven years, and continual assessment is needed. Most of the indicators show that the impacts from land had decreasing trends except for those in Fukuoka. The concentration of population and industries cause increasing impacts from land. Appropriate managements along with the change in social and economic situations should be considered in such developing areas.

In Korea, the dike construction gives a huge impact to the environmental change in the wide tidal flat area. Before and after the dike enclosure, nutrient condition, transparency and chemical oxygen demand were changed. Fortunately, the area didn't become eutrophic by the dike construction; however, in general, such a huge coastal development gives a huge impact on not only the marine environment but also marine ecosystems.

In Russia, eutrophication status was assessed using TN, TP, nitrate, dissolved silica, and river and wastewater input. In some sea areas of Peter the Great Bay, TN and nitrate had an increasing trend in the last five years. In addition, riverine input of phosphate is increasing in some rivers. The source of phosphate is wastewater, so, treatment of wastewater is necessary.

As shown above, only dissolved nitrogen and phosphorus are common available indicators for assessing pressures/threats of eutrophication. Total nitrate and phosphorus and chlorophyll-*a* are important indicators; however, they are not available in some member states. Similar information gap happens in the case of indirect indicators. Use of fertilizer, population, and land use are useful indirect indicators to understand the causes of eutrophication: however, they are available only in some countries.

Such gaps/differences of data availability were also mentioned in the past CEARAC's activity "Development of Common Procedure for Assessment of Eutrophication Status including evaluation of land-based sources of nutrients for the NOWPAP Region (NOWPAP Common Procedure)". The NOWPAP Common Procedure which was developed in 2009 shows the potential assessment indicators through the Toyama Bay case study. Each member state applied the NOWPAP Common Procedure and tried eutrophication assessments using available data. As shown in Table 11, member states used their own indicators due to the difference of monitoring by countries.

At least, it is important to grasp the current status of the marine environment and country/region-unique characteristics of pressures/threats by utilizing/analyzing available information.

However, in the future, it is necessary to select common monitoring parameters among the member states for a common assessment in the NOWPAP region.

Table 11. Parameters used in the NOWPAP member states (NOWPAP CEARAC 2011)

Category	Assessment parameters	China	Japan (Northwest Kyushu)	Japan (Toyama Bay)	Korea	Russia
I	Riverine input of TN		✔	✔	✔	✔
	Riverine input of TP		✔	✔	✔	✔
	Riverine input of DIN	✔				✔
	Riverine input of DIP	✔				✔
	Sewage plant input of TN		✔			
	Sewage plant input of TP		✔			
	TN concentration		✔	✔	✔	
	TP concentration		✔	✔	✔	
	Winter DIN concentration		✔	✔	✔	
	Winter DIP concentration		✔	✔	✔	
	Winter DIN/DIP ratio		✔	✔	✔	
	Annual mean DIN concentration	✔				✔
	Annual mean DIP concentration	✔				✔
	Annual mean DSi concentration					✔
	Annual mean DIN/DIP ratio	✔				✔
II	Annual maximum of chlorophyll-a	✔	✔	✔		✔
	Annual mean of chlorophyll-a	✔	✔	✔	✔	✔
	Ratio of area with high chlorophyll-a concentration				✔	
	Red tide events	✔				
	Red tide events (diatom sp.)		✔	✔	✔	
	Red tide events (dinoflagellate sp.)		✔	✔		
III	Annual minimum DO (surface)		✔	✔		✔
	Annual minimum DO (bottom)					✔
	Annual mean DO (surface)				✔	
	Annual mean DO (bottom)	✔			✔	
	Fish kill incidents		✔	✔	✔	✔
	Annual mean COD	✔	✔	✔	✔	
IV	Red tide events (Noctiluca sp.)		✔	✔	✔	
	Shellfish poisoning incidents		✔	✔	✔	
	Benthic fauna and flora					✔
	Kill fishes					✔

[Non-indigenous species]

Regarding non-indigenous species (NIS), the most basic information, the number and distribution of NIS, is not available in most member states. There are no common direct and indirect indicators on NIS. In particular, the Korean pilot assessment focused on the impact of the dike enclosure on eutrophication, thus not all indicators are available in Korea.

NOWPAP DINRAC (Data and Information Network Regional Activity Centre) has published “Regional Overview and National Reports on the Marine Invasive Species in the NOWPAP Region” and “Atlas of Marine Invasive Species in the NOWPAP Region”. According to these reports, the situation of NIS in the NOWPAP member states is: 37 species are reported in China, 30 exotic species have been identified in Japan, there are 41 species suspected to be invaders in Korean coastal waters, and 31 marine invasive species were known by 2010 in Russian waters. The reports also show characteristics of NIS introduction in each country. For example, out of 37 invasive species in China, 26 are found in the Chinese pilot study area, and most of them are transferred through aquaculture. On the other hand, most of NIS found in Japan are through ship ballast water. These characteristics should be considered in the selection of indicators.

In China, information on aquaculture of NIS is available. To monitor the cultured species is useful for assessment of the impact of NIS.

In Japan, the status of NIS is assessed based on its distribution. However, monitoring of NIS isn’t implemented regularly. To find the change in NIS, a national framework for regular monitoring is expected to be implemented. In the case of Japan, one of the main routes of NIS is foreign ships. The number of foreign ships and the volume of discharged ballast water are key indicators in the assessment of the impact of NIS. In addition, Japan is also engaged in aquaculture. In recent years, introduction of foreign species is not active, but NIS such as *Glossaulax didyma* is crossed accidentally with other indigenous commercial species in Japanese coastal waters. To prevent such accidental introduction, a careful check is required before indigenous commercial species are stocked into the ocean.

In Russia, the status of NIS is assessed using scientific historical data. In addition to the anthropogenic introduction, climate change is another reason for NIS presence in Russia. Warm-water species migrate into the Russian coastal waters through the branch of the Tsushima Current. The number of migrant species from southern regions has been increasing in recent years, and it is a concern that they root in the Russian coastal waters due to the warmer sea water created by climate change.

The characteristics of NIS introduction differ from country to country. Therefore, it may be appropriate to select indicators based on the situation of each country.

[Habitat alteration]

There aren't so many data available on habitat alteration in the NOWPAP member states with the exception of Japan. The Northwest Pacific region is one of the areas where coastal development is increasing due to the rapid economic growth. Coastal development causes habitat loss for marine species, namely seagrass/seaweed beds, tidal flats and rocky shores. In order to understand the impact of habitat alteration on marine biodiversity, it is expected that the member states start and strengthen monitoring/survey in their respective sea areas.

In China, habitat in both counties has been strictly protected in according with relevant regulations.

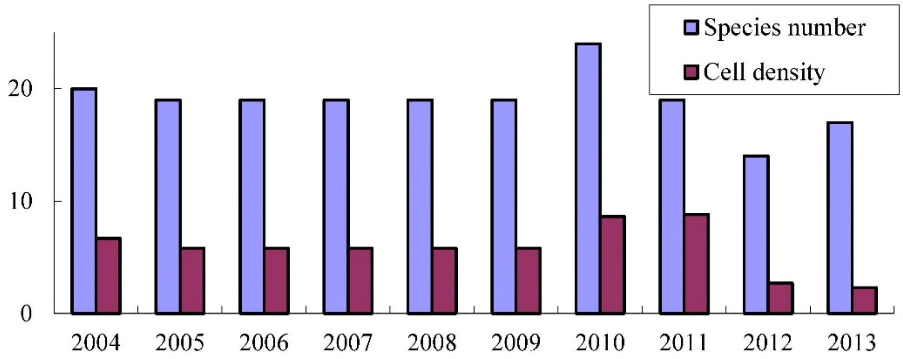
In Japan, the status of habitat alteration is assessed using data on natural coastline, landfills, dredging/collection of sea gravel, and the number of dams. Increase of artificial coastline and landfills leads to loss of natural habitats for marine species in the coastal area. In Toyama, natural coastline is lost for coastal protection against erosion, and in Fukuoka, landfill activities are still on-going. In both prefectures, habitat loss is a concern, and the eco-friendly construction is expected to be applied in the coastal areas instead of the existing concrete structures. Increase of dredging and dams cause loss of sandy bottom habitats. Sandy bottom creates seagrass beds and hiding places for benthic species. In the north Kyushu sea area, dredging of sea gravel is still continued even though dredging of sea gravel is prohibited in other sea areas in Japan. It is expected that this situation will be changed in the future for the conservation of marine species.

[Impacts to marine biodiversity]

NOWPAP member states collected related information on biodiversity in each target sea area. However, in this pilot assessment, the relationship between threat and impact on biodiversity was not assessed. In order to assess the impacts of major pressures/threats on marine biodiversity, scientific study on pressures/threats is necessary. At this moment, only available related information on marine biodiversity is shown in the pilot assessment.

China has information on the number and cell density of phytoplankton species, and the number and density of benthic species (Figure 37). In Changhai County, 14-24 phytoplankton species are observed and their cell density ranged between 2.3×10^4 and 8.8×10^4 cells/L, and 5-10 benthic species with their density between 1.5×10^2 and $1.8*10^2$ indiv./L. According to the latest research, marine organisms including 43 phytoplankton species, 38 zooplankton species, and 72 benthic species are reported in Changdao County. The abundance and density of zooplankton and benthic species are 11.44 to 253.54 mg/m^3 and 27.5 to 725.6

indiv./m^3 in zooplankton, and 1.05 to 42.14 g/m^2 and 205 to 955 indiv./m^2 in benthic species respectively.



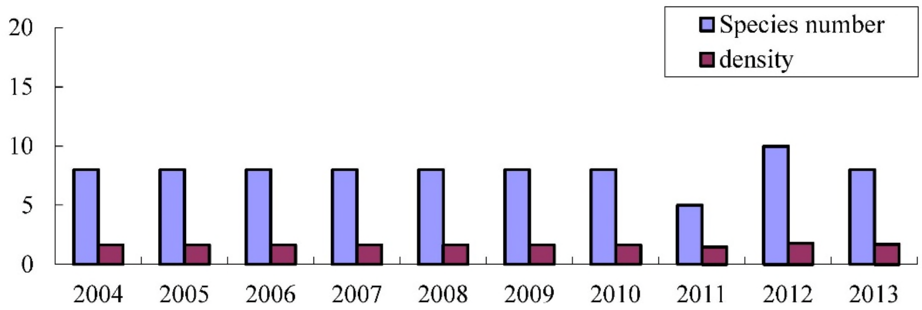


Figure 37. The number and cell density of phytoplankton (Up) and the number and density of benthic species (bottom) in Changhai County

The target sea areas in China are not in eutrophic condition now. However, monitoring of the nutrient condition and the change of marine species in the areas is important. This monitoring may clarify the impact of eutrophication on marine species. Fishery production, especially aquaculture production in the target sea areas, has been increasing rapidly in the last few years. Overfishing and aquaculture of non-indigenous species (NIS) may change the ecosystem in the target sea areas. Continuous study and appropriate management based on the study results are important to be implemented in these areas.

In Japan, information on fish catch in coastal areas (Figure 38) and distribution of seagrass/seaweed (Figure 39) is available. Fish catch in the target sea areas has no trend or a slightly decreasing trend. Main fishery target species are different in each Prefecture; however, the catch of main species has a decreasing trend. It is expected that the impacts related to the change of fish catch in each local area will be identified and understood. Regarding seagrass/seaweed beds, there is no significant change in each target sea area.

Seagrass/seaweed beds are habitats for juvenile fish, so preserving seagrass/seaweed beds contributes to marine biodiversity conservation. However, huge areas of seagrass/seaweed beds were lost by coastal development in the 1970s to the 1980s in Japanese coastal waters. It is important to keep the current situation or improve the situation to bring it back to the past one, if possible. In addition to the information above, local fishery agencies developed lists of fish species in the target sea areas, and they are useful data to understand marine biodiversity and to find NIS in each sea area.

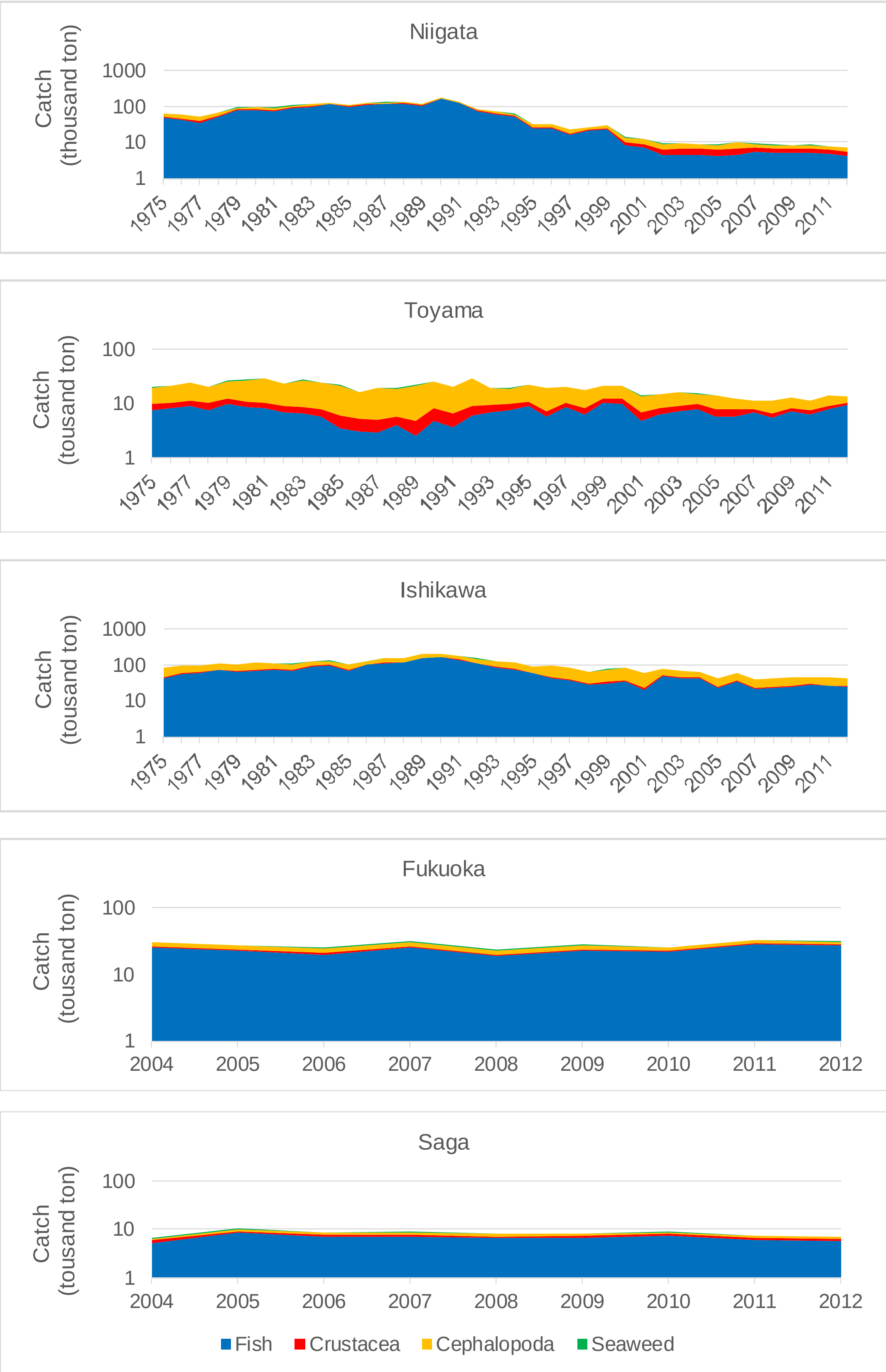


Figure 38. Fish catch in the target sea areas in Japan

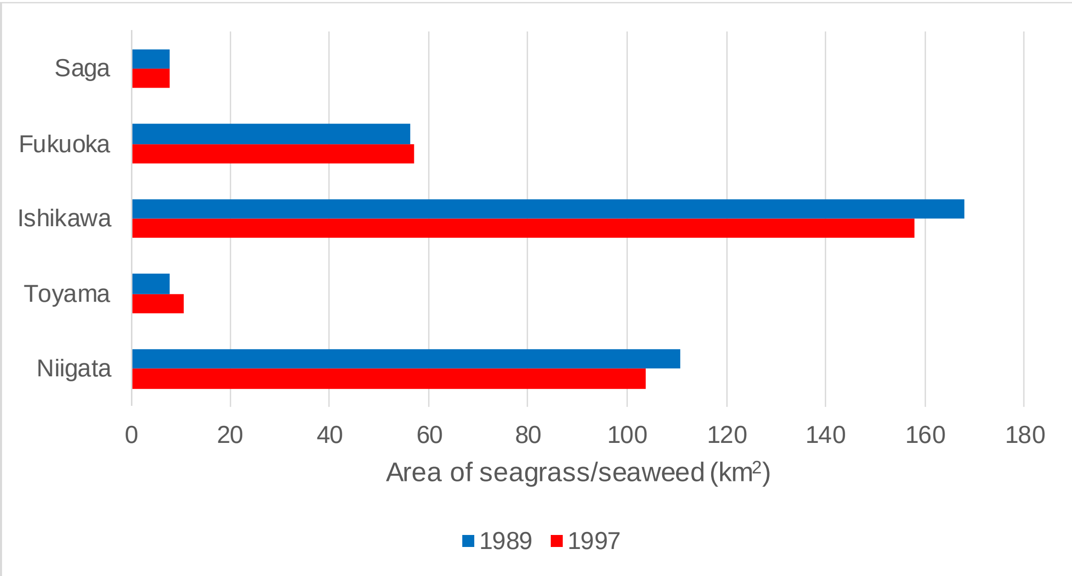


Figure 39.　Area of seagrass/seaweed bed in the target sea areas in Japan

In Korea, dominant phytoplankton species were monitored before and after the dike enclosure (Table 12). Before the dike enclosure, the dominant phytoplankton group was diatoms. However, it was changed to dinoflagellate, *Prorocentrum minimum*, and silicoflagellates, *Dictyocha speculum* in 2007 with dike construction. In 2008, after the dike enclosure, besides diatoms, there were blooms of Euglena sp., Silicoflagellate and Cryptomonads, and these species have become the dominant groups. Such changes in dominant groups indicate changes of the marine environment in the inner part of the dike. Not only nutrient condition but also water transparency influence the change. Dike enclosure also gives influences to benthic species. Before the final closure of the dike, benthos population did not show structural discontinuity between the inshore and the offshore areas; however, after the completion of the dike, benthic species were changed. *Magelona* sp.-*Sternaspis scutata* (*S. Scutata*) gathering and *Echinocardium cordatum* (*E. cordatum*) gathering were formed. In the inshore sea area, a gathering represented by Theora fragilis (*T. fragilis*)-*Melita* sp. was newly formed. In spring of 2009, organic pollution indicators, such as Musculista senhousia (*M. senhousia*), capitella capitata (*C.capitata*), Spionidae *P. ligni,* Scoletoma longifolia (*L. longifolia*), Monocorophium acherusicum (*M. acherusicum*) accounted for most of the benthos population in the inshore sea area. In addition, Theora fragilis, which is an organic pollution indicator, appeared in the sea area near Sinsi floodgate and the northern offshore sea area, and it was considered that disruption of the benthos population was ongoing. After the final closure of the dike, the stability of the benthos population in Saemanguem inshore sea area decreased remarkably, and the offshore sea areas, such as areas near tidal gates and the northern sea area, were rated as “pollution is ongoing". The abundance of commercial shellfish resources has been changed little by little. Change of the marine environment due to the dike construction will influence higher trophic species in the future.

Table 12. Long-term variation of dominant phytoplankton species in the inner dike

Time		Dominant species
Year	Month	
2002	Apr. May Aug.	*Eucampia zodiacus* *Leptocylindrus danicus* *Skeletonema costatum*
2003	Feb. May Aug.	*Skeletonema costatum* *Eucampia zodiacus* *Chaetoceros* spp., *Eucampia zodiacus*
2004	May Jul. Sep.	*Pseudo-nitzschia pungens*, *Eucampia zodiacus* *Eucampia zodiacus* *Chaetoceros debilis*, *Skeletonema costatum*
2005	Feb. May Jul. Sep.	*Asterionellopsis kariana*, *Skeletonema costatum* *Thalassiosira* sp. *Eucampia zodiacus*, *Skeletonema costatum* *Skeletonema costatum*, *Chaetoceros socialis*
2006	Mar. May Jul. Sep.	*Skeletonema costatum*, *Asterionellopsis kariana* *Cylindrotheca closterium*, *Paralia sulcate* *Chaetoceros* sp., *Pseudo-nitzchia* sp. *Chaetoceros debilis*, *Eucampia zodiacus*
2007	Mar. May Jul. Oct.	*Eucampia zodiacus* *Prorocentrum minimum* *Dictyocha speculum*, Small dinoflagellate group *Prorocentrum minimum*
2008	Mar. May Jul. Oct.	*Euglena* sp., *Dictyocha speculum* *Euglena* sp., *Dictyocha speculum*, *Cryptomonas* sp. *Skeletonema costatum*, *Cryptomonas* sp. *Cyclotella* sp., *Chaetoceros* sp., *Cylindrotheca closterium*
2009	Mar. May Jul. Sep.	*Eucampia zodiacus*, *Heterocapsa triquetra*, *Skeletonema costatum* *Leptocylindrus danicus* *Skeletonema costatum*, *P. minimum*, *Cryptomonas* sp. *Thalassiosira* sp., *Chaetoceros* sp., *P. minimum*

In the Russian pilot assessment, some impacts of pressures/threats on marine species are introduced using existing scientific papers. As a result of anthropogenic impacts and coastal runoff, namely, climate change and eutrophication, mass development of phytoplankton and oxygen deficiency happened. These changes created the optimal conditions for mass reproduction of large scyphoid jellfish, the number of which in Peter the Great Bay has increased dramatically. These huge jellyfish clog fishing nets and eat away fish eggs and fries. Eutrophication and siltation are the most probable obstacles for the full recovery of benthos communities in Peter the Great Bay. In the analysis of macrobenthos communities in Peter the Great Bay in 2003, compared with those in 1970, a significant increase of macrobenthos biomass is shown. This increase was provided by bivalves and cirripedia in the inner parts of Peter the Great Bay, and by holothurians in the outer parts. The greatest qualitative and quantitative changes of flora have taken place in the zones where it faces anthropogenic pressure through direct influence by the Razdolnaya River. Communities of dominant kelps and seagrasses were reduced; extensive associations of seagrasses have disappeared in these sites.

The threat of aquaculture is also mentioned. Aquaculture in Peter the Great Bay grew exponentially and increased its production more than 10 times during the last five years. Aquaculture facilities change not only hydrological conditions such as water exchange but also the environment and ecosystem structures in adjacent sea areas. Aquaculture facilities provide habitats for fouling species, and cultured and fouling species filter a significant volume of phytoplankton and zooplankton as feed. Increase of cultured and fouling species changes the phyto- and zooplankton communities (Figure 40). In addition to feeding, cultured and fouling species discharge a large volume of excrement. It changes the bottom environment and benthic species. There are many scientific reports on the impact of aquaculture, and such information is very useful to assess the impact of pressures/threats to marine biodiversity.

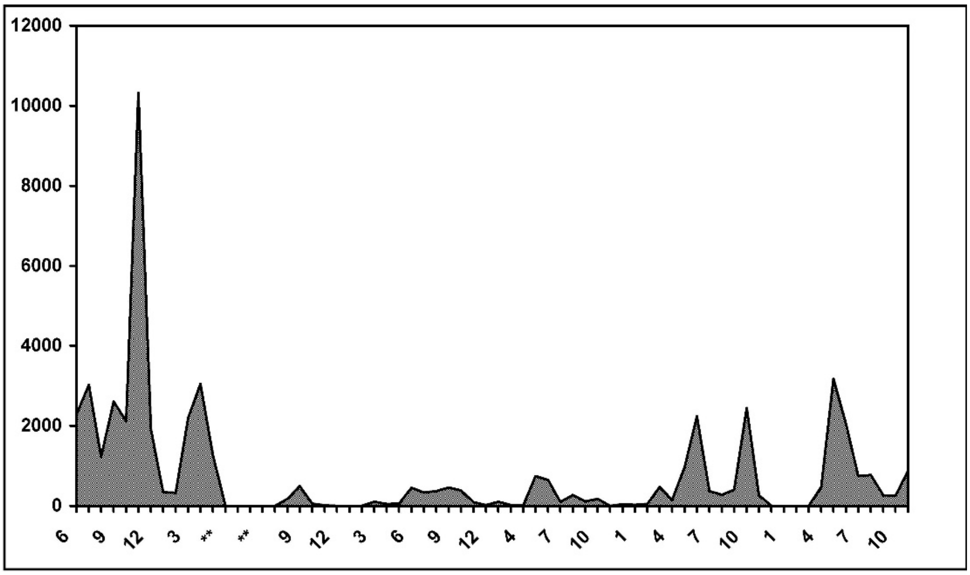


Figure 40. Overall number of larval plankton in Alekseev Inlet during the years (1986-1990) of the mariculture plantations operation: Abscissa axis indicates time (month) and ordinate axis indicates larval density (indiv./m^3)

4 Recommendation

The pilot assessments in this study are the first step for the development of a new assessment methodology to assess the impact of pressures/threats to marine biodiversity. Each member state collected available data on eutrophication, non-indigenous species and habitat alteration in their respective target sea areas. There are gaps in data availability among the member states, and the common available indicator is quite limited. However, there are other useful materials which were developed by past NOWPAP activities. Using such information, the gaps may be filled up. Moreover, the member states are expected to monitor and accumulate more data and information in the future. Fortunately, each member state has enhanced their actions on marine biodiversity conservation in order to achieve the Aichi Targets. Through the measures taken by each member state, it is also expected that additional information and data will be available in the near future. To assess the marine environment using common indicators, a collaborative regional program will be needed.

These pilot assessments show the characteristics/differences of the situation of pressures/threats among the member states. In Japan and Russia, ship transportation is a concerning route for expansion of NIS. In Korea, habitat alteration, dike construction, is a more concerning threat to marine biodiversity. Dike enclosure changed the ecosystem structure in the target sea area. Same as in Korea, habitat alteration has a huge impact on marine biodiversity in Japan. Coastal development is still on-going, and natural coast and habitats have been lost. Appropriate indicators may be different depending on the situation of the member states. When development of a new assessment methodology is considered in the next step, different concerns in each member state should be reflected in the discussion.

As the second step for the development of a new assessment methodology, CEARAC plans to assess the current situation of major pressures/threats on marine biodiversity using the outputs of the pilot assessments. Based on the pilot assessment, potential assessment indicators will be selected and potential assessment standards also will be set. Using potential assessment indicators and their standards, the current situation of three pressures/threats will be shown. In addition, the impacts of three pressures/threats to marine biodiversity should be described. Each member state provided involved information on marine biodiversity such as fish catch, composition of phytoplankton and zooplankton in this pilot study. However, the relationship between pressures/threats and marine biodiversity was not studied. It is difficult to show the relationship with limited data and information. Therefore additional collection of scientific papers on the study of the impacts should be done.

For future assessments in the NOWPAP region, we can refer approaches implemented by the North Pacific Marine Science Organization (HELCOM). HELCOM has conducted a holistic assessment of the ecosystem health of the Baltic Sea (HELCOM, 2010) and set their vision and goals with ecological objectives. In the holistic assessment, the status of marine biodiversity, eutrophication, hazardous substances and maritime activities were assessed based on ecological objectives, and several human activities and pressures were assessed using the Baltic Pressure and Impact Index. NOWPAP POMRAC (Pollution Monitoring Regional Activity Centre) plans to develop the ecological quality objectives for the NOWPAP region. Therefore, such approach can be applied to the assessment of the impacts of threats in the NOWPAP region.

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