NOWPAP CEARAC

Northwest Pacific Action Plan

Special Monitoring and Coastal Environmental Assessment

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Assessment of major pressures on marine biodiversity in the NOWPAP region

NOWPAP CEARAC 2018

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Contents

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Executive Summary

The Northwest Pacific region (NOWPAP region) is one of the sea areas with rich biological diversity in the world. On the other hand, this region is the most populated area with high economic growth, and there are many anthropogenic impacts on marine biodiversity.

The Aichi Biodiversity Targets set Strategic Goal B to reduce the direct pressures on biodiversity and promote sustainable use. In order to contribute to the achievement of Strategic Goal B in the NOWPAP region, it is necessary to understand the situation of pressures and their impacts on marine biodiversity and share the findings among the NOWPAP member states.

As the first step, the Special Monitoring and Coastal Environmental Assessment Regional Activity Centre (CEARAC) had implemented pilot assessment on the impacts of major threats to marine biodiversity in the NOWPAP region in the 2014-2015 biennium, in order to collect available data for assessing the impacts of three major pressures, namely eutrophication, non-indigenous species and habitat alteration, in the selected sea areas of the NOWPAP member states. This report is constructed based on the outputs of the pilot assessment and other outcomes of past NOWPAP biodiversity-related activities.

In this report, eutrophication, non-indigenous species, and habitat alteration are focused on as major pressures on marine biodiversity, and the current situations of these three pressures are assessed using the DPSIR framework. The DPSIR framework is widely used in order to understand the links between human pressures and changes in the state of marine environments. In this report, “Drivers” are economic and social activities related to eutrophication, non-indigenous species, and habitat alteration. Starting from “Drivers”, interrelations among “Pressures” (emissions, changes of landscape), “States” (physical, chemical and biological status) and “Impacts” on ecosystem and biodiversity are explained. Actions against three major pressures by the central governments are introduced as “Responses” for conservation of marine biodiversity.

Through the assessment using the DPSIR framework, this report provides the first systematic overview on the impacts of major pressures on marine biodiversity in the NOWPAP region. The states of the three major pressures are becoming worse due to the rapid economic growth in this region, despite various measures taken by the countries in the NOWPAP region.

There are several key elements of these three major pressures. Among the anthropogenic impacts of three major pressures, aquaculture is common in the NOWPAP region. Aquaculture is related to two pressures. Feed for cultured fish is one of the major sources of nutrient in the ocean. Aquaculture of non-indigenous species is one of the pathways of introduction of non-indigenous species in nature. Aquaculture is not a unique driver in other regions; however, its impact on marine biodiversity is quite strong in the NOWPAP region.

The NOWPAP member states have been taking effective actions to address the pressures; however, they may be insufficient for addressing the growing pressures on marine biodiversity. Providing scientific assessment through this report is a key element for policymakers of the member states to increase their understanding in order to make better decisions. It is hoped that this report will contribute to the achievement of Strategic Goal B of the Aichi Biodiversity Targets in the NOWPAP region and in the respective NOWPAP member states.

I. Introduction

[Regional Overview]

Northwest Pacific region is one of the sea areas with rich biological diversity in the world. Warm and cold ocean currents create a unique marine environment where sub-tropical, temperate and cold water marine species can cohabit (Figure 1). However, in the NOWPAP member states, the People's Republic of China (China), Japan, the Republic of Korea (Korea) and the Russian Federation (Russia), the characteristics of the marine environments are different from each other.

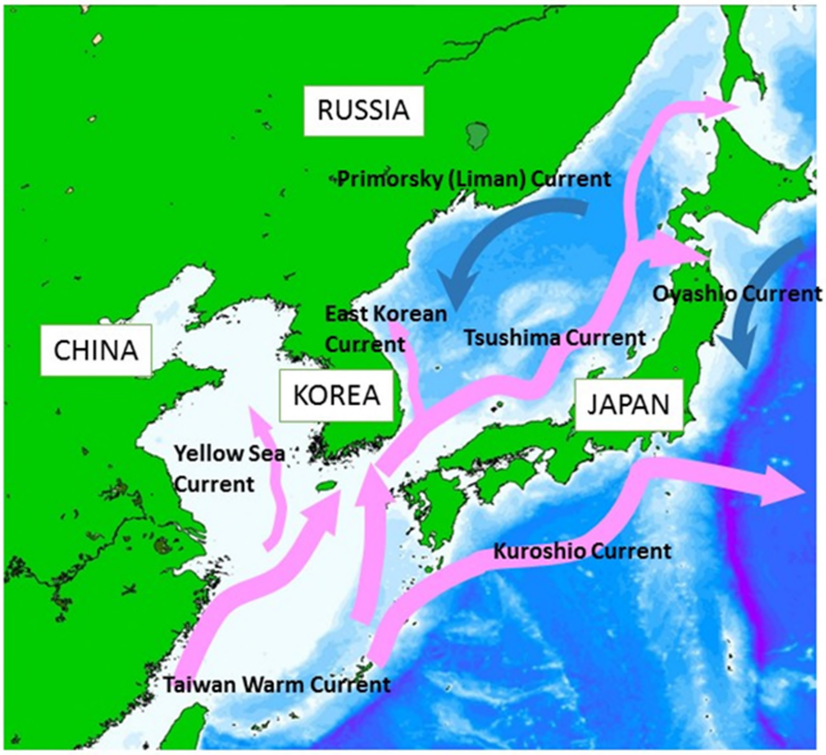


Figure 1 Ocean current in the NOWPAP region

Pink arrows indicate warm current and blue arrows indicate cold current

China faces the Yellow Sea, the East China Sea, and the South China Sea. The water depth in these sea areas is shallow since continental shelf covers most of the areas. These sea areas are main spawning grounds of many fishery species in the Northwest Pacific region and their productivity is high. The Taiwan Warm Current flows northward along the Chinese coast, and the Kuroshio Current flows in the offshore area.

Japan is an island country surrounded by the sea. The southern part of Japan faces the Pacific Ocean, and the Kuroshio Current flows along Japanese islands. Due to this warm current, the climate of the southern part of Japan is temperate, and coral reefs are formed in some coastal areas. The eastern side of Japan also faces the Pacific Ocean, however, the Oyashio Current, a cold ocean current flows southward from the Sea of Okhotsk in that area. The Oyashio Current transports rich nutrient and good fishery grounds are formed in the offshore area of Tohoku region (the northern part of the Japan mainland). On the other hand, the northern part of the main island is an international semi-enclosed sea area surrounded by Korea and Russia. The Tsushima Warm Current transports heat and various substances into this sea area. Due to the Tsushima Warm Current, this coastal area is a temperate area.

Korea, located on the edge of the Northwestern Pacific, is surrounded by water on three sides (south, east, and west). With 13,000-kilometers of its coastline and approximately 3,100 islands lying adjacent, Korea is a great habitat for diverse marine species. There are vast mud flats and a considerable number of islands in the Yellow Sea, which is influenced by tidal currents, the seasonally formed Yellow Sea Bottom Cold Water Mass and Yellow Sea Warm Current. The shoreline is also well developed in the South Sea, which is influenced by the Tsushima Warm Current. While the eastern coast of Korea has a relatively long shoreline and smaller tidal difference, deep-sea basins exceeding 3,000m in depth exist. Such different marine environment can help more variation in marine species composition, and for that reason, it is reported that species richness is high in Korea. The key currents around the Korean Peninsula include the Yellow Sea Warm Current, the Tsushima Warm Current, the Kuroshio Current, the East Korea Warm Current, and the North Korea Cold Current.

The Far East part of Russia is located in the northern part of the NOWPAP region, and its climate is subarctic. Along the Russian coast, the cold Liman Current flows westward. In the winter season, most of the coastal area is covered by sea ice. At the offshore area of Vladivostok, surface seawater is cooled and sinks down into the deep sea, and forms the Deep Sea Proper Water.

When looked at other aspects, this region is one of the most populated and economically growing regions in the world, and anthropogenic impacts on marine biodiversity, such as discharge of chemical substances from land, coastal development, and fishery activities, are serious issues in coastal waters. For example, most of marine litter is generated on land and brought through rivers to the ocean. Such pressures are obvious in coastal waters. Various above-mentioned water currents spread coastal environmental anthropogenic alteration to offshore and even to the central part of the regional sea. Marine litter and micro-plastic particles are obvious examples. Gradual change of nutrient levels and consequent biodiversity should be observed more and more carefully.

[Background on marine biodiversity conservation]

The Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets were adopted at the tenth meeting of the Conference of the Parties to the Convention on Biological Diversity (CBD COP 10) held in 2010 in Japan. In the Aichi Targets, Strategic Goal B aims to reduce the direct pressures on biodiversity and promote sustainable use of biodiversity. Responding to the adoption of the strategic goals, some efforts have been made and/or under way at global, regional and national levels.

Regional Seas Programme of United Nation Environmental Programme (UNEP) published “Global Synthesis: A report from the Regional Seas Conventions and Action Plans for the Marine Biodiversity Assessment and Outlook Series” in 2010. In this report, Regional Sea Conventions and Action Plans assessed the marine biodiversity using common indicators on drivers, state, pressure, and response, which are based on a DPSIR (Driving forces- Pressure- State- Impact- Response) model identified in the Millennium Ecosystem Assessment Report.

Each NOWPAP member state has strengthened their activities for marine biodiversity conservation based on the Aichi Biodiversity Targets. China developed China National Biodiversity Conservation Action Plan in 1994 and China National Biodiversity Conservation Strategy and Action Plan (2011-2030) in 2007. Under these Action Plans, many national plans have been implemented. The Japanese government developed National Biodiversity Strategy in 1995 and updated it in 2002, 2007, 2010 and 2012. In addition, Marine Biodiversity Conservation Strategy which focuses on marine biodiversity was formulated in 2011. Korea has three important laws on marine biodiversity conservation: Act on the Conservation and Use of the Biological Diversity, the Third National Biodiversity Strategy (2014-2018), and Conservation and Management of Marine Ecosystem Act. These three laws were enacted in 2013, 2014 and 2008, respectively. Russia has established a number of laws related to biodiversity but has no special federal laws covering biodiversity issues exclusively. Russian Federation Law on the Environmental Protection, Russian Federation Law on Specially Protected Natural Areas and Russian Federation Law on Wild Animals and Others are national laws related to biodiversity conservation.

[Efforts for marine biodiversity conservation by NOWPAP CEARAC]

Recognizing current increasing attention and actions on marine biodiversity, CEARAC decided it as one of the major themes of its activities and has been working on conservation of marine biodiversity since 2010.

In the 2014-2015 biennium, CEARAC implemented a pilot assessment on the impacts of major threats to marine biodiversity in the selected sea areas in the NOWPAP region by focusing on three threats/pressures on the marine and coastal environment in the NOWPAP region, namely eutrophication, non-indigenous species and habitat alteration.

Issues on eutrophication and non-indigenous species were recognized as quite serious in the marine and coastal environment in the NOWPAP region, and NOWPAP Regional Activity Centres (RACs) had already implemented activities on these two pressures. So, we have had some experiences and knowledge on these issues. Habitat alteration is also a serious problem in the NOWPAP region. Coastal development due to the rapid economic growth is still continuing in this region, and it has caused reduction of precious habitats of marine species. Thus, CEARAC chose these three topics as major pressures on the marine biodiversity in this region.

We understand climate change is another big issue for marine biodiversity. In particular, global warming reported in assessment reports on climate change by the Intergovernmental Panel on Climate Change (IPCC) influences water temperature and accelerates ocean acidification. The change of water temperature causes change of distribution of marine species, and ocean acidification influences growth and reproduction of marine species such as coral (Iguchi et al., 2014, Sekizawa et al., 2017). However, research on the impact of climate change on marine biodiversity has been just started, and the data and information are still very limited. Therefore, we didn’t include this issue in this project.

Based on the results of the pilot assessment and available data from the past NOWPAP activities, CEARAC assessed the current status of major pressures on marine biodiversity in the NOWPAP region in the 2016-2017 biennium.

[Pressures on marine biodiversity]

In the first Global Biodiversity Outlook published in 2001, the report uses “impacts” as a word to indicate any influence on marine and coastal ecosystems. There are mainly five impacts on marine and coastal ecosystems: chemical pollution and eutrophication; fisheries operations; global climate change; alterations of physical habitat; and invasions of exotic species. In the Global Biodiversity Outlook 2 published in 2006, the report uses the word “threats” instead of “impacts”.

The International Expert Workshop on the 2010 Biodiversity Indicators and Post-2010 Indicator Development held in July 2009, use of four kinds of indicators, namely Responses, Pressures, State and Benefits was recommended to make it easier to understand, communicate and act upon when linked together in a set that connects policies to outcomes (UNEP/CBD/SBSTTA/14.INF/14). Based on the recommendation, the fourteenth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) used the word “pressures” and recommended urgent actions to curb five pressures directly driving biodiversity loss: habitat change; overexploitation; pollution; invasive alien species; and climate change (UNEP/CBD/SBSTTA/REC/XIV/7).

From the Biodiversity Outlook 3 on, the status of five pressures have been assessed and reported. Thus, our report uses “pressures” as a word to explain the impacts on marine biodiversity in the NOWPAP region.

II. Assessment data and method

[Assessment data]

To carry out an assessment of the three pressures on marine biodiversity, namely eutrophication, non-indigenous species and habitat alteration, pilot assessments were implemented in some selected sea areas in the NOWPAP member states in the 2014-2015 biennium. Each NOWPAP member state selected one to two areas: the coastal areas of Yantai and Dalian in China, North Kyushu Sea area and the coastal area of Hokuriku region in Japan, Saemangeum in Korea and Peter the Great Bay in Russia. In the process of comparing the assessment results, it was found out that available data in these areas to be used for pilot assessment were limited, so past outputs of some NOWPAP activities were also used in order to fill gaps.

NOWPAP CEARAC developed “Procedures for Assessment of Eutrophication Status including Evaluation of Land Based Sources of Nutrients for the NOWPAP Region

(NOWPAP Common Procedure)" in 2009, then implemented an assessment of the eutrophication status in some selected sea areas using this procedure. The assessment results were summarized in the "Integrated Report on Eutrophication Assessment in Selected Sea Areas in the NOWPAP Region: Evaluation of the NOWPAP Common Procedure" in 2011. Based on the first assessment in the member states, the NOWPAP Common Procedure were refined and the second assessment was implemented in the member states in the 2012-2013 biennium. Then, CEARAC published "Application of the NOWPAP Common Procedure for Eutrophication Assessment in Selected Sea Areas in the NOWPAP region" in 2013. Through these assessments, data of various kinds of assessment indicators were collected to assess the status of the impact of eutrophication in the NOWPAP member states. In the following 2014-2015 biennium, CEARAC conducted the preliminary assessment of the eutrophication status in the entire NOWPAP region. In this assessment, CEARAC used chlorophyll-*a* by satellite, Chemical Oxygen Demand (COD), and the occurrence of hypoxia and red tide as indicators. Data on the assessment indicators were collected in the four member states and they are available through the WebGIS developed by CEARAC (http://ocean.nowpap3.go.jp/WebGIS/). CEARAC also operates the "Marine Environmental Watch Project" (http://ocean.nowpap3.go.jp/?page_id=862) to provide marine environmental data by satellite remote sensing. Through this project, satellite images of chlorophyll-*a* in the NOWPAP region are available to the public.

NOWPAP Data and Information Network Regional Activity Centre (DINRAC) functions as a data and information center of NOWPAP and collects various data and information from the NOWPAP member states. DINRAC has developed a database on marine environmental data, and data on several indicators on eutrophication assessment is available through this database.

DINRAC published the "Atlas of Marine Invasive Species in the NOWPAP Region" in 2013. This report shows the occurrence and distribution of marine invasive species in all NOWPAP member states, and it is very useful to understand the status of the pressure of non-indigenous species in the NOWPAP member states. DINRAC also collected information on red lists of NOWPAP member states in the 2014-2015 biennium and provided information through the DINRAC website.

NOWPAP Pollution Monitoring Regional Activity Centre (POMRAC) published the "State of the Marine Environment Report for the NOWPAP region (SOMER 2)" in 2014 in collaboration with other RACs and relevant experts. In this report, the status of non-indigenous and invasive species, and habitat transformation due to construction and urbanization are reported, and such information can contribute to the assessment of the status of impacts by non-indigenous species and habitat alteration in the NOWPAP member states.

In Table 1, assessment data in the past NOWPAP activities which were used in this report are summarized. Besides the above-mentioned activities and reports, CEARAC has implemented several activities on harmful algal blooms (HABs) and published a report on feasibility studies towards assessment of seagrass distribution.

Table 1. Data for assessment of eutrophication

Major pressures	Assessment data	Sea area where data is available	Data sources
Eutrophication	Total nitrogen (TN) and phosphorus (TP)	North Kyushu sea area and coastal area of Hokuriku region in Japan Saemangeum in Korea Peter the Great Bay in Russia	Pilot assessment
		Jiaozhou Bay in China North Kyushu sea area and Toyama Bay in Japan Jinhae Bay in Korea	Eutrophication status assessment (2011 and 2013)
	Dissolved inorganic nitrogen (DIN) and phosphorus (DIP)	Coastal areas of Yantai and Dalian in China North Kyushu sea area and coastal area of Hokuriku region in Japan Saemangeum in Korea Peter the Great Bay in Russia	Pilot assessment
		Jiaozhou Bay in China North Kyushu sea area and Toyama Bay in Japan Jinhae Bay in Korea Peter the Great Bay in Russia	Eutrophication status assessment (2011 and 2013)
	River input of nutrient	North Kyushu sea area and coastal area of Hokuriku region in Japan Peter the Great Bay in Russia	Pilot assessment
		Jiaozhou Bay in China	Eutrophication

		North Kyushu sea area and Toyama Bay in Japan Jinhae Bay in Korea Peter the Great Bay in Russia	status assessment (2011 and 2013)
	Chlorophyll-*a* (field data)	North Kyushu sea area and coastal area of Hokuriku region in Japan Saemangeum in Korea	Pilot assessment
		Jiaozhou Bay in China North Kyushu sea area and Toyama Bay in Japan Jinhae Bay in Korea Peter the Great Bay in Russia	Eutrophication status assessment (2011 and 2013)
	Chlorophyll-*a* (remote sensing)	Whole of the NOWPAP region	Marine Environmental Watch Project
	Total volume of industrial wastewater discharge	Coastal areas of Yantai and Dalian in China North Kyushu sea area and coastal area of Hokuriku region in Japan Peter the Great Bay in Russia	Pilot assessment
	Use of fertilizer	Coastal areas of Yantai and Dalian in China North Kyushu sea area and coastal area of Hokuriku region in Japan Peter the Great Bay in Russia	Pilot assessment
	Feeding of aquaculture	North Kyushu sea area and coastal area of Hokuriku region in Japan	Pilot assessment

	Water quality	Coastal areas of Yantai and Dalian in China North Kyushu sea area and coastal area of Hokuriku region in Japan Saemangeum in Korea Peter the Great Bay in Russia	Pilot assessment
		Jiaozhou Bay in China North Kyushu sea area and Toyama Bay in Japan Jinhae Bay in Korea Peter the Great Bay in Russia	Eutrophication status assessment (2011 and 2013)
		All member states	Database of DINRAC
	Chemical Oxygen Demand (COD)	NOWPAP region in China, Japan, Korea and Russia	Preliminary Eutrophication Assessment
	Hypoxia	NOWPAP region in China, Japan, Korea and Russia	Preliminary Eutrophication Assessment
	Bottom environment	North Kyushu sea area and coastal area of Hokuriku region in Japan Saemangeum in Korea	Pilot assessment
	Red tide occurrences	North Kyushu sea area and coastal area of Hokuriku region in Japan Saemangeum in Korea	Pilot assessment

	Jiaozhou Bay in China North Kyushu sea are and Toyama Bay in Japan Jinhae Bay in Korea	Eutrophication status assessment (2011 and 2013)
	NOWPAP region in China, Japan, Korea and Russia	Preliminary Eutrophication Assessment
	NOWPAP region in China, Japan, Korea and Russia	Integrated Report on Harmful Algal Bloom for the NOWPAP region (2005, 2011)

Table 2. Data for assessment of non-indigenous species (NIS)

Major pressures	Assessment data	Sea area where data is available	Data sources
Non-indigenous species	Number of NIS	North Kyushu sea area and coastal area of Hokuriku region in Japan Peter the Great Bay in Russia	Pilot assessment
		NOWPAP region in China, Japan, Korea and Russia	Atlas of marine invasive species (DINRAC)
	Distribution of NIS	NOWPAP region in China, Japan, Korea and Russia	Atlas of marine invasive species (DINRAC)
		NOWPAP region in China, Japan, Korea and Russia	SOMER2(POMRAC)
	Endangered species	North Kyushu sea area and coastal area of Hokuriku region in Japan	Pilot assessment
		NOWPAP region in China, Japan, Korea and Russia	SOMER2 (POMRAC)
	Red lists	All member states	Database of DINRAC
	Protected species	Coastal areas of Yantai and Dalian in China North Kyushu sea area and coastal area of Hokuriku region in Japan	Pilot assessment
	Aquaculture of NIS	Coastal areas of Yantai and Dalian in China North Kyushu sea area and coastal area of Hokuriku region in Japan	Pilot assessment

		NOWPAP region in China, Japan, Korea and Russia	Atlas of marine invasive species (DINRAC)
		NOWPAP region in China, Japan, Korea and Russia	SOMER2(POMRAC)
	Volume of ballast water discharge	North Kyushu sea area and coastal area of Hokuriku region in Japan	Pilot assessment
	Port cargo	Coastal areas of Yantai and Dalian in China North Kyushu sea area and coastal area of Hokuriku region in Japan Peter the Great Bay in Russia	Pilot assessment

Table 3. Data for assessment of habitat alteration

Major pressures	Assessment data	Sea area where data is available	Data sources
Habitat alteration	Natural coastlines	North Kyushu sea area and coastal area of Hokuriku region in Japan Peter the Great Bay in Russia	Pilot assessment
	Landfills	North Kyushu sea area and coastal area of Hokuriku region in Japan Saemangeum in Korea	Pilot assessment
		NOWPAP region in China, Japan and Korea	SOMER2 (POMRAC)
	Dredging/collection of sea gravel	North Kyushu sea area and coastal area of Hokuriku region in Japan	Pilot assessment
	Number of dams	North Kyushu sea area and coastal area of Hokuriku region in Japan	Pilot assessment
	Seagrass bed distribution	Swan Lake in China Nanao Bay and Toyama Bay in Japan Jangheung Bay in Korea Eastern Section of the Far Eastern Marine Reserve in Russia	Feasibility study towards assessment of seagrass distribution

[Assessment method]

In this report, the DPSIR (Driving forces- Pressure- State- Impact- Response) framework is applied in order to understand impacts of three major pressures on marine biodiversity. The DPSIR framework is a widely adopted assessment method to determine and assess the links between human pressures and the state of marine and coastal ecosystems. It was developed based on the PSR (Pressure-State-Response) model, and used in the Organization for Economic Co-operation and Development (OECD), the European Union (EU), the US Environmental Protection Agency (EPA) and the European Economic Area (EEA). The DPSIR framework has five basic components. The first component is “Driving Forces” which shows the basic sectorial trends, namely trend of industry and agriculture and so on. The second component is “Pressure”, various human activities which directly affect the environment caused by driving forces. The third component is “State”, observable changes in the environment by pressures. The fourth component is “Impacts”, effects of the changed environment. And the fifth component is “Response”, actions of society and/or nations to solve the problems (Partricio et al. 2016).

In our project, since three major pressures (eutrophication, non-indigenous species, and habitat alteration) are often caused by human activities, it is appropriate to use the DPSIR framework in order to understand the driving forces, pressure, state, and impacts of these three major pressures on marine biodiversity as well as response to conserve the marine and coastal environment.

Then, in this assessment, “driving forces”, “pressure”, “state”, “impacts” and “response” of eutrophication, non-indigenous species and habitat alteration are defined as follows, respectively.

- **Eutrophication**

  Driving forces: Population, Industrial manufacturing (GDP), agricultural production, aquaculture

  Pressure: Discharge of nutrients

  State: Sea water quality

  Impacts: Influence on marine species and/or biodiversity

  Response: National actions/measures

- **Non-indigenous species**

  Driving forces: Transport by ship, aquaculture

  Pressure: Ballast water discharge, ship hull-fouling, aquaculture of non-indigenous species

State: Occurrence of non-indigenous species

Impacts: Influence on native species/endangered species

Response: National actions/measures, Number/area of MPAs

- **Habitat alteration**

  Driving forces: Coastal development

  Pressure: Change of coastal area and Landfill

  State: Loss of natural habitat and/or wetland area on the seashore

  Impacts: Influence on marine species/endangered species

  Response: National actions/measures

III. Status of major pressures in the NOWPAP region

- **Eutrophication**

  Driving forces: Population, Industrial manufacturing (GDP), agricultural production, aquaculture

  In recent years, most cases of eutrophication occured by anthropogenic activities such as wastewater discharge, and industrial and agriculture activities. The Northwest Pacific region is famous for its dense population along coastal areas as well as rapid economic development. Especially, rapid population and economic growth are happening in some countries (Figure 2 to 4), and they could trigger eutrophication unless proper treatment and management of those social changes are developed and furnished.

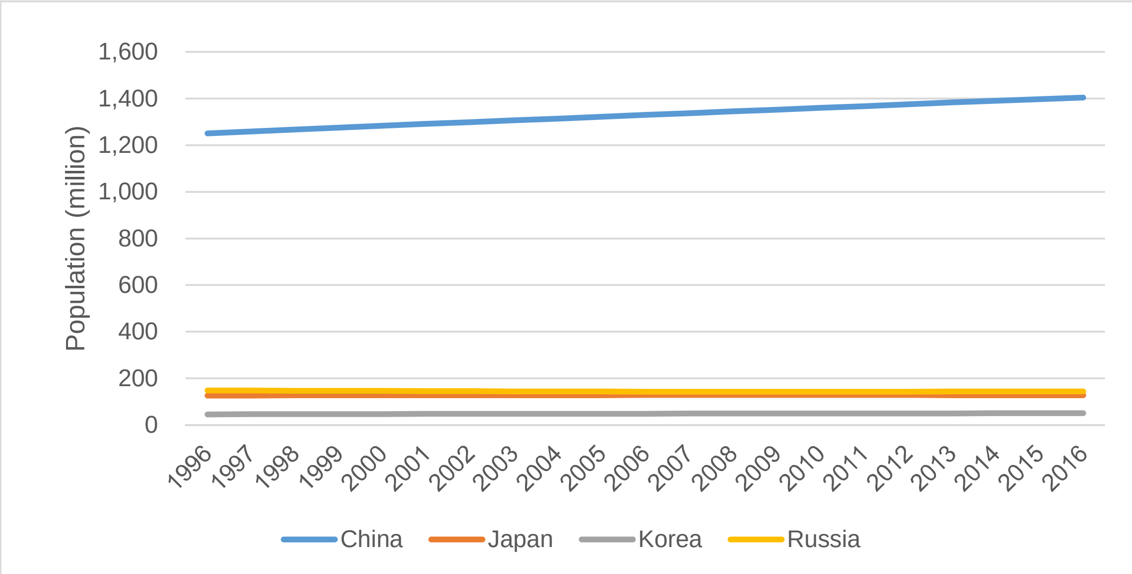


Figure 2. Population in the NOWPAP member states

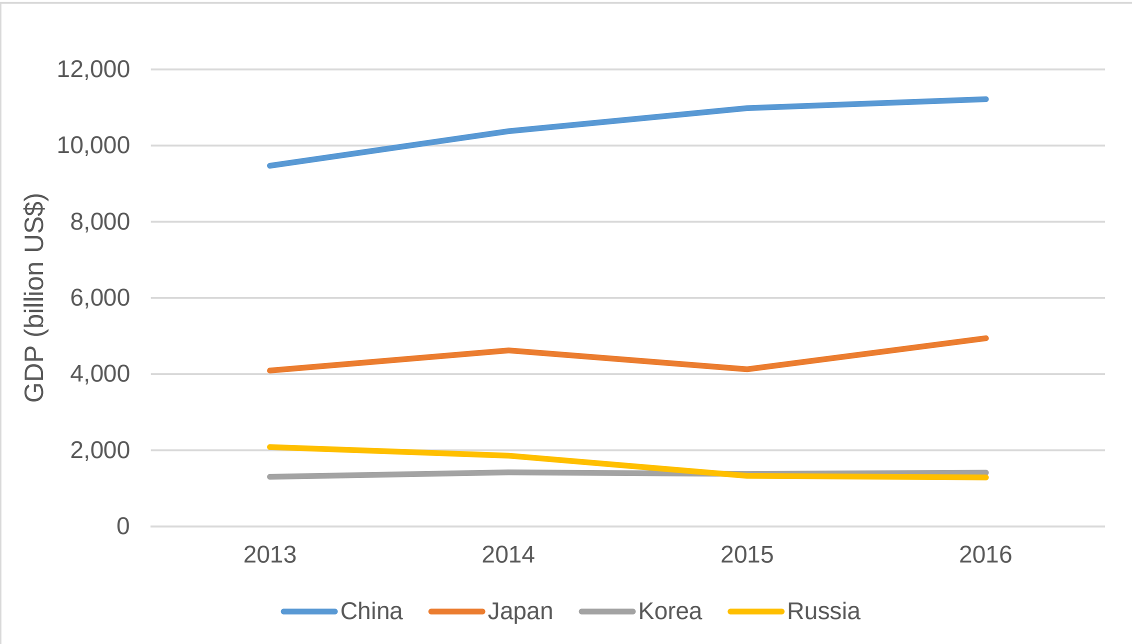


Figure 3. GDP of the NOWPAP member states

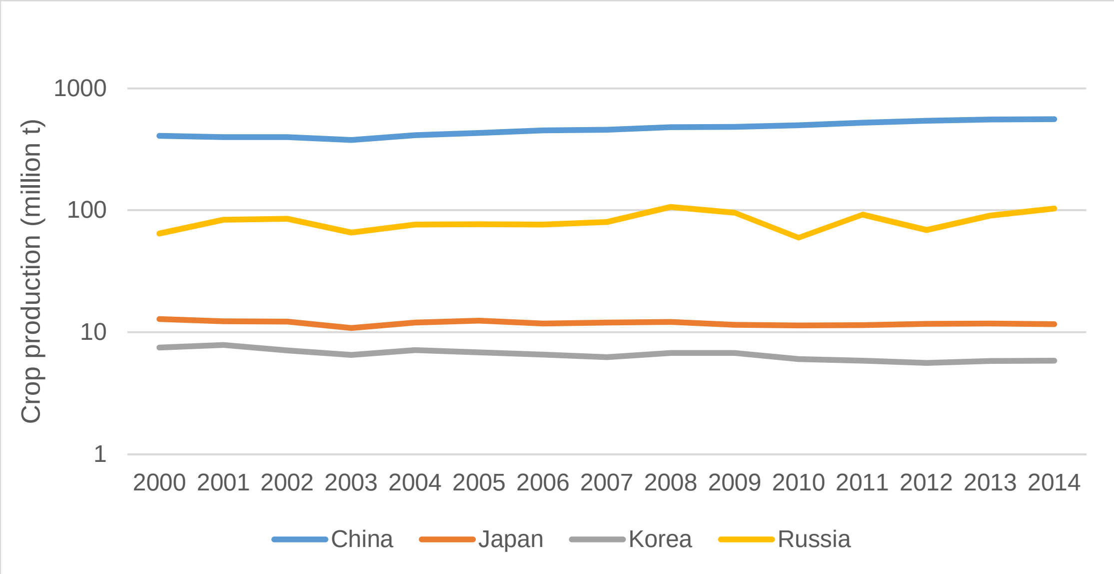


Figure 4. Crop production of the NOWPAP member states

In order to produce crops, fertilizers are widely used in the world. However, excess use of fertilizer causes pollution and eutrophication of groundwaters and coastal waters. To prevent eutrophication by excess use of fertilizers, the EU developed “Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural resources” in 1991. In Japan, each prefectural government has developed guidelines on the standard of fertilization in order to prevent excess use of fertilizers. In the NOWPAP member states, to meet the demand for food for people, a great volume of fertilizers is used in agriculture. Figure 5 shows the consumption of fertilizers per area of cropland in the NOWPAP member states. In China, the consumption of fertilizers has increased in the last decade and decreased from 2015.

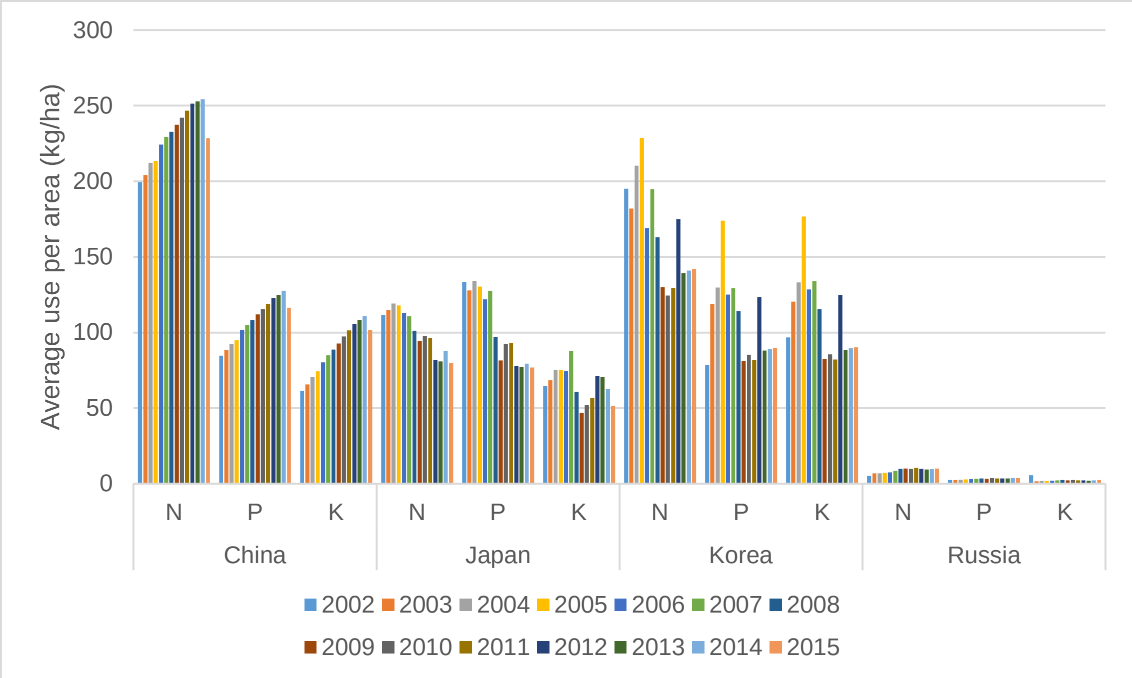


Figure 5. Average use of fertilizers (N: nitrogen, P: phosphate, K: potash) per area of cropland (Source: FAOSTAT)

In recent years, overall consumption of fertilizers is decreasing compared with past years due to technical evolution. However, a huge volume of fertilizers is still used for agriculture and it could trigger eutrophication in the coastal areas. Figure 6 shows the utilization of fertilizers in five prefectures in Japan. Gross agricultural production in 2016 is 189.7 billion Japanese Yen (JPY) in Niigata, 51.9 billion JPY in Toyama, 40.9 billion JPY in Ishikawa, 183.9 billion JPY in Fukuoka and 98.8 billion JPY in Saga. Prefectures which have high gross agricultural production trend to increase usage of fertilizers.

Figure 6. Utilization of fertilizer in Niigata, Toyama, Ishikawa, Fukuoka and Saga prefectures (from top to bottom) in Japan

In the world, aquaculture production has been increasing dramatically in the last few decades (Figure 7). Specifically, the NOWPAP region is the most active sea area in aquaculture operation in the world. In 2015, 60% of world aquaculture production was conducted in the four NOWPAP member states: 61 million tons in China, 1.1 million tons in Japan, 1.6 million tons in Korea and 0.1 million tons in Russia (Figure 8). These aquaculture productions include production in fresh water. Most of aquaculture is operated in freshwater areas; however, aquaculture in sea areas has been increasing in recent years.

In aquaculture in sea waters, fish and crustacean aquaculture is one of the causes of eutrophication. In general, aquaculture of shellfish and seaweed has a positive effect to reduce nutrient from seawater; however, to cultivate fish and crustacean, a huge volume of feed is used and it is one of the sources of nutrient supply. In addition, fecal production by shell-fish has negative impact on the bottom environment when dense aquaculture is operated. Large amount of fecal production causes eutrophication and hypoxia in bottom waters.

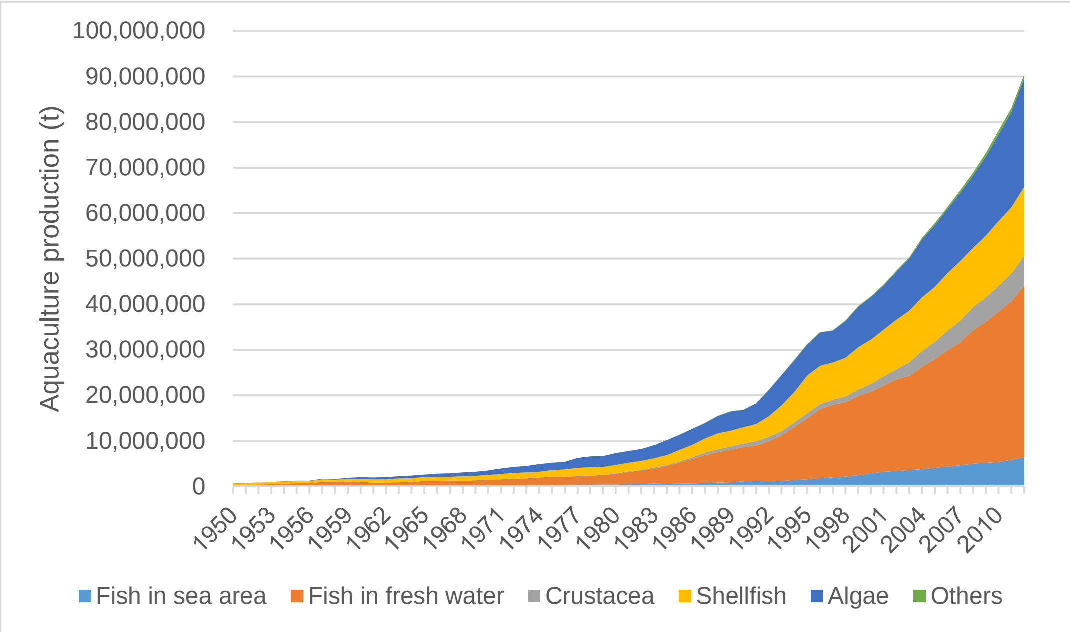


Figure 7. Aquaculture production in the world

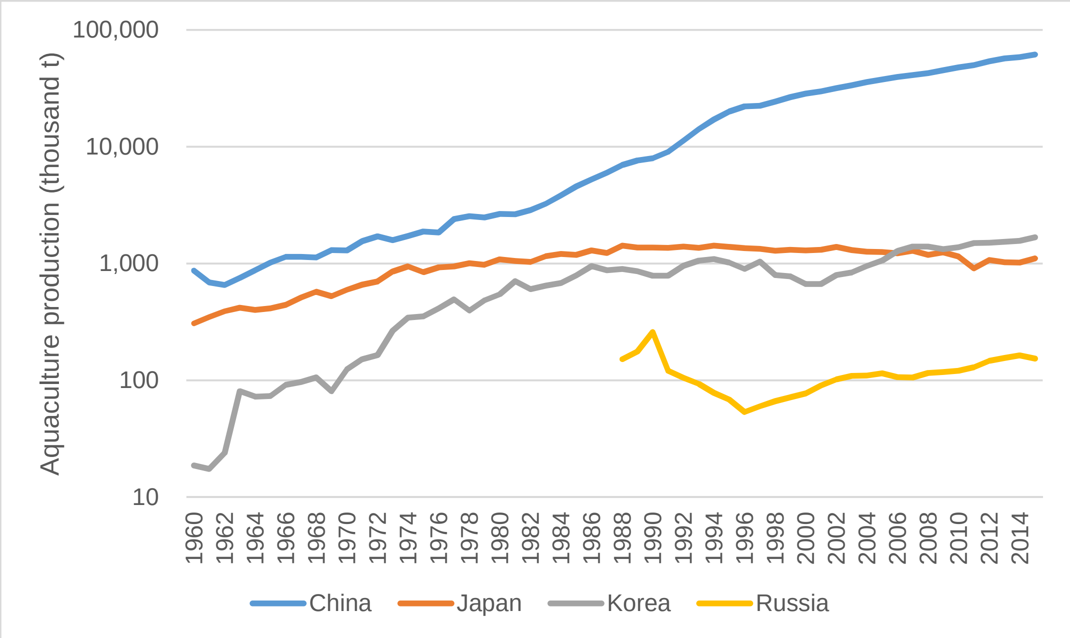


Figure 8. Aquaculture production in the NOWPAP member states
(Source: The World Bank)

<u>Pressure</u>: Discharge of nutrients

As shown in Figures 9 and 10, during the past two decades, total river discharge of nutrients (TN and TP) has not changed in three prefectures in Japan. River input in Niigata Prefecture is much higher than the other two prefectures because one of the biggest rivers in Japan runs through the prefecture. Total river discharge of nutrients is proportionate to the river input; therefore, nutrient supply is higher in Niigata Prefecture than in other prefectures. In addition, rivers often flow through agricultural areas, and it is another reason of rich nutrients in river waters.

In Russia, data on river discharge of the Razdolnaya River (Figure 11) are available. The Razdolnaya River is one major river flowing into the Peter the Great Bay, as 47 % of total river input to the Peter the Great Bay is from this river. Chemical characteristic of river discharge of the Razdolnaya River is COD: 21.2, BOD: 11.6, N (NH4+): 0.87, N (NO3-): 0.20 and P (PO43-): 0.071, (average data in 2001-2007) respectively. The trend of river discharge shows a slight increase.

In case of China and Korea, the trend of riverine input of dissolved inorganic nitrogen (DIN) and phosphorus (DIP) are shown in a CEARAC report (2013). In the inner part of Jiaozhou Bay in China, riverine input of DIN and DIP has an increasing trend. On the other hand, riverine input of TN and TP in Masan-Haengam Bay (in wider Jinhae Bay) in Korea shows a decreasing trend.

In some member states, nutrient discharge through rivers has an increasing trend. Population and economic growth are some of the reasons of increased nutrients, and the low number of water-treatment facilities may be another reason.

On the other hand, the situation in Japan is different from the other member states. In the 1960-70s, coastal areas of Japan became eutrophic due to rapid economic growth and population concentration. The Japanese government has controlled the total nutrient input in some eutrophic bays and sea areas. Under this regulation, the conditions of some large sea areas such as the Seto Inland Sea have been on improvement due to the decrease of nutrient input.

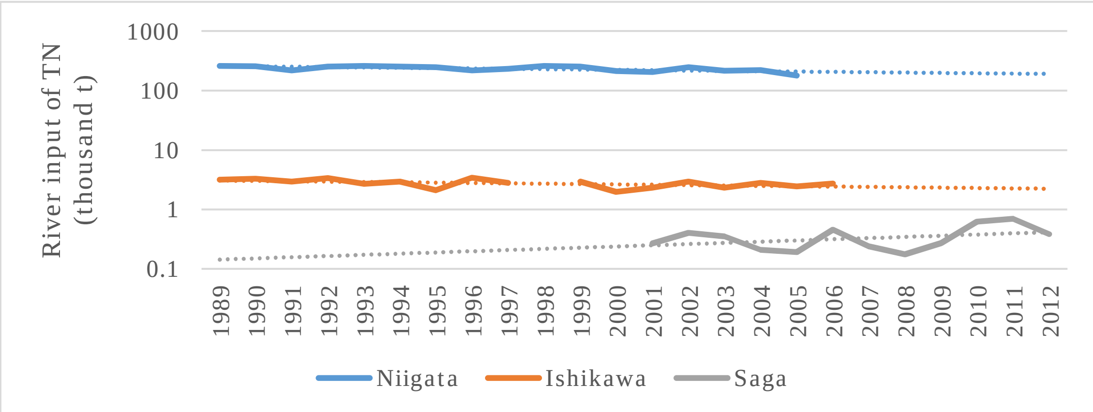


Figure 9. River input of TN in Niigata, Ishikawa (Hokuriku region) and Saga (North Kyushu sea area) prefectures in Japan

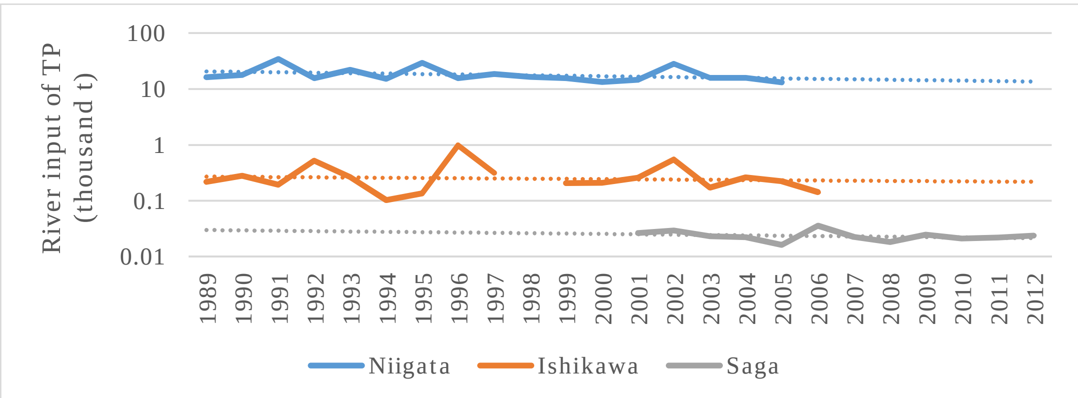


Figure 10. River input of TP in Niigata, Ishikawa (Hokuriku region) and Saga (North Kyushu sea area) prefectures in Japan

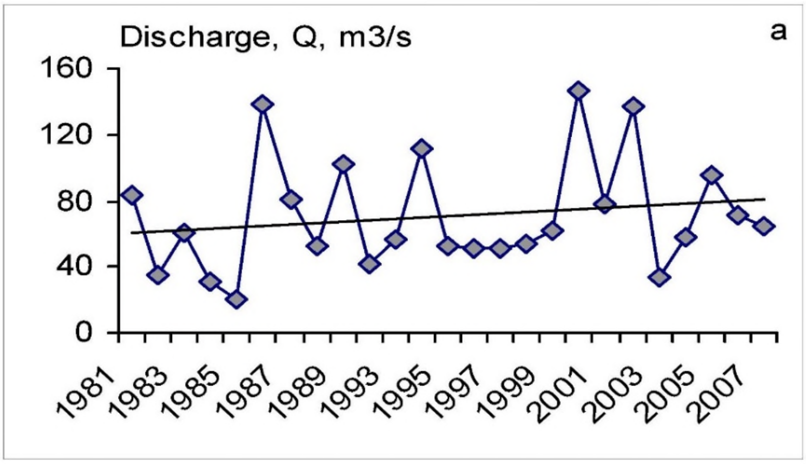


Figure 11. River discharge of the Razdolnaya River in Russia

The Case Study Reports on Assessment of Eutrophication Status in selected sea areas (2011) provided information on TN and TP nutrient inputs from rivers in the NOWPAP member states (Figure 12). The input from the Changjiang River in China, 32,000 m^3/s is much bigger than any river in the other three member states.

In addition to river input, direct input of wastewater from municipal sewage and industrial wastewater is one source of nutrient input. The volume of direct discharge of wastewater in the NOWPAP member states is available in “Regional Overview on River and Direct Inputs of Contaminants into the Marine and Coastal Environment in NOWPAP Region with Special Focus on the Land Based Sources of Pollution” published by NOWPAP POMRAC in 2009. A huge volume of nutrients is discharged by direct input; however, available data is limited and it is difficult to clearly show the rate of impact from these sources in each country.

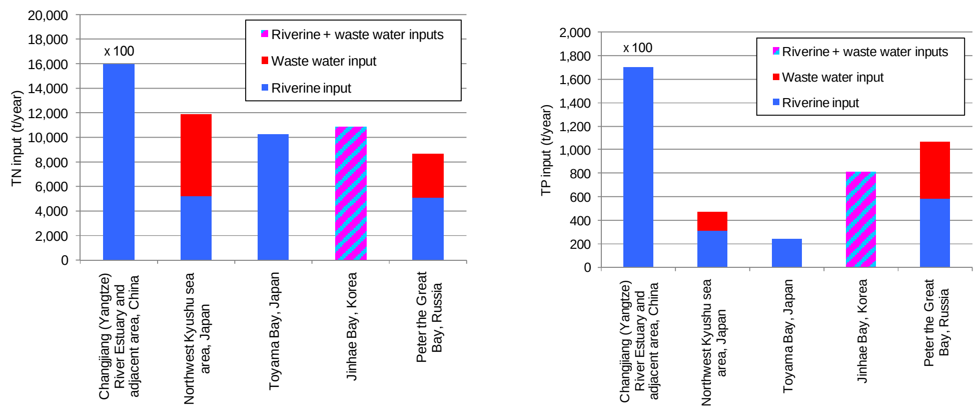


Figure 12. TN (left) and TP (right) inputs in selected sea areas in the NOWPAP region.

State: Sea water quality

Pilot assessment in 2014-2015 shows the change of nutrient condition in the sea areas of the member states.

Dissolved inorganic nitrogen (DIN, which includes nitrate (NO3-), nitrite (NO2-) and ammonium (NH4+)) in Changdao County and Changhai County in China is shown in Figure 13. DIN concentrations are lower than the Chinese National Reference Value; however, it shows an increasing trend in last 10 years.

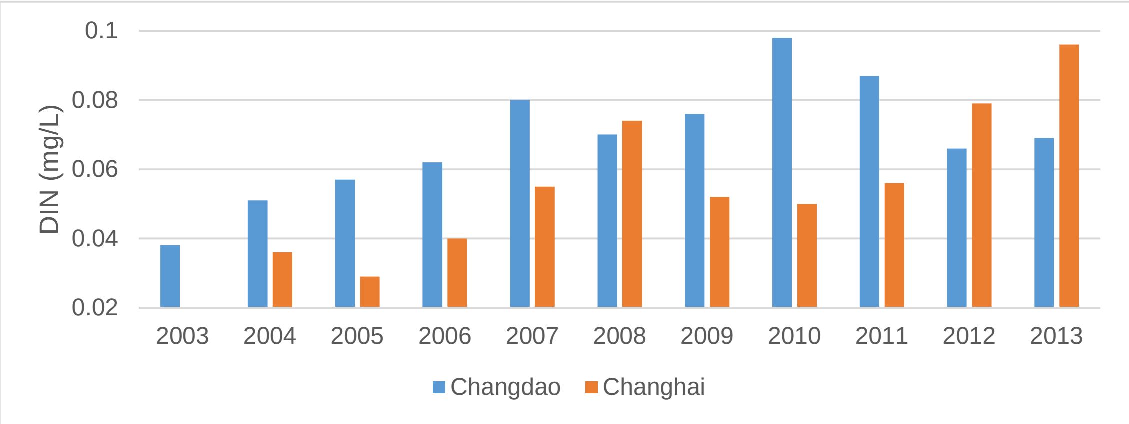
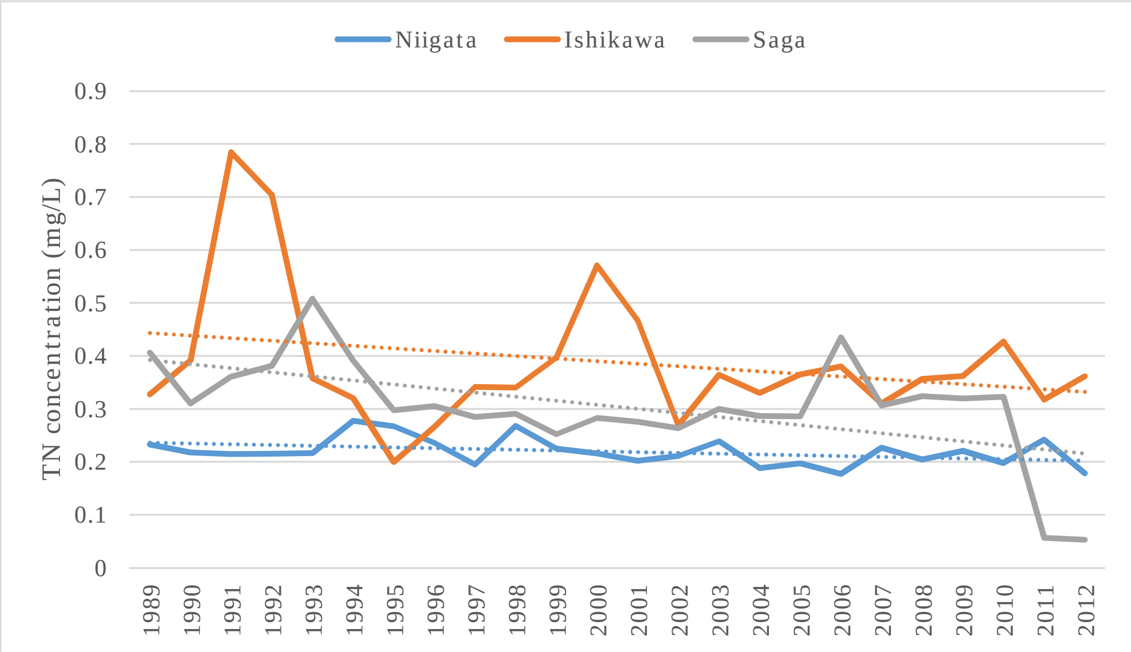


Figure 13. DIN in Changdao County and Changhai County in China

Figure 14 shows the average TN concentration and TP concentration in the sea areas of Niigata, Ishikawa and Saga prefectures in Japan. Including these three prefectures, the coastal area of Japan has a decreasing trend of nutrient concentration.



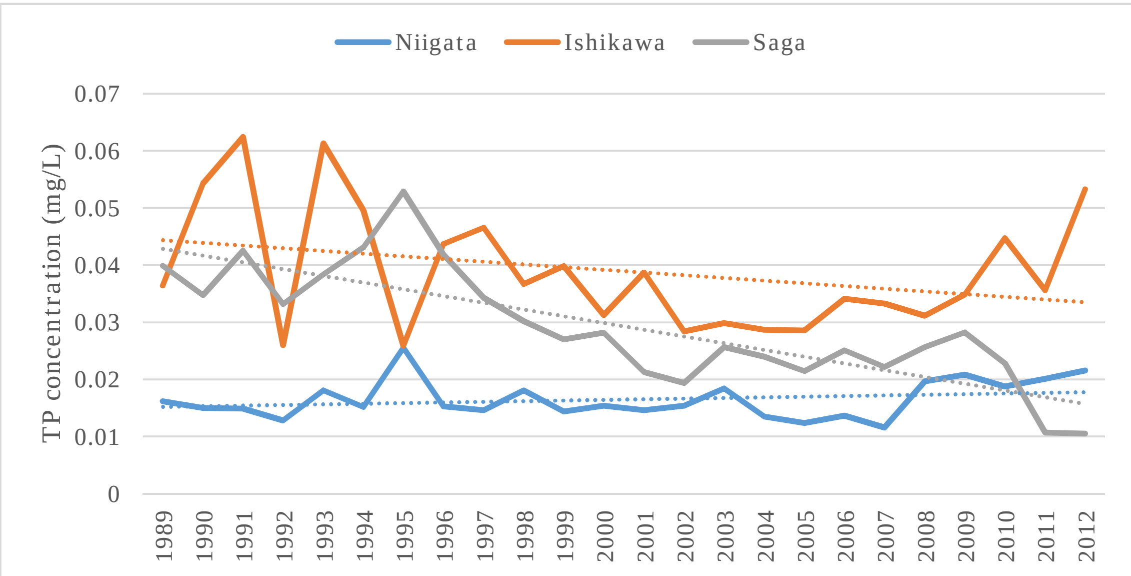


Figure 14. TN (upper) and TP (bottom) concentration in Niigata, Ishikawa and Saga Prefecture in Japan

Saemangeum in Korea is the sea area where a huge dike was constructed. The nutrient conditions of both inner and outer dike were monitored before and after dike construction (Figure 15). After the dike construction, DIN concentration in the inner dike area showed high DIN concentration in summer and low DIN concentration in the outer dike area compared with the time before the dike construction.

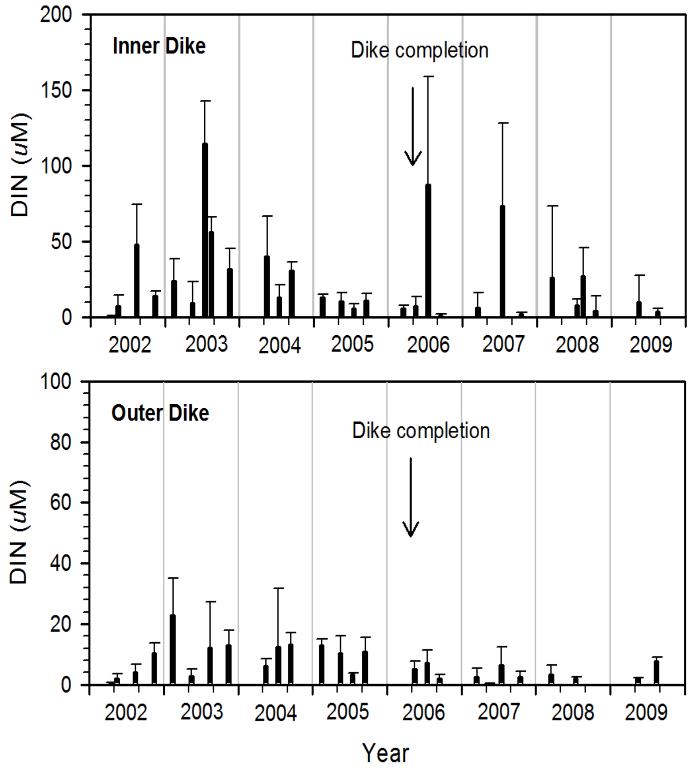


Figure 15. Variation of DIN concentration in 2002-2009 in the Saemangeum area. DIN in the inner dike area (up) and the outer dike area (bottom).

Figure 16 shows the concentration of TP, TN, NO3, and DSi in each sub-area of Peter the Great Bay. While TN showed an increasing trend in almost all sub-areas of Peter the Great Bay, Nitrate and TP did not show any clear trends.

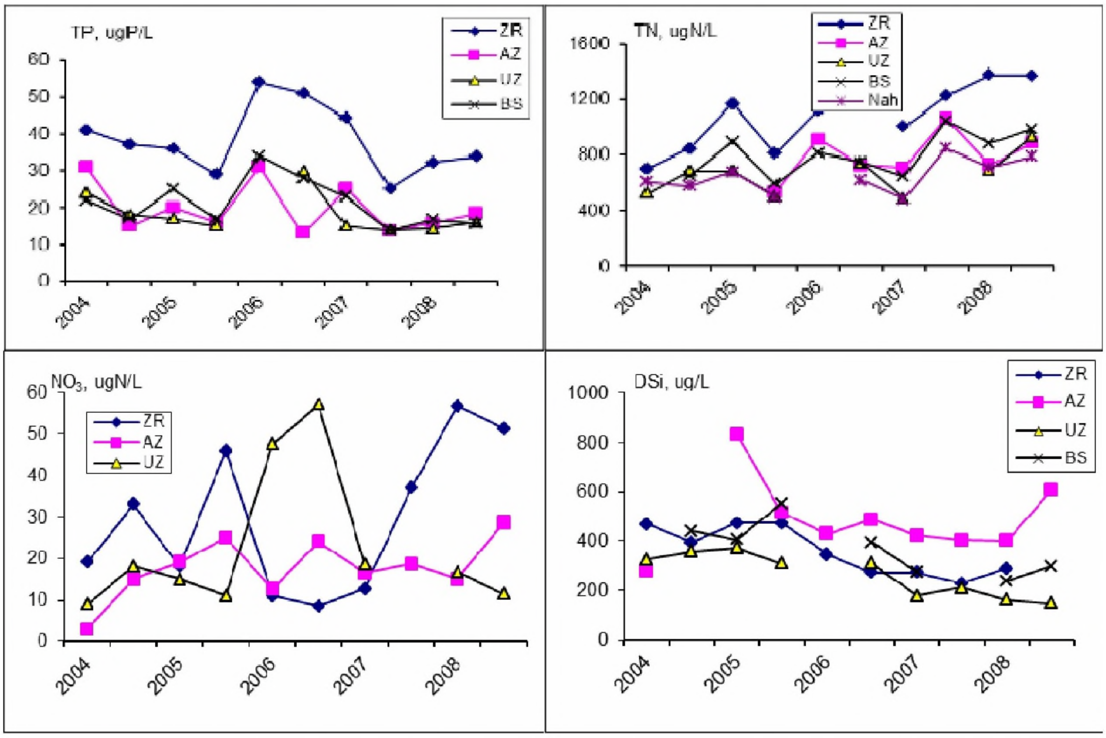


Figure 16. Trend of TP, TN, NO3, and DSi in each sub-area of Peter the Great Bay: Golden Horg Bight (ZR), Amursky Bay (AZ), Ussurisky Bay (UZ), Bosphorus Strait (BS) and Nakhodka Bight (Nah).

Impact: Influence on marine species and/or biodiversity

Impacts of eutrophication on marine biodiversity have been reported in the NOWPAP member states.

Li et al. (2013) studied anthropogenic impacts on hyperbenthos in the coastal waters of Sishili Bay, the Yellow Sea in China. They investigated the impact of putative anthropogenic activities related to the presence of sewage outfalls, harbors and aquaculture sites on the benthic ecosystem and showed that the concentration of NO3-N and Chl-*a* were slightly positively correlated with the hyperbenthic community structure.

Dokai Bay is located in northern Kyushu. In the 1950-60s, the water quality of Dokai Bay changed due to eutrophication caused by heavily polluted industrial waters. Hypoxia occurred frequently and Dokai Bay was called “Dead Sea”. Most of marine lives were lost by eutrophication. However, in 1970, the Japanese government established measures for the treatment of industrial wastewater. After the measures, the environment of Dokai Bay had recovered rapidly. With the improvement of water quality, the biodiversity of phytoplankton, macroalgae, sessile animals, fish and shrimp has been increased (Yamada 2015).

Itaoka and Tamai (1993) investigated the relationship between the meiobenthos community structure and eutrophication of the bottom sediments in Hiroshima Bay, Japan and showed that stressful bottom conditions such as low oxygen concentrations and high total sulphide caused the change of the meiobenthic community structure. Nematode increase and copepod decrease in low oxygen and high sulphide bottom condition.

Lee and Kim (2008) studied characteristics of algal blooms in the southern coastal waters of Korea and characterized the marine environment and its conditions associated with the appearance of organisms causing algal blooms using long-term water quality data.

Galysheva (2004) investigated subtidal macrobenthos communities of Vostok Bay, Russia under anthropogenic impacts and reported the impacts of eutrophication on macrobenthos communities.

In addition to these studies, CEARAC introduced many scientific papers on the impacts of eutrophication on marine biodiversity and ecosystems in its report, Application of the NOWPAP Common Procedure for Eutrophication Assessment in Selected Sea Areas in the NOWPAP Region (2013).

Response: National actions/measures

[China]

The National Seawater Quality Standard of China was developed in 1997 and the usage of sea areas was established. ‘Class II’, suitable for aquaculture water bodies, defines the reference value of DIN and DIP concentration in the sea area as 0.3mg/L and 0.03 mg/L respectively. In addition to DIN and DIP, the reference value of COD is also defined in the standard. Central and local governments of China have been making effort to achieve the reference values.

Then, “The Action Plan for Prevention and Control of Water Pollution” was promulgated by Chinese State Council in 2015. Objectives of this action are: by 2020, 1) water environment quality nationwide will be periodically improved, 2) environmental quality in offshore areas will get better, and 3) water ecological environment in Beijing-Tianjin-Hebei Region, Yangtze River Delta, Pearl River Delta and other areas will be somewhat improved. It is expected that overall water environment quality will be better and water ecosystem functions will be preliminarily recovered by 2030. It is expected that by the middle of this century, overall ecological environment quality will be improved and virtuous cycling of ecosystems will be achieved.

[Japan]

In Japan, the environmental quality standards for water pollution were decided by the Ministry of the Environment in 1971. Same as China, quality standards are designed based on the use of the sea area. There are four types in the standards, and Type I is for conservation of natural environment while Type II and III are for fishery use and Type IV is for industrial use. The standard quality of TN and TP was set: 0.2 mg/L (Type I), 0.3 mg/L (Type II), 0.6 mg/L (Type III) and 1.0 mg/L (Type IV) for TN; and 0.02 mg/L (Type I), 0.03 mg/L (Type II), 0.05 mg/L (Type III) and 0.09 mg/L (Type IV) for TP.

In addition to the environmental quality standards, total volume control for water quality is conducted in several specific sea areas where eutrophication has happened in past, such as Tokyo Bay, Ise Bay, and the Seto Inland Sea. These bays are located on the Pacific Ocean side, out of the NOWPAP region. Based on the total volume control, each prefectural government of these areas controls the discharge of nitrogen, phosphorus, and COD to the sea areas.

[Korea]

In Korea, the environmental quality standards for water pollution were decided by the Ministry of the Oceans and Fisheries. Unlike China and Japan, quality standards are designed based on water quality index which is calculated by chlorophyll-*a*, transparency, DIN, DIP and DO. Standard values for each parameter are different depending on the areas which are divided into five ecosystem areas and 65 waters. There are five grades in the standards from Grade I to V, indicating ‘very good’, ‘good’, ‘average’, ‘poor’ and ‘very poor’.

[Russia]

The latest set of quality standards for the sea waters which could be used for fishery purpose in Russia was established in 2010. Reference values for DIN and DIP were defined as 0.1 mgN/L and 0.05-0.2 mgP/L depending on trophic level. There is clear understanding that above-mentioned nutrient concentrations in seawater are determined by the number of processes, and might not be connected with anthropogenic eutrophication. Therefore, dissolved oxygen with threshold value 4 mg/L is considered as a major indicator of hydrochemical problems connected with eutrophication issues. Value of BOD, 3.0 mgO/L was defined in Russia as a measure of easy oxidizable organic matter and could be used as a complimentary indicator of eutrophication. Local governments have concentrated on the control of waste discharge of nitrogen, phosphorus and organic compounds (COD/BOD) to the sea.

- **Non-indigenous species (NIS)**

Driving forces: Transport by ship and aquaculture

Main routes of artificial introduction of NIS are aquaculture and maritime trade. Marine species move to other regions by ship fouling and ballast water. The NOWPAP region is used as a main fairway for the NOWPAP member states; therefore, many foreign ships come and go between big ports in and out of the region. All NOWPAP member states ratified the International Convention for the Control and Management of Ships' Ballast Water and Sediments; however, appropriate treatment has been just started.

The number of ship containers in some major ports has also dramatically increased in the NOWPAP member states in the past decades, specifically the rate of increase in China and Korea is very high (Table 4). Such situation may be a driver of the introduction of NIS.

Table 4. Cargo Volume in major ports in China, Japan, and Korea (Thousand tons)

Name of Port	Year (1999)	Year (2014)
Qingdao (China)	70,180	450,100
Dalian (China)	75,150	320,800
Kita-Kyushu (Japan)	87,346	100,097
Busan (Korea)	107,757	313,800
Ulsan (Korea)	148,332	167,900
Gwangyang (Korea)	131,059	127,600
Incheon (Korea)	108,227	112,600

Figure 17 shows the number of foreign ships entering ports in five prefectures in Japan. Kita-Kyushu Port included in Table 4 is located in Fukuoka Prefecture. In

Fukuoka Prefecture, in addition to Kita-Kyushu Port, Hakata Port is also a major international port, and this is the reason why Fukuoka Prefecture has a much larger number of foreign ships compared with the other four prefectures in Japan.

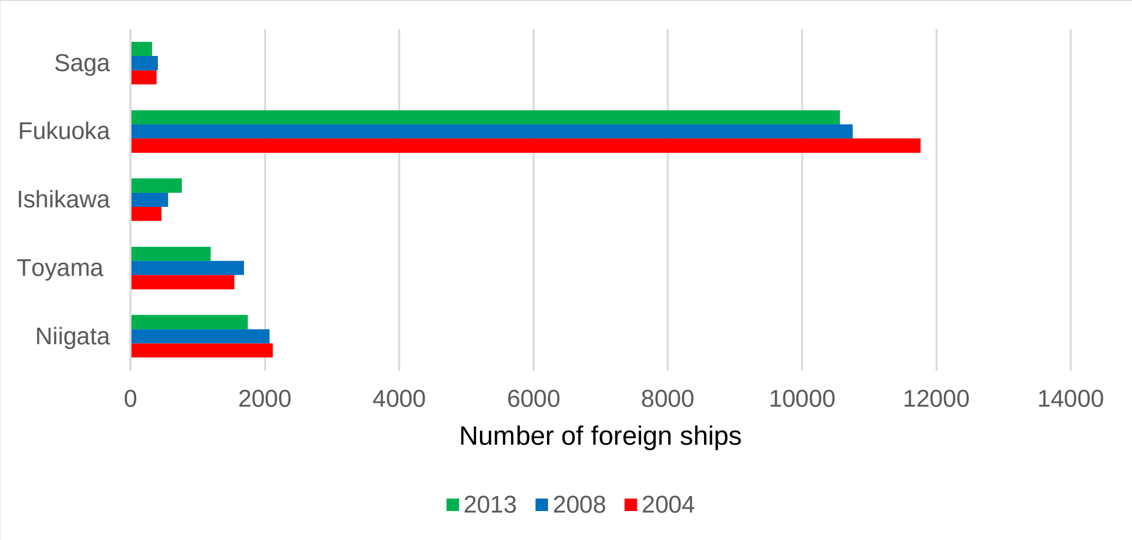


Figure 17 Number of foreign ships entering ports in five prefectures in Japan

In the Far Eastern region of Russia, about 16,000 ships enter ports and harbors every year, and among them, about 8,000 ships operate in international lines. The total volume of cargo handled at seaports located in Peter the Great Bay is more than 80 million tons per year.

Japan developed effective methods of cultivation of commercial species such as abalone and scallop in the 1970s. These species were exported to the other NOWPAP member states with cultivation techniques, and other NOWPAP member states started aquaculture actively due to the increase of needs for fishery products. Now, the NOWPAP region became a sea area where fish and shellfish aquaculture is very active. Figure 18 shows the production of marine aquaculture in the NOWPAP member states. Production of marine aquaculture of several NOWPAP member states has been increasing dramatically in the past 15 years and it includes introduced aquaculture species from other countries. In recent years, high economic value, high production and fast growth of cultured species have been essential requirements. Towards these ends, non-indigenous species, with origins in Europe, North America, and other regions were introduced into this region. In China, 25 % of the total production is production of non-native species (Xiong et al. 2017). Unless appropriate management is implemented in aquaculture farms, it may be a driver of the introduction of NIS into nature. Some species, such as eels, spotted seatrout, red drum and American shad have become valuable marine fishing species in China. In addition, it is indicated that escaped NIS cause damage to native marine ecosystems by predation and hybridization (Xiong et al. 2017).

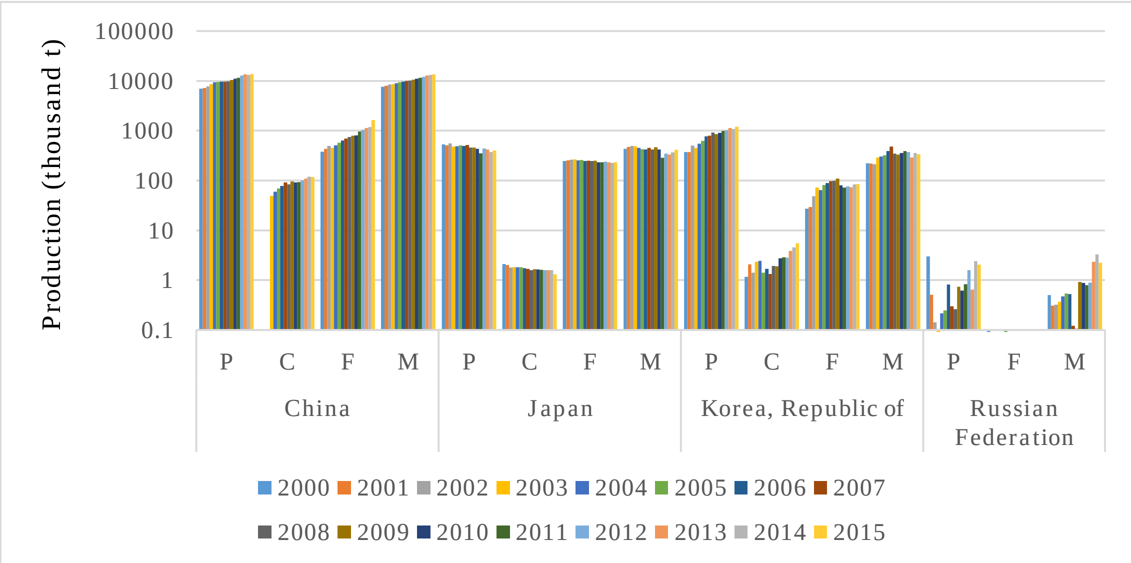


Figure 18. Production of marine aquaculture in the NOWPAP member states. P is aquatic plant (brown, green and red seaweeds), C is crustaceans, F is marine fishes and M is molluscs. (Source: FAO)

<u>Pressure</u>: Ballast water discharge, ship hull-fouling, aquaculture of NIS

One of the routes of NIS introduction is ballast water discharge. Transportation of ballast water is increasing because of the rapid increase of ship transportation by economic growth in the world (Figure 19). In the past 50 years, the volume has increased about six times.

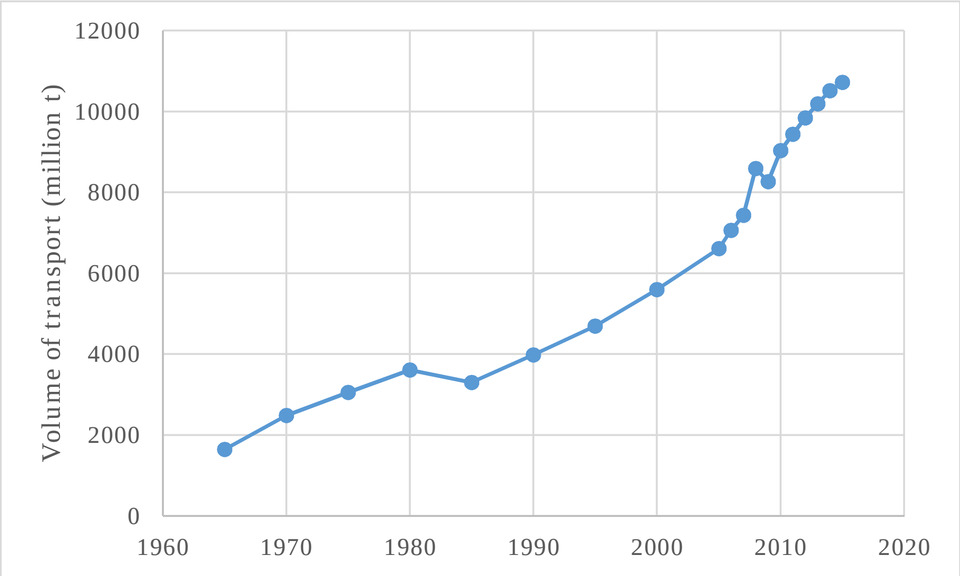


Figure 19. Volume of cargo transport by ship in the world

Because of the increase of ship transportation in the world, the threat of introduction of NIS by ballast water and ship hull-fouling is growing in the NOWPAP region.

In total, 3 billion tons of ballast water is transported in the world annually. In Japan, 17 million tons of ballast water is brought in and 300 million tons of ballast water is brought out to other regions. In Korea, 90 million tons of ballast water is brought in and 14 million tons out of this amount is going to six major ports (Busan, Ulsan, Daesan, Kwangyang, Incheon, and Pohang) annually. According to the survey conducted in 2012, around 90 % of ballast water brought in is from Asian countries, and 239 million tons of ballast water is brought out to other regions. In Russia, the sources and ways of introduction of alien species into new marine areas are fouling of ship hulls and ballast water. New invading species are still in the early stages of acclimatization, and their number in this region does not exceed 3 % of the total number of species (Zvyagintsev, 2009). The number of vessels visiting the ports in the Peter the Great Bay annually is about 16 thousand, and 10 thousand vessels out of them visit Vladivostok Harbor. The bay annually receives at least one million tons of untreated ballast water from all over the world (Zvyagintsev, 2005). In the future, the number of alien species will considerably increase due to climate change and intensification of tanker shipping. Peter the Great Bay is now the terminal of the Eastern Siberia-Pacific Ocean oil pipeline. The terminal in Koz'mino Harbor will load and discharge up to 50 million tons of petroleum a year (Adrianov, 2014). The increase of oil production in Russia may increase ship transportation between Russia and other countries.

Another route of NIS introduction is aquaculture. The Northwest Pacific region is one of the most active sea areas of aquaculture operation in the world. As shown in Figure 8, 60 % of aquaculture in the world is produced in the three NOWPAP member states, China, Japan, and Korea.

Atlantic bay scallop (*Argopecten irradians*) is an edible species of saltwater clam which was originally found on the east coast of the United States. This species was firstly introduced by Fusui Zhang in 1982 and soon became an important aquaculture organism in China, especially in Shandong and Liaoning Provinces, with annual production of about 80,000 tons in recent years (Figure 20). The bay scallop is highly adaptive to a new environment with a short lifespan, and with high growth rate and production, the species has maintained its rapid development in Changhai County. Yesso scallop (*Patinopecten yessoensis*) is found around the far eastern Asian coast and is native to Japan, Korea, and southern Russian waters. It was introduced to China by Liaoning Ocean and Fishery Science Research Institute from Japan in 1980 and is now an economically important species for aquaculture in Shandong and Liaoning Provinces. It has gained a renowned reputation globally for its large size, strong adductor muscle, and tasty flavor. The non-indigenous bay scallop and yesso scallop have become the prime shellfish species in Changhai County by now. Such introduced species are found in the wild environment surrounding the aquaculture areas.

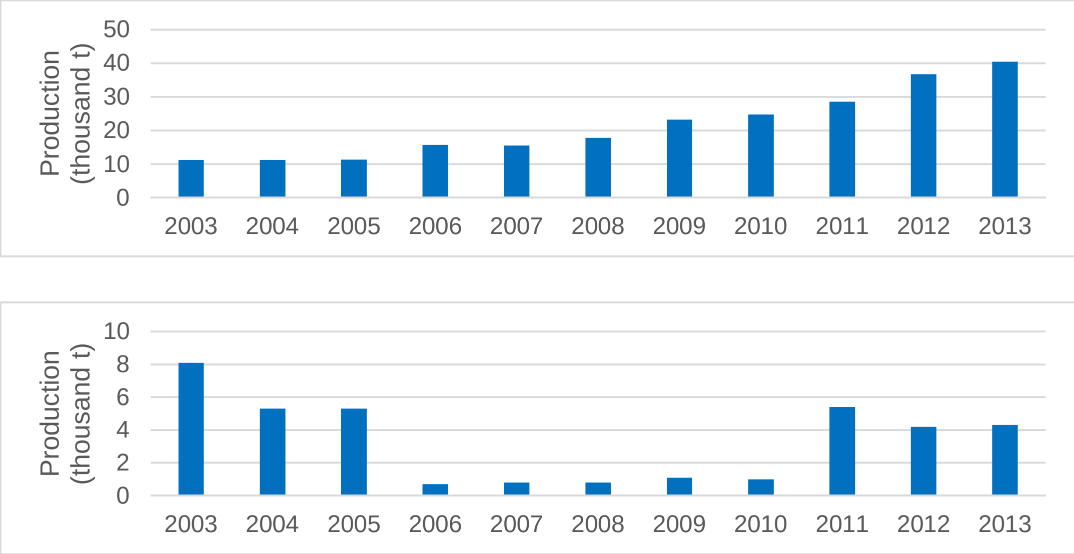


Figure 20. Production of NIS aquaculture (Argopecten irradians)
in Changhai County (up) and Changdao County (bottom)

In Japan, marine species which are originated in another country are not basically cultured in the sea areas. However, in the past, rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) were introduced as aquaculture species and settled in nature. Continental seabass (*Lateolabrax* sp.) has been intentionally introduced to Japan from China in 1989, and, their wild population was found in Japanese waters in 1992. They affect natural marine ecosystems by predation on small fishes and competition with native seabass (*L. japonicas*) (POMRAC 2014).

In addition, in recent years, some unintentional introduction has occurred. For clam digging, which is one leisure activity in coastal areas in summer in Japan, manila clam (*Tapes philippinarum*) was imported from China and Korea. Together with manila clam, black top-point moon snail (*Euspira fortunei*) was released unintentionally. This species cause predation on clam fishery resources and the damage on native species by black top-point moon snail has expanded in Japan.

The fisheries production of Korea increased from 2.51 million tons in 2000 to 3.30 million tons in 2014, showing an average annual growth rate of 5 %. As of 2014, aquaculture accounted for almost half of total fisheries production, 48%.

One of the typical introduced species observed along the coast of Korea is tropical *Zostera capricorni*, which flowed into the seas adjacent to the Korean peninsula due to rising water temperature. *Zostera capricorni* is proliferating into all parts of the southern coast of Korea. Zostera marina is losing its habitat even after habitat restoration because of the continuing rise of seawater temperature.

Despite the low level of aquaculture, Russia has the most valuable target species of world aquaculture. The development of aquaculture in Russia is at an early stage, yet only in Peter the Great Bay, more than 200 thousand hectares have already been allocated for aquaculture (Maslennikov, 2014). Theoretically, sea farms in Russia can produce up to three million tons of aquaculture products per year (Regional center for aquaculture, NSCMB FEB RAS, http://www.imb.dvo.ru/misc/aquaculture/inde-x.htm).

State: Occurrence of NIS

More than 100 NIS are observed in the NOWPAP member states. In Chinese coastal waters, 27 NIS have been found. Among them, 14 species are benthic species and 13 species are planktonic species (POMRAC 2014). Atlas of Marine Invasive Species in the NOWPAP Region published by DINRAC reported 80 invasive species and their distribution in the NOWPAP member states (Table 5).

In Japanese coastal waters, 31 exotic brackish/marine species have been identified. Seven species are plant and phytoplankton species: five phytoplankton species, one green macroalgae species, and one cordgrass species have been introduced in Japanese waters. 24 species are animal species: five barnacle species, one isopod, three crab species, three gastropod, six bivalve, one bryozoan species, three polychaete species and two tunicate species were found in Japanese waters (DINRAC 2013).

There are 41 species suspected to be NIS in Korean coastal waters. These species belong to seven major groups, namely bivalves, echinoderms, barnacles, tunicates, bryozoans, phytoplankton and fishes (DINRAC 2013).

In Russian waters of the NOWPAP region, 37 marine invasive species were known by 2010; however, it was mentioned that the number may have increased up to 66 (DINRAC 2013).

Table 5. List of marine invasive species in the NOWPAP member states (NOWPAP DINRAC 2013)

	China	Japan	Korea	Russia
Plants and phytoplankton				
Saccharina japonica	✔			
Macrocystis pyrifera	✔			
Undaria pinnarifida	✔			
Desmarestia ligulata	✔			
Cutleria multifidia		✔		
Ulva fasciata		✔		
Spartina alterniflora	✔	✔		
Spartina anglica	✔			
Pseudo-nitzschia calliantha	✔		✔	✔
Chattonella marina		✔	✔	
Heterosigma akashiwo	✔	✔	✔	
Alexandrium catenella	✔	✔	✔	
Cochlodinium polykrikoides	✔	✔	✔	
Karlodinium veneficum	✔		✔	
Heterocapsa circularisquama		✔		
Animals				
Ficopomatus enigmaticus		✔		
Hydroides elegans		✔		✔
Hydroides dianthus		✔		
Pseudopotamilla occelata				✔
Haliotis discus	✔			
Haliotis gigantean	✔			
Haliotis rufescens	✔			
Haliotis fulgens	✔			
Crepidula onyx		✔		
Nassarius sinarus		✔		
Euspira fortune		✔		
Mytilus galloprovoncoalis		✔	✔	✔
Perna viridis		✔		
Xenostrobus secures		✔	✔	

Mytilopsis sallei		✔		
Argopecten irradians	✔		✔	
Mizuhopecten yessoensis	✔			
Crassostrea gigas	✔			
Mercenaria marcenaria	✔	✔		
Panopea japonica	✔			
Balanus glandula		✔		
Amphibalanus amphitrite		✔	✔	✔
Amphibalanus improvisus		✔	✔	✔
Amphibalanus eburneus		✔	✔	✔
Amphibalanus zhujiangensis		✔		
Megabalanus coccopoma		✔		
Perforatus perforatus			✔	✔
Paracerceis sculpta		✔		
Portunus sanguinolentus				✔
Plagusia depressa tuberculate				✔
Pyromaia tuberculata		✔	✔	
Rhithropanopeus harrisii		✔		
Carcinus aestuarii		✔		
Diogenes nitidimanus				✔
Litopenaeus stylirostris	✔			
Litopenaeus vannamei	✔			
Marsupenaeus japonicus	✔			
Monocorophium acherusicum				✔
Bugula neritina			✔	
Bugula stolonifera		✔		
Bugula californica			✔	
Tricellaria occidentalis		✔	✔	
Conopeum seurati				✔
Schizoporella unicornis				✔
Strongylocentrotus intermidus	✔			
Styella plicata			✔	
Ciona intestinalis			✔	
Ciona savignyi				✔

Molgula manhattensis		✔		✔
Polyandrocarpa zorritensis		✔		
Ascidiella aspersa		✔		
Halocynthia roretzi	✔			
Lateolabrax sp.		✔		
Oncorhynchus kisutch	✔			
Oncorhynchus mykiss	✔			
Salmo salar	✔			
Paralichthys dentatus	✔			
Paralichthys lethostigma	✔			
Verasper moseri	✔			
Solea senegalensis	✔			
Solea solea	✔			
Anguilla anguilla	✔			
Anguilla rostrate	✔			
Morone saxatilis	✔			
Sciaenops ocellatus	✔			

Impact: Influence on native species/endangered species

Smooth cordgrass (*Spartina alterniflora*) is distributed almost all coastal areas of south China. It occupies niches of native species, destroy habitats of native birds and threaten local marine species. Cui et al. (2011) reported the invasions of *Spartina alterniflora* and its impacts on crab communities in a western Pacific estuary in China. The total number and biomass of crabs caught were much higher in Spartina-invaded habitats than in non-invaded habitats. However, species richness was much lower. These results suggest that Spartina invasions are likely to keep pace with shoreline dynamics accelerated by global change and have significant ecological consequences for crab communities. One kind of sea urchin (*Strongylocentrotus intermidus*) was introduced from Japan into northern China. It escaped from breeding cages into the natural marine environment and became a huge threat for seaweed beds in the coastal areas (POMRAC 2014).

Nishi and Kato (2004) reported the vector and impact of the introduced polychaete. In Japanese waters, only four species, *Nereis succinea*, *Perinereis aibuhitensis* Grube, *Ficopomatus enigmaticus* and *Hydroides elegans* are known as introduced species. The main introduction vectors of polychaete are ballast water and fouled ships. Some species polychaete are imported with introduced oysters, scallops and other commercially important mollusks. Additionally, some species are introduced with marine litter and imported as “fishing bait worms”. *Hydroides elegans* was introduced by ballast water and ship fouling and selected as one species of 100 of the Japanese worst NIS. *Hydroides elegans* impacts oyster as competing species and cause huge fishery damage.

Kim et al. (2009) reported the extension of the distribution of the NIS seagrass *Halophila nipponica* in the coastal area of Korea. Park et al. (2017) also compared the growth patterns between *Halophila nipponica* and native seagrass species, *Zostera marina*, and expected that increasing water temperature on the coasts of Korea may facilitate the persistence of the meadows of *Halophila nipponica* in Korea.

Alexandrium catenella is the responsible species for outbreaks of Paralytic shellfish poisoning (PSP) in Jinhae-Masan Bay, Korea. Shin et al. (2017) reported that the introduction of this toxic dinoflagellates was related to ballast water from bulk-cargo shipping in this area.

In Peter the Great Bay in Russia, naturalization of NIS such as *Amphibalanus improvises* and *Mytilus galloprovinciallis* has been reported. The predominance of these species may lead to suppression and displacement of other indigenous species. Increasing competition between native and alien species is an inevitable ecological consequence of invasions. Zvyagintsev et al. (2009) reported the introduction of NIS by ballast water in Peter the Great Bay and its impacts on native ecosystems. They also showed the vector of introduction and spreading of each species.

<u>Response</u>: National actions/measures

[China]

In China, inspection and quarantine departments and the maritime administration are mainly responsible for management of ship ballast water. In general, the maritime administration is in charge of preventing oil pollution and hazardous chemicals pollution by ship ballast water to sea areas. The administration also investigates whether a ship installs a special ballast tank (ballast water management system) on board and where the ballast water is taken from.

[Japan]

Japan ratified the International Convention for the Control and Management of Ships' Ballast Water and Sediments (Ballast Water Management Convention), and amended the Act on Prevention of Marine Pollution and Maritime Disaster on 8th September, 2017. Now, the ministerial ordinance of the Act on Prevention of Marine Pollution and Maritime Disaster requires ship holders to manage ballast water based on the Ballast Water Management Convention and to install ballast water treatment equipment.

[Korea]

In Korea, a program of ballast water risk assessment was firstly developed by the Korea Institute of Ocean Science and Technology (KIOST) in 2010. The program was established based on the GloBallast project initiated by the International Maritime Organization (IMO) and a relative overall risk assessment was conducted accordingly (DINRAC 2013).

- **Habitat alteration**

Driving forces: Coastal development

Coastal development including landfills is a main driving force of habitat alteration. The Northwest Pacific region is one of the economically rapidly growing areas in the world, and habitats of marine species have been lost in the NOWPAP member states.

Landfill has been decreased in Dalian City, China in recent years compared with past years when landfill was conducted more actively. Table 6 shows the size of landfill area in Dalian City.

Table 6. Landfill area in Dalian City, China

Year	2000-2005	2005-2010	2010-2014
Landfill areas (Km^2)	73.36	188.21	125.50

In Japan, landfill has been decreased in recent years compared with past years. However, in several sea areas, coastal development is still continued. Figure 21 shows the accumulated area of landfills in Niigata, Toyama, Ishikawa, Fukuoka and Saga Prefectures.

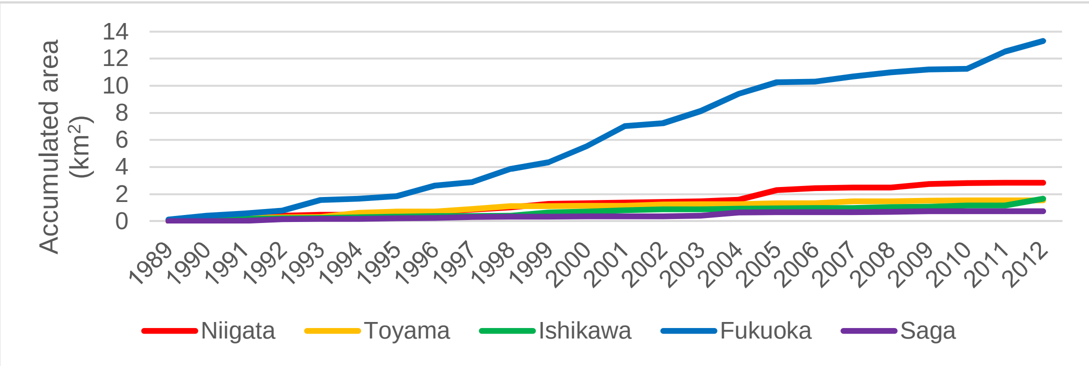


Figure 21. Accumulated area of landfills in five prefectures

In Fukuoka Prefecture, landfill continued in the past two decades. Because Hakata Bay and Kitakyushu Bay, main international ports in the northern coast of Kyushu, are located in Fukuoka Prefecture, coastal areas in Fukuoka were reclaimed for increasing volume of cargo.

In Korea, the Saemangeum Reclamation Project was launched in 1991. In April 2006, a 33-km-long dike was constructed and 401 km^2 of tidal flat was transformed into a lake and land. In addition to the Saemangeum Reclamation Project, there are many reclamations already conducted and/or planned. Figure 22 shows the reclamation projects on the west coast of Korea.

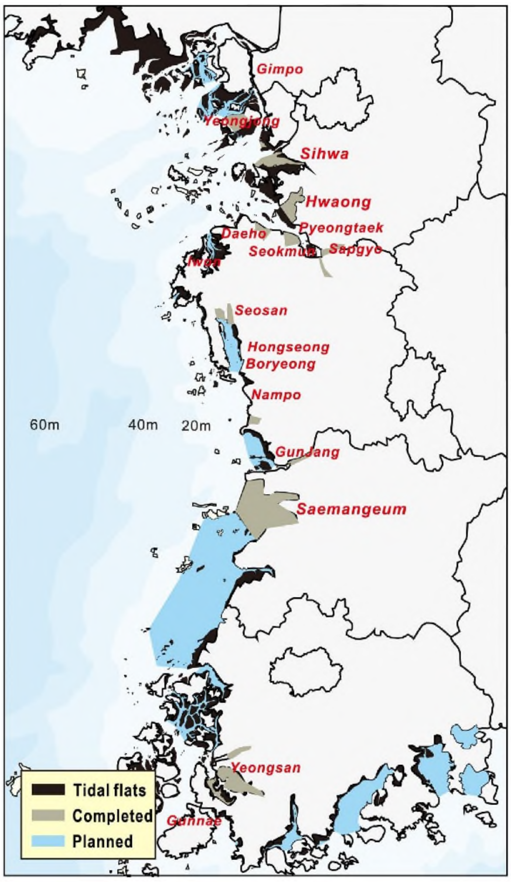


Figure 22. Distribution of tidal flat in the western sea of Korea and the reclamation plan established by the Korean government in 1996. (Koh and Khim 2014)

<u>Pressure</u>: Land use

Due to the coastal development, many natural coasts have disappeared in the NOWPAP member states. Figure 23 shows the change of the coastlines in Niigata, Toyama, Ishikawa, Fukuoka and Saga Prefectures in Japan. The northern coasts of Japan are eroded by waves in winter. Especially, monsoon in winter season generates strong wind waves. To protect coasts and sand beaches against strong wind waves, most of the coasts are protected by concrete block walls and/or wave-dissipating blocks. It is the main reason why natural coasts in five prefectures in Japan are lost.

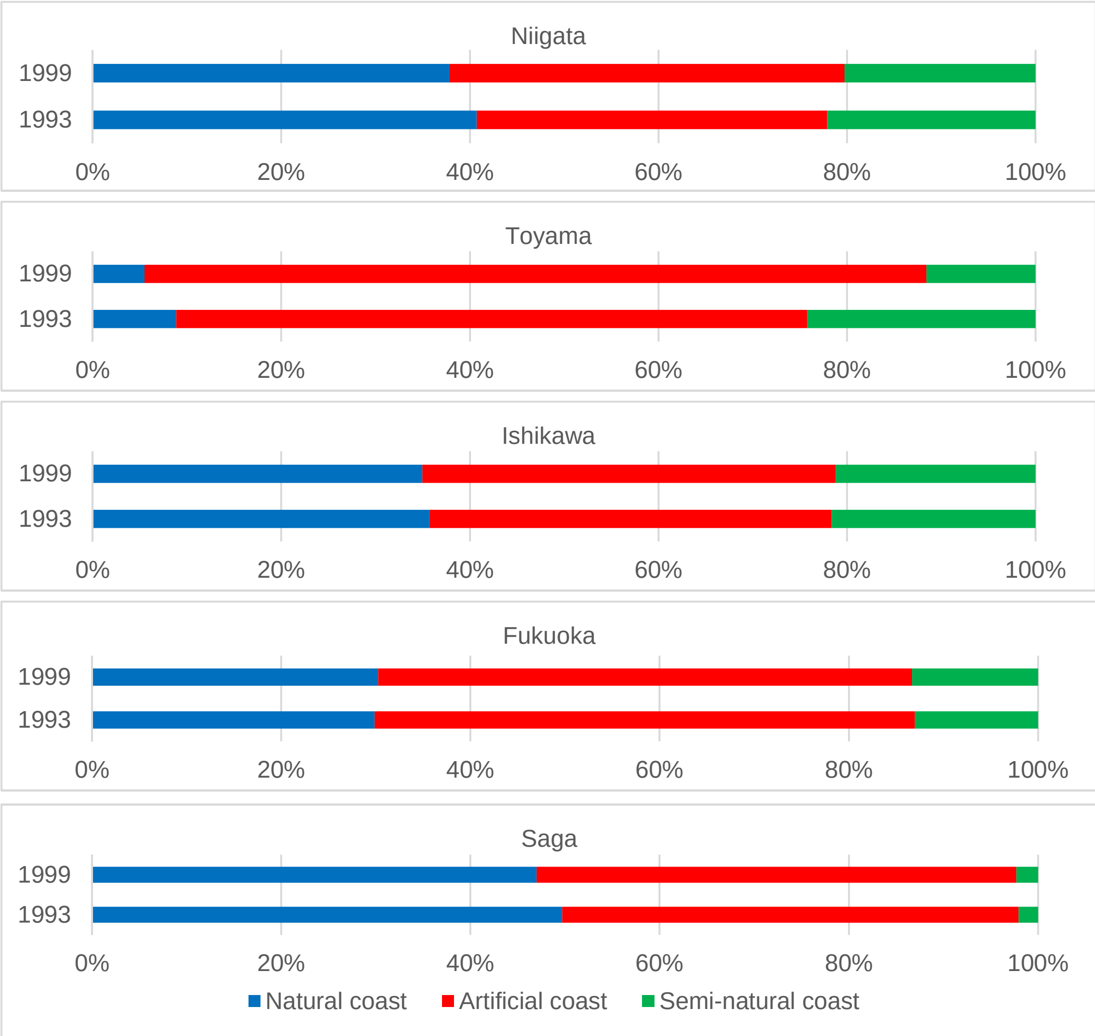


Figure 23. Percentage of natural, artificial and semi-natural coasts in five prefectures in Japan.

In addition to coastal development, collection of sea gravel is a big pressure on habitats (Figure 24). Collection of sea gravel causes not only disappearance of habitats for species living in sand beds but also occurrence of hypoxia in the bottom, and negative influence on benthic marine species. When a depressed sea bottom area is formed by collection of huge sea gravel, water exchange will be weakened. In addition, suspended substances will sink into these depressions due to decreased water mixing. Consequently, aerobic biological activities changed into anaerobic ones, and hypoxic water will be generated. Therefore, in several sea areas, collection of sea gravel in coastal areas has been prohibited by local governments since the 1990s in Japan. On the other hand, a huge volume of sea gravel collection is still continued in the north Kyushu sea areas.

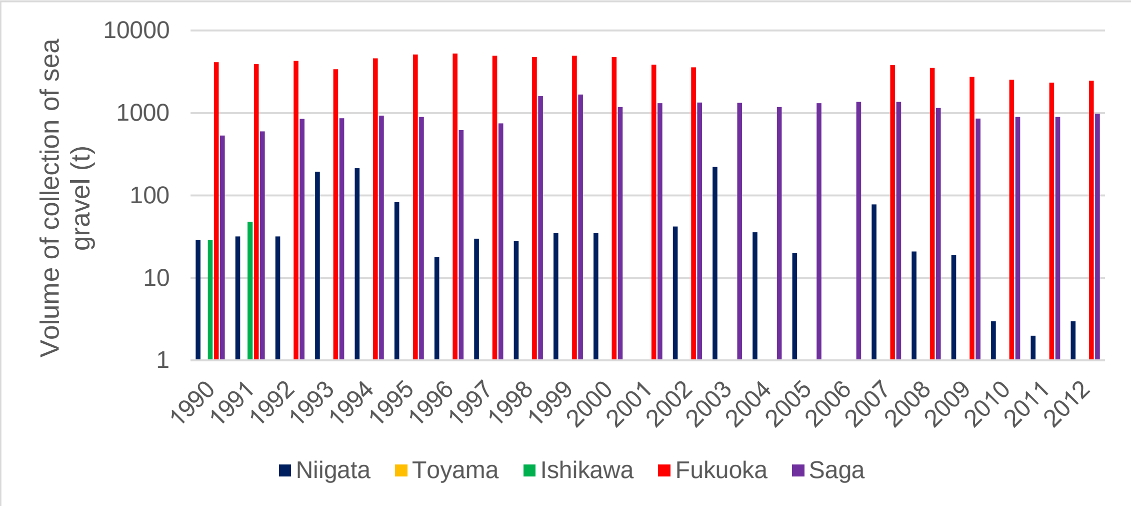


Figure 24. Volume of sea gravel collection in five prefectures in Japan

In Russia, aquaculture of clams, mussels, oysters, and luminaria were introduced from Japan and Korea in the mid-70s. Such aquaculture was operated in the coastal area of Peter the Great Bay, and they changed the environment of habitats of benthic and pelagic marine species. 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 ten times in five years (Figure 25).

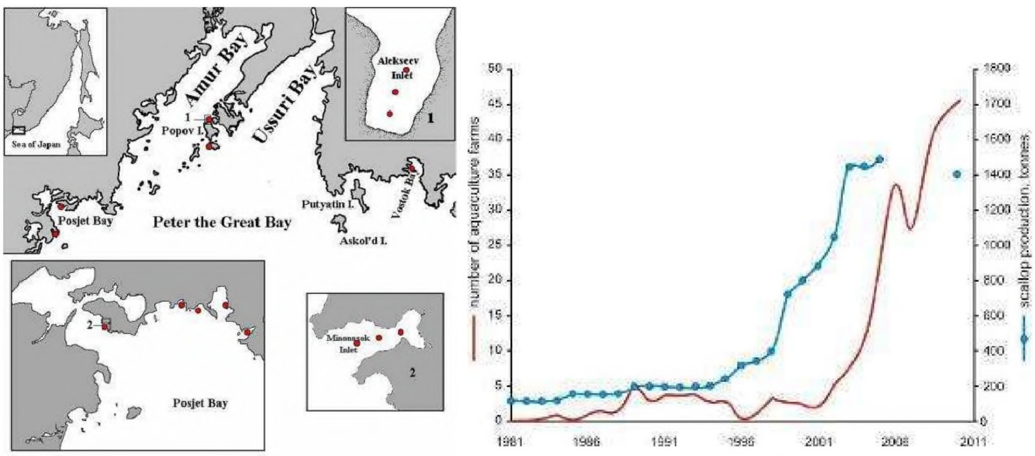


Figure 25. Data on aquaculture habitat alteration in Peter the Great Bay (left), and dynamics of scallop production (right).

State: Loss of natural habitat

In Japan, coastal habitats, such as seagrass/seaweed beds and tidal flats were lost for coastal development in the last 100 years (Figure 26).

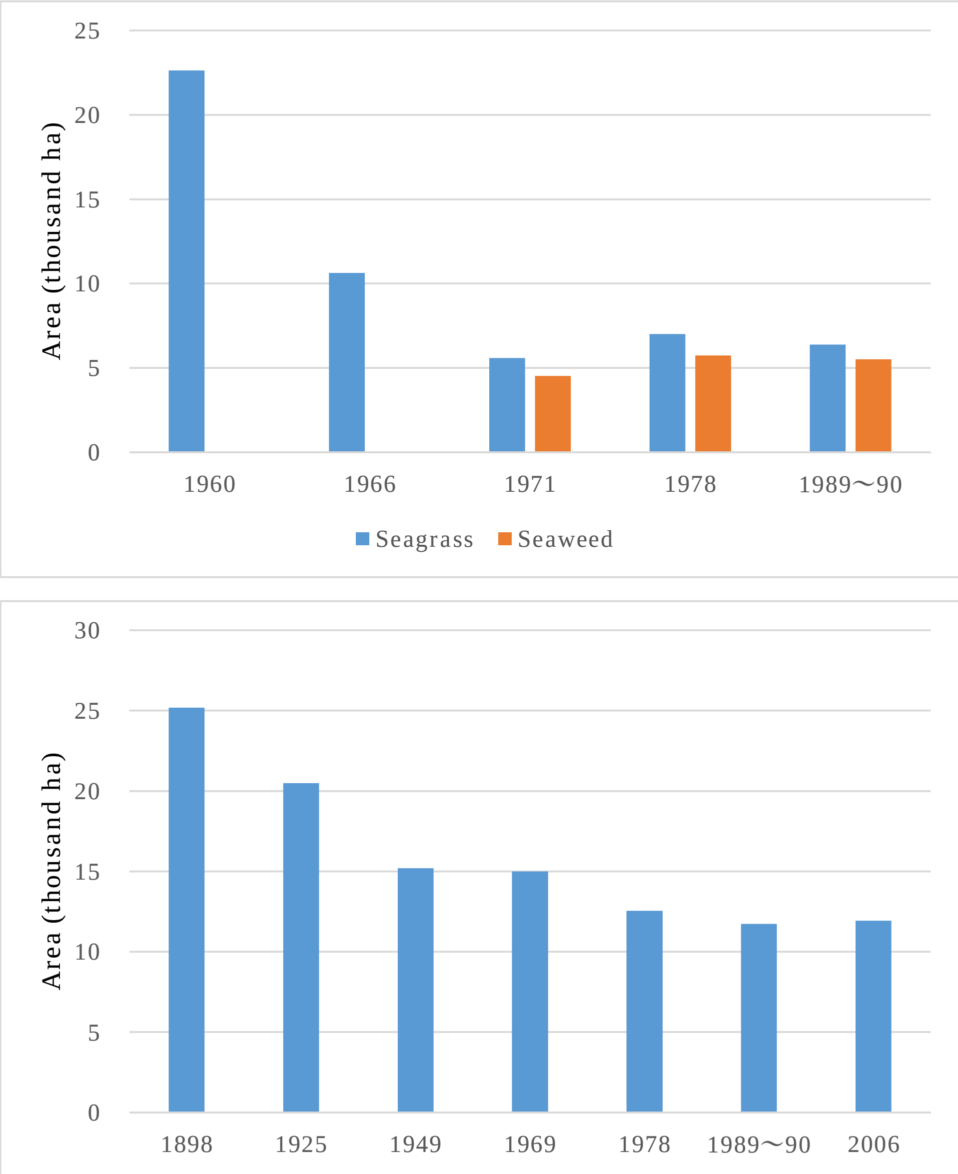


Figure 26. Change of areas of seagrass/seaweed beds (up) and tidal flats (bottom) in the Seto Inland Sea (Source: Setouchi Net)

The main reason for area decrease is filling in land. Due to past landfill, about 50 % of seagrass beds and tidal flats disappeared in the Seto Inland Sea. In recent years, the areas of seagrass/seaweed beds are recovering due to the vigorous effort of conservation, restoration and creation by the actions of local people.

Due to the Saemangeum Reclamation Project in Korea, about 400 km^2 of tidal flat was lost. In addition to the Saemangeum Reclamation Project, many reclamation projects have been planned in the west coast of Korea and some of them were already completed. Koh and Khim (2014) reported that 1,700 km^2 of tidal flat was lost since the 1970s.

Impact: Influence on marine species/endangered species

Yan et al. (2015) investigated the impacts of reclamation on macrozoobenthos in coastal wetlands and tried to quantify the impacts. Their research showed significant negative impacts on species diversity and biomass of macrozoobenthos.

In “Threatened Animals of Japanese Tidal Flats: Red Data Book of Seashore Benthos” (Japanese Association of Benthology, 2012), 651 species (462 molluscs, 138 arthropods, 21 polychaetes, and 30 other invertebrates) were designated as threatened benthic animals. Henmi et al. (2014) assessed the current situation of threatened benthic animals in the tidal flats of Japan. They reported that the main reasons of threatened molluscs and polychaetes are vanishing from tidal flat due to coastal development near the mega cities.

Hong et al. (1997) studied the changes in the benthic communities before and after the construction of Shihwa Dike in the west coast of Korea and they found sequential changes in macrofaunal assemblages due to eutrophication and salinity changes in this area.

Park et al. (2009) investigated the characteristics of organic carbon distribution in the Saemangeum area in Korea during the construction of artificial sea dike. They reported phytoplankton blooms and increase of particulate organic carbon due to eutrophication caused by the construction in this area.

Lee et al. (2017) reported the effects of the Saemangeum Reclamation Project on migratory shorebird in the Saemangeum and Geum Estuaries. They showed that shorebird abundance declined by approximately 95% and 97.3% during the northward and southward migrations, respectively, as a result of reclamation in Saemangeum.

Response: National actions/measures

[China]

In “The Action Plan for Prevention and Control of Water Pollution” which was promulgated by the Chinese State Council in 2015, Action 8 “Full Guarantee of Water Ecological Environment Safety” includes the following points to protect marine ecology:

- To faithfully implement a sea reclamation regulation program,
- Strictly manage and supervise sea reclamation,
- Forbid sea reclamation in key bays, core areas and buffer areas of marine nature reserves, key areas and reserved areas of marine special reserves, important estuary areas, important coastal wetland areas, important sandy coastlines and sand source protected sea areas, special protected islands as well as important fishery sea areas,
- To impose strict restrictions on sea reclamation in ecologically fragile and sensitive areas and sea areas with poor self-cleaning capacity.
- To seriously investigate and deal with illegal sea reclamation behaviors and hold people concerned accountable.
- To include protection of natural coastlines into performance assessment for coastal local governments. By 2020, natural coastlines possession ratio nationwide should be no lower than 35% (excluding island coastlines).

[Japan]

The Act on Reclamation of Publicly-owned Water Surface was enforced in Japan in 1922 and revised in 1978. Based on this law, coastal reclamation and landfill are managed by a governor of each prefectural government. In addition to this law, several specific sea areas are protected by other laws such as the "Act on Special Measures concerning Conservation of the Environment of the Seto Inland Sea".

Sea gravel collection is regulated by the Gravel Gathering Act in Japan.

IV. Conclusion and recommendation

The NOWPAP region is one of the sea areas in the world where marine biodiversity faces strong anthropogenic pressures. However, the situation is quite different in each NOWPAP member state.

Eutrophication is a common pressure in the member states. However, this problem doesn't occur in every coastal area of the member states, but serious in several specific coastal areas where impacts of human activities are strong. Due to high population in major cities, the water quality deteriorated in nearby coastal areas. All NOWPAP member states understand this problem and they are taking countermeasures against eutrophication. Fortunately, the natural environment of several sea areas has improved and marine species once lived there have been recovered.

CEARAC implemented preliminary assessment of the eutrophication status in the 2014-2015 biennium and identified several potential eutrophic sea areas in the NOWPAP region. Outputs of this project can help planning and implementing preventive actions for marine biodiversity conservation in future.

NIS is also a common pressure on marine biodiversity in the four member states. Ship transportation in all member states will become more active in the future, thus this region will face more serious situations unless some preventive actions are taken now. Fortunately, all NOWPAP member states have adopted the International Convention for the Control and Management of Ship's Ballast Water and Sediments, and it is expected that all ballast water will be properly managed by Ballast Water Management System in the near future. On the other hand, fouling of ship hulls has not been controlled yet, and International Maritime Organization (IMO) set a voluntary guideline to reduce organism transfer via ship hull fouling. But it is still voluntary based, and CEARAC will observe the future development of the regulation to be discussed in IMO and also other international organizations.

Another route of introduction of NIS is aquaculture. China, Japan, and Korea culture marine species very actively. Natural fishery resources have a decreasing trend in the world, thus aquaculture in this area will be more active in the future. Some member states import NIS as cultured species because of their efficiency of aquaculture and their economic value. It is difficult to monitor and control the expansion of all cultured species to nature. However, it has been reported that some cultured NIS escape into nature and affect native species, and mate with native species and generate hybridization. In the

NOWPAP region, the pressure of NIS by aquaculture may become most serious in the future. It is expected that all of the member states start considering future actions for this issue as soon as possible. As the aquaculture industry has already developed various technologies to maintain NIS species from eggs to adult marketable stages in on-land controlled facilities, it will be highly recommended to set a direction of aquaculture industry not to utilize wild coastal water areas, but construct on-land culture farms. The release of juveniles to the wild environment has been conducted for some marine species such as salmon, shrimp, and sea urchin. But the pressure from such activity to wild environment has not been scientifically evaluated in a proper way yet. It is also necessary to assess the pressure by release aquaculture.

In this report, we don't consider any pressure of climate change. However, especially in Russia, an increase of seawater temperature is one trigger of NIS introduction. Because of the seawater temperature rise, some reports mention that temperate species can survive in Russian coastal waters and settle there. Study on the influence of climate change on marine organisms in this area is being conducted in some member states now. It is expected that these studies provide us with useful input to develop future actions for the conservation of marine biodiversity in this area.

Habitat alteration is another common issue among the four member states. Urbanization of coastal area of the member states will be continued in the future for economic growth in this area. Governments of the member states have controlled landfills in recent years, therefore the impact of coastal development may become smaller in the future. Actually, the cause of the current problem of habitat alteration is by past coastal development and important habitats have already been lost. It takes a long time to recover the original environments. The constant monitoring of the change of habitats from the past to the future is expected to take place. CEARAC tries to develop a monitoring methodology of seagrass beds in the NOWPAP region using satellite images. This project will contribute to understand the change of seagrass beds and to identify its factors. To apply such new methodology is useful for marine biodiversity conservation in this region. In China and Korea, since tidal flat is one of the important habitats for marine organisms, it may be required to develop a methodology to monitor the change of tidal flat areas for the NOWPAP region in the future. In Japan, collection of sea gravel is one of the big problems in habitat alteration. This is a problem only in Japan as Japan is an island country and the place for collecting sand/gravel is very limited. However, collection action affects marine organisms strongly. Thus, it is necessary to investigate the situation in other member states, whether there are any sand/gravel actions operated in their coastal areas and whether these actions affect marine organisms negatively.

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