NOWPAP POMRAC

Northwest Pacific Action Plan
Pollution Monitoring Regional Activity Centre

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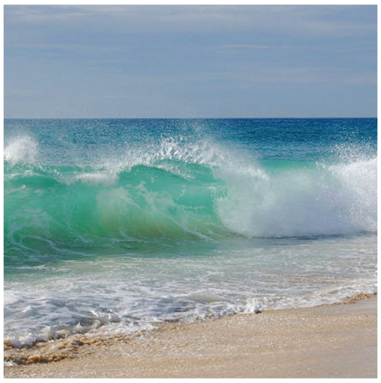
State of the Marine Environment Report for the NOWPAP region (SOMER 2)

2014



List of Acronyms

CEARAC	Special Monitoring and Coastal Environmental Assessment Regional Activity Centre
COD	Chemical Oxygen Demand
DDTs	Dichloro-Diphenyl-Trichloroethane
DIN, DIP	Dissolved Inorganic Nitrogen, Dissolved Inorganic Phosphorus
DO	Dissolved Oxygen
DSP	Diarethic Shellfish Poison
EANET	Acid Deposition Monitoring Network in East Asia
EEZ	Exclusive Economical Zone
FAO	Food and Agriculture Organization of the United Nations
FPM	Focal Points Meeting
GDP	Gross Domestic Product
GIWA	Global International Waters Assessment
HAB	Harmful Algal Bloom
HCHs	Hexachlorcyclohexane compounds
HELCOM	Baltic Marine Environment Protection Commission
HNS	Hazardous Noxious Substances
ICARM	Integrated Coastal and River Management
IGM	Intergovernmental Meeting
IMO	International Maritime Organization

JMA	Japan Meteorological Agency
LBS	Land Based Sources
LOICZ	Land-Ocean Interaction in the Coastal Zone
MAP	Mediterranean Action Plan
MERRAC	Marine Environmental Emergency Preparedness and Response Regional Activity Center
MIS	Marine invasive species
MTS	MAP Technical Report Series
NGOs	Nongovernmental Organizations
NIES	National Institute for Environmental Studies, Japan
NOWPAP	Northwest Pacific Action Plan
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	PolyChloro-Biphenyles
PCDD/PCDF	Polychlorinated dibenzodioxins/ Polychlorinated dibenzofurans
PICES	North Pacific Marine Science Organization
POMRAC	Pollution Monitoring Regional Activity Centre
POPs	Persistent Organic Pollutants
PSP	Paralytic Shellfish Poison
PTS	Persistent Toxic Substances
RACs	Regional Activity Centers
ROK	Republic of Korea
SOMER	State of Marine Environment Report
TBT	Tri-Butyl Tin
TN,TP	Total Nitrogen, Total Phosphorus
TOC	Total Organic Carbon
UNEP	United Nations Environment Programme
YSLME	Yellow Sea Large Marine Ecosystem

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1. Introduction

According to the decision of the 14th NOWPAP Intergovernmental Meeting, one of the NOWPAP POMRAC activities for 2012-2013 biennium was the preparation of the second "State of Marine Environment Report for the NOWPAP region" (SOMER-2).

First "State of Marine Environment Report for the NOWPAP region" (SOMER) has been compiled by POMRAC in close cooperation with other RACs in 2006 and published in 2007. The main goal of that report was to give a holistic description, analysis and overview of marine environmental problems of the NOWPAP sea area.

First SOMER for the NOWPAP region was based on the results obtained through the NOWPAP RACs activities implemented before 2005. The achievements of other regional and international programs/projects, and information from the scientific literature were broadly used as well. During the last 8 years since 2005, there is significant progress in the activities of all NOWPAP RACs.

In fact, the activities of all NOWPAP RACs are already implemented in more and more holistic way. Therefore, the regular compilation or synthesis of environmental problems, status and trends connected with natural and socio-economical conditions seems logical stage in the NOWPAP activities. The regular assessments of the state of marine environment was proposed as one of the key thematic elements of the NOWPAP medium-term strategy 2012-2017. The regularity of the assessment procedure is in line with the UN approach ("UN Regular Process for Global Reporting and Assessment of the State of the Marine Environment Including Socioeconomic Aspects"). All above mentioned provided background for the preparation of the SOMER-2.

The objective of SOMER-2 is the synthesis of information on the environmental problems, status and trends related to existing and changing natural and socio-economical conditions in the NOWPAP region. The main peculiarity of the SOMER-2 compared with the previous SOMER (2007) is intrinsic consistency with the "UN Regular Process". At this moment, the structure and contents of the first World Ocean Assessment are clear and many chapters are being prepared already. The approach based on the "ecosystem services" concept is one important feature of the assessment. This SOMER-2 is prepared taking into account peculiarities of the "UN Regular process", though the international experts on Regular process stressed the inevitable contradictions in any attempts to implement "tripartite" approach combining ecosystems services, human activities and stresses induced by these activities, and biodiversity/habitats issues.

The most important feature of SOMER-2 is its integrative nature. SOMER-2 has been prepared in close collaboration of all NOWPAP RACs as it has been done during the preparation of the first SOMER. Moreover, compared with first SOMER, the earlier involvement of all collaborators was realized during the SOMER-2 preparation.

Different chapters of SOMER-2 required the input of the different experts, NOWPAP RACs, and other organizations. The list of the experts involved has been determined after the discussion, finalization and approval of the structure of SOMER-2.

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The compilation and edition was carried by V.M. SHULKIN.

2. Current Status of Marine Environment

2.1. Geographical features of NOWPAP region

According to an agreement among four NOWPAP countries (China, Japan, Korea and Russia) in 1994, the geographical scope of NOWPAP covers marine, coastal zones about 33°-52°N and 121°-143°E (Figure 1). Formally, the western part of the NOWPAP region, namely the Bohai Sea, was not included in the NOWPAP region.

Figure 1. NOWPAP Region with main marine currents.

The main climatic feature of the NOWPAP region is a monsoon circulation with prevailing winds from the land (from the northwest) in winter and from the sea (from the southeast) in summer. Given the region's 2,500 km stretch from north to south, its climate ranges from temperate to subtropical. The climate of Jiangsu Province and Shandong Province in China belongs to the warm temperate zone. In summer these provinces are often hit by typhoons. Annual precipitation in Jiangsu Province is about 1,000 mm, while Shandong Province gets 550-950 mm. The northeastern Chinese Provinces (Liaoning, Jilin, Heilongjiang) belong to the temperate continental monsoon climate zone with averaged annual precipitation from 420-520 mm in Heilongjiang, to 400-600 mm in Jilin, and to 632-684 mm in Liaoning Province. The rather dry climate of northeastern China does not exclude heavy rain events due to typhoons in the end of summer.

The climate of the eastern part of the NOWPAP area is characterized by heavy snowfall due to humid northwest winter monsoons. Annual precipitation increases from 1,218 mm at Otaru (Hokkaido) to 2,133 mm at Toyama (middle Honshu) and then decreases to 1,632 mm at Fukuoka. Summer seasons in Japan, as well as in China, have a tendency to bring typhoons.

The climate in Korea is similar to the one showing in Japanese and Chinese coasts. Rainfall is concentrated during summer season starting from June to September. The river runoff is maximal during summer season as well. The southern coast usually gets affected by typhoons in the late of summer season that comes along with strong winds and heavy rains. Average annual precipitation in Seoul is 1,370 mm and 1,470 mm in Busan.

Cold dry winters and moderate warm humid summers are typical for the Primorsky Krai – Russian mainland part of NOWPAP region. There is clear shift of air temperature decrease in winter and increase in summer in moving away from the coast to the west even for the distance 30-50 km. Annual precipitation decreases from about 800 mm at the sea coast to 650 mm near the Khanka Lake 200 km away the sea. 80-95% of annual precipitation comes in the April to October period, and major part of river runoff takes place in summer.

Climate in the southwestern part of Sakhalin is milder than in adjacent Russian mainland. Annual precipitation varied between 750 mm and 990 mm for the different place, which is close to Primorsky Krai, but distribution throughout the year is more even, and distinctive snow accumulation is observed around the whole island.

Two large hilly peninsulas, Liaodong and Shandong, with an average elevation of 500 m, are located between the Bohai Sea and the Yellow Sea. The major relief of Jiangsu province, Shandong province and Liaoning province are hilly and plain regions, while mountain regions cover a big proportion in the other two provinces - Heilongjiang and Jilin. Besides, natural and artificial lakes of Jiangsu province is quite large with 17% of the whole province. The region's major river basins include the Songhua, Liaohe, Haihe, Huanhe, Huaihe and Changjiang Rivers; in 2002 the total river flow in the NOWPAP marine area from China was 1,193 km^3, and in 2005

– 1,117 km^3, and in 2011 – 1,205 km^3 that is rather stable. The Changjiang (Yangtze) River provides 80% of the region's river flow. If the Changjiang and Songhua Rivers (a tributary of the Amur River) are excluded, annual river flow could be about 177 km^3. All rivers have peak runoff during summer season and shows minimum river flow during winter season.

Land use in eastern part of the China is very intensive. The percentage of land surface covered by forests, bush and grassland, that is not used as arable lands and farms, in Liaoning, Heilongjiang and Jilin Provinces are 28.7%, 41.9% and 42.4%, respectively. In contrast to these provinces, non-agriculture vegetation coverage rates in Shandong and Jiangsu Provinces are much lower: 21.5% and 10.6%, respectively.

The western part of Japan is rather mountainous, with elevations up to 3,000 m in central Honshu Island and up to 1,800 m in the south of Kyushu Island. Despite relatively high population and intensive agriculture, state and privately held forests and wildlife parks cover 71.4% and 13.9%, respectively of the prefectures facing the NOWPAP marine region. Eight large rivers exist among the numerous rivers on the west coast of Japan: Teshio and Ishikari at the Hokkaido Is., Yoneshiro, Omono, Mogami, Agano, Shinano and Jintsu at the Honshu Is. These rivers had a total annual discharge about 70 km^3(2005), whereas total input from all west coast Japanese first class rivers reached up to 126 km^3.

The southern part of the Korean peninsula is mostly rugged, mountainous terrain 400-600 m high and only one-fifth of the western side of the land base is covered in plains. The coastal plains in the east and south are very narrow. The highest mountain is Halla (1,950 m) which is situated on the Jeju Island. 75% of the Korea is covered by forests, mostly hand planted. Protected areas cover about 7 % of South Korea and include more than a dozen national parks. Except the east coast, South Korea has a highly rugged coastline characterized by high tidal ranges, especially in the west coast where tides reach up 5 m and well developed tidal mudflats located. There are five key rivers: Han, Geum, Yongsan, Somjin and Nakdong with a total annual flow around 46 km^3, though inter annual variation is very significant (31-93 km^3).

The Russian part of NOWPAP includes Primorsky Krai, parts of southeast Khabarovsky Krai, and parts of southwest Sakhalin Island. Massive mountain ridges belonging to the Sikhote Alin mountain system cover about 80% of Primorsky Krai and the adjoining part of Khabarovsky Krai. Average elevation is 600 m, with the highest peaks reaching 1,855 m. The southwestern part of the Sakhalin Island has low mountains and hills. Almost 80% of the territory is covered by forest and an additional 8.1% is occupied by protected areas. The main rivers are the Tumannaya (Tumen), Razdolnaya (Suifun), Suchan, Samarga, Koppi, Botchi, Tumnin with total annual flow is around 27 km^3. Total annual input of all rivers from Russia within the NOWPAP area is around 43 km^3 (2005).

Just beyond the northern border of the NOWPAP area is the mouth of the Amur River whose annual flow is around 344 km^3. The Amur River does not directly flow into the NOWPAP area and so is not featured in this report. However, from a scientific perspective, the material load from the Amur River does influence water quality in the NOWPAP area, at least in the northern part of the Tartar Strait where the Amur's discharge rate is significant and some fresh water flows south in winter. During summer season, when most of the Amur's water flows into northward, the river flow increases water temperature along the northeast Sakhalin coast and affects other water characteristics at the northeastern corner of NOWPAP sea area.

Climatic characteristics and morphological features divide the NOWPAP marine area into two sub regions (Figure 1, Table 1). The integrated measure of climatic differences within NOWPAP marine area can be expressed in seasonal changes in sea surface water temperature (Figure 2). The multi-year water circulation pattern is similar although current speed and location have significant seasonal variations (Figure 1).

Table 1. Basic characteristics of key NOWPAP sea areas

	Sea Area A	Sea Area B
Surface area (km^2)	1,008,000	420,000
Volume (km^3)	1,360,080	17,731
Average depth (m)	1,350	44
Maximum depth (m)	3,796	100

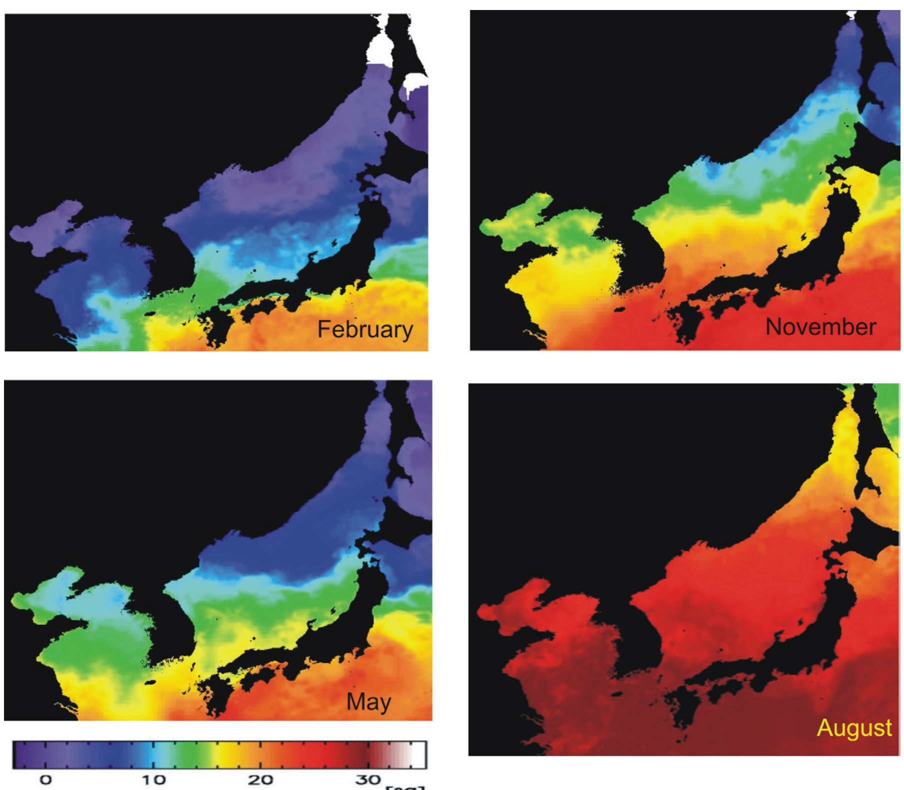


Figure 2. Seasonal changes in the surface temperature in NOWPAP sea areas
Sequence: February, May, August, November. Source: www.ocean.caos.tohoku.ac.jp

Sea Area "A" is located between the Japanese Islands and Sakhalin Island in the east and the Russia mainland and the Korean peninsula in the west. It is the biggest, deepest and coldest basin (Table 1). The seasonal differences in this area are the most extreme (Figure 2). During winter season, the northern part of the basin is covered by ice, and even in May more than half of the area has a water temperature below 8°C. Water circulation is characterized by a warm Tsushima current that flows from the south through the straight between Korea and Japan (Figure 1). This current is then divided into several branches, leaving all southern parts of marine area A warmer than the northern part, with a distinct thermal front oriented from the middle of the Korean peninsula to the Tsugaru Straight (Figures 1 and 2). With the exception of the one or two warmest months, this is a permanent thermal front (Figure 2). A branch of this warm current runs along the west coast of Hokkaido and comes out through the La Perouse (Soya) Strait. The northward current moving along the west coast of Sakhalin reverses at the Tartar Straight and moves south as a cold Primorsky (Liman) current.

Sea Area "B" is situated west and south of the Korea peninsula. Surface water temperature in January varies dramatically, from 3-4°C in the northwestern part to 17°C near Jeju Island. Summer temperatures are much more even: 28-30°C in July-August. Water circulation is characterized by the Kuroshio branch: a northward Yellow Sea current with two crosswind currents running along the coasts of the Korean and Shangdong peninsulas (Figure 1). Significant tidal currents are typical for the west coast of Korea. A key feature of the western part of this sub region is the pronounced direct influence of large Chinese rivers: Huaihe, Huanhe, Haihe and Liaohe.

Two key factors determine the human impact on environmental quality: 1) population and population density, and 2) character and intensity of human economic activity. A crucial, third factor is social organization that implies as capacity to treat waste and sewage properly, and to provide ecosystem based management of natural resources. Experience in countries shows that effective management for nature conservation and sustainable use of land are possible even in the place having very intensive industrial activities with a high population density.

The population in the northeast Chinese provinces facing the NOWPAP sea area is the highest among NOWPAP countries. The population is 285.4 million people with an average population density of 391 people/km^2 in 2012. Since 2002 it increased 12.8 million people and 18 people person/km2 correspondingly. Korea has the highest population density – 518 person/km^2 that increased 40 person/km^2 over the last 10 years. Its population number also grew from 46.1 to 51.8 million people. The lowest population and population density are in the Russian area facing the NOWPAP marine area (Table 2). Finally the number of people directly determines the volume of municipal sewage that can possibly influence river and coastal water quality, though one must also account for the level of waste treatment.

The total GDP increased approximately 1.5 times from 2002 to 2012, up to 4.4 trillion USD. China has shown the most rapid growth of GDP, about 5.3 times; the slowest growth rate in the same period was in Japan, about 1.5 times.

Table 2. Main socio-economic features of countries facing the NOWPAP marine area in 2002 and in 2012

NOWPAP region	Population (million)		Population density (per/km^2)		GDP, 10^6 USD		GDP per capita, USD/person	
	2002	2012	2002	2012	2002	2012	2002	2012
China*	272.6	285.4	261	273	473,048	2,512,230	1,641	8,802
Japan**	34.4	33.6	195	191	527,435	779,704$^{(2010)}$	15,340	23,183$^{(2010)}$
Korea	46.1	51.8	478	518	457,200	1,147,490	9,446	22,708
Russia***	1.4	1.3	14	13	1,611	3,437$^{(2011)}$	1,118	2,882$^{(2011)}$
Total	353.5	372.1	248	261	1,459,294	4,442,861	4,128	11,940

* - Heilongjiang, Jilin, Liaoning, Shandong, and Jiangsu Provinces; ** - Hokkaido and Prefectures of the west coast of Honshu and Kyushu; *** - coastal districts of Primorsky Krai, Khabarovsky Krai, and Sakhalin

All NOWPAP countries are classified as industrial. There are, however, huge differences in their industrial sectors. Industry in Japan, Korea, and recently in China, has undergone gradual and sometimes drastic changes to maintain economic competitiveness. Japan and Korea have applied modern technological advances to comply with progressively stricter environmental standards. Some industries in Russia and China still use technologies installed when the plants were originally built. Industry in these countries began to change rapidly in the 1990s. Industrial production in Russia has declined, many old industries have been closed or renovated and this process is resulting in new, profitable and more environmentally friendly operations. Industrial decline in China ended earlier and economic growth is now more pronounced than in Russia. There have been significant changes in the region's economics in the last 15 years. Japan has maintained its position as the world's second-largest economy, but Korea and China have also demonstrated major growth (Table 2).

Regional economic activity is reflected in gross domestic product (GDP) and GDP per capita. In 2002 the provinces of China, Japan and Korea within NOWPAP region had similar, absolute GDPs, though GDP per capita varies by 6-10 times. Russian regions in the NOWPAP area had lower GDPs and consequently have less human pressure on the environment. By 2010-2012 the China and Korea have shown significant economic growth with higher regional GDP than in the Japanese provinces within NOWPAP region. The GDP per capita in Japan continues to be the maximal, but GDP per capita in Korea in 2012 become very close to those in Japan. Regional GDP and GDP per capita in the Russia within NOWPAP region continue to be minimal comparing with other countries, though 2.5 times increase of GDP and GDP per capita takes place in Russia as well (Table 2).

Each NOWPAP country has a full spectrum of industrial, service and agricultural enterprises. At the same time, there are distinct differences in the structure of manufacturing sectors of these countries. In Japan most workers (69%) are employed in tertiary industries (service, trade). The number of service workers is about 30%. The same is true for Korea, with 59% in tertiary and 40% in secondary industries. In both Japan and Korea only 1% of workers are employed in a primary industry (agriculture, fishing, forestry). In 2011 the number of employers working in Chinese primary industry was 34.8% with 29.5% working in secondary industry, and 35.7% working in tertiary industry. In Russia most workers (54.8%) in 2002 were employed in secondary industries, though tertiary industry employment is about 41.5%, with only 3.7% of workers employed in primary industries (agriculture, fishing and forestry).

Anti-pollution measures can make human economic activity environmentally friendly and can significantly decrease harmful impacts on environment quality. Measures should include full treatment of municipal and industrial sewage, exclusion of most dangerous substances from technological processes, and innovations that minimize resource consumption.

In Japan 58% of the population had sewage treatment in 1998; this figure in 2001 was 63%. Human sewage or night soils is 100% treated. 78% of the gray water (sewage from kitchens, laundries, etc.) discharge in Japan was treated in 2003. In Korea there were 114 sewage treatment plants in 1998 having a treatment capacity of 16.6 million tons/day (66% of daily production). In 2002 the percentage of Korea's population with sewage treatment systems rose to 79% nationwide, varying from 41 to 98.9%, depending on the province. The most common treatment method is secondary treatment using activated sludge. Even so, many rural areas in Korea still have treatment rates less than 11% (NPEC, 2002). China's wastewater treatment rate is currently only 25.8%, but according to China National Economic and Social Development Statistics Bulletin, 2012 city sewage treatment rate in 2012 was 84.9%. Domestic wastewater treatment in Russia's Primorsky Krai covers only 27% of all sewage.

2.2. Assessment of the supporting and regulating ecosystem services

2.2.1. The main oceanological, hydrological and hydrochemical features of the water bodies in the region and its parts

The hydrological and hydrochemical features of the NOWPAP marine areas are studied pretty well (e.g. YSLME Reports, PICES Reports, numerous scientific publications), and continue to be studied. The NOWPAP sea area could be divided on the two areas “A” and “B” (Fig. 1) mainly based on the different characteristics in geographical, hydrological and many other aspects.

Sea area “A” is surrounded by the Russian mainland and Sakhalin Island at the north, the Korean Peninsula at the west, and the Japanese islands at the east and south. The Tartar, La Perouse (Soya), Tsugaru, Kanmon and Korean (Tsushima) straits provide the water exchange of NOWPAP sea area “A” with open Pacific and Yellow Sea. The sea area ‘A” has a surface area of about 978,000 km^2, a maximum depth of 3,742 m and a mean depth of 1,752 m. The coastal length is about 7,600 km (without islands) with the largest part belonging to Russia.

The bottom topography is characterized by three sub-basins with water depth more than 2000 m: Ulleung, Yamato and Japan separated by Yamato Rise. Continental shelves are rather narrow, and only northern Tartar Strait has large areas with depth 100-200 m. All straits connected sea area “A” with adjacent ocean are shallow 150 m and these sills determine the many features of water characteristic within this basin [Talley et al., 2004, Talley et al., 2006]

Main factors ruling the hydrological regime of the NOWPAP sea area “A” are the interaction of its surface waters with the atmosphere along the seasonal change of climatic conditions and the water exchange through the straits with the adjacent water basins. The first of these factors is the major one for the northern and north-western parts of the sea area “A”. Here, under the influence of the winter north-western monsoon winds bringing the cold air masses from the continent the surface waters are considerably cooling. Besides, in the semi-enclosed coastal water in the Peter the Great Bay first of all, and in the Tartar Strait, the ice cover is formed, and the intensive convection processes are developed in the adjacent open sea areas. The convection involves water layers considerably (till the depths of 400-600 m), and in some extremely cold years it reaches the near-bottom layers of the deep water basin while ventilating the cold, relatively homogeneous deep-water mass making 80 % of the total sea water volume. As a result the nearly isolated NOWPAP sea area “A” is very well ventilated at all depths from the surface to the bottom [Talley et al., 2006].

Water exchange through the straits is a major master variable for the hydrology of the southern and eastern parts of the sea area “A”. Subtropical waters of the Kuroshio branch which are in-flowing through the Korean Strait, during the whole year are heating the southern and east southern sea areas adjacent to the Japan. During the whole year, the northern and north-western parts of the sea stay colder than the southern and south-eastern ones with sharp subpolar east-west front between (Fig. 2). Another consequence of big temperature difference between north-western and south-eastern parts of this sea area is a plenty of snowfalls transported to the west coast of Japan by winter monsoon. Subpolar front is a major water-mass boundary, dividing the sea into subtropical and subpolar regions.

The coldest months at the sea area “A” are January and February with the average air temperature of −20 °C in the north and 5 °C in the south. The west-northern part of this sea area, namely the Tartar Strait down to 48-50 ºN and inner parts of the semi-enclosed bays like Peter the Great Bay, Gigit Bay and Posyet Bay freeze for about 3–5 months. The timing and extent of freezing vary from year to year, so the duration being covered by ice may start from the north of Tartar Strait as early as in October and disappear around June. This phenomenon covered by ice continues only in the bays and forms floating patches in the open sea.

The sea currents circulate in the counterclockwise direction. The Kuroshio (Japan Current), the Tsushima Current and the East Korea Warm Current bring warmer and more saline water to the north. There they merge into the Tsugaru Current and flow into the Pacific Ocean through the Tsugaru Strait. They also feed the Sōya Current and exit through the La Perouse Strait to the Sea of Okhotsk. The returning branch is composed of the cold Primorsky (Liman) Current and its continuation of North Korean Current which bring fresh and cold water along the mainland coast to the south.

Water temperature is mostly affected by exchange with the atmosphere in the northern part of the sea and by the currents in the southern part. Winter temperatures are 0 °C or below in the north and 10–14 °C in the south. In this season, there is a significant temperature difference between the western and eastern parts owing to the circular currents. So at the latitude of Peter the Great Bay, the water temperature is about 0 °C in the west and 5–6 °C in the east. This east-west difference drops to 1–2 °C in summer, and the temperatures rise to 18–20 °C in the north and 25–27 °C in the south (Fig. 2).

As a result of the enclosed nature of the sea, its waters form clearly separated layers which may show seasonal and spatial variability. In winter, the temperature is almost constant with the depth in the northern part of the sea. However, in central-southern parts, it may be 8–10 °C down to 100–150 m, 2–4 °C at 200–250 m, 1.0–1.5 °C at 400–500 m and then remain at about 0 °C until the bottom. Heating by the sun and tropical monsoons increases the depth gradient in spring–summer, and at the northern part of NOWPAP sea area “A” the surface layer (down to 15 m) may heat up to 18–20 °C. The temperature would sharply drop to 4 °C at 50 m, then slowly decrease to 1 °C at 250 m and remain so down to the seabed. On the contrary, the temperature in the south part of this sea area could gradually decrease to 6 °C at 200 m, then to

2 °C at 260 m and to 0.04–0.14 °C at 1000–1500 m, but then it would rise to about 0.3 °C near the bottom. This cold layer at about 1000 m is formed by sinking of cold water in the northern part of the sea area "A" during winter season and is brought to the south by the sea currents. Such stratification is rather stable and is observed through the year.

There are complex tides within sea area "A" induced by the tidal waves of the Pacific penetrating through the Korea Strait and Tsugaru strait. The tides are semi-diurnal in the northern part of the Strait of Tartary. They are diurnal at the eastern shore of Korea, Russian Far East and the Japanese islands. Mixed tides take place in Peter the Great Bay and Korea Strait. The tidal currents have a speed of 10–25 cm/s in the open sea. They accelerate in the Korea Strait (40–60 cm/s), La Pérouse Strait (50–100 cm/s) and especially in the Tsugaru Strait (100–200 cm/s). The amplitude of the tides is relatively low and varies across the sea. It reaches 3 m in the south near the Korea Strait, but quickly drops northwards to 1.5 m in the southern tip of Korean Peninsula and to 0.5 m in the North Korean shores. Similar low tides are observed in the east coastal areas. The tide height, however increases up to 2.3 – 2.8 m toward the north of the Strait of Tartary due to its funnel-like shape. Apart from tides, the water level also experiences seasonal, monsoon-related variations across the entire sea with the highest levels observed in summer and lowest in winter. Wind may also locally change the water level by 20–25 cm; for example, it is higher in summer at the Korean and lower at the Japanese coasts.

Water balance of NOWPAP sea area "A" is characterized by the predominance input (52,200 km^3 or 97%) through the Korean Strait and predominant discharges through the Tsugaru Strait (34,610 km^3 or 64%), and La Pérouse Strait (10,380 km^3 or 19%). The rest outflow is realized through the Korean Strait. Rainfall, evaporation and river runoff make only 1% of the water balance. Between October and April, the outflow exceeds the inflow due to the lower income through the Korea Strait; this balance reverses between May and September.

Salinity of the NOWPAP sea area "A" are determined by the water exchange with the adjacent sea areas which in turn controlled by the semi-isolated nature of this basin. The precipitation-evaporation, ice formation/melting, and continental runoff in coastal areas are the other master variables for major hydrochemical parameters.

During the winter season, showing the largest area of the sea surface, water salinity exceeds 34‰ which is mainly conditioned by high-salinity waters (34.6‰) supplied from the East-China Sea. Less saline waters are concentrated in the coastal areas of the Asian continent and islands where their salinity decreases to 33.5 - 33.8‰. During the spring season, salinity of subtropical part increases and in the subpolar part decreases because of ice melting in the Tartar Strait and Peter the Great Bay. When the season closes to the summer, after the surface waters of the East China Sea (which are freshened due to the abound precipitation) are supplied to the sea through the Korean Strait, overall salinity in the sea water decreases to the values less than 34‰. In August, of salinity varies in the range of 32.9-33.9‰. However, the salinity level in the north of the Tartar Strait decreases to 31.5‰, and even to 25-30‰ in some parts of the coastal zone. During the autumn season, with the increase of the northern winds, it occurs the water surge with mixing of waters in the upper layer that drives to increase of salinity. Minimal seasonal changes of salinity on the surface (0.5-1.0‰) are found in the central part of the sea, and the maximal ones (2-15‰) - in the coastal areas of the north-western part and in the Korean Strait.

With depths, along with the general increase of salinity values, the variability of salinity declines both in space and in time [Tally et al, 2004, 2006]. By the average long-term data, even at the depth of 50 m, seasonal salinity variations in the central part of the sea do not exceed 0.2-0.4‰, and in the north and south of the water area - 1-3‰. In the 100 m depth, the horizontal salinity changes around the year do not exceed 0.5‰, and on at 200 m – 0.1‰, that shows consistent trend.

By the vertical, water masses in the open part of the NOWPAP sea area "A" are subdivided into the surface, intermediate, and deep ones in accordance with spatial-temporal variability of temperature and salinity.

Surface water mass is located in the bounds of the upper mixed layer and it is limited beneath by a seasonal thermocline. In the southern warm sector surface subtropical water mass is formed due to the mixing of waters supplied from the East China Sea and the coastal waters of Japanese Islands, and in the cold northern sector - by mixing of the coastal waters freshened by the continental runoff with the waters of the open areas of the adjacent sea area. In the course of the year, the temperature and salinity of the surface waters vary in a wide range, and their thickness varies from 0 to 120 m.

The core of intermediate water mass is located at the depths of 60-100 m, and the lower boundary - at the depth of 120-200 m. Salinity in its core is ~ 34.1-34.8‰, but at the local area to the east of the Korean Peninsula coast, the low salinity water mass is observed at depths of 200-400 (34.0-34.06‰).

Deep water mass is usually called the main proper water. It occupies layers deeper than 400 m and is characterized by homogeneous values of temperature (0.2-0.7°) and salinity (34.07-34.10‰). High content of dissolved oxygen in its core suggest active renewal of the deep layers by the surface waters.

The distribution of such important hydrochemical parameters as nutrients (Si, N, P) compounds and dissolved oxygen is determined by the set of processes.

NOWPAP sea area "B" includes Yellow Sea. The square of NOWPAP sea area "B" is about 420,000 km^2 with volume 17,731 km^3 and average depth 44 m only and maximum depth about 140 m.

The bottom relief of the Yellow Sea is presented by a shallow shelf with wide shoals (less than 20 m) at west side and little bit more deep in the east side. Rather narrow late glacial paleo

Huanhe Channel with depth 60-80 m is placed between. Such structure suggests that the water column will be readily affected by seasonal changes.

Based on the salinity level, the Yellow sea water system and the coastal water system could be distinguished. Also, depending on the temperature variability, comprehensive studies on the water structure have been conducted [Chu et al., 2005]. The water mass of NOWPAP sea area "B" is in continuous circulation within Yellow Sea, Bohai Sea and the East China Sea. Water circulation in the Yellow Sea is a basin-wide cyclonic gyre (Fig. 1). The Yellow Sea Warm Current is a branch of the Tsushima Warm Current, which comes from the East China Sea carrying saline (>33‰) and warm (>12°C) water flowing northward along the Korean peninsula coast and then eastward into the Bohai Sea (Fig. 1). Backward Yellow Sea Coastal Current flows to the south along China mainland. The water exchange in semi-enclosed Yellow Sea is rather slow with residence time 5-6 years [Kim, Khang, 2000].

During the winter season, the surface water temperature in the Yellow Sea may decrease to the freezing point in the northern part, but with temperatures is getting warming up to 6-8°C towards the south. During the summer season, the water temperature may rise to as high as 27 - 28°C and the difference between the southern and northern parts become negligible (Fig. 2).

There are significant seasonal variability of averaged salinity in the Yellow Sea having maximum 32.9 - 33.2 ‰ in winter and spring and minimum 32.2-32.8 ‰ in summer and fall. The combined action of Yellow Sea Warm Current inflow, the input of waters diluted by Yangtze River, and the seasonal evaporation/precipitation is a reason of this variability [Ma and Qiao , 2004].

The significant influence of river runoff is one of the main peculiarities of the Yellow Sea. The Yalujiang, Liao He, Hai He, and HuangHe (Yellow River) in China and Han River in Korea are major rivers inputting to the Yellow Sea directly and having important effects on salinity of Yellow Sea, whereas the Yangtze River exerts strong influence on the hydrography of the southernmost part of the Sea. As a result the NOWPAP sea area "B" receives a huge volume of sediments (around 1.6 billion tons annually) mainly from the Huanghe River on its north border and Yangtze River on its south border; both rivers forming large deltas at their mouths. All rivers have peak runoff in summer and minimum discharge in winter.

The Yellow Sea is under the influence of the north-east Asian monsoon which is characterized by strong north-westerly wind during the period from autumn to early spring, with a brief wet summer and a relatively dry season for the rest of the year. Precipitation over the Yellow Sea is estimated as 460×10^9 m^3 yr^{-1} and the total river discharge ca. 120×10^9 m^3 yr^{-1} [Lee and Kim 1989]. The winter monsoon winds transports aeolian material from the Mongolian and Chinese arid areas. The summer monsoon rain transports riverine material from the contiguous land masses.

The river runoff is about 120×10^9 m^3 yr^{-1}. This discharge excludes the Changjiang River discharge. During the summer, Changjiang River water intrudes into the south Yellow Sea and may account for as much as a third of the total river discharge. However, this discharge is very difficult to quantify, so it is considered to be quantitatively insignificant to the overall budgets. The average water exchange time in the Yellow Sea is estimated to be about seven years, and is confirmed by $^{228}Ra/^{226}Ra$ distributions.

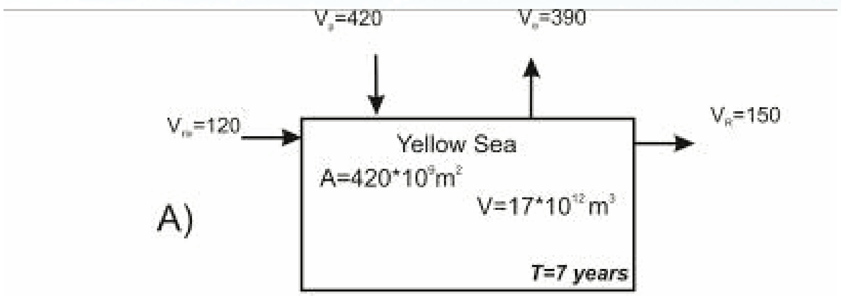
Thus NOWPAP sea area "B" is a rather shallow marginal basin having relatively restricted water exchange with offshore waters. It makes this sea area vulnerable to the river and wastewater runoff which is very large here.

2.2.2. Sea/Atmosphere and Sea/Sediment interaction

The role of sea/atmosphere interaction is crucial in the water and gas global cycles. The evaporation of water from sea surface considers as an "engine" for the migration of many chemical substances. There are two main aspects of the sea/atmosphere interaction which supports and regulates services of marine ecosystems.

First of all, atmosphere is a significant route by which both natural and anthropogenic compounds are transported from land-based sources to coastal and offshore waters [e.g. Jickells, 1995]. This is of particular importance for semi-enclosed seas, such as the NOWPAP sea area "A" and especially NOWPAP sea area "B" due to the vicinity of land-based emissions and densely populated coastal provinces of China and Korea.

The importance of the atmospheric precipitation in the water balance of the two major parts NOWPAP sea areas "A" and "B" is obvious from the Figure 3 redrawn from (Yanagi, 2002 and LOICZ budget by Chung et al, 2002, respectively). For the sea area "B" (Yellow Sea), the annual flux of atmospheric precipitation 3.5 times exceeds the river runoff. For the sea area "A" annual flux from atmosphere overdo the river runoff 7.7 times. It means more relative significance of atmospheric deposition for sea area "A". At the same time one order higher water volume of rather well mixed 200 m upper layer of sea area "A" compare with all water volume of sea area "B" makes latter one much more susceptible to the outer land-based sources of material including atmospheric precipitation.



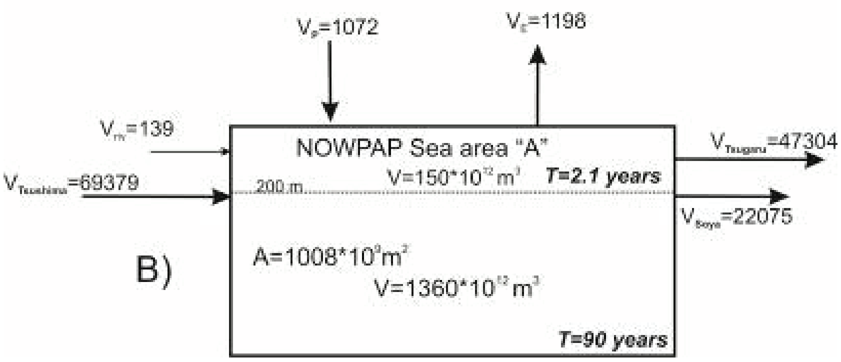


Figure 3. Water balance of the Yellow Sea by LOICZ budget [LOICZ, Chung et a., 2002] and NOWPAP sea area "A" by [Yanagi, 2002]. Annual water inputs and outputs (V_R) in km^3

The relative contribution of fluvial runoff and atmospheric deposition is controlled besides others by the size of sea area considered and simple assessment model could be proposed for the evaluation of size area where river runoff is equal to, or strongly prevails the atmospheric deposition [Shulkin, 2011].

The flux of any component through atmosphere to sea is determined by (1) its burden in the air; and (2) the rate at which it is deposited on to the sea surface.

The burden of substances in atmosphere is identical to the air pollution assessment. This issue is under serious government control in all NOWPAP countries because driven by rapid economic development and intensive energy use, emissions of atmospheric pollutants have caused severe atmosphere pollution in some NOWPAP areas. SO_x NO_x and particulate matter (dust) are the main atmospheric pollutants in the region though some other compounds (e.g. ozone and benz(a)pyrene) are also subject of concern.

The dynamic of atmosphere pollution by SO_x in the region during last decades (Fig. 4) reveals the significant improvement of situation in Japan more than 20 years ago. In China situation continues to be severe due to broad use of coal burning for power generation, though improvement is obvious during last years. The atmosphere pollution by nitrogen oxides due to car exhausts mainly continues to be a problem in all NOWPAP countries but the regional differences in inter-annual trend have shown as well (Fig. 4).

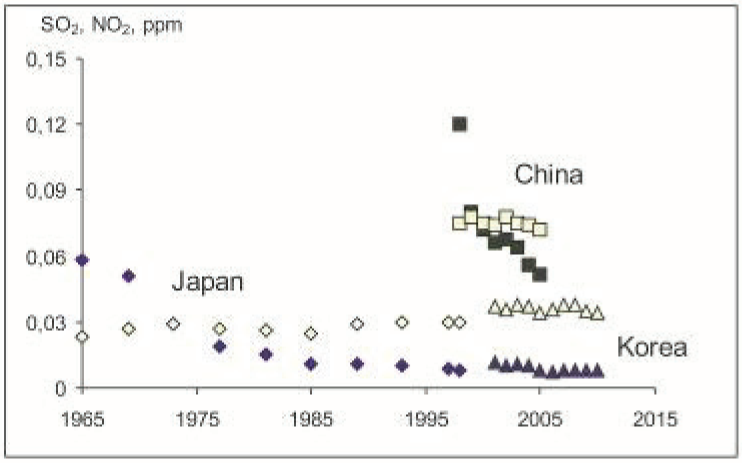


Figure 4. The interannual trend of air pollution by SO_2 (filled symbols) and NO_2 (unfilled symbols) in the Beijing (by Chan, Yao, 2008), Seoul (by www. ECOREA-2011) and 14 ambient monitoring stations in Japan (by www.env.gov.jp)

The atmosphere pollution by particulate matter in NOWPAP region has clear seasonal component and reaches maximum in April-May due to spring sand storms in the deserts of north China and Mongolia. In that time the elevated concentration of particulate matter in air takes place in the northeastern China, Korea and even in Japan. Rest time of year the air pollution problem by particulate matter is restricted by China, though significant efforts led to the improvement of situation even here [Zhao et al., 2013].

Air to sea fluxes result from the removal of material that is present in the atmosphere by gravitational settling and turbulent diffusion ("dry" settling) and by precipitation scavenging ('wet' deposition). For the assessment of latter flux the concentration of substances in the rains (snow) is needed, and data on the solubility of the dust particles is also needed for the assessment of "dry" deposition.

Low alkalinity of the atmospheric precipitations leads to their elevated acidity to pH 6 even at the background conditions. The anthropogenic exhaust of SO_2 and NO_2 is accompanied by the further decline of rain pH down to 4.0-4.5. The decrease trend of pH was observed and registered by analyzing rains sampled in the Russian Far East [Kondratyev, 2009].

Acid rain does not appear to be a serious problem in the NOWPAP region at the moment. However, the impact of acid deposition is hard to evaluate without having monitoring data in the long-term scale. In the case of small lakes and soil with little buffering capacity in coastal areas, the long-term effects of acid deposition can appear suddenly. Long-term monitoring programs for acid deposition like EANET are needed to be maintained.

Atmospheric depositions on the coastal and sea ecosystems act as an additional input of chemical substances (nutrients and/or toxic compounds). It was also pointed out that the major source of dissolved inorganic nutrients is deposition from atmospheric precipitation in the central region of the Yellow Sea [Wan et al. ,2002, and Lin et al., 2005]. Precipitation has exhibited increasing N concentrations resulting from the atmospheric transport of chemical fertilizer. The budget assessment of dissolved inorganic nitrogen (DIN) for the Yellow Sea by LOICZ methodology also confirmed the prevailing contribution of atmospheric deposition. For the NOWPAP sea area “A”, dominance of atmospheric source for DIN was observed due to influence of rains in the water balance (Fig. 5).

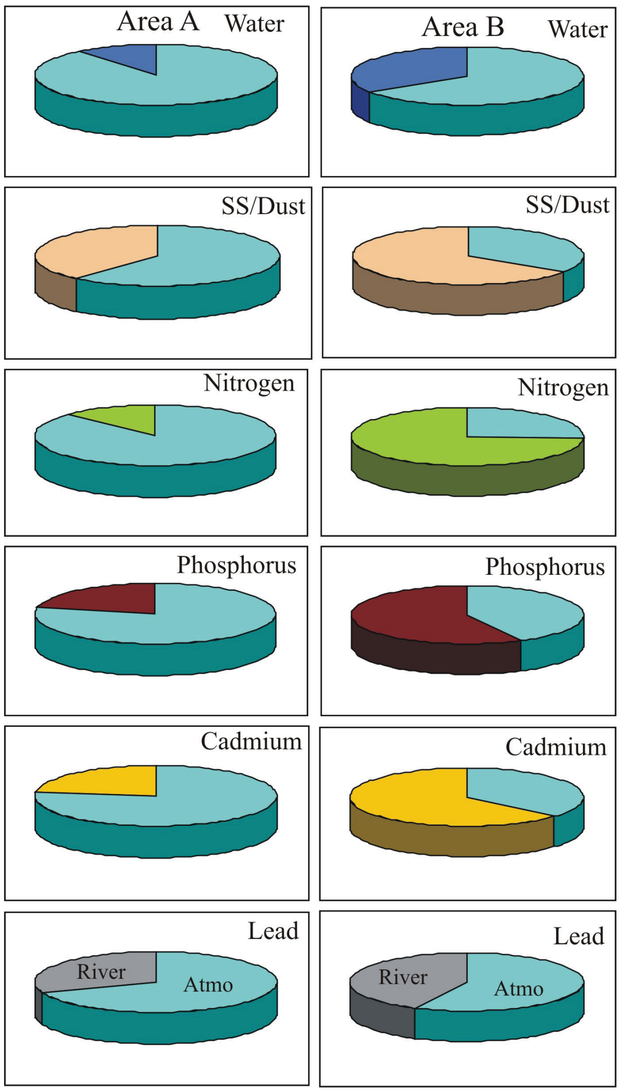


Figure 5. The relative role of atmospheric input (blue) and river input (other colors) of different substances on the NOWPAP sea area “A” (left) and NOWPAP sea area “B” (right)

For the time being comparison between atmospheric and river inputs at the basin level clearly indicate that for marine area A, atmospheric sources dominate for all components, including the water itself. In marine area B (Yellow Sea), the situation is different and atmospheric input dominates for water, DIN and lead. For phosphorus, dust (particulate matter) and cadmium the fluxes through atmospheric input to the sea area B vary from 26 to 42 % of total inputs

[SOMER, 2007]. In offshore regions and for entire basins, atmospheric inputs are dominant and additional attention is needed for any potentially dangerous substances migrating via atmosphere fluxes. The contribution of atmospheric inputs will be determined by the ratio of concentrations of substances in the rain/snow and in river water, by the ratio of river run-off and the amount of precipitation, and by the size of the area considered due to non-point nature of atmospheric deposition against point source of river runoff.

Second aspect of the importance of air/sea interface is a contribution of this boundary in the gas exchange and gas balance. The atmosphere is the major source of gases to seawater. The ocean can act as either a source or a sink for atmospheric gases. The air – sea exchange of CO_2 and CH_4 is very important in the climate system. The cycle of oxygen in the oceans which is critical to many ocean biogeochemical processes and to sustaining much of the marine biosphere is also controlled by the air-sea interaction. In the case of gases for which the ocean is a source, the gas is produced by a wide variety of processes including biological activity in the oceans. The contribution of air-sea interface to the overall flux to the atmosphere is varied from 3-5% for methane (CH_4) to 20% for CO and Hg, and to 60-90% for N_2O, dymetylsulphate, and CH_3I [Chester, Jickels, 2012].

The ocean including shelf areas represents a net sink for CO_2 absorbing about 30% of current anthropogenic emissions by biological uptake and net physical transfer [Tsunogai et al., 1999]. At the same time there is significant seasonal and spatial variability of gas exchange fluxes at the air-sea boundary especially within shelf areas. For example within Yellow Sea pCO_2 in the surface layer showed the highest values in summer and the lowest in winter. During summer and winter, the pCO_2 distribution in most parts of the study areas was strongly influenced by sea surface temperature, while biological processes played an important role during fall and spring. As a result Yellow Sea acts as a net CO_2 source [Xue et al., 2012]. The flux of oxygen between the atmosphere and ocean is approximately in balance although this does involve very large fluxes mediated by biological and physicochemical factors.

Sea-sediment interface is a next ubiquitous border surface which plays important role in the biogeochemical cycles in marine ecosystems. The intensity of the processes at the benthic boundary layer is explained by the sharp gradients of many physical, chemical and biological characteristics observed [Santschi et al., 1990]. The major function of recent bottom sediments in the biogeochemical cycles of marine ecosystems is to be a depository of substances through the sedimentation process. This unidirectional process is realized as a complex set of reversible processes and reactions, including physical re-suspension, biogeochemical decay in the boundary layer of settled organic matter and material produced by benthic communities. The situation is complicated by the diagenetic process in the upper layer of bottom sediments.

The decomposition of organic matter is a major driving force of the benthic system and its processes which are mostly catalyzed by microbial activities. It is well established that most parts of the primary produced organic matter is decayed in the upper water zones. On average only about 1% of the produced organic matter reaches the sediment surface in the open ocean and about 7% - in the coastal areas [Berger et al., 1989].

The vast majority of deposited organic matter (ca. 90% in coastal areas and 97% in open ocean) is decomposed at the bottom surface and in upper layer of sediments. As a result, only small part (usually less than 1%) of the organic matter produced in the photic zone will ultimately become buried, and 97-99% are decomposed by microbial activities and returned to the water column in the form of dissolved constituents (Figure 6).

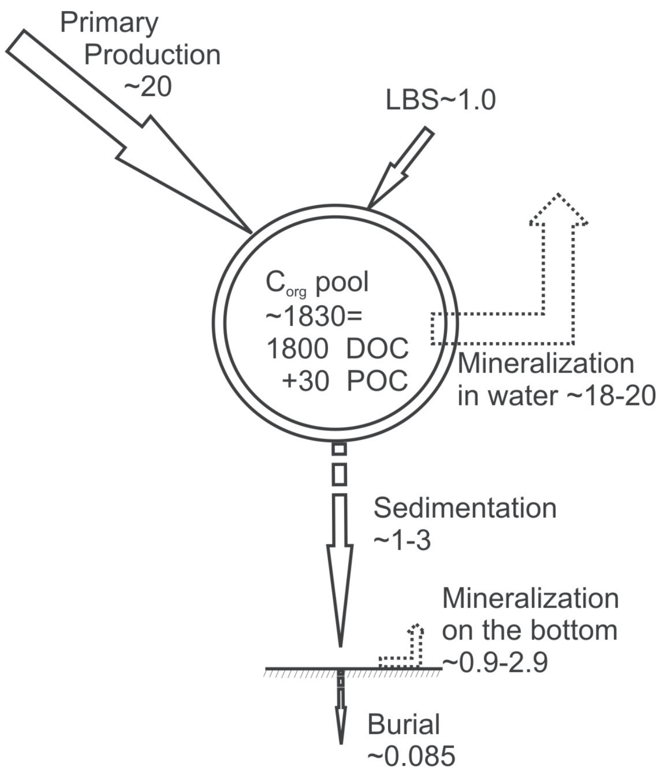


Figure 6. The fluxes of Corg (109 tons/year) and the pools in World Ocean (109 tons) of dissolved organic carbon (DOC) and particulate organic carbon (POC) (by data from Romankevich, 1977).

As a result, sedimentation process cannot be defined by one transport direction. On the one hand, deposition and burial in sediments remove elements from the marine cycles over geological periods. But vast proportions of settled and accumulated particles, which are organic matters, first of all are subject to dissolution and microbial decomposition during sediments forming. Marine sediments, therefore, also act as a 'secondary' source of released dissolved components and in some case, this source becomes important especially in the coastal and estuarine environments [Friedl et al., 1998]. To assess the contribution of the benthic flux to overall supply of nutrients for the ecosystems is an important process at the regional and local scales. The decision of this task is based on the experimental and modeled studies of the benthic fluxes by different methods.

In the NOWPAP region, assessment studies were carried out at the coastal areas in Japan [Sarker et al., 2005, Sohma et al., 2001], Korea [Waska et al., 2011], Peter the Great Bay and Bohai Bay [Liu et al., 2011]. Most of these research as well as data obtained from other regions show that the benthic nutrient fluxes play an important role in the nutrient cycle of the coastal ecosystems. For example, in the Bohai Bay benthic nutrient fluxes were 2–3 times higher than the riverine input based on the regeneration rate of phosphate being slower relative to DIN and dissolved silicate. The release of dissolved silicate and phosphate from sediments may mitigate the decrease of dissolved silicate and phosphate due to the reduction of freshwater discharge [Liu et al., 2011].

Besides benthic fluxes of nutrients due to destruction of the organic matter settled, deposited and produced by benthos organisms, there is phenomenon of submarine ground discharge (SGD) of waters from land aquifers through the bottom sediments. SGD plays significant role in the nutrients balance of many coastal areas without big rivers. Masan Bay and west coast of Korea [Waska, Kim, 2011] are the places reflecting the findings mentioned above, and even in the Bohai Bay, submarine ground water discharge provides nitrogen supply similar to benthic flux [Liu et al., 2011].

2.2.3. Primary production

Primary production is one of the most important processes in the ecosystems. Higher trophic level organisms in the sea, such as fish and bird, are directly or indirectly supported by primary production produced by phytoplankton. Primary production is also important for material cycle and energy flow. It is known that CO_2 absorbed by ocean, presented mostly as bicarbonate ion, is used by primary producers and converted to particulate and dissolved organic materials. Parts of the particulate and dissolved organic materials sink to deeper part of the ocean and used as foods and energy source of organisms living in deep sea and converted to inorganic carbon and stored.

Changes of primary production may dramatically influence the ecosystem. Eutrophication and other anthropogenic perturbation of the coastal area and climate changes are known to change the primary production. It is also suggested that the serious anthropogenic perturbation influences primary production and causing direct and indirect environmental problems in the NOWPAP region, although causes of some problems are difficult to separate from natural climate variation.

2.2.3.1. Seasonal and Interannual Variability

In most of the NOWPAP sea area “A”, typical spring and autumn blooms of phytoplankton was observed by ocean color satellite [Kim et al., 2000; Yamada et al., 2004] and primary production was also following the variation [Yamada et al. 2005]. This seasonal variation can be believed to be caused by typical light limitation during winter and nutrient limitation during summer. Timing of the seasonal variation is different depending on the locations. Early phytoplankton spring blooms can be found along the subpolar front and Prymorye coast, and it occurs late in the northern areas. This difference seems to be caused by the difference of timing of stratification, and it could be well reproduced by an ecosystem model [Onitsuka et al, 2007]. On the other hand, the seasonal phytoplankton bloom is not very clear in the coastal area, such as Toyama Bay, where nutrient input from land is more important [Onishi et al., 2007]. Nevertheless, phytoplankton abundance in large portion of the NOWPAP sea area "A" is not directly influenced by nutrient input from land.

Interannual variation of the spring bloom was also reported in the NOWPAP sea area "A" [Yamada et al., 2004]. Spring bloom timing is late when sea surface wind during spring was high, and it indicates that the wind mixing is an important controlling factor. The variation during 1997 to 2005 showed that the spring bloom was early and late in El Nino and La Nina years, respectively, which indicate the large scale climate variation is the important factor.

The timing of the interannual variation seemed to be related to even longer variation of phytoplankton and zooplankton [Chiba and Saino, 2002]. With the long time series ship observation data by Japan Meteorological Agency, they found summer phytoplankton population was dominated in spring sampling period after 1976/77 indicating that the spring bloom already ended at the observation time in 1980'. Chiba and Saino (2003) also found that the zooplankton community and abundance was also different for those time period which is known to be before and after the climate regime shift. Those variations related to climate change may also significantly influence to the higher trophic levels of the marine ecosystem, and it is speculated that the possible similar change may be happened with the human induced climate change.

Seasonal and interannual variation of primary production in the NOWPAP sea area "B", Yellow Sea and East China Sea, is very different from the eastern region of the NOWPAP sea area "A" (Fig. 7). Spring bloom can be seen in very limited area in the Yellow Sea and East China Sea [Yamaguchi et al., 2013, Xu et al., 2013]. One of the factors which influence primary production in this area, is large river discharge, specifically Changjiang River. Turbidity caused by the resuspension of the sediment is also an important factor. Kim et al. (2009) and Yamaguchi et al. (2012) found that satellite chlorophyll-a in the large area of the East China Sea was higher than surrounding area during summer, and the extension area, and the concentration was positively correlated with Changjiang River discharge with 0-2 months time lag. The lag was shorter and longer near the river mouth and in the Tsushima Strait, respectively, where the freshwater supplied from the Changjiang River are extended. These results strongly support that the Changjiang River discharge influences to the summer interannual variation of the primary production in the East China Sea and in the NOWPAP sea area "B".

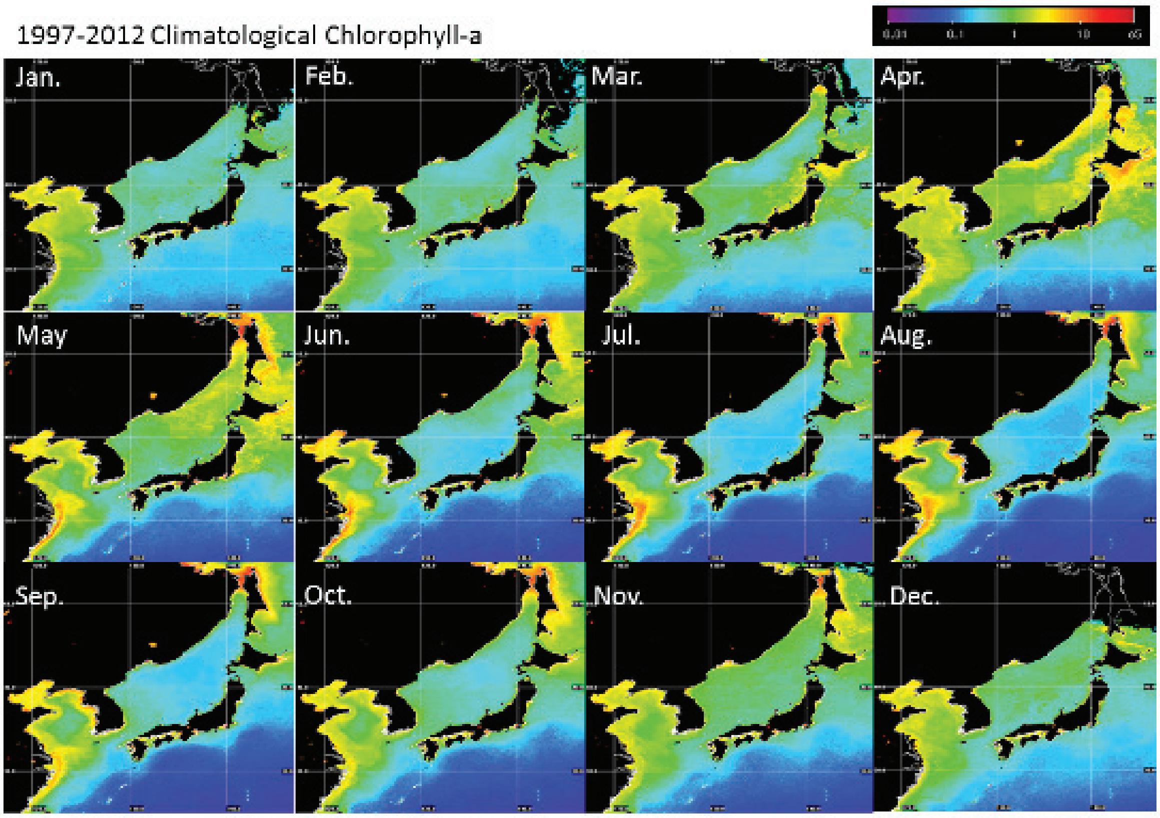


Figure 7. Climatology of satellite chlorophyll-a concentration (mg m^{-3}) from 1998-2012. Data of SeaWiFS for 1997-2007 and MODIS/AQUA for 2002-2012 was used. Eastern NOWPAP regions were NASA standard products, and western NOWPAP regions were processed using algorithms by Yamaguchi et al. (2013).

It is also well known that recently nutrient, specifically nitrogen, discharge from surrounded rivers including the Changjiang River to the western NOWPAP region has been largely increased. It is also noticed that the nitrogen flux from atmosphere is also increased [Kim et al., 2011]. Those indicate that the eutrophication may significantly influence to the ecosystem of the western part of the NOWPAP region. Nitrate concentrations and N/P ratio of even fairly offshore water from the mouth is significantly high and still increasing [Siswanto et al., 2008]. The increase is expected to influence to primary production in this area. Satellite data between the Changjiang River mouth to the Tsushima Strait does not show significant increase of chlorophyll-a concentration probably masked by shorter time scale variation of river discharge [Yamaguchi et al., 2012]. The increase of satellite chlorophyll-a from 1998 to 2008 was observed in the Yellow Sea during summer and spring [Yamaguchi et al., 2013]. On the other hand, decrease of chlorophyll-a was reported from 1980's to 1990's in the Yellow Sea, and it was suggested as influence of climate change [Lin et al., 2005]. Sea surface temperature in the Yellow Sea slightly decreases during the 1998 to 2008 and the increase of chlorophyll-a may also include influence of climate change.

2.2.3.2. Abnormal Events

a) Harmful Algal Blooms

Red tide events in the NOWPAP region are described in another section specifically. Thus, this section will briefly describe its status. There are two major areas of large scale red tide events; coast of Korea and offshore of Changjiang River. *Cochlodinium polykrikoides* and *Prorocentrum shikokuense*, which are recently reported synonym of *P. donghaiense* and *P. dentatum* [Takano and Matsuoka, 2011], and are the serious causing organisms along the Korean coast and off Chagjiang River Estuary, respectively.

Along the Korean coast, red tide events were reported from long time ago; however, harmful algal bloom (HABs), typically caused by dinoflagellates, only reported recently. Large bloom of fish-killing *C. polykrikoides* has been reported since 1995. This bloom typically started from southeastern part of Korea, expanded to east and reached north along the Korean western coast when it was severe, and it seems to be transported to the northwestern coast of Japan. Large interannual variation was also reported, and the reason was not still clear [Kim, 2010; Miyahara et al., 2009].

Off Changjiang River Estuary, increase of red tide events has been reported from 1980', and the shift of the timing from July-August to May-June and dominant phytoplankton groups from diatom to dinolagellates during last two decades were reported [Tang et al, 2006]. Red tide caused by *P. shikokuense* increased after 2000, and it covered 10,000 km^2 in 2004. Fairly large cell number of this species could be sometimes found in the Chingjiang Diluted Water in middle to eastern East China Sea [Kiyomoto et al., 2013]. The cause of red tide may be related to eutrophication of the freshwater input and the interaction between coastal upwelling of Taiwan Warm Water. On the contrary, red tide of Trichodesmium sp. decreased from 1960's.

b) Giant jellyfish, Nemopilena nomurai, outbreak

Increase of jellyfish is reported globally. In the eastern NOWPAP region, frequent outbreak of one of the largest jellyfish, *Nemopilema nomurai*, has been reported recently [Kawahara et al. 2006]. There were very few reports of the outbreak until 2001; however, after 2002 it has been observed almost every year until 2009 except 2008. The massive outbreak along the Japanese coast caused serious damages to fisheries in the area, such as breaking of net and unsalable fish. The giant jellyfish is believed to come from the NOPWPAP sea area "B" through the Tsushima Strait, and transported toward the northeast along the Japanese coast and some came out to the Pacific side through Tsugaru Strait and down to the south when it was a severe outbreak. The polyp, source of jellyfish, was not found in nature, but the origin seems to be the northern part of the East China Sea and/or Yellow Sea coastal area because it is the only place for the young jellyfish could be found. It is speculated that the eutrophication, global warming, and overfishing may be related to the increase [Uye, 2011].

Xu et al., (2013) used satellite data to confirm the hypothesis that warming temperature, eutrophication and match/mismatch to blooming of phytoplankton was related to the survival of young jellyfish stage during spring as a cause of giant jellyfish outbreak. They found that the temperature increased 1976 to 2010 and chlorophyll-a also increased from 1997 to 2010, and these indicate both warming and eutrophication may be important for increase of jellyfish outbreak. They also confirmed that temperature was lower in 2008, and 2010 when there was no outbreak, and suggested that the warm temperature is also important factor for the outbreak. Regarding the match/mismatch hypothesis, they could not explain the difference of outbreak and non-outbreak years although they found significant spatial differences of chlorophyll-a bloom in the area. Presently, an international collaboration work between Japan-Korea-China is still on going.

c) Green tide event

The news of massive accumulation of algae, *Ulva prolifera*, called green tide, along the coast of Qingdao just before 2008 Beijing Olympic sailing regatta became the focus of worldwide attention. Liu et al. (2009) suggested that the green tide comes from the coast of Jiangsu Province where the aquaculture of *Porphyra yezoensis* (Nori) was expanded. Similar green tide has occurred every year from 2007 to 2012, and Liu et al. (2013) reported the microscopic propagates (seed stocks) always present in seawater and sediments of the mudflat of the Jiangsu Province. They suggested that the fermented chicken manure waste water discharged through the coastal animal aquaculture ponds may be causing the green tide, and reduction of the discharge is necessary to prevent them.

Primary production in the NOWPAP region seems to be quite different condition between eastern and western parts. Primary production in most of NOWPAP sea area “A”, showed distinctive seasonal pattern, spring and fall blooms, and seems to be less influence of eutrophication. While, the one in the western NOWPAP sea area “B” seems to show large influences of eutrophication; increase of chlorophyll-a, red tide, jellyfish outbreak and green tide. Quick action may be necessary to maintain the marine ecosystems in the NOWPAP region.

2.3. Assessment of provisioning ecosystem services

2.3.1. Sustainable use of the biological resources

Northwest Pacific region, where the NOWPAP region is located, is one of the biologically diverse marine areas in the world. The area includes various marine environments (e.g. the tropical region with coral reefs in the south and the subarctic zone covered with ice during winter season in the north) and their associated ecosystems. These rich environments can allow a large number of marine species to inhabit. It is reported that there are 22,629 species in Chinese waters [Liu, 2013], 33,629 species in Japanese waters [Fujikura et al., 2010], and 9,534 species in Korean waters (Republic of Korea, 2009). According to Fujikura et al., it is possible that there may be 155,524 species along the Japanese archipelago, and it is estimated that the number of marine species found in the NOWPAP region will increase along with the development of observation techniques.

Such diverse ecosystem in the NOWPAP region can nurture rich fishery resources. Figure 8 shows the world's fishery catch. The average catch in the northwest Pacific is 20 million tones, accounting for one-fourth of the world's total. The target fish includes low trophic level fish species, such as sardine which graze on phytoplankton, to high level predacious species, such as tuna and bonito.

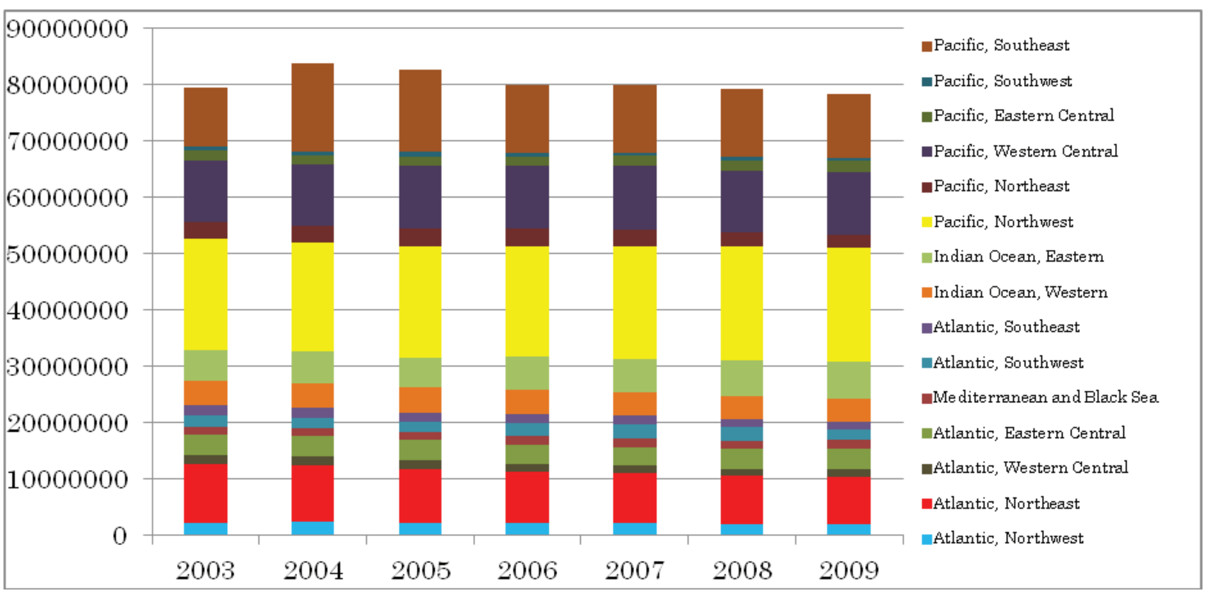


Figure 8. Fishery catch (tonnes) in the world (FAO, 2013).

Figure 9 shows the trend of the marine trophic level in this region. From the 1980s to 1990s, the trophic level lowered temporarily due to the increased catch of sardine; however, the overall average is approximately 3.5, indicating successful transfer of energy.

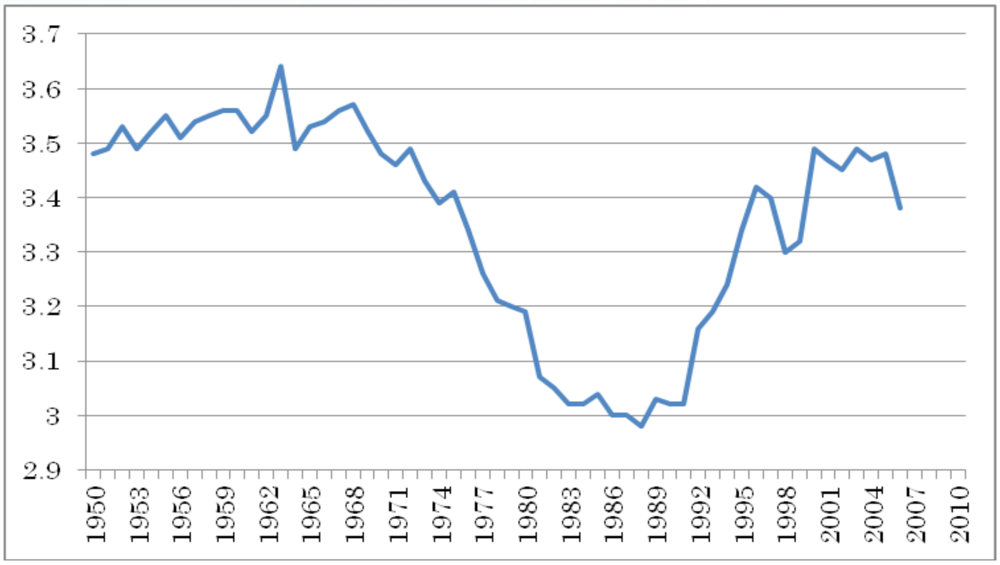


Figure 9. Marine Trophic Index in the northwest Pacific (source: Sea Around Us datasets,2013)

Both figures (8 and 9) are the evidences of the high biological diversity with rich marine organisms and resources in the NOWPAP region. However, on the other hand, this is one of the most populated in the world and the economic growth in the surrounded countries is quite fast.

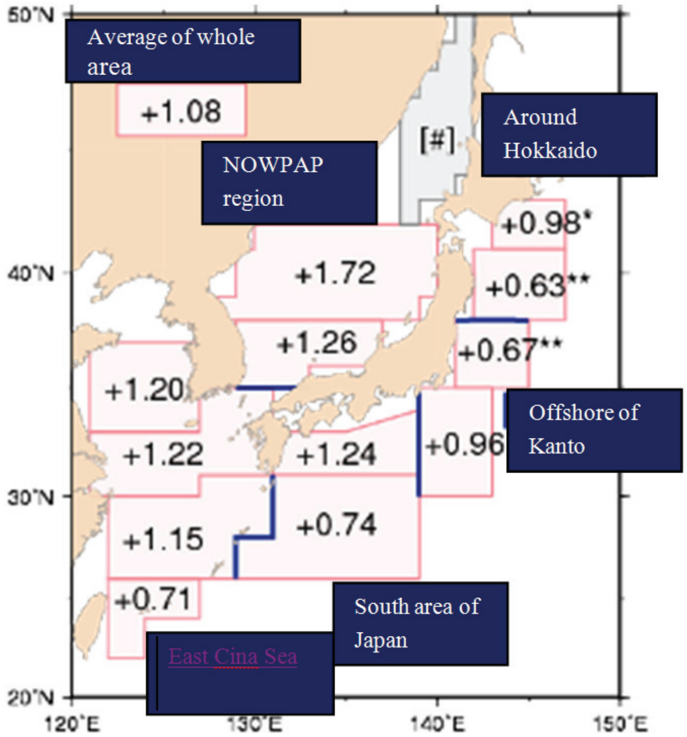


Figure 10. Change of the sea surface water temperature in the past 100 years in the NOWPAP region. (source: Japan Meteorological Agency, 2012)

As a result, negative events such as eutrophication by excessive nutrient from land, harmful algal blooms and hypoxia have been observed and multiple anthropogenic pressures (e.g. overfishing to support 6 billion people in the NOWPAP region) is threatening the health of the marine environment. Climate change also affects ecosystem services and benefits which the marine environment provides. Figure 10 shows change of the sea surface water temperature in the past 100 years in the NOWPAP region. It is reported that the temperature in this region has increased at a faster pace than other regions. Warming of the seawater may change the distribution of marine organisms and lead to structural change in the ecosystem. It has been concerned that biological diversity of the marine environment may be lowered by warming.

While the NOWPAP region has high biological diversity in the marine environment, it has been threatened by multiple stressors. In order to conserve the rich ecosystem and its services and benefits for the future, it is urgent to develop and implement appropriate management. In particular, minimizing the environmental modification induced by anthropogenic causes and sustaining the optimum conditions of the environment for inhabiting organisms are essential.

The 10th meeting of the Conference of the Parties (**COP 10**) to the Convention on Biological Diversity (CBD) was held in Nagoya, Aichi, Japan, and the Aichi Targets were adopted, which set post-2010 targets on biodiversity conservation. One of the Aichi Targets are on coastal and marine areas: By 2020, at least 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes (See http://www.cbd.int/sp/targets/). As IUCN defines marine protected areas (MPA) as "a protected area is a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long term conservation of nature with associated ecosystem services and cultural values", it be one of the effective tools to conserve marine biodiversity and sustain its providing services and benefits. Following the adoption of Aichi Targets, it is expected to expand the number and area of MPAs around the world.

The NOWPAP member states (China, Japan, Korea and Russia) have also tried to establish new MPAs and/or enhance management of the existing MPAs under their domestic laws and regulations to protect marine biodiversity and sustain ecosystem services. Unfortunately, the present rate of MPAs in the NOWPAP region is much less than 10 per cent of the area and this is one of the priorities to be addressed. The Special Monitoring & Coastal Environmental Assessment Regional Activity Centre (CEARAC) of NOWPAP has collected information on legal regulations and the current status of the existing MPAs in the region and has been developing "the regional report for conservation of marine biodiversity and sustainable use of marine ecosystem services in the NOWPAP region.", which is one of the implementing activities for the 2012-2013 biennium. The current status of MPAs in the NOWPAP member states are in the next section, and it is expected such information can contribute to development/enhancement of conservation strategy for marine biodiversity, establishment of more MPAs, and sustainable use of marine ecosystem services in respective NOWPAP member states.

China. Marine Protected Areas are designated based on the following three systems, in addition, there are geological parks and scenic spots in Chinese coastal area. The latter two types of protected area are not included as types of MPAs in this report:

(1) Marine Nature Reserve

According to the article two of "Management Regulation on Marine Nature Reserve", Marine Nature Reserve is established in order to protect the natural environment and resources. This system covers seashores, estuaries, inlands, wetlands and sea water. Now, 26 sites are designed as Marine Nature Reserve and the covered area is 1.41 million hectares.

Example: Qianliyan Island Marine Ecosystem Provincial Nature Reserve
Yalujiang River Estuary Wetland National Nature Reserve
Kongtong Islands Provincial Nature Reserve
Changdao National Nature Reserve


Haiyang Qianliyan Island Marine Ecosystem Provincial Nature Reserve


Yalujiang River Estuary Wetland National Nature Reserve

(2) Special Marine Reserve and Marine Parks

According to the article two of "the Management Regulation on Special Marine Reserves," Special Marine Reserve is established which aims to protect areas which possess special geographic conditions, ecosystems, living or non-living resources. This system requires special permission for the marine development and management by adopting effective protection measures and scientific development methods.

The number of areas on Special Marine Reserve is 22 and they cover 127,000 hectares in Chinese waters.

Examples: Zhifu Archipelago National Special Marine Reserve, Jiaozhou Bay Wetland Provincial Special Marine Reserve, Haizhou Bay National Ocean Park.

(3) Fisheries Genetic Resources Reserve

According to the article two of "the Interim Measures for the Administration of Aquatic Genetic Resources Reserve," Fisheries Genetic Resources Reserve protects waters, tidal flats and their adjacent reefs and land areas which are main breeding regions of aquatic genetic resources with great value of economy and genetic breeding and afforded special protection and management on the purpose of protecting aquatic genetic resources and their survival circumstances.

Its aim is to protect important aquatic genetic resources and their survival circumstances; to promote sustainable development of fishery; to protect the important national fishery resources and their habitats such as hatching field, feeding field, wintering field and migratory path; to establish the protection network of aquatic genetic resources in seawaters, main rivers and lakes; and to alleviate the adverse effect of human activities and degradation of fishery resources and aquatic ecosystem. The number of Fisheries Genetic Resource Reserves is 26 and they cover 1.48 million hectares in Chinese waters.

Examples: Rongcheng Bay National Fisheries Genetic Resource Reserve, Rizhao Sea Area *Coelomactra Antiquata* National Fisheries Genetic Resource Reserve, Rushan National Fisheries Genetic Resources Reserve.

Japan. Marine Protected Areas (MPAs) is defined as "Marine areas designated and managed by law or other effective means, in consideration of use modalities, aiming at conservation of marine biodiversity, supporting the sound structure and function of marine ecosystems and ensuring the sustainable use of marine ecosystem services." Based on this definition, there are following categories in MPAs.

(1) Protection of natural scenery

Natural Park

For the purpose of protecting outstanding natural scenery and promoting its use, some areas are designated as either National Park or Quasi National Park. Development of landfill is regulated in these areas.

While the minister of the Ministry of the Environment designates National Park, a governor of a prefecture designates Quasi National Park. The number of National Park and Quasi National Park is 30 and 56 respectively, and the area of them is 14,414 km2 (including 157.7 km2 in sea area) and 4,204 km2 (19.9 km2 in sea area), respectively.

Example: Daisen-Oki National Park, San'in Kaigan National Park, Niseko-Shakotan-Otarukaigan Quasi National Park,

Genkai Quasi National Park.

-

Natural Coastal Protected Zone

Some areas have been designated as Natural Coastal Protected Zone to maintain the state of nature so that seashores and ponds could be used for bathing, shellfish gathering and so forth in the future. In the designated areas, construction of new structure, transformation of land properties, and mining of minerals and earth/rock are regulated. 91 sites are designated only in the Seto Inland Sea.

(2) Protection of natural environment or habitats and growing areas for organisms

Nature Conservation Area

This is to protect outstanding natural environment which requires specific conservation. In the designated areas, development such as land transformation is mainly controlled. Only one site is designated in sea area.

Example: Sakiyama Bay (1.28 km^2)

Wildlife Protection Area

Some areas are designated for protection of wildlife and hunting is controlled there. Development such as construction of structure is also controlled. 82 sites are designated by the minister of the Ministry of the Environment and 3,759 sites are designated by prefectural governors.

Example: Kanmurijima-Kutsujima National Wildlife Protection Area, Kosado-toubu National Wildlife Protection Area.

Natural Habitat Conservation Area

This area aims to conserve national endangered species of wild fauna and flora. Development is controlled in the monitored zones, and harvest of designated species and use of power-driven vessels are regulated in addition to development control in the controlled zones. All designated areas are located in inland areas.

Natural Monument

The purpose of this system is to protect animals, plants, geographic features and minerals of high scientific value. Change of the current state requires permission by Agency for Cultural Affairs. 1,005 Natural Monuments are designated (animal: 194, plant: 546, mineral: 242, area: 23) and 11 sites among them are located in the sea areas.

Example: Danjyo Guntou Islands, Breading Habitat of Streaked Shearwater and Japanese Cormorant in Awashima Island

(3) Protection, cultivation etc. of aquatic animals and plants

Protected Water Surface

The purpose is to protect and cultivate aquatic animals and plants. In the designated areas, development, such as landfill and dredging, and harvest of designated aquatic animals and plants are controlled because the areas are suitable for egg laying and growth of juvenile fish. 55 sites are designated.

Example: Seto Inland Sea, Ariake Sea

Coastline Marine Resource Development Area, and Designated sea area

The purpose is to promote streamlining of development activities and use of marine fishery resources by the measures to systematically promote multiplication and aquaculture of aquatic animals and plants. Development, such as sea bed transformation and digging is controlled. The covered area is 223.97km2 for Coastal Marine Resource Development area and 309,912 km^2 as Designated sea area.

Example: Toyama Bay

Area designated by prefecture, fishery operator group, etc

The purpose is to protect and cultivate aquatic animals and plants, and to secure their sustainable use. The harvest of specified aquatic animals and plants is controlled.

Common fishery right area

The purpose is to enhance fisheries productivity (protecting and cultivating aquatic animals and plants, and ensuring their sustainable use), etc. Harvest of aquatic animals and plants is controlled by the Rules on Exercise of Fishery Right. A right to petition based on real rights, a right to claim compensation or damages, and, at the same time, a charge of the infringement on fishery rights will apply to infringement by any third party. The total area of Common fishery right area is 89,587 km^2. This area is designated in the whole of Japanese coastal area.

Korea. There are nine categories in MPAs.

(1) Protected Marine Area

This area is designated based on Conservation and Management of Marine Ecosystem Act. There are six areas in this category, covering 219 km^2. These areas are managed by the Ministry of Land, Transport and Maritime Affairs (MLTM, currently renamed as Ministry of Oceans and Fisheries, MOF).

(2) Wetland Protection

This area is designated based on Wetland Conservation Act. There are 12 areas, covering 141.4 km^2. These areas are managed by MOF (previously called, MLTM).

(3) Marine Environment Conservation

This area is designated based on Marine Environment Management Act. There are four areas, covering 1,882 km^2. These areas are managed by MOF (previously called, MLTM).

(4) Fisheries Resource Protection

This area is designated based on National Land Planning and Utilization Act. There are 10 areas, covering 3,034 km^2. These areas are managed by MOF (previously called, MLTM) and the Ministry of Food, Agriculture, Forestry and Fisheries.

(5) Special Island

This area is designated based on Special Act on Island. There are 167 areas designated and the total cover is 10.5 km^2. These areas are managed by the Ministry of the Environment (MOE).

(6) National Park

This area is designated based on Natural Park Act. There are 4 areas in this category, covering 3,348 km^2. These areas are managed by the MOE.

(7) Ecosystem/Landscape Conservation

This area is designated based on Natural Environment Conservation Act. There are three areas, covering 34.6 km^2. These areas are managed by the MOE.

(8) Wildlife Protection

This area is designated based on Wildlife Act. The number of these areas is 166 and covered 207.8 km^2. These areas are managed by the MOE.

(9) Natural Heritage

This area is designated based on Cultural Heritage Protection Act. There are 13 areas designated, covering 1,126 km^2. These areas are managed by the Cultural Heritage Protection Administration.

Russia. There are 9 categories in MPAs.

(1) State Natural Reserve including biosphere

(2) State Natural Park

(3) Natural Park

(4) Natural Monument

(5) Refuges of various significance

(6) Refuges of local significance

(7) Dendrological Park

(8) Botanic Garden

(9) Health Improvement Localities and Resorts

In addition to establishing governmental measures such as MPAs, it is important to effectively promote conservation and sustainable use of marine biodiversity by local communities which utilize or manage the sea. Any user of the sea is responsible for simultaneous conservation and utilization of marine biodiversity. In Japan, a new concept “Sato-umi” is recognized as one of measures to protect/use the sea in sustainable manner, which is engaged by local people autonomously. Perhaps, similar action has been taken in other NOWPAP member states. To maintain the current status of marina biodiversity and marine ecosystem services in the NOWPAP region, it will be required to promote such active involvement by local people in the whole NOWPAP region.

2.3.2. NOWPAP marine and coastal areas as a provider of mineral resources, energy and transport routes.

Marine ecosystem services are those provided by natural features and processes of the marine environments for the benefit to human wellbeing. In addition to biological resources discussed in the previous section, physical resources of marine and coastal areas are also critical when assessing ecosystem services in NOWPAP regions. For example, rich undersea deposits including oil and gas resources and gas hydrates in deep seabed are the greatest incremental resources for supporting human society sustainable development. Nakahara (2009) reported the added value of gravel quarrying, oil and natural gas, ocean transport, and harbor transport service for 40,888, 7,774, 217,569, and 843,922 million Yen, respectively, as of year 2000. This section provides an overview of those services which are related to mineral resources, energy, and transport routes.

2.3.2.1. Mineral Resources

The mineral resources in marine and coastal environments that provide the most benefit to human wellbeing are oil and gas. There have been many exploration and development of oil and gas in NOWPAP regions. One of most active regions where those activities have occurred is Yellow Sea, especially its northern part. The Yellow Sea seabed includes the South Yellow Sea Basin and the North Yellow Sea Basin, which are divided by the line connecting Shandong Peninsula, China and Baeng-nyeong Island, Korea. The South Yellow Sea Basin is composed of three exploration blocks (Block I, II, and III in Figure 11) by Republic of Korea (ROK) Korea National Oil Corporation (KNOC). The exploration activities in the Yellow Sea include a total of 51,181 km of seismic data collection and five exploratory wells. Although not successful yet, the South Yellow Sea Basin is still considered to have highly possible area for oil and gas. KNOC and Chinese National Offshore Oil Corporation (CNOOC) recently agreed to exchange the existing seismic data and interpretations to better understand hydrocarbon potential in the Yellow Sea.

The Democratic People's Republic of Korea (DPRK) has conducted large-scale surveys and drilling works in the eastern and central North Yellow Sea Basin and they detected several oil wells in the area [Zhang, 2011].

Figure 11. Oil and gas exploration blocks operated by KNOC, overlaid with sedimentary basins.

The Ulleung Basin is located in the sea between Korea and Japan. It is characterized by thick clastic sediments (>10 km) on the southwestern margin where the commercial gas was discovered. The exploratory wells in two exploration blocks of the KNOC (see Figure 11) encountered numerous gas outlets. The commercial gas field (named Donghae-1) is composed of the late Miocene sandstone reservoirs, and started commercial production from 2004. The production base for Donghae-1 is located some 58 km to southeast of Ulsan, Korea, which is inside the exclusive economic zone with the depth of 150 m waters (Figure 12). The gas is being pumped up from 2,700 to 3,000 me below the seabed, with the daily production of 1,000 tons of LNG. Recently, the KNOC and Woodside Energy Limited (WEL) agreed to explore the deepwater block in the Ulleung Basin and the first deepwater drilling campaign was carried out in 2012.

Figure 12. Donghae-1 gas field, Korea.

The Iwafune-oki oil and gas field in Japan was discovered by the successful Iwafune-oki SIM-1 exploration well drilled in 1983. JAPEX has constructed an offshore production platform in water depth of 36 m (Figure 13). The crude oil and natural gas produced here are transported to an onshore facility via a 21 km long subsea pipeline.

Figure 13. Iwafune-oki oil and gas field, Japan.

Russia also put a variety of efforts in exploration and production of oil and gas in NOWPAP region. For example, they launched the Sakhalin-2 project, oil and gas development in the Piltun-Astokhskoye oil field and the Lunskoye natural gas filed near Sakhalin Island, Russia just eastward of NOWPAP area border (Figure 14).

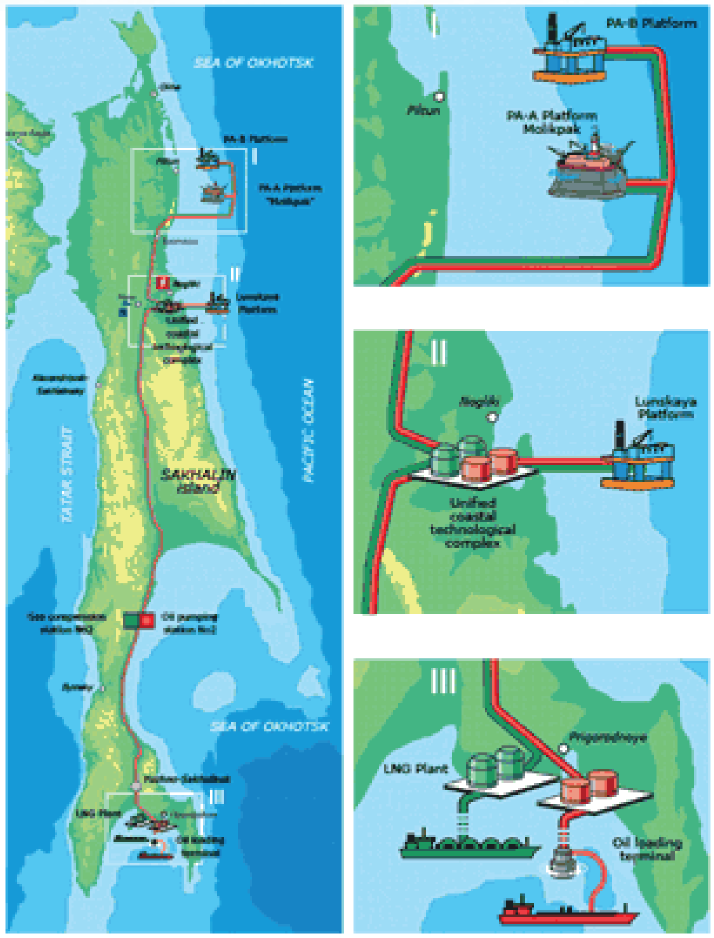


Figure 14. Schematic of Sakhalin-2 development plan.

About 60 percent of the gas from Sakhalin is earmarked for Japan with the remainder going to the USA and Korea from the terminal at the south end of Sakhalin Is. that is within the NOWPAP region.

Large quantities of methane are stored as ice-like gas hydrates below the ocean floor that are emerging as another important mineral resources, although it is still under research or experimental production mode. The Japanese drilling project for gas hydrate has been focused in the Nankai Trough region along the southeastern margin of Japan (Figure 15). In the late 1999 and early 2000, Japan commissioned six exploration wells in the eastern Nankai Trough region, to characterize the natural gas hydrate deposits and investigate their overall commercial potential. Cores taken in a depth between 1,152-1,210 m revealed the presence of gas hydrates in three different zones. Japan Oil, Gas and Metals National Corporation (JOGMEC) and Japan Petroleum Exploration Company (JAPEX) conducted 21 core sampling operations at the test site during June-July 2012 [Yamamoto et al., 2012]. They estimated the existence of at least 7.35 trillion cubic meters of methane hydrate, which is equivalent to around 80 years of Japanese gas consumption [JAPEX, 2011].

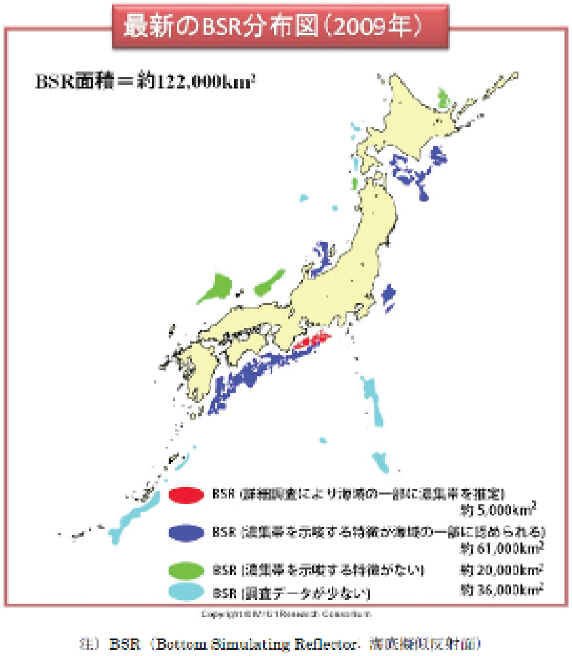


Figure 15. Distribution of methane hydrate around Japan, based on bottom simulating reflector (Photo Courtsey: MH21 Research Consortium)

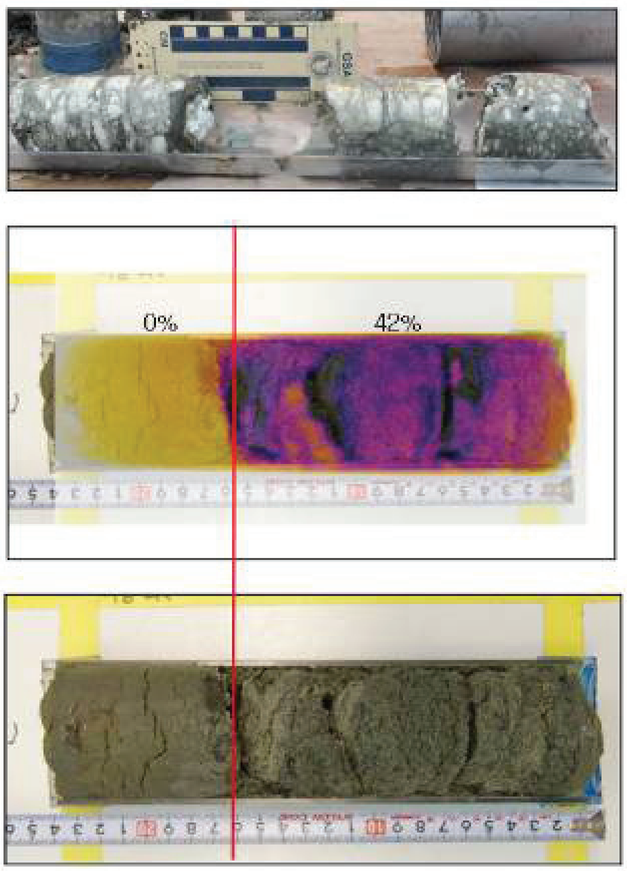


Figure 16. Hydrate samples retrieved during UBGH2 (modified from Lee, 2011)

Republic of Korea initiated Korean National Gas Hydrate Program in 2005 after they found bottom simulating reflector in sea between Japan and Korea during their preliminary gas hydrate study from 2000 to 2004. In June 2007, Korea Institute of Geoscience and Mineral Resources (KIGAM) research team successfully sampled first natural gas hydrate using piston corer. Korea conducted the 2nd Ulleung Basin Gas hydrate expedition (UBGH2), where relatively thick hydrate bearing sandy layers were found (Figure 16; Lee, 2011).

Chinese Academy of Sciences (CAS) implemented a hydrate-focus “973” research program in the East China Sea continental slope and Chinese Ministry of Land and Resources conducted higher resolution surveys in 2001 in the East China Sea. Guangzhou Marine Geological Survey discovered gas hydrates in borehole in southeast of the Shenhu Shoal.

Japan has been conducting researches on hydrothermal vents in their EEZ in search of rare metals such as germanium, used in the production of fiber optics, and gallium, used in the production of integrated circuits (Figure 17 and Figure 18).

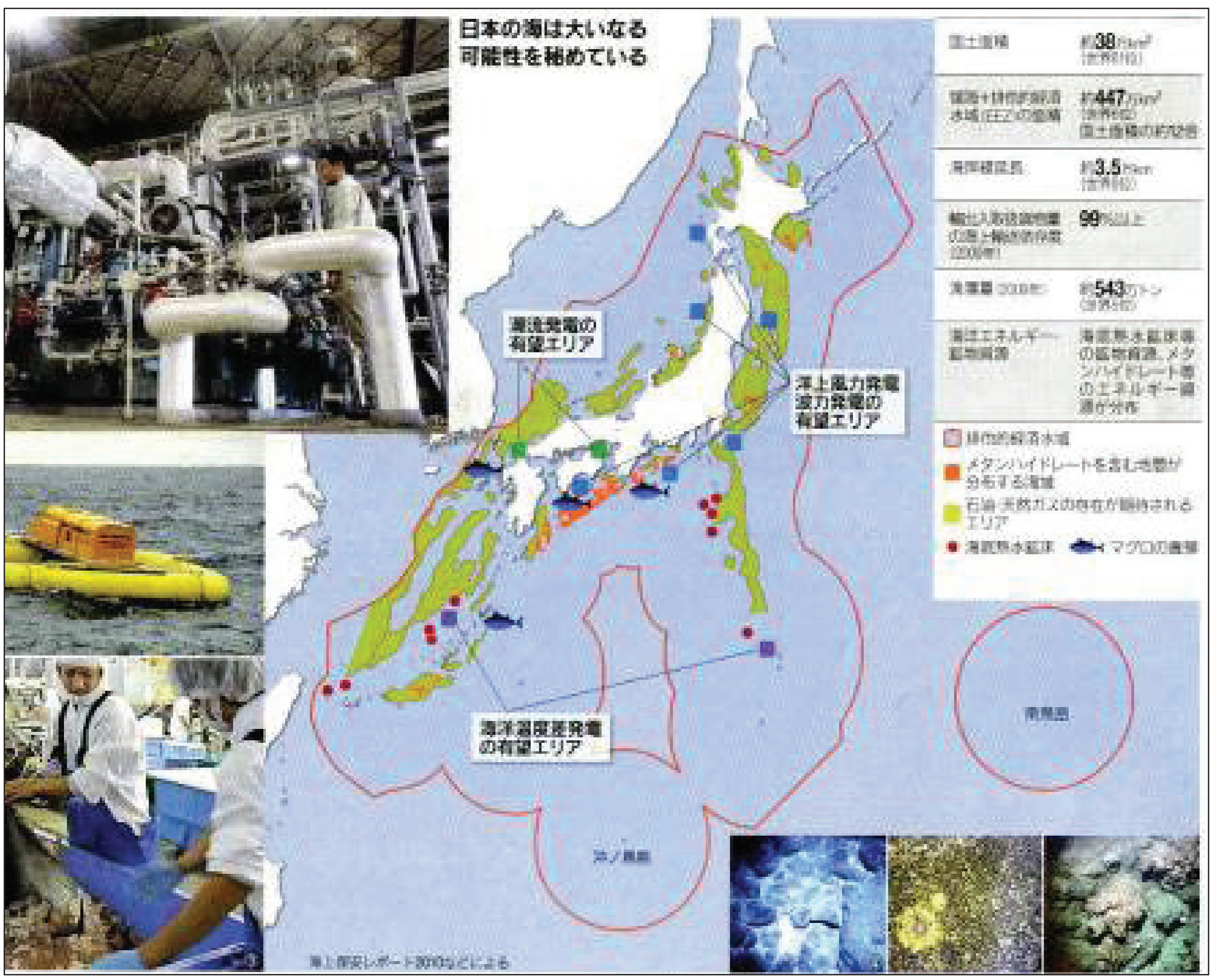


Figure 17. Distribution of mineral resources around Japan. Orange line represent EEZ. Orange colored area show the potential methane hydrate, green area show natural gas and oil and red dots for hydrothermal vent.

（出所）（独）石油天然ガス・金属鉱物資源機構
http://www.jogmec.go.jp/mric_web/koenkai/060124/briefing_060124_tanahashi_nessui.pdf

Figure 18. Development of seafloor hydrothermal vent (photo courtesy: JOGMEC)

Sand and gravels at the seabed are one of most useful ecosystem services provided by marine and coastal areas. In 2010, Korea used a total of 26,348,000 m^3 of sand and gravels from the ocean. Japan developed 40,888 million Yens of gravels from the ocean in 2000 [Nakahara, 2009]. Mineral resources on or in the bottom of the sea between Japan and Korea include magnetite sands too.

2.3.2.2. Energy

The marine and coastal areas provide us energy to generate electric power. There are three basic ways, including the ocean's waves, tides and thermal energy (i.e., temperature difference), and wind energy over the ocean is another critical resources. Korea sets up a renewable energy target as 50% of the electricity by the renewable generation by the year 2030. Recently, they built up 2MW and 3 MW wind turbines around Jeju Island [Kim et al., 2011; Figure 19]. They made up an offshore wind farm road map, where 2.5 GW of new capacity will be installed by 2019 in the Yellow Sea [Lee et al., 2011].

Wind power plant in Japan is 1,850,000 kW as of 2008, which has been increased 22.2% for the past 5 years. Out of this, offshore wind power plant in operation is about 26,000 kW from two offshore power plants, which is 1.4% of total wind power generation. It is expected that the market for offshore power plant will continue to grow, and the potential wind energy power from the offshore area around Japan is estimated at 68,000 kW. Japan estimated a potential wave power generation could be as much as 5GW in the marine area around Japan.

China has implemented a number of offshore wind farms including 102 MW capacity of Shanghai area (Figure 20). A total of 242.5 MW of wind power plants were installed offshore China, which is still only a fraction compared to the potential development of 43 GW. Their target for the offshore wind farm development is announced as up to 30 GW in 2020 [Li et al., 2012].

Figure 19. 3MW prototype wind power generator offshore Jeju Island, Korea

Figure 20. Shanghai Donhai Bridge offshore wind farm.

Tidal power generation is very active in Korea. Sihwa Lake Tidal Power Station, located in the Yellow Sea coast, is the world's largest tidal power installation with a total power output capacity of 254 MW. In 2009, Korea also constructed a 1 MW tidal current power pilot plant in the South Sea (Figure 21), and plans to move on a commercialized application of 90 MW capacity.

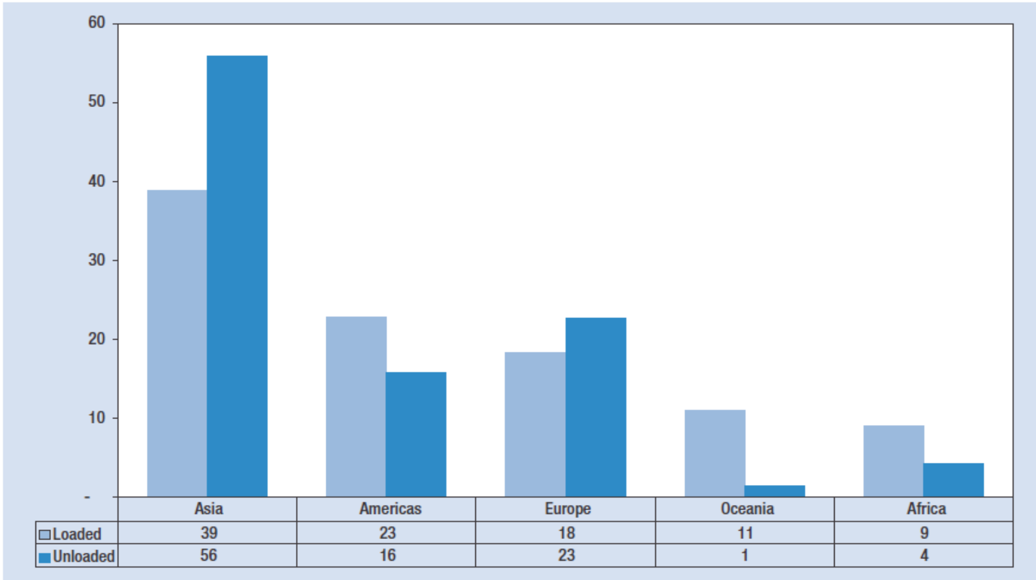
Jiangxia tidal power station, south of Hangzhou in China has been operational since 1985, which generate 3.2 MW, and plan to implement more plants near the mouth of Yalu River.

Figure 21. Tidal current power plant in Korea.

2.3.2.3. Transport routes

NOWPAP region is used actively by marine transportation among 4 member countries as well as internationally. According to United Nations Conference on Trade and Development (UNCTAD, 2012), the seaborne trade takes a total volume of 8.7 billion tons worldwide and 3.2 billion tons in Asia (Figure 22). China, Japan and Korea built more than 93% of the tonnage of world fleet delivered in 2011, and are ranked in top 5 lists in terms of market share in maritime transport. More than half of top 20 container terminals are located in NOWPAP member countries (Table 3). These statistics indicate the important value of maritime transport in NOWPAP region.

Figure 1.3 (c). World seaborne trade, by region, 2011 (Percentage share in world tonnage)



Source: Compiled by the UNCTAD secretariat on the basis of data supplied by reporting countries, and data obtained from the relevant government, port industry and other specialist websites and sources. Figures are estimated based on preliminary data or on the last year for which data were available.

Figure 22. World seaborne trade, by region, 2011 (modified from UNCTAD, 2012).

Table 3. Top 20 container terminals and their throughput (modified from UNCTAD, 2012).

Table 4.2. Top 20 container terminals and their throughput for 2009, 2010 and 2011 (In TEUs and percentage change)

Port Name	2009	2010	Preliminary figures for 2011	Percentage change 2010–2009	Percentage change 2011–2010
Shanghai	25 002 000	29 069 000	31 700 000	16.27	9.05
Singapore	25 866 400	28 431 100	29 937 700	9.92	5.30
Hong Kong	21 040 096	23 699 242	24 404 000	12.64	2.97
Shenzhen	18 250 100	22 509 700	22 569 800	23.34	0.27
Busan	11 954 861	14 194 334	16 184 706	18.73	14.02
Ningbo	10 502 800	13 144 000	14 686 200	25.15	11.73
Guangzhou	11 190 000	12 550 000	14 400 000	12.15	14.74
Qingdao	10 260 000	12 012 000	13 020 000	17.08	8.39
Dubai	11 124 082	11 600 000	13 000 000	4.28	12.07
Rotterdam	9 743 290	11 145 804	11 900 000	14.39	6.77
Tianjin	8 700 000	10 080 000	11 500 000	15.86	14.09
Kaohsiung	8 581 273	9 181 211	9 636 289	6.99	4.96
Port Klang	7 309 779	8 871 745	9 377 434	21.37	5.70
Hamburg	7 007 704	7 900 000	9 021 800	12.73	14.20
Antwerp	7 309 639	8 468 475	8 664 243	15.85	2.31
Los Angeles	6 748 994	7 831 902	7 940 511	16.05	1.39
Tanjung Pelepas	6 016 452	6 530 000	7 500 000	8.54	14.85
Xiamen	4 680 355	5 820 000	6 460 700	24.35	11.01
Dalian	4 552 000	5 242 000	6 400 000	15.16	22.09
Long Beach	5 067 597	6 263 399	6 061 085	23.60	-3.23
Total top 20	220 907 422	254 543 912	274 364 468	15.23	7.79

Source: UNCTAD secretariat and *Containerisation International Online* (May 2012).
Note: In this list Singapore does not include the port of Jurong.

Korea Shipowners' Association [KSA, 2012] reported that the total income of maritime transport in Korea was estimated up to 426 trillion Korean won in 2011. The total maritime transport in Korea was a little over 1 billion Revenue Ton (R/T), out of which 56.4 million R/T is for between Korea-Japan and 333.4 million is for Korea-Asia other than Japan. The container transport was 21.6 million TEU (twenty-foot equivalent unit) in Korea during 2011, out of which 1.6 million TEU between Korea-Japan and 2.3 million TEU between Korea-China [KSA, 2012].

Figure 23 shows the density of all types of vessel in 1997. The traffic density was estimated by applying 0.5 degree mesh [Japan Maritime Disaster Prevention Center, 1999]. A total of 122,051 ships were counted, out of which cargo was 102,556 (84%), tanker was 14,057 (14%), and liquid gas tanker was 3,619 (3%). We have not recent data on this issue but taking into account the economic growth of NOWPAP member states, especially China one can suppose the further increase of maritime density.

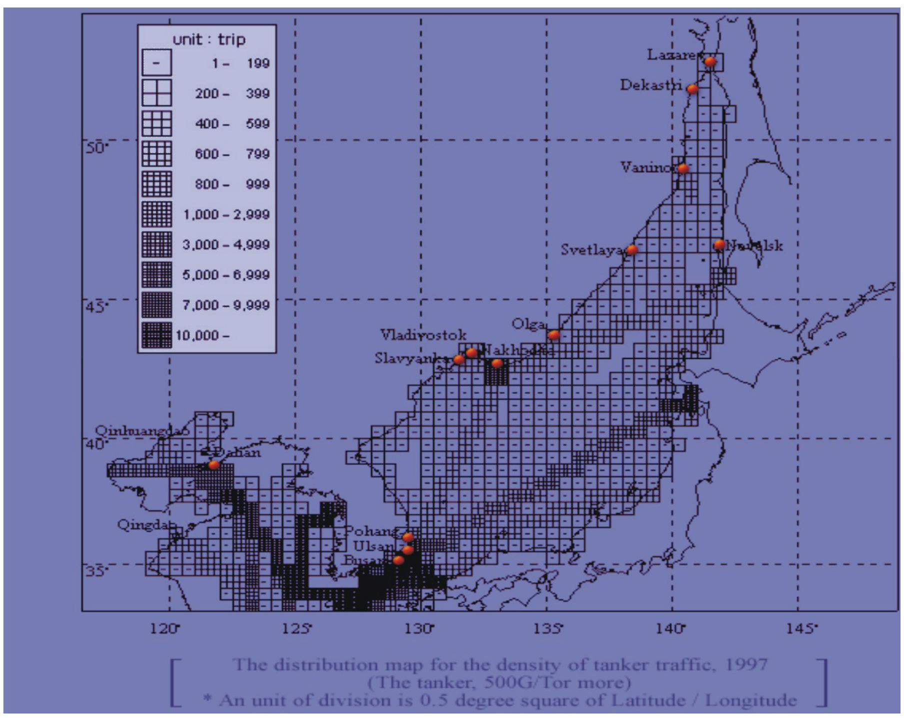


Figure 23. Vessel traffic density during 1997.

3. Marine Environmental Problems and Issues

3.1. Assessment of the anthropogenic impacts on the marine environment

3.1.1 Contamination by hazardous substances due to atmospheric deposition, river runoff and direct inputs

The list of potentially hazardous anthropogenic substances inputting to the sea areas includes huge varieties of materials which could be divided on several groups: 1) macro nutrients; 2) trace chemical elements; 3) petroleum hydrocarbons (oils); 4) marine litter, including microplastics; 5) trace organic substances. The inputs of nutrients, oils and marine litter are considered in the separate sub-chapters. In this sub-chapter the contamination by trace elements and trace organic substances will be in focus.

The transport paths of pollutants to the sea areas are also very diverse. Atmospheric deposition, river runoff and direct inputs of sewage and dumped materials are considered as main routes.

The sophisticated and expensive methods of analysis and possibility of contamination during sampling, pretreatment and chemical analysis are other difficulties hampered the availability of reliable data on some trace elements and organic substances in the environment and especially in water samples. As a result the time series for the hazardous substances in water environment is rather short and restricted even in the developed countries. The lucky exclusion is the “records” of some chemical substances saved in the composition of the cores of recent bottom sediments. In the tropic area the chemical composition of the massive corals also are used as a proxy of time series.

3.1.1.1 Contamination by trace elements

The reliable data on the trace elements concentrations in the river and coastal waters within NOWPAP region continues to be an issue of scientific publications not of regular routine monitoring. The main reason is rather high ecological quality standards (EQS) for the trace elements (Table 4) and corresponding MDL (method detection limit) of the methods used which are 1-2 order of magnitude higher than the mean concentration or the same trace elements in the not severely polluted rivers of the World according with modern overview by [Gaillardet et al., 2003]. As a result the regular monitoring data sheets for such trace metals as Pb, Cd, Hg have majority of cells "below MDL". The dissolved Cu is only exception with EQS being comparable with data observed in nature due to excessively strict EQS in Russia. The concentration of majority of the trace elements in the sea waters is less than in the rivers. The some anion-type elements like Mo, U, Se are the exception.

The rivers with significantly elevated concentration of trace elements are rather rare and are connected with distinct and specific anthropogenic activities such as mining, ore-dressing, industrial waste waters. These sources are local "hot spots". Their influence on the nearby and adjoining fresh and coastal waters could be severe but local in space. The Rudnaya River in Russian Far East with dissolved Zn, Pb and Cd concentrations being equal to 120, 0.64, and 0.25 µg/l respectively is an example [POMRAC, 2007]. Yongsan River and Chaobaixinhe are the examples of such contaminated rivers in Korea [Kang et al., 2009] in China [POMRAC, 2007], respectively.

Table 4. Comparison of trace elements ecological quality standards EQS (µg/l) for Surface Waters in NOWPAP Countries and World average for rivers [Gaillardet et al., 2003]

Characteristic	China*	Japan**	Korea***	Russia****	World rivers
Cu ≤	10	4	-	1	1.48
Zn ≤	50	30	-	10	0.36
Se ≤	10	10	-	10	0.07
As ≤	50	10	50	5	0.62
Hg ≤	0.05	0.5	0.05	0.5	0.005
Cd ≤	1	10	10	1	0.08
Pb ≤	10	10	10	6	0.079
$Cr^{6}+$ ≤	10	50	50	20	0.7

*- EQS for Grade I waters;
** - EQS for Grade AA waters and human health protection;
*** - WQS for Grade I Water;
**** - most strict MPC for fishery purpose waters

For the time being the regional assessment of the some trace elements, petroleum hydrocarbons (PHC) and phenols with river runoff to the NOWPAP sea areas could be assessed as follows (Table 5).

Table 5. Annual river water discharge (km^3/year), suspended solids (SS, tons/year) and flows of some chemical substances (tons/year) from countries facing the NOWPAP sea areas

	China*	Korea	Input to the sea area B	Japan	Russia*	Input to the sea area A
Water	193	45.9	238.9	124.66	42.35	167.0
SS	nd	662,567	11,403,586	1,717,108	2,287,300	4,004,408
PHC	72,950	nd	>72,950	nd	847	>847
phenols	228.54	nd	>228.54	nd	67.3	>67.3
Pb	791.7	nd	>791.7	nd	3.3+281.4****	>3.3+281.4
Cd	34.5	nd	>34.5	nd	1.1+6.1****	>1.1+6.1
Hg	13.5	nd	>13.5	nd	nd	nd

*- without Yangtze River for China and without Amur River for Russia, **- data recalculated for the whole river discharge; *** - COD_{Cr}; **** - flux of dissolved forms plus flux in suspended solids; nd – no data

In discussing metals input with river runoff it is important to remember that most metals are not dissolved but are adsorbed on the surface of suspended particles. This is why the particulate phase is the dominant transport form for heavy metals in rivers. Monitoring programs in China, Japan and Korea measure total metals only, without filtering the sample. These data strongly depend on the suspended solids content. For example total concentrations of Zn, Pb and Cd in the Rudnaya River runoff reach up 250, 15.6 and 0.99 μg/l. Spatial and temporal inter-comparison of data requires a sampling strategy that is representative of total suspended sediment transport. This is almost impossible with the sampling frequency normally applied by national monitoring agencies because including one highly turbid sample or not in a data set may completely change the resulting average assessment.

Atmospheric deposition is another potentially important source of trace elements for the sea areas. The role of atmospheric precipitation in the water balance of sea area "A" is 7 times more than river input. Even at the sea area "B" (Yellow Sea and Bohai Bay), the contribution of rains to the water balance is 3.5 times higher than the one from the river water input (Fig. 3). It means that role of atmospheric deposition as a route of trace elements delivery to the sea surface of the basins as a whole should be higher than river runoff. In fact the calculation based on the concentrations in the rains and in the river runoff [SOMER, 2007] confirms it at least for Cd and Pb (Fig. 5). And only for the Yellow Sea with very high input of river suspended solids the contribution of riverine Cd exceeds the atmospheric one. Thus in offshore regions and for entire basins, atmospheric inputs are dominant and additional attention is needed for any potentially dangerous substances migrating via atmosphere fluxes.

The role of atmospheric inputs for coastal marine areas will be determined by the ratio of concentrations of these substances in the rain/snow and in river water as well as by the ratio of river run-off and the amount of precipitation.

3.1.1.2. Contamination by persistent toxic substances (PTS)

A list of PTS approved by the Stockholm Convention (2001) includes aldrin, endrin, dieldrin, chlordane, DDTs, toxaphene, mirex, heptachlor, hexachlorobenzene, dioxins and furans. All these substances are persistent in the environment; resistant to degradation; toxic; can bioaccumulate and can move long distances in the environment. Beside these twelve substances, many other trace organic substances satisfy these criteria. For example, PAHs, organic mercury compounds, organic tin compounds, HCHs, and brominated flame retardants (PBDE) have been proposed as persistent toxic substances in the Regional Assessment for Central and North Asia [UNEP Chemicals/GEF, 2002].

Contamination of the environment with PTS may come from point sources (industrial discharges and wastewater treatment plant effluents) or, more frequently, from diffuse sources (atmospheric transport and deposition), the major pathway for transfer of persistent organic pollutants to remote sites.

Reliable data on persistent organic pollutants (POPs) in rivers is limited in the NOWPAP region Elevated POPs concentrations have been detected in a wide range of environmental media and aquatic biota [Monirith et al., 2003]. Existing data on the Japanese unpolluted rivers like Ishikari correlate well with the lower range of PTS concentrations in European rivers (Table 6).

Table 6. Comparison of POPs concentrations in the Ishikari River with recent data for other rivers

POPs	Ishikari	Ebro **	Rhone **	Seine **	Nile**	German rivers***
Cyclodiene POPs*	0.085	0.4-1.6	0.2-0.6	0.2-0.6	0.004-0.008	no data
Total DDTs	0.54	0.3-0.9	3.6	0.2-0.8	26-103	no data
HCHs	1.29	0.7-2.7	5.6	7.0	0.05-0.5	0.2- 1.5

*- sum of Endrin, Dieldrin, Aldrin, Heptachlor; ** - data from UNEP/MAP/MTS 141, 2003.

Data on PTS concentrations in sediments and aquatic biota are more readily available. The lack of current data makes it unrealistic to estimate river input of PTS into the NOWPAP marine environment at regional or sub-regional levels. The use of data on PTS concentrations in bottom sediments and in mollusks might be an alternative way to assess the impact of land based sources on coastal marine areas since contaminated coastal sediments are mainly a result of freshwater discharge.

The prevailing of the atmospheric routes for the majority of PTS especially at the long distance transport is well proven [e.g. Wania, 2003]. The combination of the field based and modeling approaches was very successful at the study of such PTS as DDT, HCH and some others in the Arctic region [Muir, de Wit, 2010 and cited herein]. There are examples of successful research on PTS atmospheric transport in the NOWPAP region as well [Tian et al., 2009].

3.1.1.3. The use of sediment records as indicator of contamination by trace elements and PTS.

The absence of the reliable and long time series of trace pollutants in the water and air media hamper the assessment of the pollutants input in past and present and forecasting of future trends. In attempt to overcome this difficulty the study of the recent sediment cores is rather fruitful because many PTS are hydrophobic compounds which are highly associated with suspended solids and sediments. The same is true for the majority of trace elements.

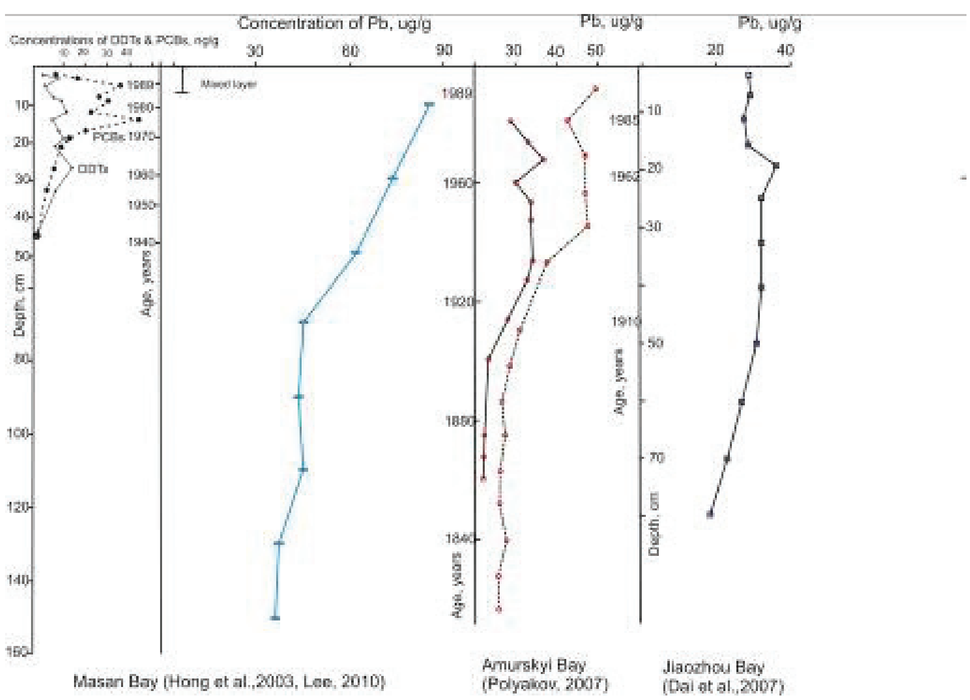


Figure 24. The distribution of POPs and Pb in the upper layer of recent bottom sediments of the different semi-enclosed bays within the NOWPAP region (source: NOWPAP POMRAC, 2011).

Several reports have analyzed sediment core samples in order to obtain a time trend for PCBs, PCDD/PCDFs and other pollutants in Japan [Araki, et al., 2000; Okuda et al., 2000]. It was shown that PCBs concentrations were the highest in the 1960s followed by a decline that has now slacked. Distribution in sediment cores obtained from an estuary in southern China near Macau shows that DDTs peaked at 79 ng/g in 1993 while the level was lower, between "not detected" and 29 ng/g, after 1960. Total HCHs peaked at 82 ng/g in 1993 and then decreased to less than detectable levels [Zhang, et al., 1999].

The most important results were obtained for the coastal areas with significant influence of river runoff and/or anthropogenic impact. In Jiaozhou Bay (Qingdao, China) sediment cores with ^{210}Pb dating have shown absent of severe contamination by trace metals but significant change of sedimentation rate [Dai et al., 2007].

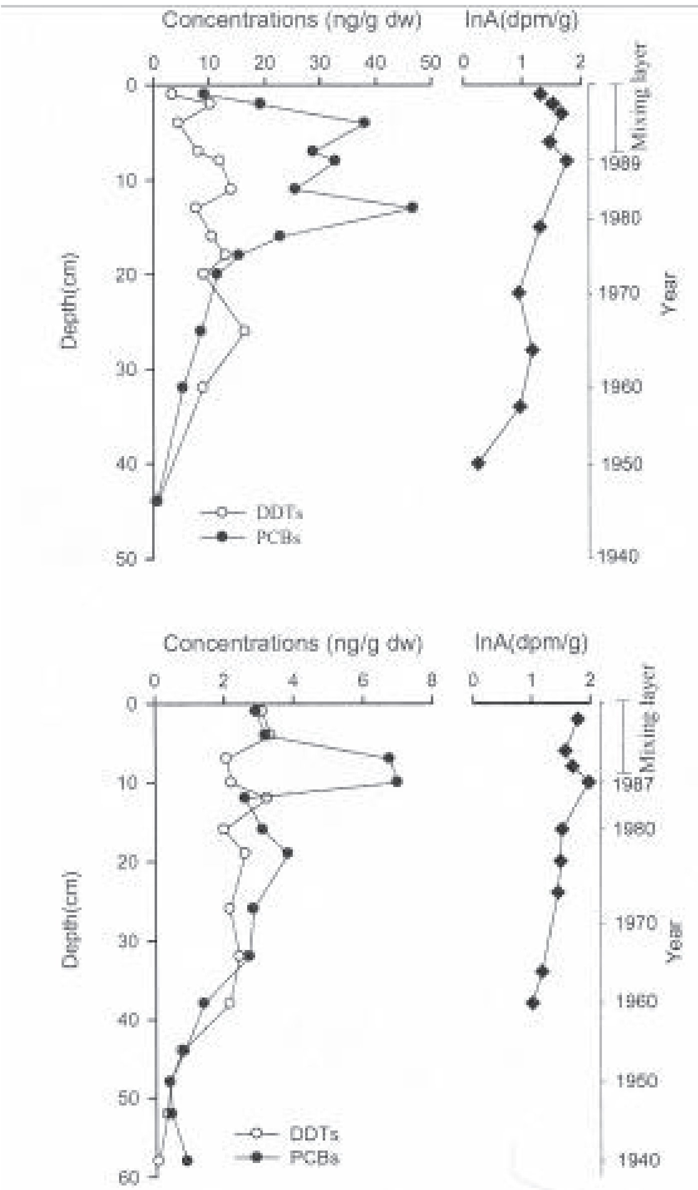


Figure 25. Distribution of DDT and PCBs in the dated sediment core of Masan Bay (top) and Jinhae Bay (bottom) (From Hong et al., 2003).

3.1.2. Oil and HNS spills

The NOWPAP region is especially vulnerable to marine pollution incidents due to its high shipping density along with industrial development and economic growth. Furthermore, the NOWPAP members have extensive coastline and the high density of transport activity among them, accordingly they are exposed to high risk of oil and Hazardous and Noxious Substances (HNS) pollution incidents.

To prepare for and respond to oil and HNS spill incidents that may occur at ports, oil and HNS handling facilities and offshore oil operations, NOWPAP members have established and enhanced their national and regional response capabilities under the International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC) 1990 and OPRC-HNS Protocol. NOWPAP Marine Environment Emergency Preparedness and Response Activity Center (MERRAC) Focal Points had developed and reviewed the draft text of the NOWPAP Regional Oil and HNS Spill Contingency Plan (NOWPAP RCP) in order to provide an operational mechanism for mutual assistance through which the NOWPAP members can co-operate during major marine oil and HNS pollution incidents in the region. Accordingly, the NOWPAP RCP and related Resolution were adopted at the 13th NOWPAP Intergovernmental Meeting (Jeju, Korea, October 2008) and came into effect in 2009.

3.1.2.1. Oil Spills

With the growth of marine transportation and vessel traffic, the NOWPAP region is more than ever an area with high risk of oil spills and major oil spill incidents may result in wide-ranging impacts on fisheries, marine wildlife and their habitats, coastal industries, tourism and even in political, social and economic aspects. According to the data collected by NOWPAP members, every year more than 5 oil spill incidents spilled over 10 tons have occurred and a total of 282 oil spill incidents have recorded from 1990 to 2011 (Figure 26). Among them, 15 major oil spill accidents exceeding 1,000 tons are listed in Table 6. Most oil spill incidents occurred near coastal areas, resulting in severe impacts on the marine and coastal environment. Statistics shows that collision (46%), grounding (20%) and sinking (16%) are the major causes of oil spills in the NOWPAP region (Figure 27).

At the time of *Hebei Spirit* oil spill incident, the Hong Kong registered tanker *Hebei Spirit* (146,848 GT) spilled about 12,547 tons of crude oil at Taean coastal area in the Republic of Korea. The spilled oil was spread to Taean coastal area by strong winds and currents, and the thin oil slicks were spread on sea surface of the west coast of Korea. As a result, over 70 km of coastline and nearby 101 islands were contaminated with oil and tar. The NOWPAP RCP came into effect immediately after the *Hebei Spirit* oil spills. China and Japan provided sorbents to Korea within the framework of the NOWPAP RCP. About 56 tons of sorbents were shipped from China to designated port in Korea. The Japan Government provided 10 tons of sorbents free of charge via airplane and 7 experts for technical assistance to the Korean Government related to the oil spill response operation. MERRAC supported practical co-operation with NOWPAP members during the response operation.

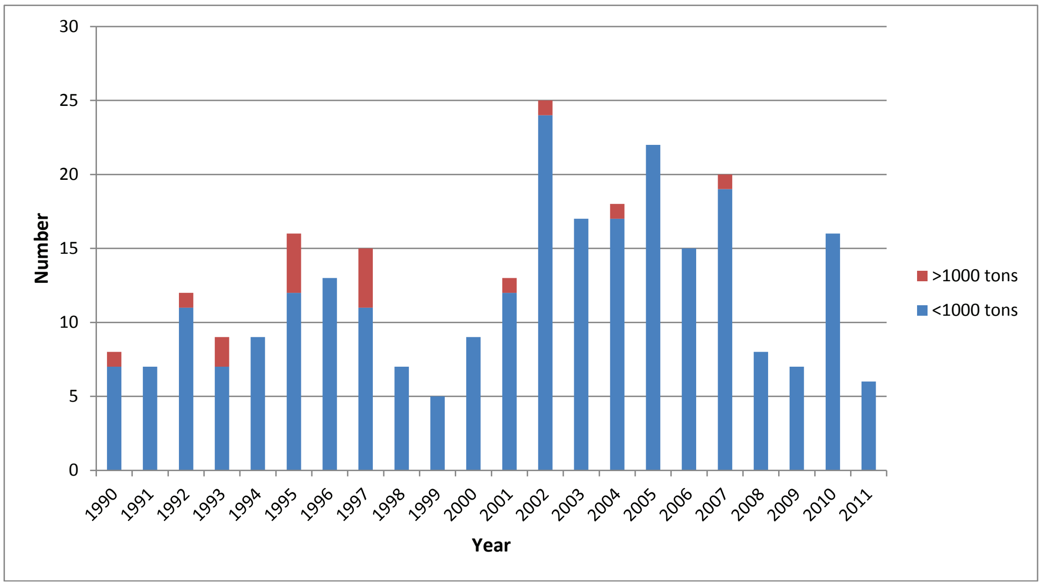


Figure 26. The number of major oil spill accidents exceeding 10 tons that have occurred in the NOWPAP region (1990-2011).

After the *Hebei Spirit* oil spill incident, for more efficient implementation of the NOWPAP RCP, the 11th NOWPAP MERRAC FPM agreed to organize NOWPAP BRAVO (Communication Exercise) continuously and especially on a regular base. The meeting decided to hold the exercise twice a year. Accordingly, MERRAC has carried out the NOWPAP training and exercise for the practical implementation of the NOWPAP RCP through further cooperation with NOWPAP members. To confirm whether the communication system functions normally, when large-scale oil spills and other maritime accidents occur, MERRAC has carried out the NOWPAP BRAVO Exercise twice a year. The NOWPAP DELTA-Joint Oil Spill Response Exercise has been conducted every two years in order to increase the NOWPAP members' level of preparedness in joint response to major marine pollution incidents within the framework of the NOWPAP RCP. Recently, the 4th NOWPAP DELTA exercise (Joint Oil Spill Response Exercise) was conducted in Yeosu, Korea on 18 May 2012 by Korea and China in conjunction with the 15th NOWPAP MERRAC FPM and the 7th CNA Meeting, during the period of "Expo 2012 Yeosu, Korea". The exercise was organized by KCG and China Maritime Safety Administration (MSA), and co-organized by NOWPAP MERRAC, Yeosu City and Organizing Committee of Yeosu Expo 2012. A total of 34 vessels, 2 helicopters, 345 personnel, 6 oil skimmers and 2,500 meters of oil booms were mobilized by KCG, China MSA, Korea Marine

Environment Management Co-operation (KOEM) and Yeosu Regional Maritime Affairs and Port Office. One response vessel and crew from China MSA participated in the exercise. Other NOWPAP members and participants of the NOWPAP MERRAC FPM took part in the exercise as observers.

Table 7. The list of major oil spill accidents exceeding 1,000 tons that have occurred in the NOWPAP region (1990-2011)

No.	Date	Location	Name of vessel	Nationality	Type of vessel	Quantity (Tons)	Type of oil	Cause
1	07.12.07	N36°52′07″ E126°03′12″ Off Taean	Hebei Spirit	HongKong	Oil tanker	12,547	Crude oil	Collision
2	97.01.02	N37°10′ E130°06′	Nakhodka	Russia	Oil tanker	5,304	Cargo oil	Sinking, after hull Broken
3	93.06.16	N37°13′ E126°24′	Korea venus	Panama	Oil tanker	4,280	Diesel oil	Grounding
4	95.07.23	N34°24′ E127°48′	Sea prince	Cyprus	Oil tanker	4,150	Crude oil	Grounding
5	95.09.21	N34°54′ E128°58′	No.1 yoil	Korea	Oil tanker	2,900	Fuel oil	Sinking, after grounding
6	97.04.04	N34°36′ E128°34′	No.3 ohsung	Korea	Oil tanker	1,700	Fuel oil	Sinking
7	90.07.15	N37°28′ E126°36′	Korea hope	Korea	Oil tanker	1,500	Fuel oil	Collision
8	95.11.17	N34°51′ E127°16′	Honam sapphire	Panama	Oil tanker	1,400	Crude oil	Collision
9	97.07.02	N35°21′ E139°43′	Diamond Grace	Panama	Oil tanker	1,318	Cargo oil	Grounding
10	02.10.01	N34°41′ E139°27′	Hual Europe	Bahama	Car carrier	1,300	Fuel oil	Grounding
11	93.09.27	N34°52′ E127°45′	No.5 Kumdong	Korea	Oil tanker	1,220	Fuel oil	Collision

Furthermore, in order to provide practical and technical guidelines to promptly and effectively respond to major marine pollution accidents within the framework of the NOWPAP RCP, MERRAC has been carrying out several Specific Projects including 1) Legislations and Practice on Marine Pollution Damage Civil Liability and Compensation, 2) Practical Assistance Procedure and System under the NOWPAP RCP, and 3) Manual on Conduction of Oil Spill Response Operational Exercise. The purpose of the first project is to compare the difference on the legislations and practice related to civil liability and compensation for marine pollution damage from ships in NOWPAP members and find solutions or suggestions for better implementation of the NOWPAP RCP in case of oil and HNS spill incident due to ships. The second project has been reviewing the NOWPAP RCP by assessing the current status of its application and improving its practical implementation of the NOWPAP RCP. Lastly, the third project has been developing in order to harmonize and unify the process of preparing and conducting the NOWPAP exercises, based on the experience of NOWPAP members, as well as to significantly facilitate the management of oil spill response forces and equipment of participating countries during the exercise.

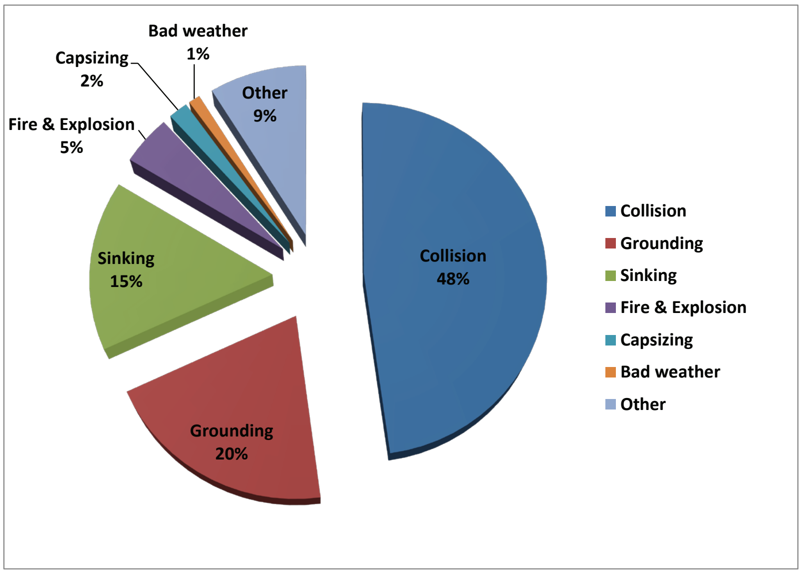


Figure 27. The causes of oil spill accidents exceeding 10 tons that have occurred in the NOWPAP region (1990-2011).

3.1.2.2. HNS Spills

The huge volume of HNS introduced into the marine environment can create hazards to human health, harm living resources and marine life, damage amenities and interfere with other legitimate uses of the sea. The involvement of HNS in an accident, due to their physical and chemical characteristics, can cause fire, explosion, suffocation, toxic effects, and corrosion, etc. As a consequence, an HNS spill incident has the potential to damage human life and property as well as the marine environment.

Table 8. List and contents of major chemicals transported in bulk over one million tons in the NOWPAP Region in 2007

Rank in volume	Chemical name	Volume of traffic (Tons)	Ratio (%)
1	Aqueous Ammonia	14,276,000	22.7
2	Styrene	6,739,771	10.7
3	Xylenes	4,922,851	7.8
4	Benzene	4,678,440	7.4
5	Methyl Alcohol (Methanol)	2,757,288	4.4
6	p-Xylenes	2,265,320	3.6
7	Sulfuric acid	1,565,089	2.5
8	Coals	1,500,000	2.4
9	Acrylonitrile	1,495,372	2.4
10	o-Xylenes	1,485,805	2.4
11	Ethylene glycol	1,407,848	2.2
12	Toluene	1,376,750	2.2
13	m-Xylenes	1,173,000	1.9
14	Sodium Hydroxide	1,126,855	1.8
Sub total		46,770,389	74.3
Others (< 1million tons)		16,165,722	25.7
Total		62,936,111	100.0

According to the data on the volume of HNS transported by ships, a wide variety of HNS was transported in bulk in the NOWPAP region. In 2007, the total volume transported was estimated to be over 62.9 million tons (Table 8). Over one million tons of 14 different HNS including Ammonia, Styrene, Xylene and Benzene were transported and these substances accounted for 74.3% of the total volume transported in 2007.

In the NOWPAP region, a total of 56 HNS spill incidents exceeding 10 tons occurred during the period of 1990-2011, including unknown spillage incidents (Figure 28). Seven cases of major HNS spills exceeding 1,000 tons occurred as shown in Table 8. These HNS spill incidents mainly occurred in the coastal area, resulting in serious damages. Similar to oil spill statistics, the major causes of HNS spill incidents in the NOWPAP region are collision (43%), grounding (18%), and sinking (12%) (Figure 29).

Table 9. The list of major HNS spill accidents exceeding 1,000 tons that have occurred in the NOWPAP region (1990-2011)

No.	Date	Location	Name of vessel	Nationality	Type of vessel	Quantity (Tons)	Type of HNS	Cause
1	09.01.08	N37°02′00″ E126°09′00″ Off Taean	Samho Gloria	Marshall	Chemical tanker	8,689	Parm oil	Intention
2	93.10.01	N37°00′ E127°45′	Frountier express	Panama	Tanker	8,320	Naphtha	Ran aground
3	95.12.22	N35°24′ E129°25′	Danita	Panama	Tanker	4,970	Kerosene	Collision
4	96.02.09	N32°58′ E126°54′ Jeju, Korea	Sunny Breeze	Panama	Tanker	3,794	Gas oil	Explosion and fire sinking
						226	Solvent	
5	04.09.11	N36°45′ E122°31′	JINDA 266	China	Chemical tanker	2,000	Hydro-chloric Acid	Sinking
6	92.05.10	N34°53′ E128°57′	Stainless princess	Greece	Non-Tanker	1,600	MEP/ MDO	Aground
7	04.05.26	N34°39′ E127°57′	Mornong Express	Panama	Tanker	1,200	Naphtha	Collision

MERRAC has published a variety of the Technical Reports on HNS. The NOWPAP HNS Response Operation Guideline (MERRAC, 2009) was developed based on international and other regional HNS manuals, focusing on first actions, risk assessment (properties, spill behavior and drift forecasting), monitoring, sampling, body protection, and response measures. The report on HNS Database in the NOWPAP region (MERRAC, 2009) was developed in order to establish a database on HNS substance information in response to possible HNS spills in the NOWPAP region. Also, the manual for HNS training (MERRAC, 2011) was developed to explain about training course for the purpose of giving sufficient preparedness for and response to marine HNS incidents to the participating trainees. Finally, the Regional Report on HNS Preparedness and Response (MERRAC, 2012) was published for better understanding of the current status of HNS spill preparedness and response in the NOWPAP region and providing an operational mechanism for mutual assistance of NOWPAP members.

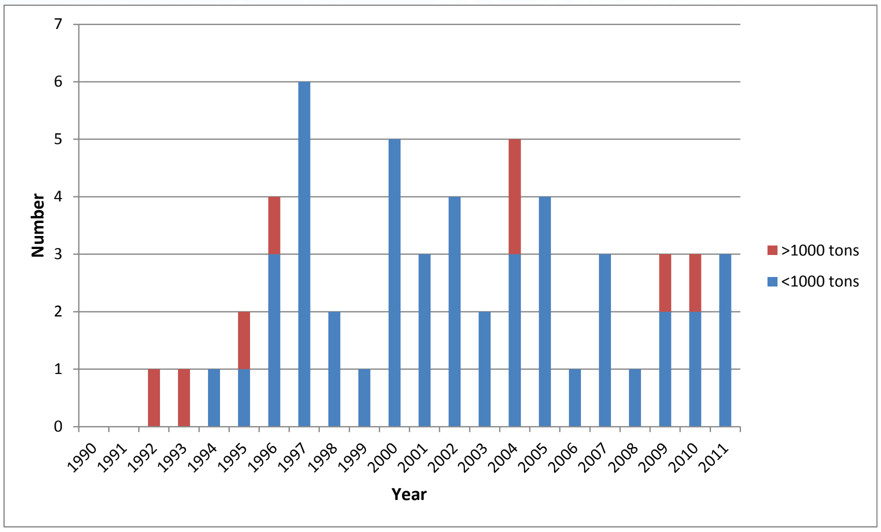


Figure 28. The number of major HNS spill accidents exceeding 10 tons that have occurred in the NOWPAP region (1990-2011).

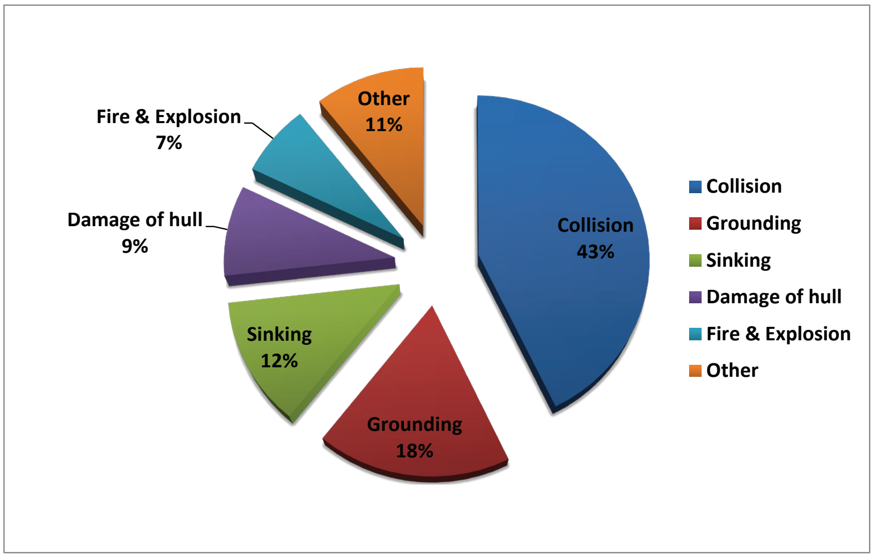


Figure 29. The causes of HNS accidents exceeding 10 tons that have occurred in the NOWPAP region (1990-2011).

In addition, MERRAC is carrying out new Specific Project on Development of Pamphlet on HNS Database and Spill Response in the NOWPAP Region. The purpose of this project is to make better practical, operational use for the relevant operators who are dealing with HNS on-situ as well as public awareness to promote easy understanding on HNS. For the further improvement on efficient preparedness and response for HNS spills, MERRAC continues to co-operate with NOWPAP members to share experience for HNS spill response, collect information on response equipment and technique, and develop specialized equipment for response to incidents by HNS.

3.1.3. Nutrient and organic matter excessive inputs – HAB, eutrophication and hypoxia

3.1.3.1. Harmful algae blooms (HAB)

The NOWPAP region has faced serious problems due to the frequent occurrence of HABs. This is due to increased nutrient inputs from land associated with economic development, and an increase in agricultural production in surrounding countries. Even though the number of HABs has decreased in recent years, due to the establishment of sewage plants and appropriate treatment of discharged water, HABs occur every year in the region. HABs cause damage to aquaculture and fisheries that are highly active in the region and increasing in demand.

There are 62 causative species recorded in the NOWPAP region. Heterosigma akashiwo has been reported in all NOWPAP member states, and while the characteristics of the species have not changed its distribution in the region has. In recent years, C. polykrikoides has moved northward in Japan and Chaetoceros sp. causing red tides have been reported in Russia.

All member states have reported causative species of shellfish toxins [6 paralytic shellfish poisonings (PSPs), 7 diarrhetic shellfish poisonings (DSPs) and 8 amnesic shellfish poisonings (ASPs)], but only PSPs and DSPs (PSPs in Japan and DSP in China) have been reported in the NOWPAP region.

To prevent damages by causative species, all of the NOWPAP member states have strengthened their systems of HAB surveillance, and all conduct regular red tide and shellfish toxin monitoring in the sea area where HABs occur frequently (Fig. 30). The NOWPAP member states monitor red tides and toxin-producing plankton, as these species cause significant damage to fisheries. Each member state has introduced its own warning and action standards, requiring fisherman to be warned and to take certain action after the cell density of causative species reaches a specified level (Table 9). These standards are based on empirical data, and aim to reduce the damage to fisheries and aquaculture.

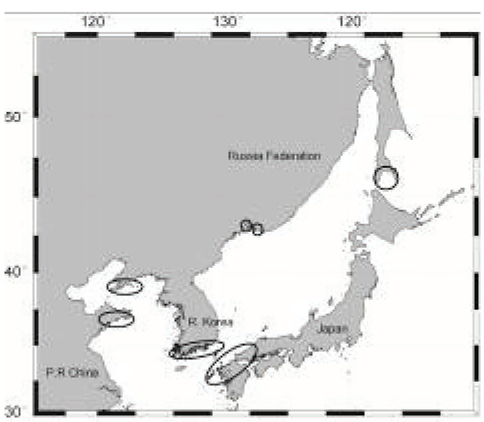


Figure 30. Location of HAB monitoring conducted in the NOWPAP region

The dashed line indicates the NOWPAP region, which covers approximately 121-143˚E longitude and 33-52˚N latitude without prejudice to the sovereignty of any state.

Table 10. Warning and action standards for each causative species

Region		Species name	Warning/action standards (cell/ml)	
			Warning standard	Action standard
China		*M. rubra*	500	
		N. scintillans	50	
		S. costatum	5,000	
		H. akashiwo	50,000	
		E. zodianus	100	
		C. marina	100	
		A. tamarense	1,000	
Japan	Yamaguchi Pref.*2	*K. mikimotoi*	500	5,000
		H. akashiwo	5,000	50,000
	Fukuoka Pref.*3	*H. akashiwo*	-	10,000
	Nagasaki Pref. *4	*C. antiqua*	1	10
		C. marina	1	10
		K. mikimotoi	100	500
		C. polykrikoides	50	500
		H. akashiwo	1,000	10,000
		H. circularisquama	10	50
Korea		*Chattonella* spp.	2,500	5,000
		C. polykrikoides	300	1,000
		Gyrodinium sp.	500	2,000
		K. mikimotoi	1,000	3,000
		Other dinoflagellates	30,000	50,000
		Diatoms	50,000	100,000
		Mixed blooms	40,000	80,000
Russia		*Pseudo-nitzschia calliantha*	500	
		Pseudo-nitzschia delicatissima	500	
		Pseudo-nitzschia fraudulenta	500	
		Pseudo-nitzschia multistriata	500	
		Pseudo-nitzschia multiseries	500	
		Pseudo-nitzschia seriata/pungens	500	
		A. tamarense	0.5	
		D. acuminata	0.5	
		D. acuta	0.5	
		D. fortii	0.5	
		D. norvegica	0.5	
		D. rotundata	0.5	
		P. reticulatum	500	

Sources:*1 Integrated Report of Harmful Algal Blooms for the NOWPAP Region (NOWPAP CEARAC 2011)

The regular monitoring process involves the checking of certain marine environment indicators, such as the water temperature, salinity and nutrient concentrations. In addition to the regular monitoring process, post-red tide monitoring is conducted in China, Japan and Korea, with additional monitoring of *C. polykrikoides* in Korea. Local fishery agencies and other involved organizations are responsible for analysing and monitoring the data and identifying the relationship between red-tide occurrences and environmental conditions.

In the past years, there were about 50 red-tide events occurred annually in the NOWPAP member states (Fig. 31). The number of red-tide occurrence was the highest in Japan followed by Korea. Between 2006 and 2008, there were 19 red-tide events in China, 208 in Japan, 21 in Korea and 31 in Russia. It is difficult to compare these figures, due to the difference in monitoring frequency of each member state. Japan, however, had the largest number of red-tide events, which have caused increasing damage to fisheries as well as the previous years. The most concerned species which induce damage to fisheries in the NOWPAP region are *Karenia mikimotoi*, *Cochlodinium polykrikoides* and *Chattonella antiqua*.

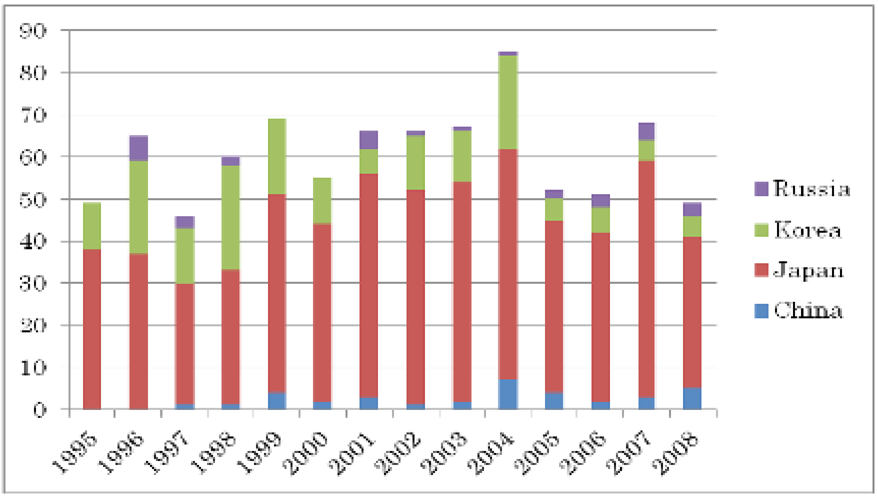


Figure 31. The number of red-tide occurrence in the NOWPAP member states

Recently, several huge fishery damages by concerned species were reported in Japan. In 2010, the loss to Japanese fisheries reached 5 billion Japanese Yen (about USD 60 million) due to blooms of *Chattonella antiqua* in the Ariake Sea, the Omura Bay and the Yatsushiro Sea, and in 2012, the loss reached 2 billion Japanese Yen (about USD 25 million) due to blooms of *Karenia mikimotoi* in the Bungo Strait in the Seto Inland Sea.

On the other hand, the number of red tides in Korea has approximately halved since 2005, from an average to 5 occurrences to 2-3 per year. Since 2009, there have been no *Cochlodinium* bloom occurrences, and so it appears that HAB occurrences in Korea have declined in recent years. However, in 2012, blooms of *Cochlodinium polykrikoides* occurred again. In the west coast of Korea, *Cochlodinium* blooms occurred for the first time in 13 years. These blooms caused USD 4 million loss in fisheries.

The new issue is reported in the NOWPAP region. In 2008, massive green macroalgae (*Ulva prolifera*) blooms occurred in the Yellow Sea and the East China Sea and became stranded in the coastal area of Qingdao, China. The bloom covered an area of approximately 2,400 km^2 and the total volume of blooms removed from the sea reached 1 million tons [Hu and He 2008]. The removal and treatment of such a large volume of *U. prolifera* cost more than USD100 million. A similar massive bloom (1,600 km2) occurred in 2009 [Hu et al. 2010]. These massive green macroalgae blooms have occurred continuously even in 2012.

To reduce HAB damage to fisheries, there are several kinds of direct and indirect measures taken. Direct measures include the use of physical, chemical and biological controls against causative species, while indirect methods include the control and improvement of water quality. In 2007, NOWPAP Special Monitoring and Coastal Environmental Assessment Regional Activity Centre (CEARAC) published the 'Booklet of Countermeasures against Harmful Algal Blooms in the NOWPAP Region. Various countermeasure methods, clays, flocculants, hydroxide radicals, biological secretion etc. have been implemented in the NOWPAP region and many are under research and/or development.

In addition to introducing countermeasures, forecasting and early detection are effective tools to help cope with HABs. In the NOWPAP region, remote sensing and molecular genetics techniques are being studied to improve forecasting and early detection. Monitoring the movement of high chlorophyll patches detected by remote sensing is useful in preventing fishery damage, by allowing fish cages to be moved in the aquaculture area. Techniques for detecting phytoplankton species using satellite images are now under development and are expected to reduce HAB damage. Early in situ detection of harmful species is important for preventing damage. Several new techniques using molecular biological approaches, such as Fluorescent In Situ Hybridization (FISH), real-time Polymerase Chain Reaction (PCR), and Loop-Mediated Isothermal Amplification (LAMP), are under development for targeting various HAB species. Damage to fisheries will be mitigated if harmful species can be easily detected and managed before proliferation.

3.1.3.2 Eutrophication and hypoxia

The coastal areas in the Northwest Pacific region is one of the most densely populated areas in the world, and its coastal systems are subject to significant human-induced nutrient modifications. Eutrophication is perceived as a potential threat to coastal environment in the Northwest Pacific region and its evidence can be seen in frequent occurrences of red tide [Fukuyo et al., 2002; GEOHAB, 2006; NOWPAP CEARAC, 2005, 2007; Miyahara et al., 2005; Onitsuka et al., 2010], the abundance of the giant jellyfish, *Nemopilema nomurai* [Kawahara et al., 2006; Uye, 2008; Dong, 2010], massive green tides [Hu et al., 2010; Liu et al., 2010], hypoxia or anoxia [Chen et al., 2007], changes in phytoplankton communities [Chen, 2000; Harashima, 2007] and loss of marine biodiversity [NOWPAP, 2010].

The ability to monitor coastal systems in NOWPAP member states is necessary to manage and sustain a healthy coastal environment. The availability of continuous and synoptic water quality data, particularly in estuaries and bays, is lacking in some areas of the NOWPAP region, making it difficult to detect changes of water quality resulting from anthropogenic and natural factors. Furthermore, due to increase in agricultural and industrial activities, as well as possible changes in coastal run-off, there has been an increasing need for effective methods of assessing the change of water quality in the region.

CEARAC developed the NOWPAP Common Procedure, a methodology for the assessment of eutrophication status including the evaluation of land-based sources of nutrients in the NOWPAP region (NOWPAP CEARAC, 2009). To apply and evaluate the suitability of the NOWPAP Common Procedure, member states conducted eutrophication case studies in selected sea areas of each member state based on that methodology. The Yangtze River Estuary and its adjacent area in China, the Northwest Kyushu sea area and Toyama Bay in Japan, Jinhae Bay in Korea and Peter the Great Bay in Russia were selected as the target sea areas (Fig. 32).

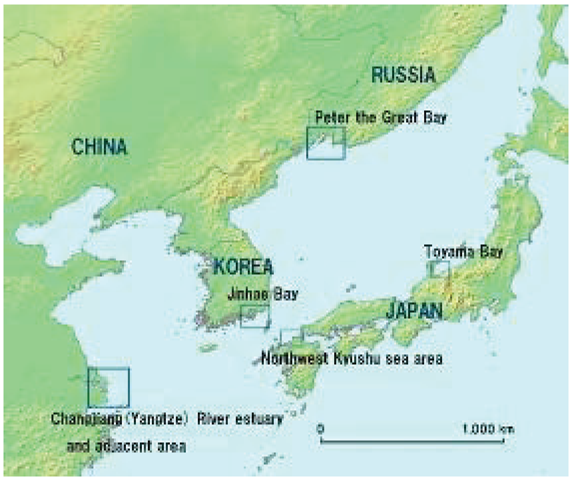
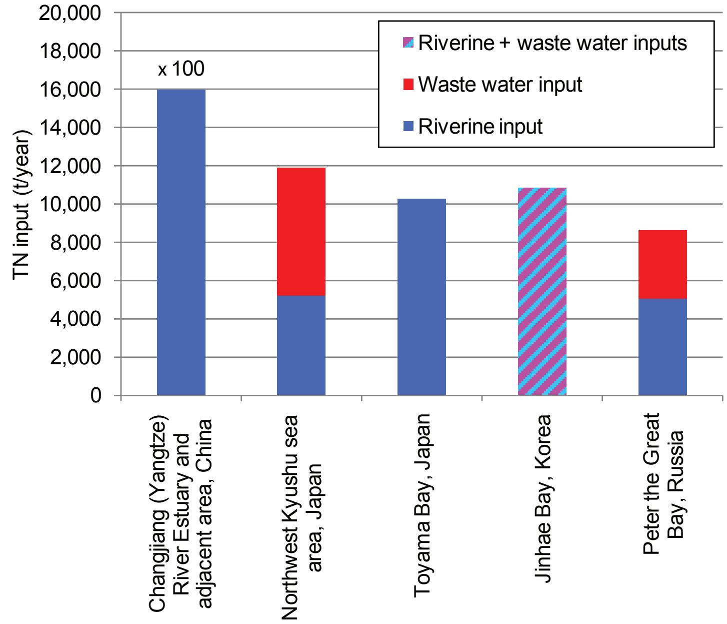


Figure 32. Location of selected sea areas for case studies the assessment of eutrophication status

The case study results provided information on TN and TP nutrient inputs from rivers. The inputs from the Changjiang (Yangtze) River are one hundred times larger than those from rivers in the other selected sea areas. The levels of TN and TP inputs from rivers in the North Kyushu sea area and Toyama Bay in Japan, Jinhae Bay in Korea, and Peter the Great Bay in Russia were almost the same. The Changjiang (Yangtze) River has the biggest flow volume in the Northwest Pacific region, and this also results in the greatest nutrient loadings.



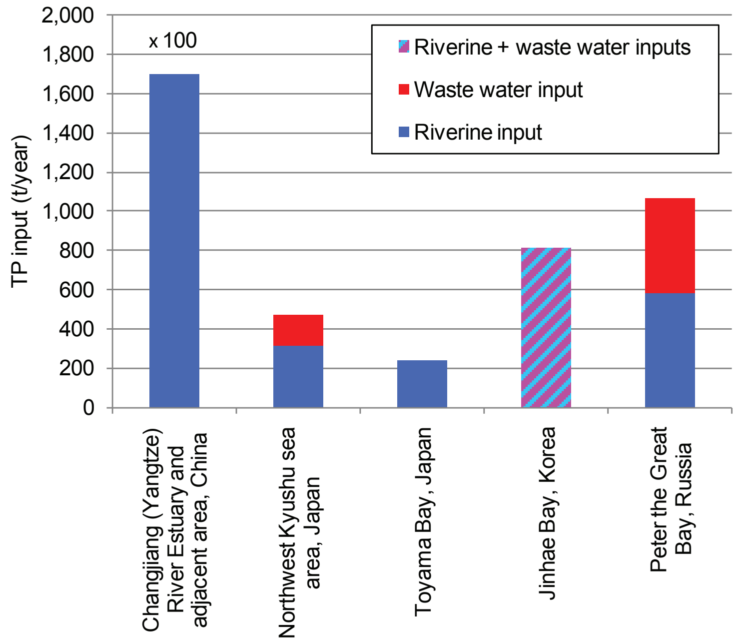


Figure 33. TN and TP inputs in selected sea areas in the NOWPAP region. Input into the Changjiang (Yangtze) River Estuary and its adjacent area needs to be multiplied by one hundred. The value of Changjiang (Yangtze) River Estuary and its adjacent area, China is for 2010. The values of the North Kyushu sea area and Toyama Bay are for 2007. Data of Jinhae Bay, Korea is an average between 1995 and 1996. Data of Peter the Great Bay is an average between 2001 and 2008.

There have been several studies done on eutrophication-related nutrient loadings in the Changjiang (Yangtze) River Estuary, and they indicate that nitrogen and phosphorus concentrations have increased compared to the 1960s [Chai et al., 2006; Wang, 2006; 2007].

The nitrogen and phosphorus concentrations were significantly elevated in the Changjiang main stream, a region 2,000 to 3,000 km inland of the river mouth [Chai et al., 2006]. With nationwide economic growth, nutrient enrichments significantly increased from the 1960s to the 2010s. Fertilizers used in agriculture and household effluents are considered to be the main nutrient sources [Liu et al., 2003]. In addition, due to the construction of the Three Gorges Dam, increases in nitrogen and phosphate and a decrease in silicon have been of concern [Chen, 2000; Gong et al., 2006]. The consequent change of the N: P: Si stoichiometric ratio can be advantageous to flagellates but not to diatom phytoplankton in the sea area [Harashima, 2007].

The TN and TP inputs from the rivers in Hakata Bay, as well as Dokai Bay and Kanmon Strait, showed a decreasing trend. In these sub-areas, nutrient loadings have decreased as a result of the improvements in sewage treatment and enacted regulations on wastewater from factories. Conversely, TN and TP inputs from rivers into the Kyushu intermediate area did not show any trend.

In the case of Toyama Bay, TN input showed no trend, whereas TP input showed a decreasing trend. Nitrogen and phosphorus loadings from factories have decreased since the Toyama Prefectural Government strengthened wastewater regulations. However, while diffuse-source nitrogen loadings from the Jinzu River have increased [Toyama Prefectural Government, 2008], TN input from all rivers has not changed.

There was no long-term data on riverine inputs into Jinhae Bay, and so nutrient loadings from rivers were not assessed. However, as TN and TP concentrations and winter DIN and DIP concentrations in Jinhae Bay have decreased, it can be concluded that land-based nutrient loadings have steadily decreased. The winter DIN/DIP ratio has been close to the Redfield ratio of 16 since 2006, but it exceeded this reference value before 2005. In other words, the DIN/DIP ratio supports that the appropriate management of nutrient loadings has been applied.

Nutrient inputs from the Razdolnaya River account for more than 70% of all inputs to Amursky Bay in Russia, where 70-90% of loadings from the river were between April and September. The DIN and DIP inputs from rivers increased between 2001 and 2007. Eutrophication caused by nutrient loadings from rivers affects ecological succession in biological communities in Amursky Bay, which is indicated by the increasing the number of pollution resistant species.

"National reports on atmospheric deposition of contaminants into the marine and coastal environment in the NOWPAP region" (NOWPAP POMRAC, 2006) and "Regional overview on atmospheric deposition of contaminants to the marine and coastal environment in NOWPAP Region" (NOWPAP POMRAC, 2007) describe atmospheric deposition of nutrients in more detail. The main focus of these reports is on the amount of atmospheric deposition and the fact that information on their influence or damage on the marine environment is scarce. Atmospheric deposition is recognized as one means of transporting nutrient loadings, particularly nitrogen, into the sea. It is reported that in the East China Sea, the volume of the deposition of ammonium and nitrate is almost the same as that of loadings coming from the Changjiang (Yangtze) River [Uematsu et al., 2002; Nakamura et al., 2005]. Deposition of terrestrial aerosols is one of the major sources of nutrients to the open waters. The effect of atmospheric nitrogen input on primary production in the eastern part of the NOWPAP sea area has been investigated using a coupled physical-ecosystem model [Onitsuka et al., 2009]. The atmospheric nitrogen deposition supports > 10% of the annual export production in the near-shore region along the Japanese coast. The increase in nitrogen availability caused by atmospheric deposition and riverine input has switched an extensive part of the study area in the Northwestern Pacific Ocean from being N-limited to P-limited [Kim et al., 2011]. Thus, nitrogen enrichments by atmospheric deposition can influence eutrophication and biological production in the marine ecosystem. It can be expected that further increases in air pollution will lead to an increase in airborne nutrient loadings to the sea. Atmospheric alley deposited substances tends to be diffused fast and widely, and nitrogen is readily available to phytoplankton. Therefore, it is possible that the deposition of these substances results in widespread pollution, further eutrophication and trans-boundary problems.

There are other sources of nutrient loadings to the sea. The greatest nutrients are derived from the pelagic sea [Nixon, 2009]. Even though the concentrations of nutrients are low, the total amount of nutrients is so large that they may have an influence on primary production, depending on the circulation of the sea water masses. The accumulation of nutrients on the sea bottom is also of concern, as they can be released back into the seawater. As the hypoxia of water at the sea bottom advances, nutrients are even more likely to be released. Thus, even if land-based nutrient loadings are reduced, its effect could not be seen immediately due to the reintroduction of nutrients accumulated in the past.

The influence of aquaculture on eutrophication has been pointed out. Aquaculture of fish and invertebrates produces postprandial leftovers and feces that accumulate at the sea bottom and these substances can accelerate eutrophication [Yokoyama, 2003]. In seaweed culture, seaweeds absorb nutrients to grow, and in doing so function to prevent eutrophication.

Submarine groundwater discharge is also a source of nutrients in the sea. This type of nutrient loading has been reported in Toyama Bay, Japan [Zhang and Satake, 2003]. In Masan Bay, Korea, negative effects from groundwater contaminated by industrialization have been reported [Lee et al., 2009].

Towards eutrophication assessment of the entire NOWPAP region

Although case studies to assess the eutrophication status in the selected sea areas by the NOWPAP Common Procedure partially revealed eutrophication status of the NOWPAP region, the CEARAC Focal Points of NOWPAP agreed that refinement of the NOWPAP Common Procedure and review of literatures are necessary for eutrophication assessment of the entire

NOWPAP region in 2011. Following this agreement, CEARAC refined the NOWPAP Common Procedure in 2012 and plans to apply its screening procedure to the whole NOWPAP region in 2014-2015.

3.1.4. Marine litter

Marine litter has been recognized as a major part of marine pollution that destroys the ecological, economic, cultural, recreational and aesthetic values of the marine and coastal environment of the Northwest Pacific region. In acknowledgement of the problems imposed by marine litter in the region, the 10th NOWPAP Intergovernmental Meeting (IGM) approved the implementation of Marine Litter Activities (MALITA) during 2006-2007 (UNEP/NOWPAP IG. 10/10), by which a NOWPAP marine litter database was established, regional overview on marine litter in the NOWPAP region and on legal instruments, institutional arrangements and programmes related to marine litter were published, a series of marine litter workshops and NOWPAP coastal cleanup campaigns have been organized.

As one of the outcomes of NOWPAP MALITA, NOWPAP Regional Action Plan on Marine Litter (RAP MALI) was approved in March 2008 by NOWPAP members and has been implemented mainly through national actions to prevent, monitor and remove marine litter which are critical for the successful tackling of marine litter problem in the region. Most of RAP MALI activities such as update of the NOWPAP marine litter database, organization of the International Coastal Cleanup (ICC) campaigns in conjunction with workshops, publication of the reports and brochures/leaflets, and public awareness are being implemented at the national level, in cooperation with local governments and authorities under the NOWPAP framework.

The NOWPAP members have implemented national marine litter monitoring programmes to understand the situation of marine litter in the respective countries. The NOWPAP Data and Information Network Regional Activity Center (DINRAC) has collected monitoring data submitted by national Marine Litter Focal Points and established a database through RAP MALI.

Depending on the spatial distribution, marine litter can be categorized into three groups, namely: i) marine litter on the shoreline, ii) marine litter on the sea surface, and iii) marine litter on the seabed. Most regular monitoring activities conducted by the member states are being focused on shoreline litter, which is considered relatively convenient and inexpensive to survey.

3.1.4.1. Marine Litter on the shoreline of the NOWPAP Region

Most of marine litter drifting on the sea surface and washed up to the beaches is generated from inland areas and transported through rivers, sewage, storm water or wind [Faris and Hart, 1994].

In the NOWPAP region, due to rapid economic growth and modern life styles on large consumption of materials including food and drinks in the member states, a lot of litter is generated. Litter without proper treatment on land outflows into the ocean. In fact, in many areas in the NOWPAP region, a large amount of marine litter is washed up to the coastal area and causes damages. To understand the situation of marine litter in the NOWPAP region, the NOWPAP member states have started national monitoring based on the NOWPAP Regional Action Plan on Marine Litter (RAP MALI). The total number of collected marine litter items for three years from 2008 to 2010 was 209,885 in 2008 (China: 28,520, Japan: 120,451, Korea: 60,370, Russia: 544), 166,489 in 2009 (China: 15,267, Japan: 91,517, Korea: 54,897, Russia: 4,808), and 123,141 in 2010 (China: 11,563, Japan: 42,453, Korea: 64,317, Russia: 4,808), respectively. In Korea, a monitoring survey has been conducted every two months in the fixed monitoring sites (Fig.34). Such periodical monitoring shows the amount of marine litter washed up to the beaches per unit time. The average number of washed up marine litter in the Korean coast is 536/100m^2/month.

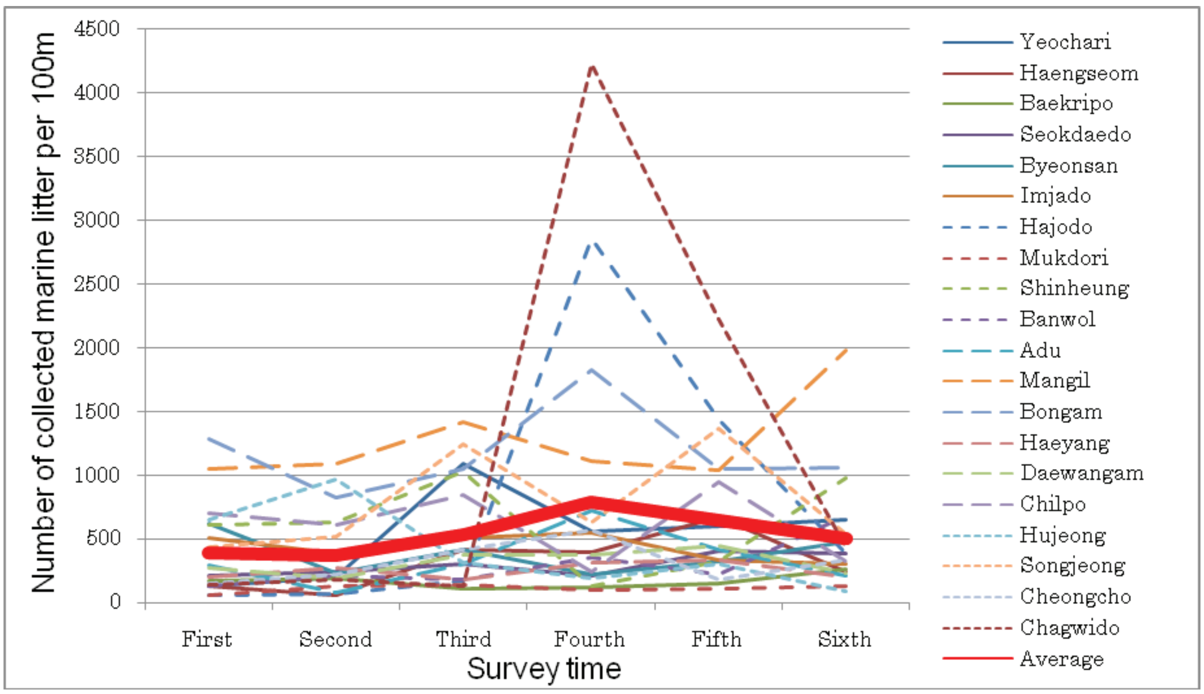


Figure 34. Number of collected marine litter per monitoring survey in each monitoring site
Thick line indicates the average of 20 monitoring sites (Source http://dinrac.nowpap.org/MarineLitter)

In addition to the washed up marine litter, it is well known that there is a lot of floating and sunken one. The monitoring on floating and sunken marine litter is rare, so it is not clear how much volume of marine litter from land-based sources is actually transported to the marine area. Japan Meteorological Agency (JMA) has a long-term data on floating plastic litter by visual monitoring from ship (Fig. 35). The result shows the seasonal change of distribution of floating marine litter. While, in summer and autumn, the number of floating marine litter increases due to increased amounts of freshwater discharge caused by melting snow and the rainy season, in winter, marine litter is washed up to the beaches by winter monsoon and the number of floating marine litter decreases. To understand such a seasonal change of marine litter distribution is useful for developing appropriate countermeasures to prevent marine litter input as well as to collect litter.

Figure 34 shows the amount of marine litter per 100m² in each monitoring site. There is not much difference in numbers among the member states, and the average number of washed up marine litter per 100m² is 550 items. In several areas, more than 1000 pieces per 100m² of marine litter are washed up, and the number seems bigger in the area facing the ocean current, namely the Tsushima Current. It means that marine litter transported by the Tsushima Current is carried to the beaches by wind and waves.

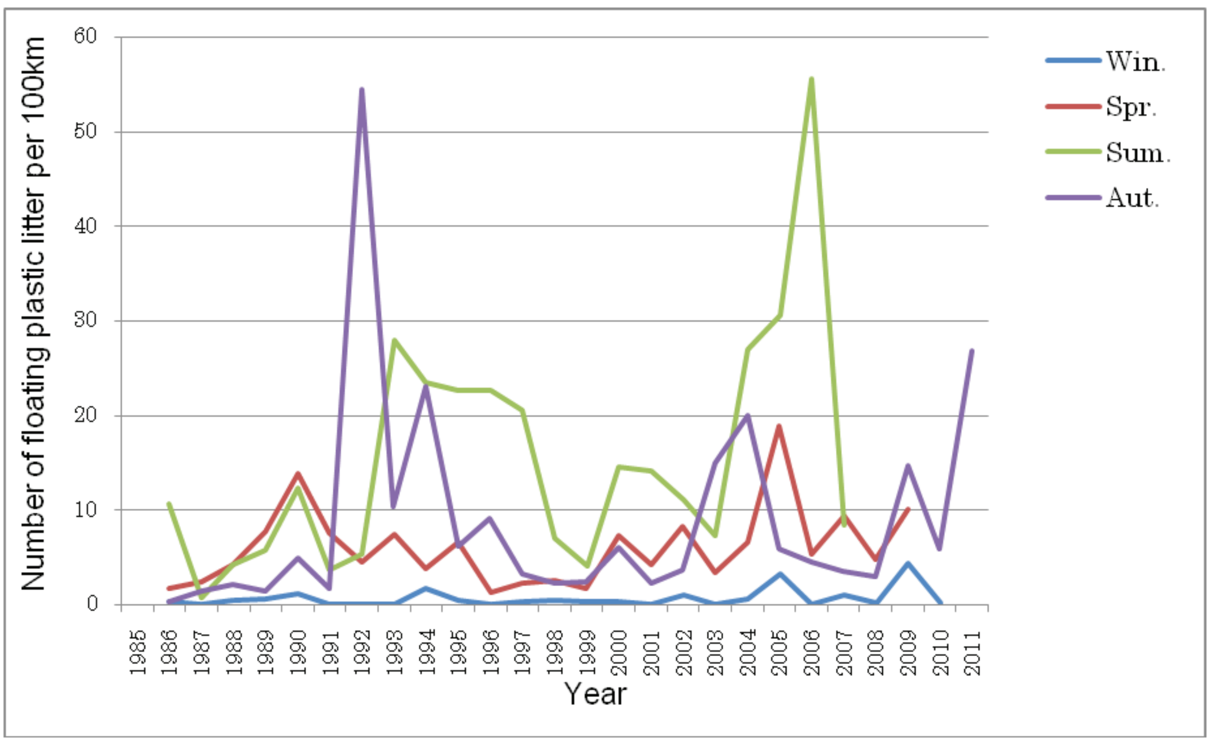


Figure 35. Distribution of floating plastic marine litter in the offshore area of Noto Peninsula (Source: JMA: Marine pollution in the northwest Pacific region)

On the other hand, the weight of marine litter per 100m² has more obvious characteristics than the amount of marine litter per 100m² (Fig. 36). The weight of marine litter per 100m² in Korea is much heavier than that of other member states. The heaviest per 100 m² is 400kg. In this site, heavy plastic, polystyrene and wood items, such as buoys, fishing nets and drifted wood are collected.

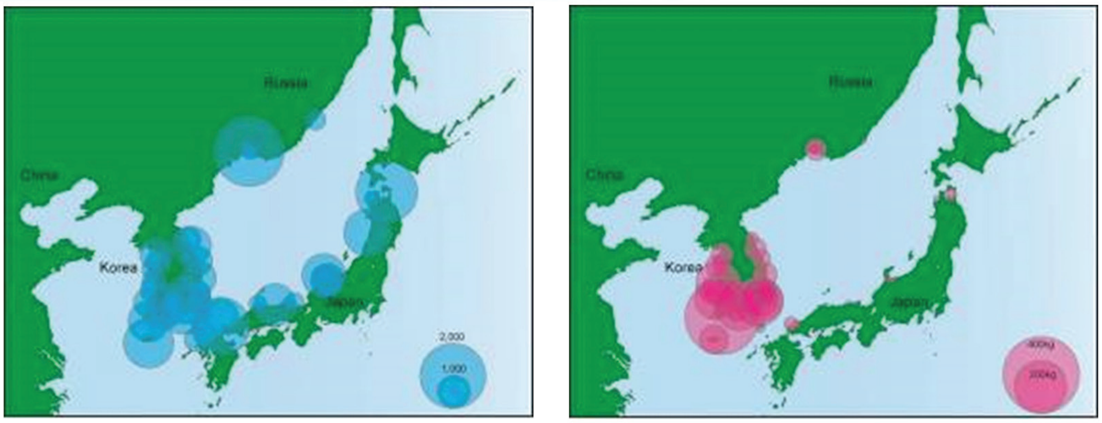


Figure 36. Distribution of marine litter in the NOWPAP region in 2010. The map on the left shows the amount of marine litter per 100m2, and the map on the right shows the weight per 100m2 at each site. The size of circles indicates the amount and the weight of marine litter respectively (Source http://dinrac.nowpap.org/MarineLitter).

Figure 37 indicates the composition of marine litter in each member state. In China, Japan, Korea and Russia, marine litter is classified by material. In all member states, plastic and polystyrene are made up a majority of collected items. It means a lot of light and disposable items such as plastic bottles and polystyrene containers are used in the member states and flushed into the ocean. On the other hand, in Russia, more metal and glass items such as empty cans and glass bottles are found as marine litter. The difference of major litter composition among the member states may be because of the difference in commonly used container materials as well as the difference of 3R (Reduce, Reuse and Recycle) practice penetration in each member states. To design/ develop and implement proper countermeasures against marine litter, the litter composition should be investigated in more detail.

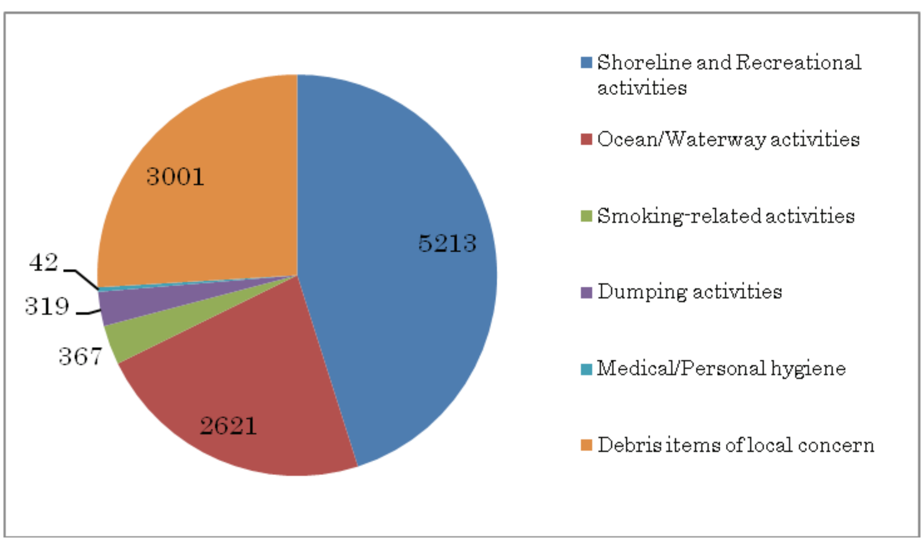


Figure 37. Composition of marine litter in China in 2010 (11,563 items in total)

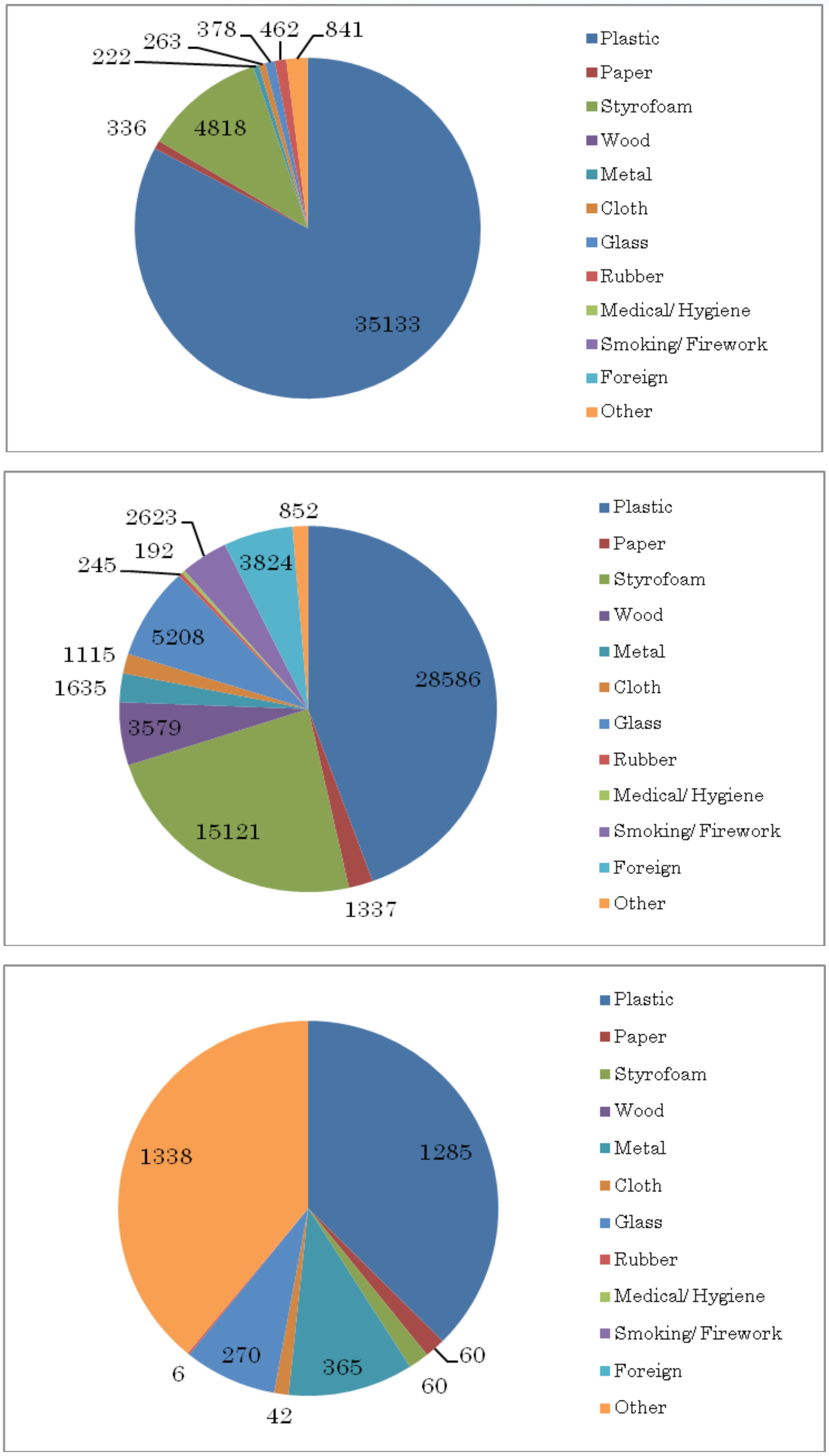


Figure 37 (continued), Composition of marine litter in Japan (top: 42,453 items), Korea (middle: 64,317 items) and Russia (bottom: 3,426 items) (Source http://dinrac.nowpap.org/MarineLitter)

As mentioned above, marine litter is transported by the ocean currents and wind, so it causes damage in the areas far from the original areas of marine litter. Most of marine litter is generated from the domestic areas (Fig. 38); however, in some areas, especially on remote islands and at the entrance of the straits, marine litter from foreign countries is observed. Actually, in Hawaii, far from the NOWPAP region, marine litter from the member states is found. It is transported long distance by the ocean currents. To reduce damage by marine litter in remote areas, all countries should take actions to prevent marine litter input to the marine area.

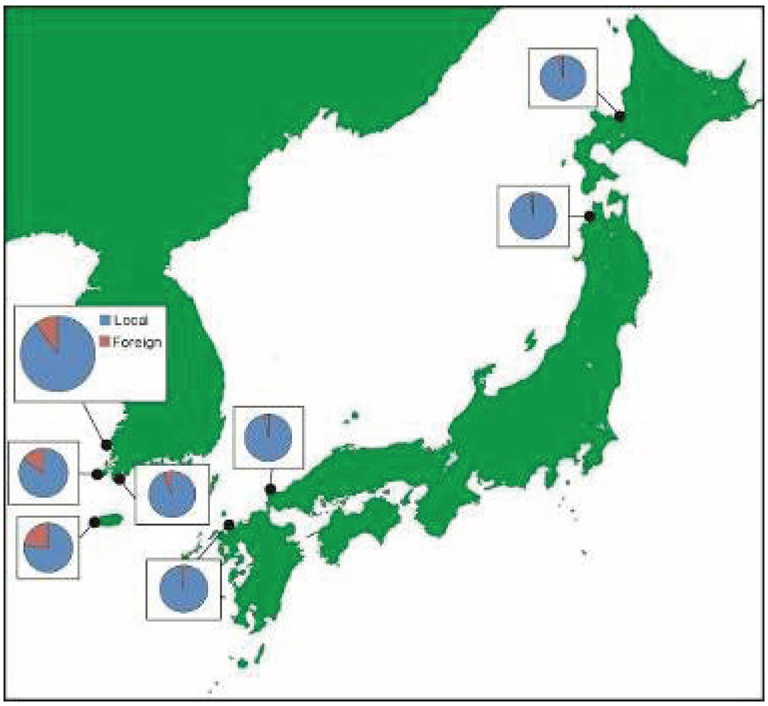


Figure 38. Ratio of marine litter sources: domestic areas (blue) and foreign countries (red)
(Source http://dinrac.nowpap.org/MarineLitter)

In the NOWPAP member states, various kinds of countermeasures for prevention of marine litter input from land-based sources are implemented by the central and local governments and other entities. Each member state has established basic polices and strategies for prevention of marine litter input, and the local governments, NGOs/NPOs and other entities have implemented activities on such as establishment of cooperation networks, effective collection/clean-up and enhancement of public awareness. Such measures and best practices for prevention of marine litter input from land-based sources in the NOWPAP region is summarized as a regional report published in 2012 by NOWPAP CEARAC.

Over the past 25 years, the ICC initiated and promoted by Ocean Conservancy (OC). It has become the world’s largest volunteer effort for ocean health. In parallel to the ICC campaign in China and Russia in 2007, all NOWPAP members with Japan and Korea have produced data from annual ICC campaigns and contributed to a better understanding of sources of marine litter. According to the ICC reports of NOWPAP members in 2010, around 80% of marine litter collected originated from shoreline and recreational activities and secondly by smoking related activities. Marine litter from shoreline and recreational activities is strongly connectedly to tourism. The items that could be related to these activities are bags (paper and plastic), beverage bottles, clothing, shoes, food wrappers and straws (NOWPAP, 2011).

Northwest Pacific Region Environmental Cooperation Center (NPEC) in Japan has initiated a research on washed-up driftage on the coasts in the NOWPAP region since 1996 and extended gradually its survey area to NOWPAP members through 24 local governments of the four member states since 2003 (NPEC, 2003). Marine litter was classified into eight categories: plastic, rubber, polystyrene, paper, cloth, glass, ceramic and metal and others. The State Oceanic Administration (SOA) in China has been organizing annual beach litter monitoring activities in 23 areas since 2007 with 8 types of litter: plastic, rubber, polystyrene, cloth, glass, metal, wood and others. Korea set out the first nationwide beach monitoring program from 2000 to 2003, and subsequently Korea National Marine Debris Monitoring Program (KNMDMP) was conducted for 5 years to investigate sources and distribution of coastal litter in a total of 20 areas since 2008. This investigation classified marine litter into 8 types: plastic, rubber, Styrofoam, paper, cloth, glass, metal and wood; and 3 categories: medical waste, cigarettes/fireworks, and foreign origin.

3.1.4.2. Marine Litter on the sea surface and sea bed

Besides marine litter generated at the land and concentrated on the shoreline and beaches, the generation of litter and wastes at the human activities on the sea is also important. This material is distributed on the sea surface and sea bed, though some litter generated on the sea can be concentrated on the shoreline, and some litter from the land-based sources can migrate far away and be concentrated on the sea surface or sink.

MERRAC has been implementing sea-based marine litter issues, especially related to the ‘garbage from ships’ defined in Annex V of the MARPOL Convention within the framework of MALITA and RAP MALI in close cooperation with Marine Litter Focal Points, MERRAC Focal Points, UNEP, IMO and other RACs under the overall management of NOWPAP RCU. MERRAC has contributed to raise public awareness about marine litter in the region and to support the development of integrated waste management polices and systems at both national and regional level through the development and publication of following technical reports and brochures.

- Guidelines for Monitoring Marine Litter on the Seabed in the Northwest Pacific Region;
- Guidelines for Providing and Improving Port Reception Facilities and Services for Ship-generated Marine Litter in the Northwest Pacific Region;

- Sectoral Guidelines for Marine Litter Management: Fishing, Commercial Shipping, Recreational Activities, Passenger Ships
- Brochure on Sea-based Marine Litter: Problem & Solution
- Best Practices on waste management (Waste Fishing Gear Buy Back Project, etc)
- Report on the Technologies and Research Outcomes on Prevention, Collection and Treatment of Marine Litter in the NOWPAP Region
- Port Reception Facilities in the NOWPAP Region, etc.
- Regional Report on Sea-based Marine Litter and Marine Litter Management: The approach of Incheon City, Republic of Korea

In addition to the beach monitoring, China in particular, has carried out regular monitoring on the floating and sea-bed litter. According to the survey in 16 coastal areas in 2009, the majority of floating litter was plastic accounting for 72% in number including Styrofoam (31 %), followed by wood (14 %). The results of sea-bed monitoring conducted along the coasts of 6 provinces of China in 2009 showed that plastic occupies 61 %, rubber 9 %, fabric 9 % and others 21 % in number.

While Japan, Korea and Russia do not have regular monitoring programs on the floating and sea-bed litter, a rough estimation of the floating distribution has been drawn from the results of a research paper and showed that Styrofoam and plastic account for 81%, and wood scraps and paper at 9.1 and 0.9% respectively, in the sea surrounding Korea. In agreement with many other studies and monitoring, plastic accounted for the largest number of marine litter.

According to the research result on the distribution of sea-bed litter in the 137 ports of Korea, the composition of marine litter by type revealed that derelict rope accounts for 25 %, metals 22 %, wire-rope 16 %, wood 8 % and tire 5 % and other 24 %. Fishing gear, such as ports, nets, octopus jars and fishing lines, accounted for about 42-72 % and 37-62 % of the litter items in the East China Sea and the South Sea of Korea respectively whereas the contribution of rubber, vinyl, metal, plastic, glass, wood, and clothing were generally below 30%. The difference of the types of marine litter in China and Korea are highly dependent on the area being monitored; China is most likely to monitor areas near the coast or estuary, whereas Korea examines more on ports or fishing grounds.

Most marine litter consists of any persistent, manufactured or processed solid material disposed of or abandoned in the marine and coastal environment (UNEP 2005). Although there are differences between the classification systems used in NOWPAP member states, plastic, wood, glass, metal, cloth and paper have been considered as most common types of marine litter. Various types of marine litter are found along the coasts, sea surface and seabed. Plastic accounts for the majority of marine litter whereas considerable amounts of wood, derelict fishing gear are also being found.

Upon the approval of RAP MALI workplan (2010-2011) at the 14th NOWPAP IGM (2009), MERRAC conducted a study on specific cases of the negative impacts of marine litter in the NOWPAP region with Expert Group consisting of national experts, nominated by NOWPAP MERRAC Focal Points and Marine Litter Focal Points. This case study has been prepared based on the national reports on negative impacts of marine litter submitted by national experts, including information on the distribution of marine litter in the NOWPAP region, in order to understand the severity of the marine litter issue and to improve public awareness in the region.

Marine litter gives rise to a wide range of negative environmental, social, and economic impacts causing direct or indirect damage to marine ecosystems, and human activities and properties.

Based upon the information referred by governmental reports, research papers and newspaper articles, the impacts of marine litter were divided into largely four categories (MERRAC, 2013):

1) Fishing and aquaculture;

2) Marine ecosystems, habitats and biodiversity;

3) Shipping and navigation; and

4) Tourism and recreational activities.

1) Fishing and aquaculture rely on marine flora and fauna which are valuable resources for human well-being. While fishing and aquaculture sectors are major victims of marine litter, they are also major sources of marine litter. There are myriad ways that marine litter brings damage to fishing and aquaculture such as damages of fishing gear, damages of aquaculture facilities, interruption of fishing operation and human casualties (death, injury, disease etc).

2) Negative impacts of marine litter on marine ecosystems, habitats and biodiversity are increasing and can bring huge economic losses. Damages caused by marine litter in marine ecosystems, habitats and biodiversity may include ghost fishing, destruction of habitat of marine species, decrease in fisheries resources and entanglement and ingestion. However, unlike direct damages such as damaged fishing gear or facilities, it is difficult to estimate the exact scale and impact of damage to marine ecosystems. To make matters worse, it takes a long time for habitats and biodiversity to recover from the damages.

3) Marine litter poses numerous safety risks to vessels for shipping and navigation. There are many instances of ship accidents and navigational hazards caused by marine litter. Plastic bags are common causes of blocked water intakes, resulting in overheating of water pumps of recreational vessels. In particular, fouling and entanglement of a vessel's propeller caused by derelict fishing gear reduce a vessel's stability in the water and ability to maneuver. These can cause sailing delay, breakdown/repair of vessel and sinking and casualties and also put vessel crews in danger, especially during poor weather conditions.

4) Marine litter on the shorelines and floating litter near the seashore significantly reduce aesthetic value of the coasts, hindering tourism and recreational activities such as fishing, swimming, diving and boating. This may lead to loss and reduction in revenues from tourism of the coastal communities of concern. In addition, accumulated litter requires clean-up operations that cost substantial financial resources and causes damage to the health and safety of swimmers and divers.

A total of 169 cases of negative impacts caused by marine litter were collected and analyzed by detailed types under the four categories. Among all the cases of damage caused by marine litter, shipping and navigation including sailing delay and breakdown of vessel are the most frequently reported cases at 110 (65.0%) followed by tourism and recreational activities including destruction of aesthetic value and costs for removal of marine litter at 33 (19.5%), marine ecosystems, habitats and biodiversity including ghost fishing, decrease of fishery resources, and entanglement at 20 (12.0%), and fishing activities and aquaculture including damage of fishing gear and aquaculture facilities at 6 (3.5%).

Composition ratio of the negative impacts of marine litter by cause showed that derelict fishing nets and ropes are accountable for more than half of the damage caused by marine litter (52%), followed by general waste (31%). Although general waste is not identified in detail, it generally includes driftwood, litter items washed ashore, etc. Domestic waste (13%) refers to litter items discarded on beaches, and the others category includes medical waste, construction waste, etc.

Considering the fact that most sailing delay and breakdown of vessel happen to fishing vessels, it can be said that the biggest victim of marine litter is the fishery and aquaculture sector. It is interesting to know that the source of most ship accidents is none other than derelict fishing gear and nets, which result from fishing and aquaculture activities. In the same way, coastal litter, which is considered a significant factor of the decline of tourists, is largely a by-product of the tourists who visit to enjoy recreation on the beach.

Marine litter, as a result, gives a wide range of negative environmental, social and economic impacts causing both direct and indirect damages to marine ecosystems, human activities and properties.

Among damages that have been caused by marine litter in the NOWPAP region, specific cases of 1) ghost fishing, 2) decrease of fishery resources, 3) destruction of habitats of marine species and 4) entanglement of animals may be included in the environmental impacts of marine litter.

Marine litter itself has implication of economic expenditure even excluding its secondary or compounding effects caused by accidents and disasters. Among damages that have been caused by marine litter in the NOWPAP region, specific cases of 1) interruption of fishing operation, 2) damage to aquaculture facilities, 3) breakdown or repair of fishing gear 4) breakdown/repair of vessels, and 5) cost of marine litter cleanup may be considered as the economic impacts of marine litter.

The social impacts of marine litter include deterioration in the quality of human life, reduced recreational opportunities, loss of aesthetic value and loss of non-use value. Among damages that have been caused by marine litter in the NOWPAP region, cases of 1) destruction of aesthetic value and 2) human casualties may be included as specific examples of social impacts.

The negative impacts of marine litter can often be a vicious circle as impacts can lead to other negative impacts. For instance, several cases of coastal litter causing damage to aesthetic value were included in the reports by NOWPAP members. Although it is difficult to convert aesthetic value into a monetary equivalent, coastal litter can result in economic losses including decline of tourism and generation of clean-up costs and it can further lead to social issues such as distrust of governments etc. Moreover, marine litter can also endanger the lives of humans directly. For instance, a vessel's entanglement in marine litter such as derelict nets and rope may cause ship accidents, which could lead to sinking and human casualty. Or in some cases, these lost or abandoned nets and ropes caused entanglement to swimmers and divers.

Recognizing the numerous effects of marine litter through case studies on the negative impacts of marine litter, and noting that polluters can be victims of marine litter too, people concerned should be mobilized in preventing marine litter from being generated and reducing its negative impact. In order to mitigate the negative impacts of marine litter in the NOWPAP region and as solutions to this continuously expanding problem of marine litter, the following actions have been suggested:

Actions regarding plastic, which constitutes the largest portion of marine litter:

Reduce use of plastic and encourage reusable materials (e.g., reusable shopping bags, reusable cups and dishes);

Conduct effective disposal and recycling of used plastic on land in order to prevent the influx of plastic into the sea by land-based activities;

Raise awareness among general public and regularly collect and remove plastic litter on the coast;

Conduct surveillance and monitoring in order to prevent dumping of plastic into the sea during maritime activities;

Encourage the use of eco-friendly degradable plastics.

Actions regarding derelict fishing gear, which cause the most serious damage to oceanic life:

Promote the use of biodegradable fishing gear and nets;

Minimize loss of fishing gear at sea (e.g., use labeled fishing gear);

Report and collect derelict fishing gear found during fishing operations and bring them back to land;

Raise awareness among fishermen of abandoned fishing gear impacts.

Enhance the public awareness of the marine litter issue and encourage participation in cleanup activities:

Conduct a systematic and detailed survey on damage to ecosystems caused by marine litter in order to inform to the public effectively;

Develop national educational and awareness raising programmes on the marine litter issue targeted for school kids as well as for general public;

Conduct beach clean-up campaigns regularly, for example, the International Coastal Cleanup Campaign (ICC).

Regular monitoring of marine litter for data collection:

Increase frequency and range of monitoring not only on beaches but also floating and seabed litter;

Establish a common classification system by member states for objective analysis;

Analyze and evaluate sources of marine litter in the region.

3.2. Assessment of ecological problems connected with biodiversity, habitat disturbance and climate change impacts

3.2.1. Non-indigenous and invasive species

There are a number of Marine Invasive Alien Species (MIS) have been found and recorded within NOWPAP Region (Table 11). According to the literature review, 102 benthic species are recorded, 14 from China, 29 from Japan, 22 from Korea and 37 from Russia. 31 pelagic species, mostly fishes, are recorded in the NOWPAP region, much less than benthic species have. However, it is difficult to identify a fish species as invasive due to the higher mobility of these species.

Table 11. The number of MIS in the NOWPAP Region

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

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

In fact, it is believed more species have the potential to become MIS in NOWPAP Region. According to literature review, 136 species suspected to be invaders in Chinese and Korean coastal waters [Seo and Lee, 2009] and over 40 marine invasive species have been recognized in Japan [Otani, 2004]. Many marine organisms, such as fishes, bivalves, gastropods, and crabs are imported from neighboring countries and areas. Some of these animals will be cultured not only in enclosed system but also in open habitat, for example tide flat. Furthermore, marine species imported for aquaculture purpose could contain living invaders. If they were released into natural environment, invaders may be able to reproduce and some of them may succeed to establish new population.

Since it not only cause huge economic loss [Liu *et al*., 2005], but also seriously threaten biological diversity [Reichard & White, 2003], attention has been paid to invasive alien species worldwide. Anthropogenic activities and environmental factors change are critical driving forces to distribution and intensity of invasive alien species, and anthropogenic activities attract more attention for better understanding of biological invasion [Myers & Bazely, 2003; Vilà

& Pujadas, 2001; Sax, 2002]. Besides that, climate factors are also always used to predict the potential distribution of invasive alien species [Sutherst et al., 1999]. Generally speaking, fishery, transportation and climate change are the main factor to help the distribution and spread of MIS within NOWPAP region.

Fishery is a main pathway. Continental seabass (*Lateolabrax* sp.) was intentionally introduced to Japan from China since 1989. In 1992, the wild population was found in Japanese waters. So far, no action for prevention, mitigation, control, or eradication had been taken. They affect native marine ecosystem by predation on small fishes and competition with native seabass (*L.japonicas*). A species of mollusk (*Perna viridis*) was introduced to Japan by ballast water or fouling on ship, also via aquaculture, and then became a huge threat [Iwasaki, 2005]. They cause damage in water pipes of electric generation plant and aquaculture nets. They also hybridize with related species, and their hybrids compete with native species.

In China, many invasive species were also introduced recently for mariculture causing frequently hybridization with indigenous species. Invaders and their hybridized offspring can easily enter the natural environment by escaping from labs, stock enhancement releasing, or even religious releasing. For example, stock enhancement releasing was often carried out in Shandong province, an non-native fish (*Scophalmus maximus*) and one kind of prawn (*Penaeus japonicas*) were released into the costal sea, the marine ecosystem would be greatly affected [Liang & Wang, 2011]. Another example is the red drum (*Sciaenops ocellatus*) which was introduced to Taiwan Province first in 1987, and 1991 to mainland China. The producing of red drum had been widely spread to coastal areas of China, and some red drum individuals had been set free into the nature environment in religious activities, for example, about 10,000 red drums were sent into nature environment at Qingdao in July, 2012. This alien species would compete with indigenous fishes, affecting native marine ecosystem.

During the later half of the 20th century, 7 to 8 exotic marine species have been recorded every decade in the Japanese coastal waters [Iwasaki et al. 2004]. There is no legal regulation for both intentional and unintentional introduction of marine abroad species into the Japanese waters, so the trend of more MIS may continue. Fishery associated introduction of abroad marine species is an important vector for new introduction of MIS.

Shipping is one of the main approaches that invaders were imported. Sea chests provide a more stable environment than ballast water for living animals such as the Mediterranean green crab (*Cercinus asetuarii*) and the hard clam (*Mercenaria mercenaria*), to survive in trans-ocean journeys [Otani, 2004].

In Korea, most of export and import cargoes are transported via ocean, and fishery plays an important part in Korean economic, because of its geographical location. Therefore, MIS can reach NOWPAP region of Korea more easily than China, Japan or Russia, by pathway of shipping and ballast waters, intentional introduction and unintentional introduction.

With climate warming and current system modifications, more and more invasive species come into NOWPAP region of Russia. Many invasive mollusks were found in Peter the Great Bay, for example, *Anadara broughtonii*, *A. inaequivalvis*, *Trapezium liratum*etc. [Lutaenko, 1999]. Some non-indigenous species are in the first stage of introduction and small-scale development [Zvyagintsev, 2003], for example, *Polydora limicola*, *Laomedeacalce olifera*, etc. They show great ecological plasticity and relatively frequently occur in the fouling of harbor fleet vessels and the northwestern NOWPAP sea area "A", and may have significant effects to native ecosystem and aquaculture.

MIS may have great threats and impact to native communities and ecosystems, MIS have done great impacts to coastal ecosystems in China. Smooth cordgrass (*Spartina alterniflora*) distributed almost all the coastal areas of south China. They occupy niches of native species, destroy habitat of native birds and aquatic, threatening local biodiversity. They also clog waterways, affecting water exchange and cause red tide. One kind of urchin (*Strongylocentrotus intermidus*) used to be introduced from Japan into northern China, then escaped from breeding cage into the natural marine environment and became a huge threat, because this alien species can not only bit the root of the algae and destroy the submarine seaweed beds, but also compete with the local *S. nudus* for food and space, and endanger the survival of indigenous urchin.

Results of adverse effects on native species reduction, landscape loss, breeding degradation, frequent red tides, etc., which were possibly caused by MIS, not only result in economic loss on marine based industry, but also trigger a series of social problems indirectly. Each year invasive alien species both terrestrial and aquatic may cost about 120,000 million RMB Yuan loss in China, including direct loss in agriculture and indirect loss in ecosystems, genetic resources and so on [Xu and Qiang, 2004]. As an example, the large-scale death of *Chlamys farreri*, which was introduced from Taiwan Province, was considered to be linked to shrimp virus disease that started to spread on a large-scale in China's aquaculture since 1993.China has to spend a good amount of money in dealing with such disease. In 2002, the shrimp virus disease and other invasive species related disease led to loss of more than 4,000 million RMB Yuan [Zhu & Zhao, 2004]. Still it's hard to account the cost of dealing with ecological and economic impact caused by other marine invasive species such as smooth cordgrass.

In Japan, MIS may cause exclusion of indigenous species [Iwasaki, 2007]. The Mediterranean blue mussel (*Mytilus galloprovincialis*) covered on the native sessile species, for example *Crassostrea gigas*, *Septifer virgatus*, *Hizikiafus iforme*, and then the invaders occupy the space for them. MIS also cause disturbances in native benthos genes and communities. Hybridization occurred between MIS and genetically closed species, such as Mediterranean M. *galloprovincialis* and *M. trossrus* in northern Japan, Chinese *Eriocheir sinensis* and the native *E. japonica*.

The Chinese snail, *Nassarius sinarus*, which feeds on gobies captured in fishery traps, has populated Ariake Inland Sea, Kyushu [Fukuda, 2004]. Another kind of snail, *Euspira frotunei* has brought catastrophic damage in manila clam fisheries in Sendai bay, northern Honshu

[Okoshi, 2004]. Though local fishermen keep removing the snails and their egg collars from tidal flats, the damage is still critical.

Though no public health problem caused by MIS has been reported, there is hidden danger in Japan. A human-parasite trematode *Paragnimus westernmanii* was unintentionally introduced to Japan with the intermediate host, the invasive Chinese mitten crab *E. sinensis*, and may infect the native crab [Iwassaki, 2007].

Ecosystem balance has been changed with the introduction of species that can multiply and spread faster than the native species. Also the invaders take more resources the indigenous used to have. Still it's not clear what ecosystem-based impacts have been taken place in Korea.

The Mediterranean mussel *M.galloprovincialis*, which is also an invader of Japan, was introduced to Korea by ship during the 1950s. The mussel spread alone the shores of Korea and became dominant over the native species. Massive fouling by this mussel throughout the inlet pipe to draw sea water makes the operation of power plant periodically stop to eradicate heavily fouled mussel. This process causes great loss in terms of unnecessary labour and financial resources. Viruses or bacteria carried by imported marine species have done great damage to Korean fisheries, the related economic loss reaches about 250 million dollars per year. For example, White-Spot Syndrome Virus, which was carried by the imported shrimp *Litopenaeus vannamei*, caused a 28.4% decrease of shrimp yield in Korea during 2004. Invasive species associated viruses and bacteria may also impact human health.

In Peter the Great Bay of Russia, naturalization of invasive species leads to the predominance of new inhabitants over native species, causing alterations in the ecosystem structure and trophic relationships and occasionally to unbalancing of coastal ecosystem. The successful naturalization of one invasive barnacle *Amphibalanus improvisus*, which was first recorded in the fouling of the hydrotechnical facilities in Peter the Great Bay and then became a common component of fouling of ship hulls, led to displacement of indigenous cirripeds from dominating macrobenthic species of the local fauna [Ovsyannikova, 2008]. Invasive phytoplankton species probablycause microalgae blooms, the effect of oxygen-defficent water and eutrophication may lead to mass mortality of benthic animals and fishes. Many ecosystems that are now severely stressed by hypoxia may be near or at a threshold of change or collapse, for example loss of fisheries, loss of biodiversity, alteration of food webs, etc. [Diaz, 2001].

Introduction of non-indigenous marine species has positive economic impacts in Russia, but the increase of invaders also has unpredictable impacts. Invasive species often compose fouling of ships, piers, buoys and other hydrotechical structures, and cause economic loss. As a result of global warming, the bloom of algae in Russia, most of which are non-indigenous, may also cause mortality of fish.

Some microalgae, as well as shellfishes, can affect human through food chains, as many of them have the ability to produce potential toxins. With more invasive shellfishes inhabitant in the NOWPAP region of Russia, shellfish poisoning could become a major threat in the future.

3.2.2. Impact of fisheries and aquaculture on the biodiversity and habitats

Fisheries and aquaculture (mariculture) situation in NOWPAP sea area "B"

NOWPAP sea area "B" (Yellow Sea) is a semi-enclosed shallow sea between north China mainland and Korean Peninsula. The sea covers area of about 438,619 km^2. Shelf area is 428,287 km^2, Inshore Fishing Area (IFA) - 202,331 km^2. The deepest southeast part of it is about 140 m. The Yellow Sea is connected with the East China Sea in the South and with the NOWPAP sea area "A" through the Korea Strait in the Southeast. The bottom sediments consist of silt and ooze brought out by continental rivers.

Hydrographic characteristics of the Yellow Sea are influenced mainly by the continent, particularly in the West, where the temperature, salinity, and currents show distinct seasonal changes. Annual variation of water temperature in the Yellow Sea ranges between 1–4C° in winter and 24–28C° in summer. The salinity averages 32 ‰.

Cold water mass in Yellow Sea protects the cold-water fauna. A temperate community dominates the deeper water and results in a high biodiversity of local benthos in the shallow middle latitude. The Bohai Sea covers area of 78,000 km ^{2}. About 95 percent of its total area, less than 30m deep, with average depth of 18 m. Laotieshan Channel is the deepest place (86m).

To estimate the contribution of each of the countries in the mariculture and fishing activities in the North-Western Pacific, the FAO Global datasets "Capture Production 1950-2011" and "Aquaculture Production 1950-2011" (http://www.fao.org/fishery/statistics) were used. Catches and aquaculture production are shown in Figures 39 and 40.

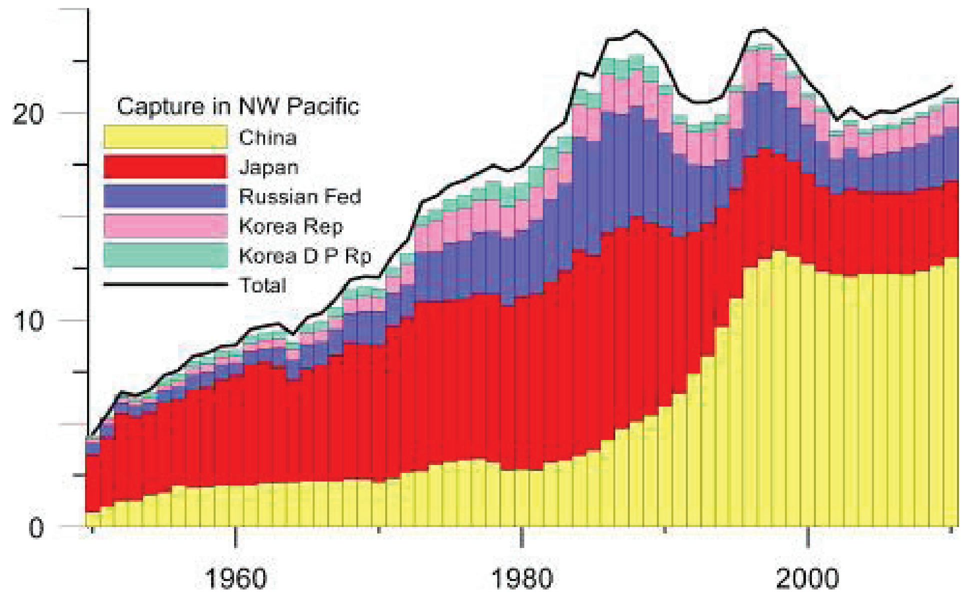


Figure 39. Total reported catch (millions of metric tons) in the North-Western Pacific by country (source: FAO Global dataset "Capture Production 1950-2011", 2013).

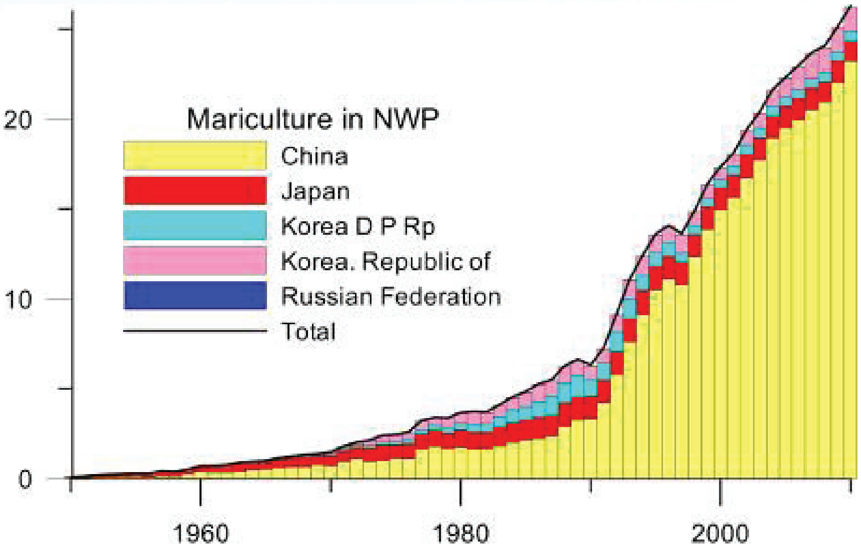


Figure 40. Total production of mariculture (millions of metric tons) in the North-Western Pacific by country (source: FAO Global dataset "Aquaculture Production 1950-2011", 2013).

The "Sea Around Us Project" is based on the databases of FAO, and emphasizes the catch time-series and fisheries-related information on every maritime country (dataset "Large Marine Ecosystems"). This dataset and a new dataset "Global Mariculture Database" (GMD) are freely available online at *www.seaaroundus.org*. In constructing the GMD, a three-pronged methodology was used for the collection and synthesis of historical production data for each coastal country engaged in mariculture production: (1) raw annual production statistics for marine and brackish-water aquaculture accumulated in a primarily electronic format from official statistical sources and published Government and other special literature; (2) data gaps were filled by rule-based systematic estimation procedure that includes both linear interpolation and extrapolation; and (3) using the same or additional references as above, production data were further taxonomically and geographically splitted. National production figures were split by the provinces, states or territories that subdivide larger countries [Campbell, Pauly 2013]. Spatial component provides additional information for analyses of stress and modification of coastal ecosystems.

The Yellow Sea multispecies fisheries is well-developed and it is multinational [Heileman, Jiang, 2008]. Total reported catches on the rise, amounting 2.49 million tons in 2000 and 2.50 million tons in 2004 (Fig. 41).

The fish communities are diverse, ranging from warm to cold-water and temperate species. About 100 species of fish, squid and crustaceans are exploited commercially, among them are, chub mackerel (*Scomber japonicus*), hairtail (*Trichiurus lepturus*), Japanese anchovy (*Engraulis japonicus*), yellow croaker (*Pseudosciaena polyactis*) and Japanese flying squid (*Todarodes pacificus*) [Heileman, Jiang, 2008]. Total reported catches in the Yellow Sea by species are shown in Figure 42.

In the case of the cold-water fish *Clupea pallasi* (170,000 tons in 1972) and of *Gadus macrocephalus* (50,000 tons in 1958); their resources have lately seriously declined and annual production has decreased to but a few thousand tons. At the same time, recent changes in trophic structure of the ecosystem and an increase of fishing efforts have resulted in the growth of catch of another small cold-water fish - the *Pacific sandlance*, *Ammodytes personatus*, the annual catch of which in 1999 increased drastically to 500,000 tons. Unfortunately, overexploitation decreased the catch in 2004, to 226,000 tons and further yet to 146,000 tons in 2009 [Liu, 2013].

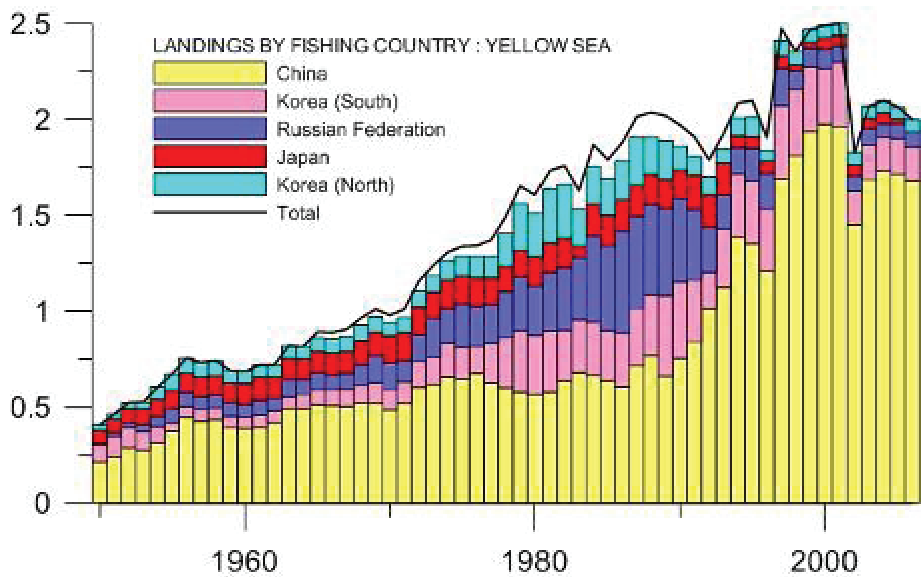


Figure 41. Total reported catch (millions of metric tons) in the Yellow Sea (NOWPAP sea area “B”) by country (source: Sea Around Us dataset “Large Marine Ecosystems”, 2013).

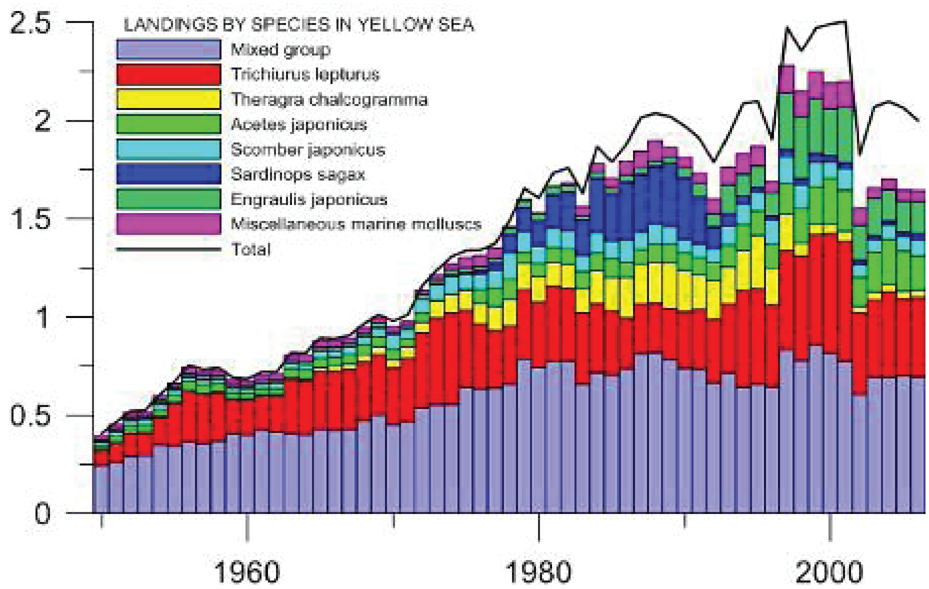


Figure 42. Total reported catches in the Yellow Sea by species

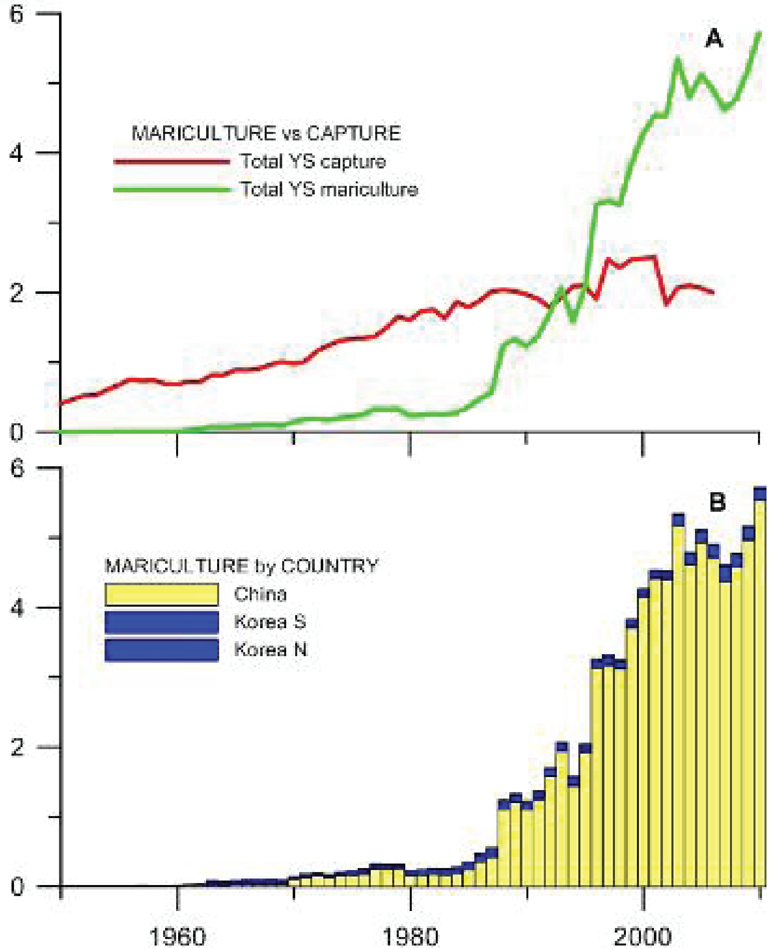


Figure 43. Production, in millions of metric tons, for aquatic animals capture (A) and aquaculture (B) in the Yellow Sea

In addition to the fisheries, the aquaculture of seaweeds and shellfish makes an important economic input in the coastal zone of Yellow Sea. The rate of sea farming and ranching production is bigger than the rate of marine capture fisheries (Fig. 43a)

In the last eleven years China's top mariculture-producing coastal provinces have individually produced more than any other average maritime country. The two of them are situated at the coast of the Yellow Sea (Liaoning, Shandong). These provinces reported an annual average production well in excess of million tons between 2000 and 2010 (Fig. 44). The experienced provinces have reported production growth of between one-and-a-half and three million tons since 1980, of primarily bivalves such as Pacific cup oyster (*Crassostrea gigas*) and Manila clam (*Ruditapes philippinarum*) [Campbell, Pauly 2013]. The growth of marine aquaculture output basically depends on the expansion in the mariculture area. Large-scale activities of reclaiming by landfill have been executed in China. As a result, large areas of beach for aquaculture and many natural spawning grounds of marine life have disappeared, and imposed some serious negative impacts on the marine biological resources of the adjacent areas.

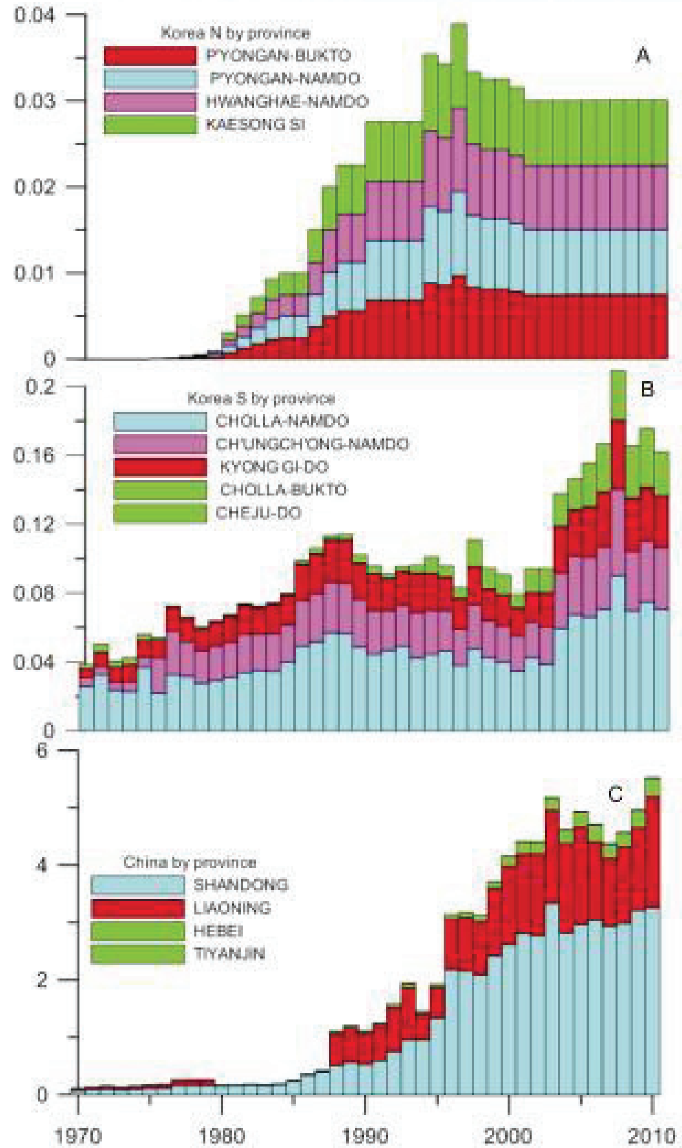


Figure 44. Production, in millions of metric tons for aquaculture in the Yellow Sea by provinces of DPRK (a), ROK (b) and China (c)

Fisheries and mariculture situation in NOWPAP sea area "A"

The NOWPAP sea area "A" is bordered by China, Japan, North Korea, South Korea and the Russian Far East. Fish stock and Marine Fisheries make the most important economic sector for the countries bordering the NOWPAP sea area "A". Both cold and warm-water fish species inhabit this sea area, with salmon, Alaska pollock, sea urchin, sea cucumber, crabs and shrimp being the most valuable items. There is a strong correlation between high catches of some species, such as mackerel and the periodic meandering of the Tsushima Current. Long-term fluctuations in appearance of South American pilchard *Sardinops sagax*, accompanied by noticeable geographic shifts in its spawning and nursery grounds have been observed, but no strict relationship has been noticed between high pilchard catches and the Tsushima Current so far.

Catches of anchovy, round herring, yellowtail, scad and squid have also fluctuated over the past few decades. Total reported landings in the NOWPAP sea area "A" reached 2.7 million tons in 1984-89 but since 2004 have declined to around 1 million tons (Figure 45).

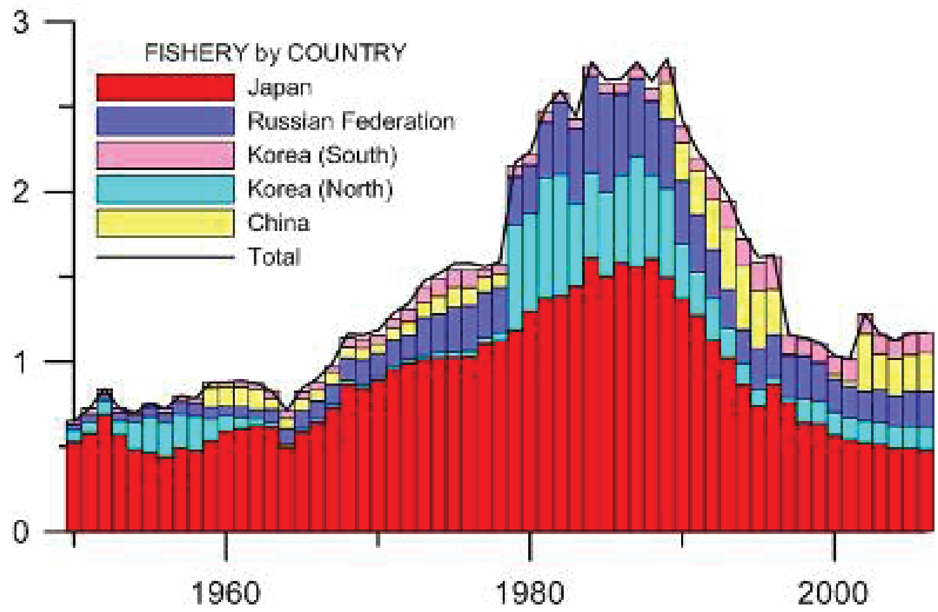


Figure 45. Total reported landings in the NOWPAP sea area "A" by country

The fluctuation in the landings can be attributed mainly to the high reported landings of South American pilchard, which accounted for 30% of the total landings in the mid to late 1980s (Figure 46).

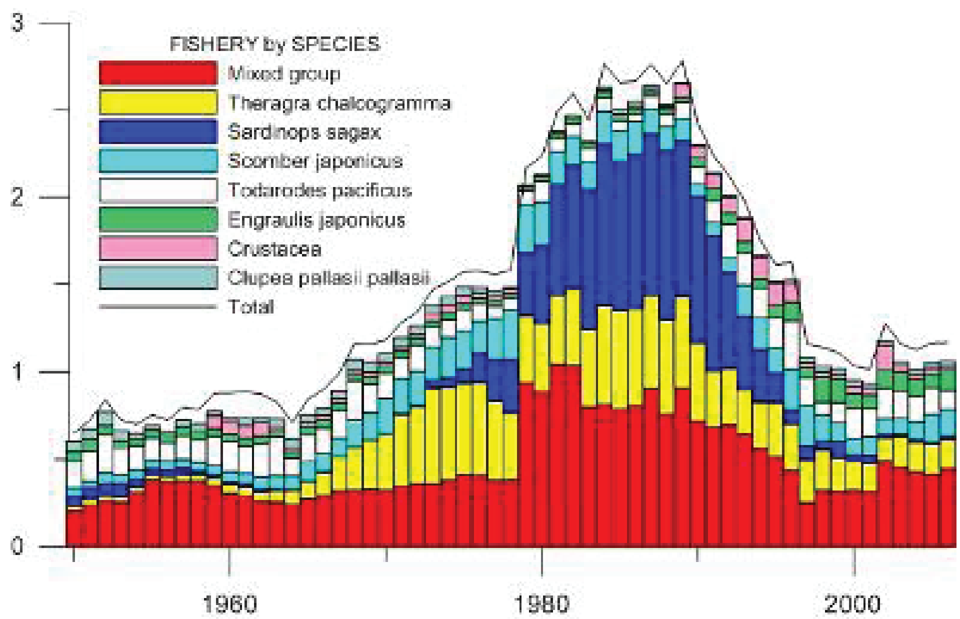


Figure 46. Total reported landings in the NOWPAP sea area "A" by species

Recent years total catch in the NOWPAP sea area “A”, reaches 1.2 million tons. This is almost twice lower than catch in the Yellow Sea.

The volume of production of mariculture in the NOWPAP sea area “A” in the last decade (average 500-600 thousand tons a year) (Fig. 47) is much lower compared to NOWPAP sea area “B” (Yellow Sea) 4.5 million tons production.

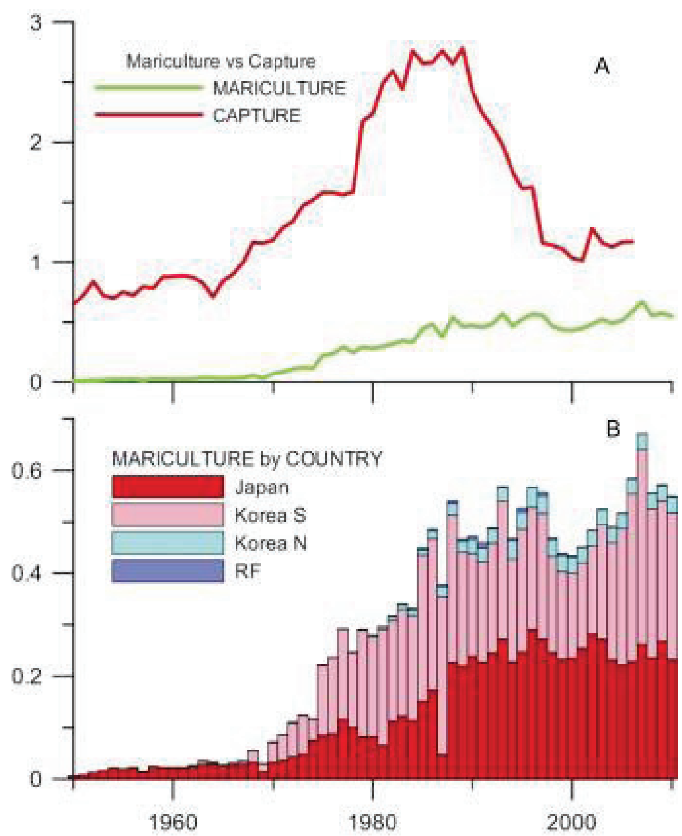


Figure 47. Production, in millions of metric tons, for aquatic animals capture (A) and aquaculture (B) in the NOWPAP sea area “A”

Distribution of mariculture production in coastal regions is shown in the Figure 48. The volumes are evenly distributed between Japan and South Korea. Japanese coast aquaculture production is concentrated in the prefectures of Hokkaido, Aomori, Nagasaki, the Korean coastal aquaculture production belongs to the Kyongsang-Namdo province.

Fishery related problems

Fishery is an environment-dependent industry and it is based on rich blessings from the sea. On the other hand, if fishery is managed improperly, it may pose a threat of significant impacts on the marine ecosystem. Overfishing of fish and shellfish will not only reduce the population size of resources but also change the species composition of their preys and predators, and even disrupt balance in the whole food web.

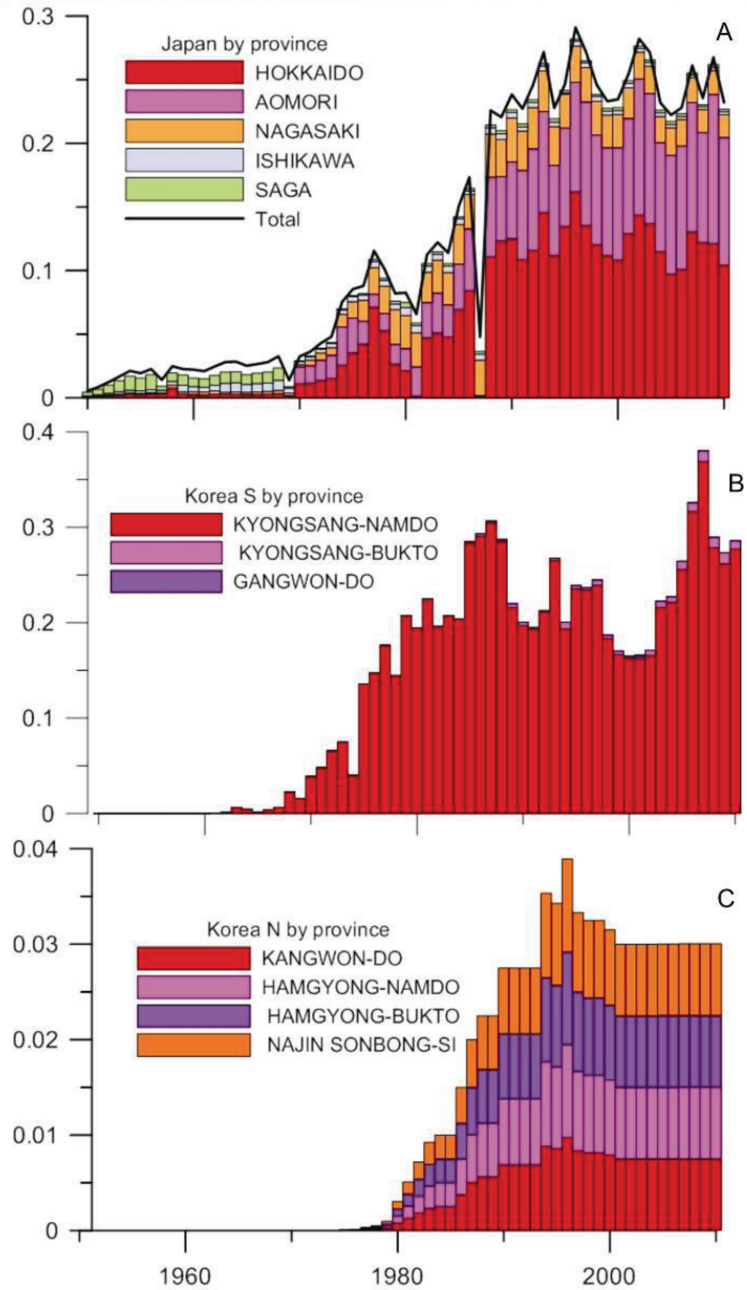


Figure 48. Production, in millions of metric tons for aquaculture in the NOWPAP sea area "A" by the different provinces in Japan and Korea

Overfishing has led to the breakdown in some marine ecosystems and in several fishing industries whose catch has been greatly diminished. According to a Food and Agriculture Organization estimate, over 70% of the world's fish species are depleted to the limit [FAO Fisheries Department, 2002]. The scientists stated that the decline was a result of overfishing, pollution and other environmental factors that were reducing the population of fish at the same time as their ecosystems were being degraded [Worm, et al., 2006]. Many countries and international managerial bodies have taken appropriate steps to manage marine resources.

Fishing may disrupt particular food webs containing some targeting, in-demand, species. There might be prey species overfishing such as sardines and anchovies, thus reducing the food sources for predators. It may also cause the increase of prey species when the target fishes are predators, such as salmon and tuna. Fisheries can reduce fish population thus disrupting the food stocks for cetaceans.

Some fishing techniques also may cause habitat destruction. Bottom trawling, removes around 5 to 25% of an area's seabed life on a single run.

Many governments and intergovernmental bodies have implemented fisheries management policies designed to curb the environmental impact of fishing. Fishing conservation aims upon control of the human activities that may completely decrease a fish stock or washout an entire aquatic environment. These regulations include the quotas on the total catch of particular species in a fishery, effort quotas, the limits on the number of vessels allowed in specific areas, and the imposition of seasonal restrictions on fishing.

The Strategic Action Programme (SAP) for the YSLME proposed a target of a 25-30 % reduction of fishing effort to be achieved through - control of boat numbers with 25-30% of the fishing fleets being decommissioned by 2020; the stopping of fishing in certain areas and seasons, to protect vulnerable stocks or life stages of certain species; and improved monitoring and assessment of fish stocks [UNDP/GEF 2009]. The SAP also proposed that fish stocks should be rebuilt through - an increase in mesh sizes and the use of more selective fishing equipment; stock enhancement by restoration of overexploited stocks and through habitat improvement; improved fisheries management and the use of Total Allowable Catch (TAC) and Individual Transferable Quotas (ITQ) [UNDP/GEF 2009].

The possible impacts of mariculture on the biodiversity

All forms of mariculture, regardless of its physical structure or economic motivation, affect biodiversity. Mariculture can degrade habitat, disrupt trophic systems, deplete natural seedstock, transmit diseases and reduce genetic variability.

Several types of effect can be distinguished. "Autotrophic" or naturally occurring trophic systems, such as kelp culture and raft culture of scallops, absorb solar energy and nutrients by naturally occurring organisms in the water body, and tend to have minor negative effects. "Heterotrophic" or artificial trophic systems, such as net culture of fish and shrimps, derive energy mainly from artificially supplied food and tend to disrupt the natural ecosystems .

Indirect biodiversity effects:

Pollution. Heterotrophic culture systems produce organic and chemical wastes that affect biodiversity by causing shifts in abundance at various levels in the food chain. The net effect of these changes is disturbance of ecosystem balance.

Organic pollution. Open waters culture systems discharge untreated wastes (fecal masses and uneaten food) directly into the water and often at the levels higher than environment can absorb. In closed bays, the overproduction of carbon-based, nitrogen and phosphorous compounds may cause phytoplankton blooms, of which subsequent degradation can drastically reduce oxygen level. In case of toxic algae bloom, fish are often killed and shellfish contaminated.

Organic carbon (particulate form) and oxygen, nitrate, sulphate typically sink to the benthos, while carbon dioxide, dissolved organic carbon, and nutrients (e.g., ammonia and phosphate) emerge from the sediment into water column. Benthic biota (including microbes and suspension feeders) as well as pelagic communities modulate these movements.

Chemical pollution. The potential danger to biodiversity in areas that receive surplus of chemicals, drugs and other additives used in mariculture, have not yet been adequately studied. Commonly used chemicals include antibiotics, pesticides, disinfectants, antifoulants and hormones.

Most antibiotics applied to mariculture systems end up in the sediment, though some can accumulate in wild fish and shellfish. Drugs, accumulated in underlying sediments, over the long-term exposure to antibiotic press on the sediment microflora, in pathogenes can increase their resistance, thus causing the natural selection in antibiotic-resistant strains and changing the genetic diversity of sedimentary microbes. Many pesticides used to control parasites and fungi are biologically potent even at quantities below chemical detection limits. The organophosphate class of chemicals like dichlorvos and trichlorphon used to control sea lice, includes many insecticides. Hormones are used to induce or prevent reproductive maturation, sex reversal and promote growth. Hormone use is not well documented and is sometimes carried out without adequate understanding of the quantities needed and of their persistence in the environment or in aquaculture products.

Effects on trophic systems. The most obvious effect of farming of carnivorous species such as salmon, trout, and sea bream is that the surplus protein in food supplied to the fish, is bigger than it is later harvested for human consumption. Most of this food comes from marine sources in the form of fish meal and fish oils. Fish protein and lipids presently came from the huge fisheries for small pelagic forms like anchoveta and Chilean jack mackerel.

Mass harvesting of small fish for sake of its conversion to fish meal depletes the food web of commercially valuable wild predatory fish, such as cod, and for other marine predators, such as seabirds and seals.

Even bivalve culture takes nutrients away from the marine food web: the bivalves remove carbon and nitrogen from the water column, leaving less for other herbivores. If the biomass of bivalves is too great and absorbs too much nutrients, the quantity of phytoplankton falls rapidly and primary production of the water body decreases, affecting the growth and reproduction of zooplankton and other herbivorous marine animals.

Since bivalves feed on material carried by the water column, there is no net addition of organic matter to the environment. Permanent extensive bivalve culture may bring about changes in the coastal food web or in benthic communities, or both.

Direct biodiversity effects:

Depletion of natural seed-stock. In culture systems, where there are no methods for artificial control of reproduction, or where such methods exist, but are beyond the means of local farmers, the manual collection of fry for purpose of its further grow out can remove significant amounts of biomass. The local or more widespread effects of this removal on non-target species have not been well studied. However, if collection is intense enough, the natural recruitment of local populations can suffer.

Transmission of diseases from farmed to wild stocks. The crowded and stressful conditions of net pen culture frequently lead to outbreaks of infection. Sometimes the infections result from organisms naturally present in wild fish; in other cases the disease-causing organism may be exotic.

Genetic effects. The genetic effects of mariculture are varied and highly significant for biodiversity. Understanding the genetic effects demands the high level of understanding of genetic structure in both the farmed and wild populations, something we do not have for each species. The field of fish molecular genetics is just starting to develop, as the new analytical techniques become available. The genetic effects of cultured marine animals on wildlife are either inadvertent (through escapes of cultured animals) or deliberate (enhancement or sea ranching).

In cultural systems, genetic diversity is deliberately constricted and channeled. Since many aquatic species are highly fecund, numerous seed can be produced from a few parents, leading to a rapid contraction of the genetic base of the farmed stock. This situation occurs when the species being farmed are local ones, and might be called “inadvertent enhancement”.

3.2.3. Habitat transformation due to constructions and urbanization

Coastal habitat is one of the most productive and biologically diverse ecosystems. According to the national report on threat to the marine and coastal biodiversity in NOWPAP region, aggressive landfill and reclamation work on coastal area is one of major threats to coastal ecosystems. Most landfill activities in the region have been driven by population growth and development on coasts. On global scale, the number of people living on the coast has been over a 35% increase since 1995 and the density of people in coasts is 3 times higher than the global average density. While people have lived in coastal areas, the enormous coastal cities that have grown over the years have quickly destroyed natural marine and coastal habitats. Coastal developments cause the loss of biodiversity and functions of marine ecosystem, resulting in the impairment of coastal ecosystem. In particular, ecological function of coastal habitat is mainly damaged by the loss of essential habitat, eventually leading to the reduction in ecosystem services.

During the last decades, coastal habitats around NOWPAP region have been widely altered by anthropogenic activities, such as landfill for urban development, agriculture and shrimp aquaculture. In many places, dams and dikes have been constructed to protect towns and cities from storm surges and high tides, particularly for land-filled area, and to enlarge farmlands for agricultural purposes. However, these constructions have destroyed natural coastal dynamics and functions, as well as very productive habitats like salt marshes in upper intertidal zone. In the early years, Japan has changed most of its soft and natural coastline into solid and artificial structure. South Korea has followed the trend. More recently, China has intensively developed the coastal area for port construction and aquaculture because of the fast demographic and economical development in the coastal regions. Russia also developed coastal zone around urban areas. North Korea, which is located within NOWPAP region but is not a member state (excluded from this report), also built several long dikes along the coast, especially Taegye-do project which reclaims approximately 88 km^2 of coastal land in the south of Yalu River estuary (39.47 N, 124.26 E).

China

According to State Oceanic Administration (SOA) statistics, the total area of licensed landfill in China amounts to be 2225.04 km^2 in 2007. The total size of actual reclaimed area increased to be 8241 km^2 in 1990 and 13,380 km^2 in 2008, based on the information gathered by the National Dynamic Monitoring and Management System. The average annual reclamation during the period was 285 km^2 [Fu et al., 2010]. Since 1949, a total of 21,900 km^2 of coastal wetland area has been lost, equivalent of 40% of total area of coastal wetlands in China. Mangrove areas dropped from 420 km^2 to the present state of 146 km^2. Coral reef also declined by 80% in total area [Zhang et al., 2005].

In Shandong province, several landfills have been done around the coast. According to the Qingdao Port Master Plan, a size of 6.41 km^2 of tidal flat in the former bay of Shandong province was landfilled in 2010. Jiaozhou Bay located in Shandong province is one of the coastal areas of China which is experiencing rapid economic development. Construction and urbanization have significantly changed the coastal landscape and reduced the sea area in this region by landfill activity [Liu et al., 2010]. In the last 80 years, about 30 % of the water body has disappeared in the bay [Wu et al., 2008]. For example, the original sea area with 402.18 km^2 in 1985 shrank to 344.51 km^2 in 2009 by analyzing a series of Landsat images of the bay [Zhang, 2012]. During the same period, about 52.6 km^2 of coastal area was landfilled in the bay, implying that most of sea area shrink attributes to the land reclamation.

In Jiangsu province, coastal habitats have been severely damaged by several landfills. The Chongming Dongtan in Shanghai (Jiangsu) province underwent from several landfilling practices during the 1956 to 1990, with a total of 552 km^2. While Changjiang Estuary Deepwater Channel Regulation Project, starting in 1998, was not a landfilled project, but aimed to secure navigational channel in the estuary, it caused benthic habitat deterioration and the decrease of benthic biodiversity on 87.6% in summer of 2002, compared with that in 1982-1983. Efforts had been placed on this area to restore benthic ecosystem from 2002 to 2004. Fifteen tones of benthos were added into the water around the new dike in the estuary. Dominant benthos changed from benthic crustacean to mollusks while the number of species, density and total biomass of benthos improved [Shen et al., 2006]. In Shanghai, the Lingang New City Project landfilled a total of 133 km^2 of coastal area to enlarge artificial land for urbanization, which was performed in 2003-2006.

In Liaoning province, the Caofeidian Land Reclamation project which aims to build a new industrial base of Shougang, expects to landfill a total of 310 km^2 of coastal area next to the island of Tangshan. The first stage construction already turned a total of 12 km^2 of the sea into artificial land in 2006.

Future landfill activities are expected in China to meet the local needs for coastal development. The overall demand is predicted to be larger than 5780 km^2, which equals to half of the total area reclaimed during the last 50 years. Three coastal provinces of China located in NOWPAP regions, including Jiangsu, Shandong, and Liaoning, have also future landfill plans targeting coastal areas during the following ten years (Table 12). According to Jiangsu coastal development plan (2009~2020), a total of 1800 km^2 in coastal area will be landfilled. In Shandong Peninsula blue sea economic zone, special plans were prepared and expected to change 420 km^2 of coastal area for concentrated and intensive sea use by 2020.

Table 12. Future landfill plans of two coastal provinces of China in NOWPAP region

Coastal provinces	Time scale	Reclamation plan	Data source
Shandong	2009~2020	420 km^2	Special plans of concentrated and intensive sea use in Shandong Peninsula blue sea economic zone (2009~2020)
Jiangsu	2009~2020	1800 km^2	Jiangsu coastal development plan (2009~2020)

Korea

Based on the government statistics, more than 1700 km^2 of coastal area was destroyed by land-filling tidal flat in South Korea since the 1920s. During the Japanese occupation in first half of the 20th century, rice production was the main purpose of landfill in the western coast of South Korea by the Japanese government, where broad tidal flat existed. The native salt marshes in upper tidal flat mostly disappeared during this period. At present, a tiny salt marsh habitat can be found only in several tens of meters off the coast. In the 1920s, a total of 405 km^2 tidal flat was land-filled to enlarge agricultural land.

Since the 1960s, South Korean economy has grown unprecedentedly fast, which demands more land for agricultural and industrial purposes in coastal area. Nearly 400 km^2 of tidal flat in the west coast was irreversibly separated from the sea by dike in the period of the 1960s and 1970s. More recently in the 1980s and 1990s, the intensive coastal alteration had been taken place in an unprecedented scale to encourage the domestic construction industry when construction workers returned from the Middle East. During the first half of 1990s, about 100 km^2 of tidal flat was altered to the land. Since 1995, a total of 764 km^2 of tidal flat has been land-filled for agriculture and urbanization. The remaining area of tidal flat amounts to a slightly more than 2500 km^2 in total.

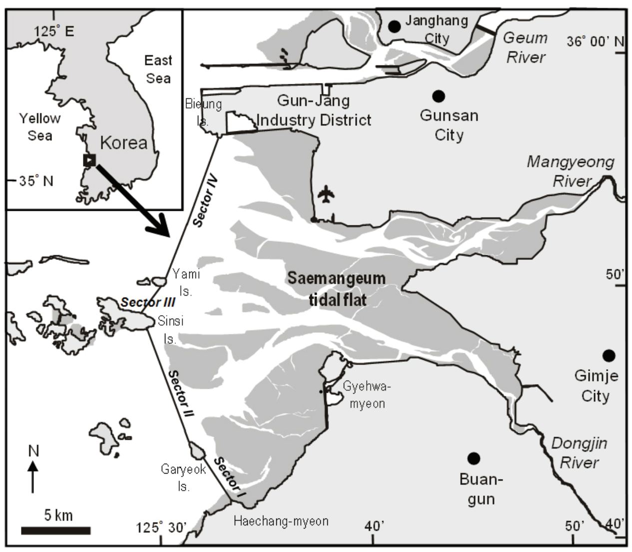


Figure 49. The geographic setting of the Saemangeum tidal flat.
The entire tidal flat was closed by four dikes (Sectors I-IV) on April 2006 [Koh et al., 2010].

The Saemangeum reclamation project which is the world-largest land earning project commenced in 1991. It built 33-km dikes to shut off seawater circulation to about 400 km^2 of the entire estuary of two rivers (Figure 49). The dike construction finished in 2006 and land development is still ongoing. The recent alteration of coastal habitat in the Gyeonggi Bay is also remarkable in the 1990s. A total of 170 km^2 tidal flat in Banweol was landfilled in 1994, which is notoriously famous for the polluted lake (Lake Sihwa). Another 50 km^2 tidal flat near Incheon was transformed to the Incheon International Airport in late 1990s. By the Korean Wetland Conservation Act of 1999, coastal landfill plans in large scale should be thoroughly evaluated. From that time coastal reclamation sharply decreased in the 2000s. From 2000 to 2010, a total of 25.7 km^2 of coastal area was licensed to landfill [MLTM, 2011].

Table 13. The size of tidal flat landfill in South Korea from the 1920s to the 1990s [Koh et al., 2010].

Year	1917-45	1946-60	1961-69	1970-79	1980-89	1990-94	1995-99	Total
Size (km^2)	405.4	6.3	172.2	193.7	93.1	98.5	764.0	1733.2

Japan

Coastal landfill and reclamation in Japan has a long history, tracking back to the 12th century for port development on the coast of Hakata Bay, and the coast of Kobe (Yasui and Yabunaka, 2002). Since then, many land reclamations have occurred to create lands for rice production throughout the Japanese coast, especially Edo Period between 17th and 19th century. This trend continued until the end of World War II (WWII). During this period, a total of 36 km^2 coastal area was reclaimed for agricultural purposes. After WWII, Japanese economy rapidly grew and the total land-filled coastal area doubled to 108 km^2 in less than 25 years due to strong demands for reconstruction of damaged port facilities and land reclamation for industrial development. Most reclamation works aimed to obtain land for industry, power plant, agricultural and other development. However, industrial demands for the land slowed because many companies began to outsource the production to developing nations. However, a certain reclamation project continues in Osaka Bay, creating a new artificial island for Kansai airport. From 1945 to 1999, approximately 450 km^2 of land reclamation and artificial islands were created [Wakabayashi, 2000].

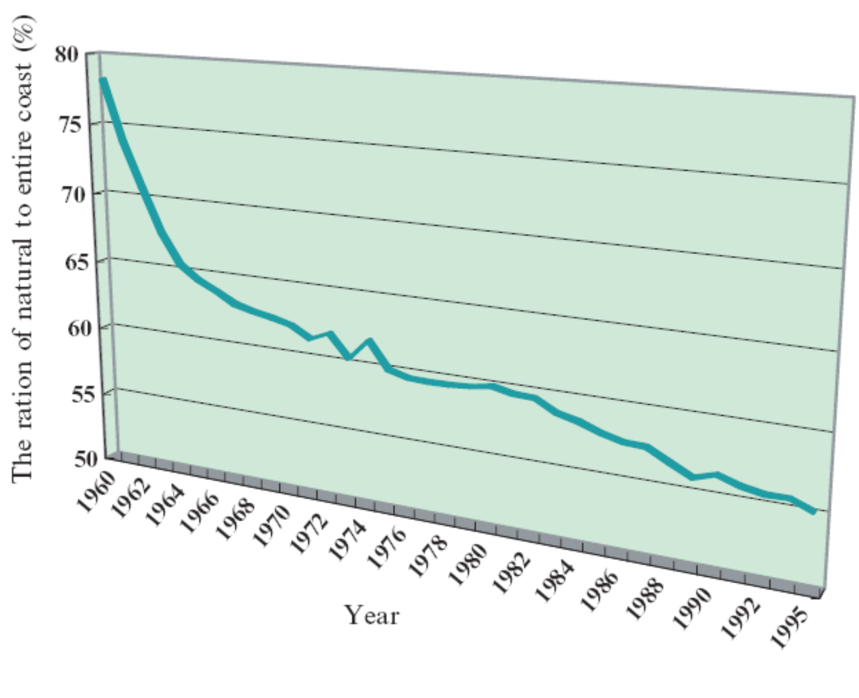


Figure 50. The Ratio of natural to entire coasts in Japan [Shikida, 2008]

All the reclamation works and landfills have increased the proportion of artificial beaches to 47% in 1995 [Shikida, Koarai, 1997]. The loss of tidal flat totaled approximately 288 km^2 since 1945. The remaining area of tidal flats amounts to a little more than 540 km^2 [Kojima, 2008].

The Japanese coastal environment has now been seriously altered. Most of coastal areas are affected by large scale reclamation and landfills. Precious tidal flat and littoral zones disappeared by coastal development. According to the Environmental Agency of Japan, 300 km^2 of a total 850 km^2 of wet land in Japan (as of 1945) were lost in the 13-year period from 1978 to 1991. In addition, 64 km^2 of seaweed beds were destroyed by coastal developments. This record of destruction can be shown by the change in the ratio of natural to entire shoreline, with a continued decrease from 78% in 1960 to 55% in 1995 (Figure 50). A greater decline is observed in the 1960s due to the high economic growth after WWII [Shikida, Koarai, 1997].

Russia

Russia Far East in NOWPAP region includes Primorsky, Khabarovsky, the Sakhalin Island. Overall length of the Russian part of NOWPAP regional sea is about 6230 km of shoreline. The total catchment area is about 142,000 km^2. Landfill of shallow water areas aimed to create space for industry and recreation. Construction of piers and embankment are also major activity to change the coastline. In the early years, the anthropogenic influence on the shore was related to the hydroengineering construction. Coastal development was mostly carried out in urban area. For example, in the jurisdiction of Vladivostok city, 12% of the natural coastline was completely substituted by the artificial one. Given the limitation of database, by the glimpse on the present coastal area of Russia Far East in NOWPAP region, most shoreline in rural area is seen as natural, which should be verified by reliable database.

3.2.4. Endangered species and the role of MPAs in their conservation

3.2.4.1 The endangered species within NOWPAP region

Comparing with marine plants, invertebrates and vertebrates in animal kingdom are more likely to be threatened by natural and anthropogenic disturbance. For cost-effective consideration, only marine animals are evaluated in this report. The risks of extinction of species within NOWPAP region are evaluated in this report. This report adopted the 2001 *IUCN Red List Categories and Criteria* (Version 3.1, see IUCN Red List Categories and Criteria).

The following categories in the 2001 *IUCN Red List Categories and Criteria* are applied in this report:

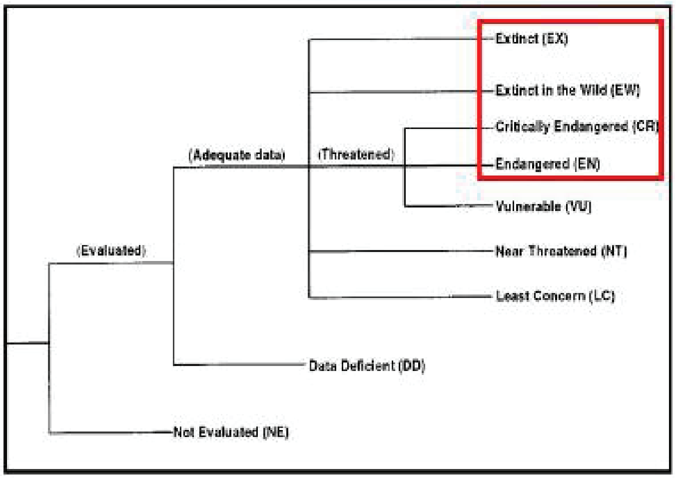


Figure 51. Species selection criteria based on the structure of the IUCN categories

However, not all species listed as **Threatened** are included into this report. The following criteria has been set out for identification of endangered species: only the species listed **Endangered** (EN), **Critically Endangered** (CR), **Extinct in the Wild** (EW), and **Extinct** (EX) in *IUCN Red List Categories* are considered to be included as endangered species in this report, the relationships between the categories is shown in Figure 51.

Altogether 194 species in 77 families, 35 orders, 7 classes under 5 phyla in animal kingdom are reviewed and evaluated within NOWPAP region. 60 species among these are identified as endangered species while the above criteria are applied.

The threatened status of species within NOWPAP region is shown in Table 14, the percentage of species listed in Endangered (EN), Critically Endangered (CR), Extinct in the Wild (EW), and Extinct (EX) are 24.74%, 5.15%, 0.00% and 1.03%, respectively, taking 30.92% of species evaluated in the report.

Table 14. The endangered status of species within NOWPAP Region

Category	Number of species	Percentage of total evaluated species/%
Extinct (EX)	2	1.03%
Extinct in the Wild (EW)	0	0.00%
Critically Endangered (CR)	10	5.15%
Endangered (EN)	48	24.74%
Vulnerable (VU)	44	22.68%
Near Threatened (NT)	4	2.06%
Least Concern (LC)	78	40.21%
Data Deficient (DD)	6	3.09
Not Applicable (NA)	2	1.03%
Total	194	100.00%

The threats derived from anthropogenic activities are the major cause of species extinction within NOWPAP region, although it is believe that the combination of over-exploitation, habitat loss, marine environment pollution, and invasive alien species become the most important threats to the species within NOWPAP region (Fig. 52).The statistics show that 26 endangered species are under the pressure of over-exploitation, 15 species are facing the loss of habitat, 8 species are threatened by environment pollution and 1 species are threatened by invasive alien species.

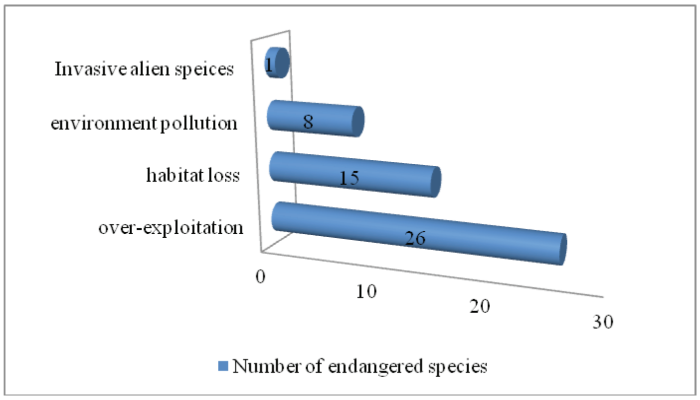


Figure 52. Threats to the endangered species in NOWPAP Region

Species of mollusks, crustaceans, reptile, fishes and mammals used for food and medicines are on average facing a greater extinction risk than species as a whole. These species are likely moving more quickly into a higher risk category. The results show that 1 species from phyla MOLLUSCA, 8 from phyla ARTHROPODA, 4 from phyla ECHINODERMATA, 3 from phyla NTIEROPNEUSTA, and 44 from phyla CHORDATA.

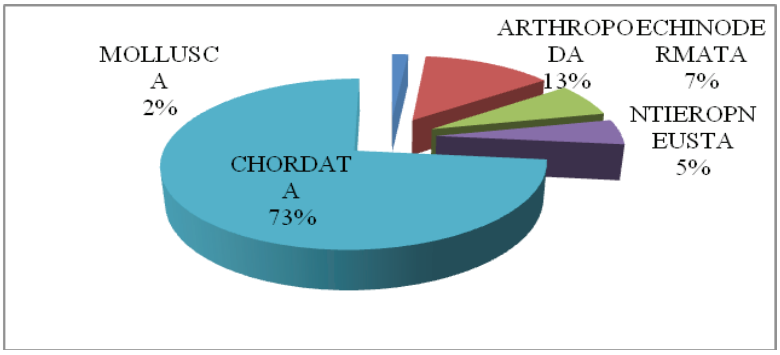


Figure 53. Endangered species in different taxonomic groups

Chinese shrimp (*Fenneropenaeus chinensis* Osbeck,1765) are used as one of the high economic value species in the coastal waters of Bohai Sea and Yellow Sea, China. It was quite often to be seen on the dining table of many Chinese families in the coastal cities around Bohai Sea and Yellow Sea. The populations of Bohai Sea and Yellow Sea have declined dramatically because of uncontrolled over-exploitation since 1970's, the catches of Chinese shrimp have significantly from over 40,000 t in 1970's reduced to 100t in 2002, and no catching season have been reported since 1990's. The catches have slightly increased to 549 t in Liaodong Bay, Liaoning Province in 2010 due to species enhancement and releasing, comparing with huge catches in 1970's.

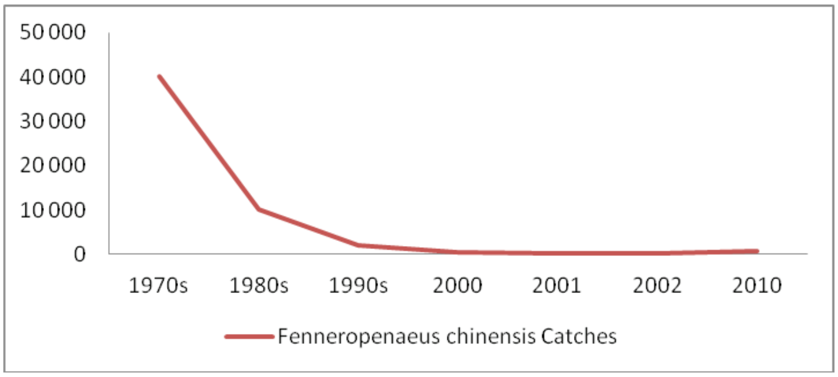


Figure 54. *Fenneropenaeus chinensis* Catches since 1970s in Bohai Sea and Yellow Sea, China

In addition to crustaceans, many marine mammals such as whales are also the taxa that are under threats of over-exploitation. Some species such as Blue whale (*Balaenoptera musculus* Linnaeus, 1758), Fin whale (*Balaenoptera physalus* Linnaeus, 1758) and Humpback whale (*Megaptera novaeangliae* Borowski,1781) in family Balaenopteridae. These huge marine mammals are often used as food, chemical and medicine products and being hunted for several centuries, causing dramatically population decline (Fig. 54). About a third of a million blue whales were killed during the industrial whaling era before the remaining few whales were finally protected. About a decade ago it was estimated that the population of blue whales remained at less than 5% of its original size.

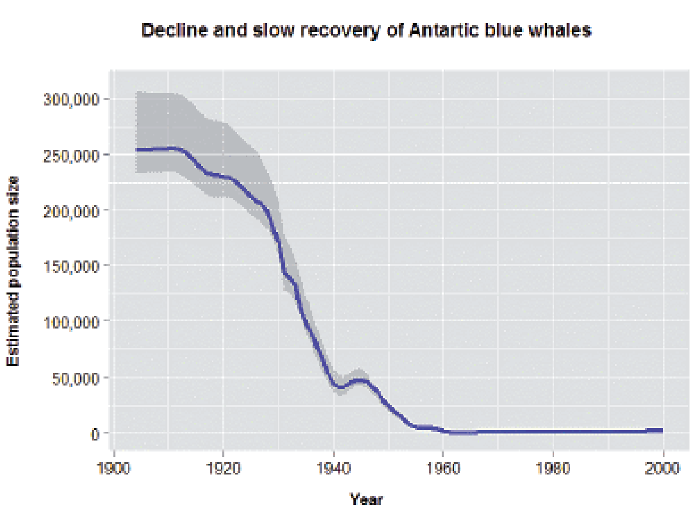


Figure 54. Decline and slow recovery of Antarctic blue whales (source: Australian Marine Mammal Centre, http://www.marinemammals.gov.au)

Although the moratorium of commercial whaling has been adopted by International Whaling Commission (IWC), whaling for other purposes, such as whaling for scientific research and aboriginal subsistence whaling have never been stopped. Instead, most NOWPAP countries have carried out such activities within NOWPAP region. After halting its commercial whaling, Japan began scientific research hunts to provide a basis for the resumption of sustainable whaling science (Fig. 55).

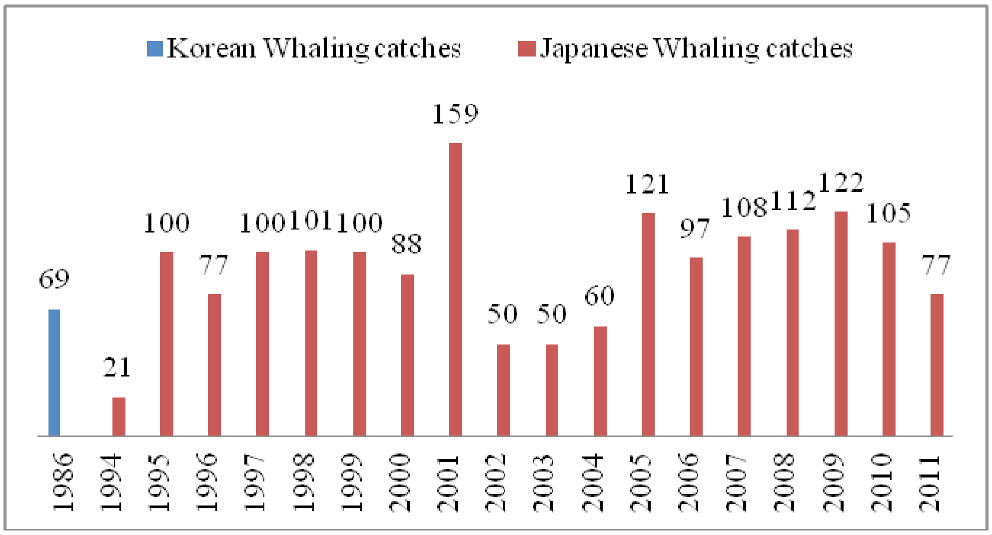


Figure 55. Korean & Japanese Whaling Catches for scientific research in North Pacific since 1986

Moreover, the catches of indigenous people in Russia Federation have maintained around 100 individuals per year since 1994 (Fig. 56).

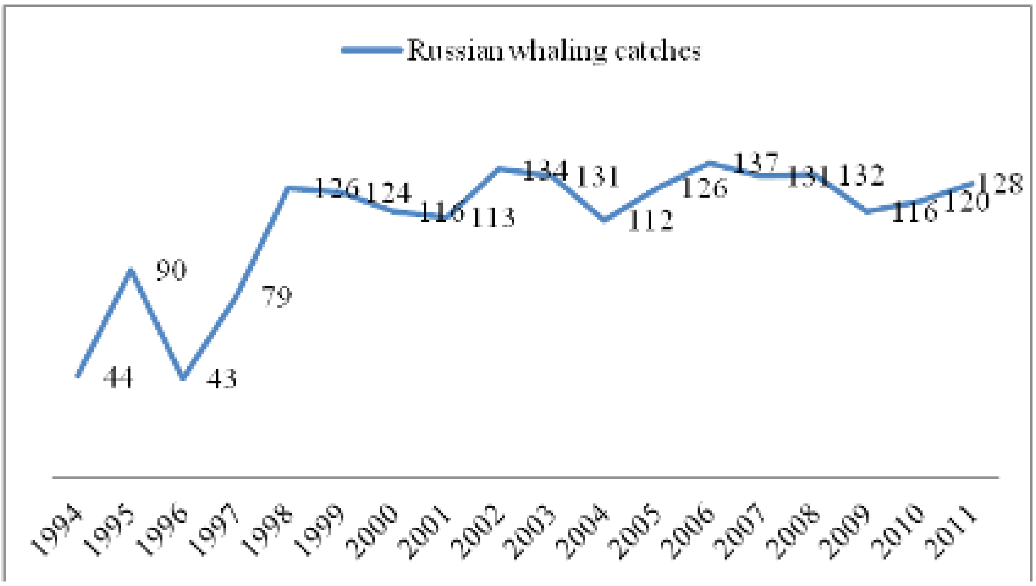


Figure 56. Russian Whaling Catches for aboriginal subsistence in North Pacific since 1994

3.2.4.2 The roles of MPAs in endangered species conservation within NOWPAP region

Lots efforts have been made by NOWPAP countries to establish marine protected areas (hereinafter with MPAs) for decades. Literature reviews show that141MPAs (Table 15) have been established within NOWPAP region, taking the total areas of 5,749,522 ha (Table 16) within four countries.

Table 15. Number of MPAs in NOWPAP Region

Country	Number	Level			Type		
		National	Provincial	Municipal/ county	Natural ecosystems	Wild animals and plants	Nature heritage
China	74	48	13	13	21	42	11
Japan	31	17	14	0	31	31	20
Korea	22	22	0	0	22	20	13
Russia	14	7	7	0	14	14	7
Total	141	94	34	13	88	107	51

Note: MPAs in Japan, Korea and Russia have multiple conservation functions, and summation of MPAs by their type exceeds the real number of MPAs

The diversity of protection objects can also be found within the region. In China, for example, protected areas are established for marine and coastal ecosystem conservation, such as vulnerable wetlands and islands, endangered species, such as fishes, marine mammals, avis and plants, or even geologically attractive nature heritages, such as Paleo-biologic fossil, ramous stone in simian Period/Cambrian and abrasion landform.

Table 16. Area of MPAs in NOWPAP Region (hectare)

Country	Area	Level			Type		
		National	Provincial	Municipal/ county	Natural ecosystems	Wild animals and plants	Nature heritage
China	3026712	2665779	212152	139667	167520	2759087	100105
Japan	408737	143945	265792	0	408737	408737	386282
Korea	357333	357333	0	0	357333	353710	333718
Russia	1956770	1121850	834920	0	1956770	1956770	756000
Total	5749552	4288907	1312864	139667	2890360	5481927	1576105

The following map (Fig. 57) shows clearly that how diverse distribution of MPAs in the region, 75 of all 87 MPAs with the geographical coordinate information have been marked in the map. It is found that MPAs are mainly located along the coast of Liaodong and Shandong Peninsula, west and south coast of Korea, northwest coast of Japan, and southeast coast of Russian Federation.

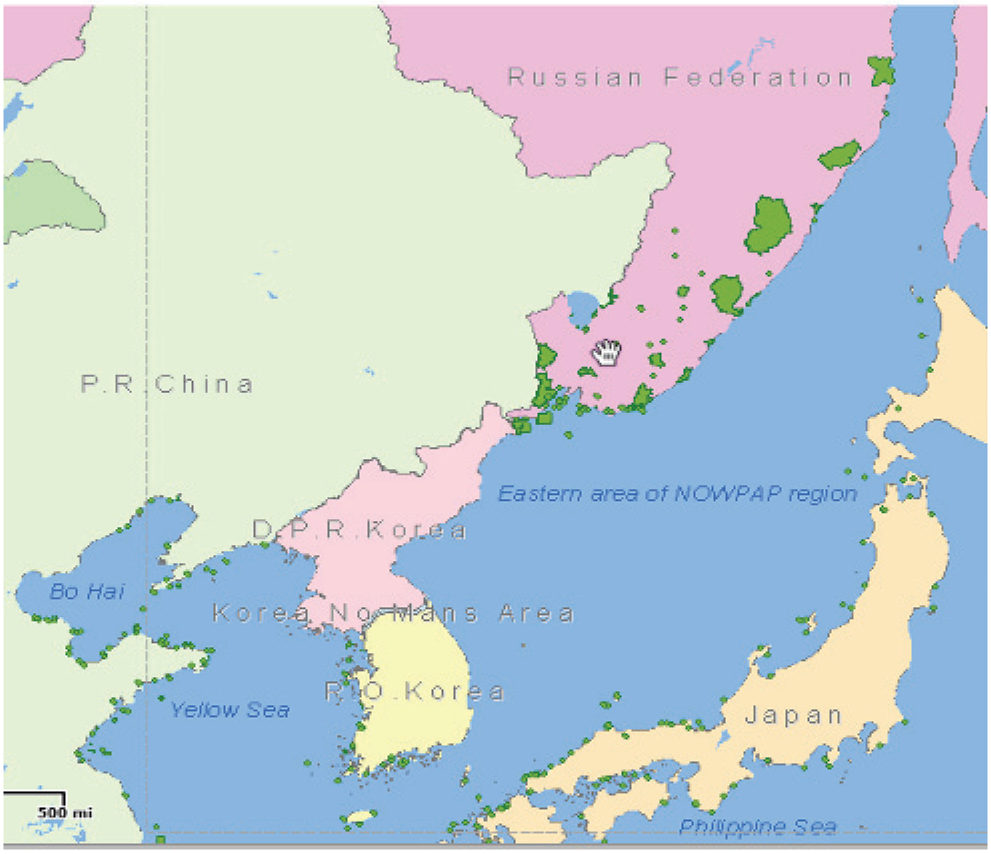


Figure 57. Location of MPAs in NOWPAP Region

It has been widely adopted that the establishment of protected areas is one of the important tools to conserve marine biodiversity in the face of the global crisis of species extinction and the loss of the world's natural capacity to support all life and human existence [SCBD, 2008]. As it is widely recognized the roles of protected area, MPAs have been used as a powerful tools to promote the recovery of exploited populations, conserving or restoring marine species's habitats ecosystems and biodiversity [Lubchenco et al., 2003].

Many studies have been done to identify the roles of MPAs [Mosquera *et al.*, 2000; Côté*et al.*, 2001; Halpern, 2003; Micheli *et al.*, 2004; Guidetti and Sala, 2007; Claudet *et al.*, 2008; García-Charton *et al.*, 2008; Harmelin-Vivien *et al.*, 2008; Lester *et al.*, 2009; Claudet*et al.*, 2010]. All the studies have indicated that MPAs can play their roles for the conservation at the species level with complex manners, depending on the differences of the establishment (design or ages) of MPAs, species composition or even socio-cultural context of MPAs. Generally, it is believed that the roles of MPAs could be categorized into two ways: direct and indirect roles.

The increase of populations and the restoration of habitats are likely the most anticipated direct roles of MPAs. Studies have shown that MPAs often lead to significant increase of fish density, size, biomass and richness. Lester *et al.* (2009) reported aggregated biomass, average density and size increase of 446%, 166% and 28% in MPAs respectively, comparing to surrounding fishing areas. Ward et al. (2001) reported that fish densities and sizes are increased in a short term because of higher habitat quality, lower individual mortality and increase of spawning biomasses.

MPAs are not only have positive role on fish resources recovery, but also vital for other taxa population recovery, such as birds. The conservation of Red-crowned crane (*Grus japonensis* P. L. S Müller, 1776) is another example to illustrate the direct roll of MPAs. Red-crowned crane is an endemic species in NOWPAP Region, and it is also one of the most endangered bird species in the world. The estimated total population of the species is only 2,650 in the wild, including about 1,000 birds in the resident Japanese population. Of the migratory populations, about 1,000 winter in East China and the remaining winter in Korea.

Until now, a lot of effects have been done to save Red-crowned crane population, including the establishments of protected areas. In 1983, for example, a protected area sized 3,000km^2 had been established along the coastal zone of Jiangsu Province, China for conserving the wintering habitats of this unique migratory species. The total number of red-crowned cranes in China increased from 500 in 2000 to the present 700, which accounts for a quarter of the total population of the world's red-crowned cranes, the peak estimations even reached to 1128 individuals in 1999 (Fig. 58) [Lu, 2008]. It is widely believed that the restrict protection of wetlands along coastal zone is a reason of such improvement.

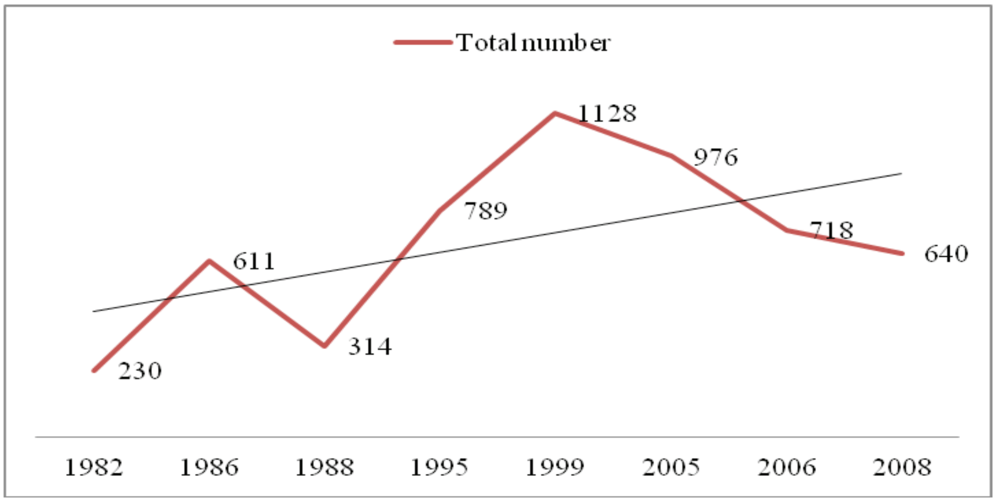


Figure 58. Population estimation of Chinese Red-crowned crane wintering population, 1982-2008

The most obvious indirect roles of MPAs can be found at ecosystems level. The establishment of marine no-take zone provides an ideal sanctuary to predator species due to fishing are generally target those species at higher trophic levels of marine food webs. Many marine ecosystems are now dominated by lower-trophic-level species [Pauly et al., 1998].

Thus the structure and dynamics of whole communities within MPAs can be indirectly affected by the increase of predator abundance through trophic cascades [Paine, 1980; Polis et al., 2000]. Trophic cascades cause the reshape of the structure of entire communities [Babcock, et al.]. Fishing often causes dramatic community changes and ecosystem shifts by shifting trophic cascades and such shifts are negative. Therefore, the re-introduction of predatory [Guidetti, 2006; Guidetti and Sala, 2007] can help to avoid those shifts in the MPAs.

3.2.5. Climate change impacts and emerging issues

The NOWPAP region includes water areas with accelerated warming in 1982-2006. These seas warmed at rates 2-4 times the global mean rate. The warming of the surrounding terrestrial regions with accelerated economical development during last decades could be one of the reasons. The changes in the river runoff could be another one [Belkin, 2009].

The data reflecting climate change within north part of NOWPAP region

The climate of the northern part of NOWPAP region is to be described as a moderate-continental climate with monsoon features. Southward the monsoon features become clearer. Moreover, within mainland part of NOWPAP area monsoon features gradually decrease from the coast towards the inland.

Field observations indicate significant climate changes in the continental southern parts of the Russian Far East which is occupied by the basin of Amur River [Novorotsky, 2004]. They are as follows.

In general, regional climate change trends are synchronous with the global ones. Warming in the region rather stably continues throughout the last 120 years to the present (Fig. 59). During this time abnormally warm periods were observed in the late 19th century, in the 1920ies, 1950ies and 1960ies. In early 1980ies the most significant warming began and continues till present. The average annual temperature increased by 1.50^{o} C over the period of instrumental observations and by 0.56^{o} C in the last 20 years (1981-2000) compared to the norm calculated for the entire period of observations. In the last decade a record increase of air temperature by 0.65^{o} C is observed compared to the average multiannual values. These regional trends are synchronous with global climate changes and are a part of them.

From 73% (at the sea coast) to 94% (in the continental areas) of annual precipitation is formed in the warm season (April-October). The multiannual regime reveals the interchange of dry and humid periods. The driest periods occurred in the first half of the 20th century. In the 1960ies and 1980ies the periods of increased humidity were registered for the entire Amur basin. Relative decreased humidity in the entire Amur basin was observed in the 1990ies and 2000ies up to 2009.

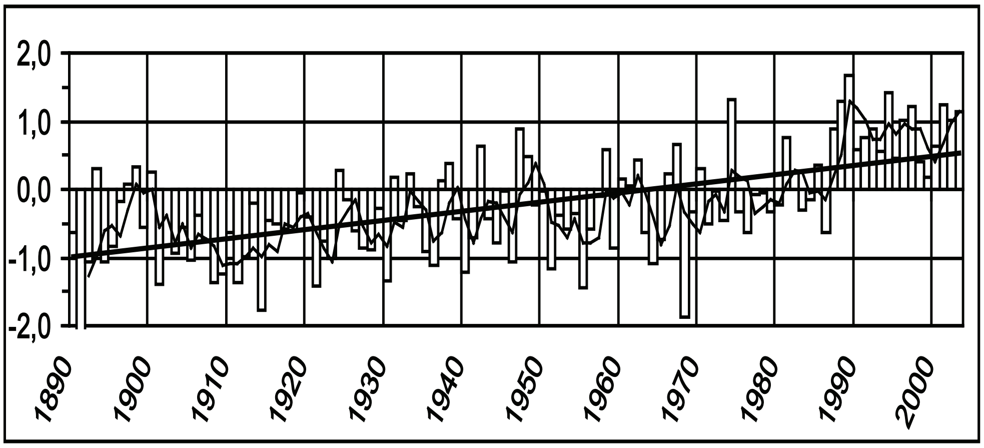


Figure. 59. The long-term trend of the anomalies of the mean annual air temperature in the Amur River basin for the period 1891-2004 (the deviation from the mean temperature of the base period 1961-1990, °C). The bold line shows three-year moving averages and the straight line shows a linear trend [Novorotsky, 2004].

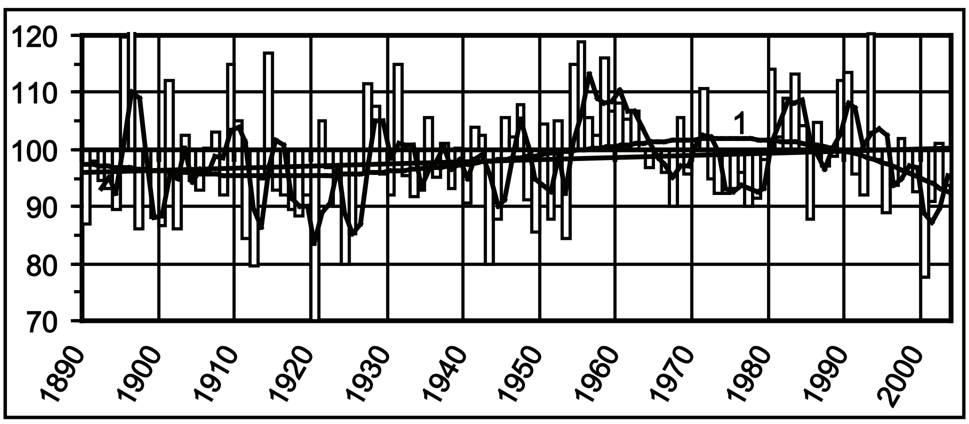


Figure. 60. The long-term trend of annual precipitation sums (%, to the rate for 1961-1990) in the Amur basin for the period 1891-2004. The bold line shows three-year moving averages; the straight line shows a linear trend; 1 – the trend approximated by a quartic polynomial. [Novorotsky, 2004].

For 120 years of observations the average increase of annual precipitation in the entire Amur basin was 3.6% (Fig. 60), mainly due to the areas of the Upper and Middle Amur basin. It should be noted that the annual precipitation sums in the Amur basin in 1976-2011 were decreasing with the rate of 1% / 10 years on average, whereas in 1976-2008 the precipitation decreasing rate was more than 3% / 10 year.

However, in the Lower Amur areas humidity has been increasing in the recent 20 years (1981-2000.) The total precipitation increased by 11.5% and in ten years (1991-2000) by 12.3%, compared with the average values of the entire observation period. By 2000 winter and cold season precipitation increased by 240 and 190%, respectively compared with 1890ies. The precipitation increase in other seasons of the year was as follows: in spring - by 54%; in summer – by 14%, in autumn - by 23%, in the entire warm period of the year - by 21.5% and in total for the year - by 31%. Thus, in the Lower Amur basin humidity was found to increase in all seasons of the year in the 20th century, compared to the end of the 19th century.

The extreme values are considered very important to study climate variability. That is why dry seasons (total precipitation less than 80% of average multiannual values) and wet seasons (total precipitation over 120%) were analyzed. The frequency analysis of humidity anomalies by seasons revealed that excess precipitation prevalence over precipitation deficits is typical for all seasons, except autumn. Excess precipitation and its deficit (in per cents) in winter was 41% and 30%, in the spring - 33% and 23%, in the summer - 26% and 21% in the autumn - 24% and 25% respectively.

In the period under study the least amount of precipitation in the Lower Amur was observed in warm periods of 1899, 1903, 1914, 1921, 1934, 1941, 1945, 1954, 1968, 1998, and 2001. Long periods of drought and low relative humidity, combined with strong winds often cause forest fires. For example, severe fires damaged the Amur taiga in 1910. Rather severe droughts and forest fires were registered in 1921, 1924, 1973, 1976, 1998, and 2001.

The heaviest rainfalls in the Amur basin were in the following years: 1896, 1897, 1929, 1956, 1959, 1964, 1969, 1970, 1971, 1972, 1979, 1981, 1983, 1987, 1991, 1992, 1994, 1995, 2000.

The data reflecting climate change within south part of NOWPAP region (Yellow Sea)

A new study identified four SST regimes in Yellow Sea waters off the western coast of Korea during the past 138 years: a warm regime before 1900, a cold regime from 1901 to 1944, a warm regime with a cooling trend from 1945 to 1976, and a warm regime with a warming trend from 1977 to 2007 (Fig. 61). Sea surface salinity was reported to have increased in this area [Lin et al., 2001]. SST regime shifts and fluctuations in herring abundance in the Yellow Sea showed a very good match.

Both historical and satellite data sets for the Yellow Sea show significant warming trends after 1985 however warming and cooling trends vary from decade to decade. The warming trends are larger and spread to wider areas in winter than in summer. Spatial structures of the SST trends are roughly consistent with the circulation pattern, suggesting that a horizontal advection may play an important role in the warming [Wang et al., 2013]. A common dominant warming in recent 20 a are found in the overall China offshore [Jin and Wang, 2011]. The North Pacific oscillation of sea level pressure plays an important role to warm the Yellow/East China Sea. Anomalous anticyclonic circulation causes a weakening of northerly mean winds over the Yellow/East China Sea during winter with subsequent warming effect [Yeh and Kim, 2010].

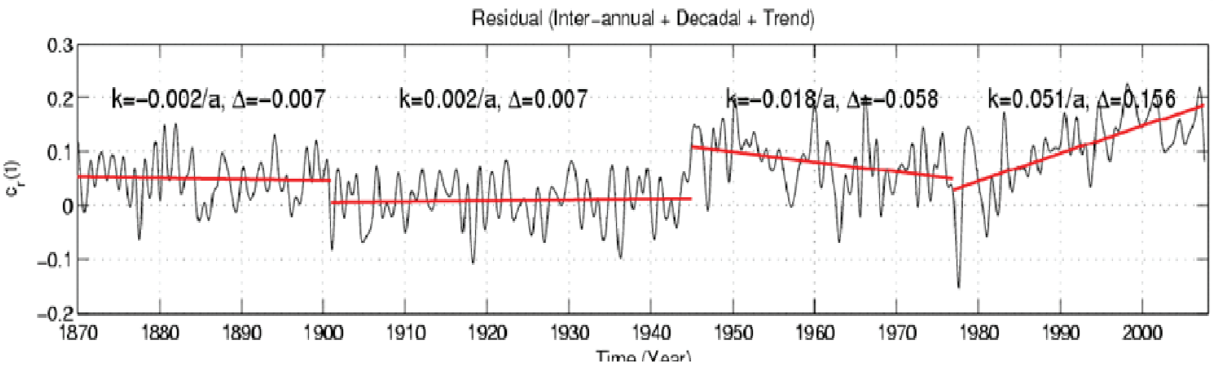


Figure. 61. The long-term trend of sea surface temperature (SST) for the eastern part of Yellow Sea

The warming sea surface temperature in Korean coastal and offshore sea areas were already reported by past studies [Jung, 2008; Min and Kim, 2006]. The linear rate estimated for coastal sea surface temperatures from 1969 to 2004, which have been measured at lighthouses along the coastline of Korea, was 0.02^{o} C yr^{-1} [Min and Kim, 2006], which is lower by 0.004 than our estimate for offshore areas.

Contrary to the sea water temperatures, dissolved oxygen content (DO) and its saturation level have generally decreased, which is expected because gas solubility decreased with increasing water temperature. However, the decreasing trend of DO and its saturation level became greater with water depths, which is opposite to temperature trend in which warming trend diminished with water depth. In deep water, in addition to decreased solubility of oxygen due to warming sea water per se, we speculate that warming mixed layer may have strengthened the degree stratification between the surface and bottom layer of the water column, inhibiting oxygen supply to deep water and intensified the DO decrease in deeper water. Together with climate-driven changes, anthropogenic factors such as eutrophication and water-quality deterioration in coastal areas of Korea [Lee and Lim, 2006] could have accelerated the decreasing trend of DO.

Climate change impacts on terrestrial ecosystems

Fluctuations of air temperature in the north part of NOWPAP area directly affect regional natural and anthropogenic ecosystems, the hydrological regime of rivers and their water content, the permafrost thickness and distribution in the area, conditions for the formation of soils, vegetation, and many other natural objects, as well as processes of their transformations.

According to various model calculations the surface air temperature may rise across the globe by 1-3° C by year 2050 [Assessment Report ..., 2008; IPCC ..., 2007]. In the north part of NOWPAP area and some northward areas (Okhotsk Sea coastal areas) the average temperature rises 1.5-2 times faster the global one. If this climate warming trend continues in the first half of the 21st century, it means that in the southern regions of the Russian Far East the average annual air temperature will rise by 1.0-1.5° C by 2025 and by 2050 C it may increase by 2.5-3.0° C. This increase in temperature will be equivalent to the shift of natural zones in the plains for 200-300 km to the north, and in mountainous areas – for nearly 200-300 m up the vertical.

Changes of basic climatic parameters significantly affect all components of the unique natural environment of the region [Climate ..., 2006]. The water content in the rivers is increasing and their hydrological regimes are changing. Permafrost areas start to degrade and their southern borders are shifting to the north. The borders of natural subzones and zones are also shifting to the north and to higher elevations in the mountains. Regional flora and fauna are undergoing changes as well, and the invasions of the southern plants and animals are observed.

One of the consequences of increasing water content in the Amur River is the acceleration of riverbed deformations. The river banks are washed out at rate of 10-20 m / year, causing the formation of large very mobile sand bars up to 2 x 10 km in size. Bars development leads to the further furcation of river channel and its sub-channels, thus reducing their conveying capacity and causing substantial accumulation of sediments in the channels. In some river passages the flow redistribution between the channels causes bank erosion even in winter.

The contrast of the extremes of such basic hydrological parameters as water levels and discharges, turbidity and solid flux tends to increase. Riverbed and other natural processes are becoming more intensive, and making the Amur River discharge of liquid, dissolved and solid matter into the sea more irregular.

In general, climate change causes various transformations of the natural processes and resources; creates conditions for the manifestation of negative phenomena, their increasing frequency and intensity; complicate the environment for human life and economic activities in the region. Due to global climate change, accelerating regional negative natural processes, the environmental security in the Far East is becoming nowadays highly urgent.

Climate warming will inevitably reduce the period of a stable snow cover and increase precipitation, especially in winter. The river surface runoff will become more irregular. The river will start freezing-up much later (Fig. 62) and ice melting on the rivers and seas will be earlier. Due to the permafrost degradation its southern border will be shifting to the north. Climate warming will cause the sea level rising and many other processes and phenomena. The observed and short-term forecasted climate change will not only negatively affect the environment. It may bring positive effects for the population and economy and improvements of living conditions, especially in winter.

Figure 31. Late autumn ice-drift of the Amur, December 1, 2005 (Photo A. Makhinov).

The following positive factors of climate warming in the region can be listed:

- the area of sea ice in the NOWPAP sea area will decrease;
- soft and warm winters will occur more often;
- the number of frost days and days with extremely low temperatures will decrease;
- the permafrost area, its thickness and temperature will reduce;
- the reduction of the house-heating season will bring lots of savings;
- the river and lake freeze-up period will be shorter and the ice-drift will start earlier;
- the thickness of ice on rivers and seas will get less;
- ice jams on rivers will reduce;
- soil freezing will be less deep and soil thawing will start earlier in spring;
- the vegetation growing season will expand.

The negative effects of global warming include:

- the occurrence and frequency of fires may increase;
- droughts, dust storms, hot days will occur more often and become more severe;
- soil aridity and erosion will accelerate in the western part of the region;
- riverbed processes and erosions will become more intense;
- abrasion of coasts will intensify;

- increasing hazardous hydrological and meteorological phenomena and processes, in particular landslides, ice dams and jams on the rivers, floods, heavy rains, high winds, etc.;
- the quantity and quality of water resource will deteriorate.

The processes associated with the permafrost degradation due to global warming are of the most significant concern [Sherstyukov, 2009]. Two-thirds of the Russian Federation is in the permafrost zone, and it takes up to 80% of the Russian Far East. The permafrost considerably extends along the Okhotsk Sea coastline, much affecting the existence and stability of coastal and marine ecosystems, as it serves a stabilizing factor of the coastline.

There are many towns, mining operations and communication networks in the permafrost zone. Especially big changes will take place in areas of spotted and broken permafrost at the southern border of the permafrost zone. In the process of global warming by year 2025 it may shift 100-150 km north on the plains and coastal marine areas, and by 2050 the shift may be 300 km or more.

The degradation of ice-rich rocks will be accompanies with the land subsidence and other dangerous permafrost (cryogenic) geological processes, such as thermokarst, thermoerosion, thermal abrasion of coasts, solifluction, etc. These processes will increase the risks of the destruction of buildings and engineering constructions, built on the frozen ground, expected to be preserved.

Depending on the precipitation regime and drainage conditions the permafrost destruction may provoke the additional emission of greenhouse gases, the conversion of forests into swamps and wetland ecosystems, as well as cause the increase of erosion and landslide processes, terrigenous material flux in the rivers and the discharge of river sediments into the marine areas. In the latter case, it will lead to the restructuring of the underwater landscapes, changing the conditions of their normal functioning. The scale of such events in the region has not yet been assessed.

The climate risk assessment is of practical importance to enable the development of appropriate adaptation measures in such economic sphere as mining, forestry and timber industry, fisheries, transport (especially river and coastal-marine), energy, infrastructure, agriculture, and tourism. On the one hand these industries are of primary importance for the further development of the Russian Far East, and on the other hand, they strongly depend on climatic conditions and directed changes. Special attention should be focused on the adaptation of continental regions, because they are more heavily exposed to environmental changes compared to the areas situated directly at the sea coasts.

Taking into account the medium- and long-term predictions of climate change, a comprehensive planning of regional economic development seems vital to ensure the future sustainable development of the Russian Far East and its economic growth in changing environmental conditions and climate warming.

The acceleration of natural hazards, caused by climate change and economic activities, coupled with dynamic natural processes, increases the risk of natural disasters and industrial accidents, complicates the further development of the region, and threatens the health and lives of the population.

Climate change impacts on marine and coastal ecosystems

Global climate change is now clearly evident in the oceanographic regime and, consequently, in the habitat of almost all marine inhabitants of the Far Eastern seas. According to recent publications [Zuenko, 2009], the north part of NOWPAP sea area underwent significant changes in thirty years of observations at the end of XX - beginning of XXI century. Water temperature was found to rise by 0.01-0.04^{0} C/year, depending on the area and time of the year. The oxygen content in the lower layers of water reduced, and the convection and intensity of coastal water circulation decreased. The rest oceanographic processes and parameters were found much less or insignificant affected by climate change. However it might be possible that significant climate variability has not been yet identified.

Dynamic processes in the Okhotsk Sea and north part of NOWPAP sea area seriously affect the circulation of nutrients and oxygen. In particular, due to the weakened winter monsoon the intensity of convective mixing of sea water in the coastal zone is reduced, thus causing the increase of nutrient concentrations in the water. This process also causes the reduction of oxygen in the deep and bottom sea water layers. The weakened water exchange reduces the biogenic substance flow from the coastal zone to the deep waters. That is why the observed tendency to water exchange weakening due to climate warming is unfavorable for the biological productivity of marine waters. Thus, modern climate change causes the decrease in the phytoplankton abundance in marine waters.

Factors, which determine the zooplankton abundance in the sea, are found to produce a positive effect on its reproduction so far and thus modern climate change is favorable for the zooplankton community of the north part of NOWPAP sea area. The conditions of common and most numerous fish populations in the Okhotsk Sea and north part of NOWPAP sea area much depend on their reproduction capacity. Most fish species, except for sardines and pollack, belong to the subtropical complex and water temperature rising due to climate change appears favorable for them. On the contrary, pollack, being a sub-boreal species, is depressed despite the fact that the temperature growth in general helps pollack regeneration. The reaction of West Pacific sardines, one of the most dominant fish species in the north part of NOWPAP sea area, to the changing environment is rather special. When the conditions are favorable for fish reproduction, West Pacific sardine population grows irrespective of increasing or decreasing water temperature.

Climate change in the last decades causes various transformations of ecosystems in the Okhotsk Sea and north part of NOWPAP sea area. The general trend is that highly productive ecosystems with low functional efficiency, typical to the mid-latitudes, are being transformed into less productive but more functional systems, typical to the subtropical regions of the World Ocean. It happens because oceanographic regime alterations due to modern climate changes are unfavorable for the production of organic matter, but most favorable for the reproduction of the dominant species of zooplankton and nekton. The impact of many of these processes on the sustainability of biodiversity in the region still seems rather uncertain. However, at the current stage, their negative tendencies are more evident.

The processes of the anthropogenic impact on the seas of the North-Western Pacific happen under global changes in the atmosphere and hydrosphere. The changing climatic environment, coupled with a variety of anthropogenic factors, modifies the impact of these factors on marine ecosystems, often making it even more destructive. Mining activities severely damaged ecosystems of the rivers of the Okhotsk Sea coast. Special emphasis should be given to the deterioration of spawning conditions for salmon species, which make regional ecosystems unique and play an important role in ecosystem sustainability. Intensive erosion processes, increased suspended matter concentrations in rivers, their pollution with various chemical and biological substances negatively affect sediment accumulation in the estuaries and adjacent marine areas. All these lead to a significant deterioration of feeding environment for fish and birds.

Increasing air temperature and precipitation will cause in future the redistribution of wetlands in the sea coastal areas. The least stable coastal ecosystems (coastal wetlands, estuary and delta areas of large rivers of the coast) will most seriously suffer from various climate change risks and other threats. Transformations of these ecosystems will significantly deteriorate the quality of freshwater, fish habitats and in general affect the state of fish resources, their biodiversity, and tourism development in the region.

Such serious problem, as sea level rising should not be ignored. Coastal areas exposed to tectonic movements of the negative sign are especially vulnerable. These coastal areas will suffer increasing threats of flooding from storm surges. Climate warming will exacerbate the problem, leading to potentially negative consequences for ecosystems and man-made infrastructure of the sea coasts.

In the next century only due to climate change the sea level is estimated to rise by 50 cm. Such a rise will cause flooding of the depressed plain areas and partial destruction of sea shores because of increased abrasion processes. These predictions of the sea level rising do not consider general tendencies in sea level changes due to many other reasons, which, as in the entire world, are also evident along the western coasts of the Okhotsk Sea and north part of NOWPAP sea area .

In many regions, wetlands and estuary areas may become more watered and even turn into shallow bays, dried once in a while. Coastal ecosystems are able to migrate inland as sea level rises, but at the mountainous relief, prevailing in the NOWPAP region, such opportunities will be very limited.

Penetration of salt water into groundwater aquifers in coastal zones could threaten water supplies of the local population.

Monitoring of global climate change impacts on terrestrial and marine ecosystems

Coastal areas including coastal sea waters can serve as model objects for monitoring current dynamics of natural processes, as they usually constitute complete natural systems which include diverse landscapes. Such monitoring will make possible not only a reliable assessment of transformations of particular basic components, but also help to reveal common patterns in the direction of environment transformations under climate change.

Specific observations of particular natural objects and processes can serve this purpose and clarify the role of climate and direct anthropogenic factors in their current changes. The following types of monitoring specific for the region under study can be proposed.

1. Monitoring of the discharge of pollutants from the Amur River into the Sakhalin Gulf, Okhotsk Sea and waters around the Sakhalin Island.

2. Monitoring of the impact of the World Ocean level rise on coastal and marine ecosystems and their particular natural components, including changes of their spatial location and area.

3. Monitoring of the distribution and productivity of toxic microalgae endangering marine life and human health due to the increased frequency and intensity of water blooming caused by global climate change.

4. Monitoring of the invasion of warm-water marine animals into the coastal waters of the Okhotsk Sea and north part of NOWPAP sea area with warm currents, ships and ballast waters.

5. Monitoring of the intensity of anthropogenic influence on the vegetative cover of coastal areas and communication corridors associated with them.

It seems vital in the nearest future to initiate studies on the assessment of environmental impacts of climate change on the dynamics of modern relief-forming processes, hydrological regimes of rivers, conditions of soils, flora and fauna, including issues of plant adaptation and animal acclimatization.

It also seems necessary to develop models of the transformation dynamics of natural systems (landscapes) with consideration of the time-varying character of global climate change.

3.3 Overall assessment and evaluation of marine and coastal areas of the NOWPAP region

NOWPAP region as a whole is one of the most densely populated areas in the World with population of more than 300 million persons and most of these people live in the coastal areas and closely depend on the various services provided by marine and coastal ecosystems. At the same time, the key word in the description of the NOWPAP region could be "unevenness" in terms of natural and socio-economical conditions. For example, population density varies from 14 person/km^2 in the Russian part of NOWPAP area to the maximum of 505 person/km^2 in Korea. The intensity of the anthropogenic influence is varied accordingly. In terms of demographic characteristics, the northeastern provinces of China with 280 million people are the first. Population determines the volume of municipal sewage that can affect river and coastal water quality, though the level of waste treatment should be taken into account. The economic development of the countries also determines the quantity and quality of industrial and agricultural wastewaters.

All NOWPAP countries are classified as industrial. There are, however, big differences in their industrial sectors. Japan and Korea have applied modern technological advances to comply with progressively stricter environmental standards. In contrast, many industries in Russia and China continue to use technologies installed when the plants were originally built long time ago. The agricultural practices and the amount of fertilizers and pesticides used are also different. The unevenness of the anthropogenic pressures is superimposed on the difference of the natural conditions: climate, river runoff, sea currents and water exchange, which determine and/or control the supporting and regulating ecosystem services. This leads to the diversity of ecological problems and their manifestation within the NOWPAP region.

The existence of two very dissimilar sea basins is the main first-order feature of the NOWPAP region, and it is necessary to take this feature into account while discussing the supporting and regulating ecosystem services within the NOWPAP region.

Sea area "A" is big, rather deep basin connected with the Pacific Ocean and East China Sea through shallow straits. The river runoff to the sea area "A" is moderate and provides less fresh water than atmospheric precipitation, but the overall water balance is mostly determined by the input with Tsushima current and output through Tsugaru strait. Despite the fair water exchange there is inhomogeneity of water masses and clear trend of dissolved oxygen decrease in the deepest bottom waters for last several decades. The less active water convection leading to the slow renewal of bottom waters is a possible reason. At the same time, active dynamics of the upper 200 m water layer indicates high assimilative capacity of the sea area "A" as a whole in relation to the possible input of contaminants from the land based sources. It does not mean that negative influence of such inputs is absent. It means that influence is rather localized.

The sea area "B" (Yellow Sea) is a shallow marginal basin having relatively restricted water exchange with offshore waters compare with the upper 200 m layer of the NOWPAP sea area "A". It makes this sea area "B" especially vulnerable to the river and wastewater runoff which are substantial here. The vicinity of the mouth of Changjiang – the biggest river of East Asia increases the possibility of the ecological problems due to river influence in the southern part of the NOWPAP sea area "B". The existence of the vast seasonal hypoxia zones confirms it.

Besides river runoff the atmospheric deposition is very significant and important route of material transport to the sea. Comparison between atmospheric and river inputs at the basin level clearly indicates that for marine area "A" atmospheric sources dominate for all components, including water itself. In marine area "B" (Yellow Sea) the situation is different and atmospheric input dominates only for water, nitrogen and lead. For phosphorus, dust (particulate matter), and cadmium the fluxes through atmospheric input to the sea area "B" vary from 26 to 42% of total input [SOMER, 2007]. In offshore regions and for entire basins, atmospheric inputs are dominant and additional attention is needed for any potentially dangerous substances migrating via atmosphere, such as persistence toxic substances. The contribution of atmospheric inputs is determined by the ratio of concentrations of substances in the rain/snow and in river water, by the ratio of the amount of precipitation and river run-off, and by the size of the area considered due to non-point nature of atmospheric deposition against point source of river runoff.

The primary production is a basis for all trophic structure of the sea and is also key process for material cycle and energy flow. Therefore the primary production could be considered as regulating and as supporting ecosystem services at the same time. The seasonal and interannual variability is an immanent feature of primary production. In most of the NOWPAP sea area "A", typical spring and autumn blooms of phytoplankton are observed. Phytoplankton abundance in large portion of the NOWPAP sea area "A" is not directly influenced by nutrient input from land.

Seasonal and interannual variation of primary production in the NOWPAP sea area "B" (Yellow Sea) and northeastern part of East China Sea is very different from the eastern region of NOWPAP (sea area "A"). Spring bloom is usually observed in very limited area in the Yellow Sea. One of the factors which influence primary production in this area is first of all large river discharge of Changjiang. Nitrate flux of Changjiang to the western part of the NOWPAP region has been largely increasing during last decades. This indicates that the observed eutrophication here may significantly influence the primary production of the western part of the NOWPAP region. Sea surface temperature in the Yellow Sea slightly increased from 1998 to 2008 and the increase of chlorophyll-a may also reflect the influence of climate change.

Food provided by the marine and coastal ecosystems within the NOWPAP region is the utmost important provisioning service and include fish, algae and invertebrates. These food resources are caught by fishermen and produced by mariculture industry. The average annual catch in all northwest Pacific is about 20 million tones, accounting for one-fourth of the world's total. The catch in the NOWPAP sea area "A", after maximum 2.7 mln tones in 1980s due to sardine capture, declined to the near constant 1.1-1.2 mln tones starting from 2000 (Fig. 47). The mariculture production gradually increased from 0.05 before 1970s to about 0.5 mln tones in late 1990s mostly due to efforts of Japan and ROK. During the last decade, the mariculture production in the NOWPAP sea area "A" continues to be at this level, but significant interannual variations take place as well.

The annual fish capture in the NOWPAP sea area "B" has continuously grown from 0.2 to 2.2 mln tones during second half of 20^{th} century, but during the last decade there are signs of decline down to 2.0 mln tones (Fig. 43) despite the enhanced efforts. At the same time the progressive increase of mariculture production takes place within NOWPAP sea area "B" (Yellow Sea) from 2.0 mln tones in the middle of 1990s to about 6.0 mln tones recently (Fig. 43): mariculture production is 3 times more than wild fish capture in NOWPAP sea area "B".

The overall fish capture within the whole NOWPAP sea area is about 3 mln tones or 15% compared with 20 mln tones in all northwestern Pacific. Mariculture production in northwestern Pacific is concentrated within NOWPAP sea area mostly, and reaches up about 6 mln tones. Therefore the overall marine food supply by NOWPAP member states is about 9 mln tones, and it increases the contribution of the NOWPAP sea area to the 37% of marine food yield in northwestern Pacific.

The role of the NOWPAP region in provisioning of the mineral resources, energy and transport services is also significant. The most valuable mineral resources in marine and coastal environments at this moment are oil and gas. There has been a lot of exploration and development for oil and gas in the NOWPAP region. One of most active areas where those activities have occurred is Yellow Sea, especially its northern part. Large quantities of methane which are stored as ice-like gas hydrates below the ocean floor are emerging as another important mineral resource, although it is still under research or experimental production mode. Sand and gravel from the seabed are also among most useful mineral resources provided by marine and coastal areas and these materials are widely used. For example, in 2010 Korea used a total of 26,348,000 m^3 of sand and gravels from the ocean.

Besides oil and gas, the marine and coastal areas can provide alternative sources of energy, including the ocean's waves, tides, thermal energy (i.e., temperature difference), and wind energy. Republic of Korea has set up a target as 50% of the electricity to be provided by the renewable sources by the year 2030. Japan and China also have the ambitious plans for the development of renewable energy sources.

NOWPAP region is used actively by maritime transport, both among 4 member countries and internationally. China, Japan and Korea have built more than 93% of the tonnage of the world fleet delivered in 2011, and are ranked among top 5 in terms of market share in maritime transport. More than half of top 20 container terminals are located in NOWPAP member countries.

The diverse natural conditions and uneven distribution of anthropogenic pressures lead to the great variety of ecological problems within the NOWPAP region. The excessive input of hazardous substances (trace elements and persistent toxic substances) can result in the increase of their concentrations in different components of coastal marine ecosystems (water, suspended solids, organisms, bottom sediments). These high concentrations are usually restricted to the "hot spots" in the coastal areas. The elevated levels of trace elements and many organic PTS can be used as tracers of anthropogenic pressure and transport/biogeochemical processes in the ecosystems. There are several sets of threshold concentrations of chemical substances in natural waters, wastewaters, soils and bottom sediments based on the toxicological effects on individual organisms. Possible damage from these substances on the ecosystem level is not clear yet. The bioaccumulation of mercury in the tissues of predator fish and long distance atmospheric transport and bioaccumulation of some organic PTS are unfavorable exclusions. The assessment of long-term input of trace contaminants to the marine ecosystems is very difficult task due to lack of reliable time series and sediment core records are sometimes the only method which could be used for such purpose.

The excessive inputs of nutrients and organic matter leading to the eutrophication could be sometimes more harmful than impacts by toxic substances. However it should be realized that dissolved nutrients are absolutely necessary for plankton production, and therefore background for all trophic chains, and in some cases the artificial fertilization could be recommended for the efficient use of marine biological resources. Nevertheless the increasing number of areas with coastal hypoxia shows the prevailing of negative consequences of eutrophication. Southern part of Yellow Sea existing under Changjiang runoff influence in China, Amursky Bay (inner part of the Peter the Great Bay) in Russia, Masan Bay in Korea are the examples of significant eutrophication and seasonal hypoxia in bottom waters in the NOWPAP region.

The oil and hazardous noxious substances (HNS) spills are the obviously harmful but fortunately not very frequent kinds of anthropogenic pressure on the marine environment. NOWPAP MERRAC activities focusing on the different aspects of preparedness and response to the oil and HNS spills are necessary and timely.

Marine litter is another obvious ecological problem for the World Ocean as a whole and for the NOWPAP sea area in particular. Marine litter causes a wide spectrum of environmental, economic, safety, health and cultural impacts. In the NOWPAP region, due to rapid economic growth and modern life styles, a lot of litter is generated. Litter without proper treatment on land outflows into the ocean.

Most of marine litter is generated from the local sources, though in some areas marine litter from foreign countries is observed. Therefore all countries should take actions to prevent marine litter input to the marine environment. In the NOWPAP member states, various kinds of countermeasures for the prevention of marine litter input from land-based sources are implemented by the central and local governments and non-governmental organizations (NGOs).

Besides the ecological problems connected with excessive input of anthropogenic substances and contamination of environment by these substances, there is possibility to analyze the ecological problems according to their relation to marine biodiversity.

The introduction of non-indigenous and invasive species due to anthropogenic activity is one of the most clear ecological problems directly connected with biodiversity. Shipping, fishing and mariculture are the main ways through which the invaders are introduced. Marine invasive species (MIS) may have great impact to native communities with ecological, economic, as well as public health consequences. Adverse effects such as native species reduction, habitat loss, breeding ground degradation, disease, frequent red tides, etc., which were possibly caused by MIS, not only result in economic loss for related industries, but also trigger a series of social problems indirectly. For example, each year invasive alien species may cost about RMB 120,000 million loss in China.

Possible threats to biodiversity can be connected with fishing and mariculture themselves. Overfishing is an obvious and direct threat to the biodiversity. Mariculture, regardless of its physical structure or economic motivation, affects biodiversity as well. Intensive mariculture can degrade habitats, disrupt trophic systems, deplete natural seed stock, transmit diseases and reduce genetic variability.

Several types of effects can be distinguished. “Autotrophic” or naturally occurring trophic systems, such as kelp culture and raft culture of scallops, absorb solar energy and nutrients by naturally occurring organisms in the water body, and tend to have minor negative effects. “Heterotrophic” or artificial trophic systems, such as cage culture of fish and shrimps, derive energy mainly from artificially supplied food and tend to disrupt the natural ecosystems and therefore additional attention is needed to such mariculture activities.

Special attention should be given to endangered species. Invertebrates and vertebrates in animal kingdom are more likely to be threatened by natural and anthropogenic disturbances. Species of mollusks, crustaceans, reptiles, fishes and mammals used for food and medicine are on average facing a greater extinction risk than other species. The visibility of some of endangered species like whales, sturgeon or red-crown crane attract the attention to the endangered species problem.

It has been widely agreed that the establishment of protected areas is one of the important tools to conserve marine biodiversity in the face of the global crisis of species extinction. The increase of populations and the restoration of habitats are likely the most anticipated direct benefits of MPAs. MPAs not only play positive role in fish resources recovery, but are also vital for other taxa population recovery, such as birds. The most obvious indirect benefits of MPAs can be found at ecosystems level. The establishment of marine no-take zone provides an ideal sanctuary to predator species as fishing activities are generally target those species at higher trophic levels of marine food web.

Climate change impacts are diverse and sometimes difficult to be identified unambiguously. The NOWPAP region includes water areas with accelerated warming in 1982-2006. These seas warmed at rates 2-4 times higher than the global mean rate. The warming of the surrounding terrestrial regions with accelerated economic development during last decades could be one of the reasons [Belkin, 2009]. Field observations in the southern parts of the continental Russian Far East support this hypothesis. But the most significant change of climatic conditions takes place in the western part of the NOWPAP region – in the Yellow Sea. Both historical and satellite data sets show significant warming trends after 1985 for the Yellow Sea with larger warming trend in winter than in summer [Wang et al., 2013]. The warming of coastal sea surface temperatures from 1969 to 2004 along the coastline of Korea was 0.02^{o} C yr^{-1} [Min and Kim, 2006]. All these changes are significant, correlated with shifts in fish resources, and could be one of the reasons of oxygen depletion in the bottom layers of water.

In general, climate change causes various transformations of the natural processes and resources; creates conditions for the manifestation of negative phenomena, including increase in their frequency and intensity; hamper the environmental conditions for human life and economic activities in the region.

Conclusions

Relevance to World Ocean Assessment

The United Nations has embarked on a regular process for global reporting and assessment of the state of the marine environment, including socioeconomic aspects, called in short the World Ocean Assessment (WOA). The first integrated global assessment should be based upon the existing regional assessments. The availability of information in the different regions is variable. The main aim of NOWPAP SOMER-2 is to provide such information about current status of marine environment in the NOWPAP region based on the recent published and open source data. Such information can be also used for the ecosystem based integrated approach to the assessment of natural processes, human activities in different sectors and biodiversity issues. At the same time, regular assessment of the marine environment was one of the initial objectives of NOWPAP necessary for the achievement of its main goal of “the wise use, development and management of the coastal and marine environment”. The regular assessment of the state of the marine environment is also included as thematic element in the Medium-term Strategy of NOWPAP for 2012-2017. This reporting process should provide information about trends in the NOWPAP marine environment and serve as feedback to improve the effectiveness of management actions undertaken within the NOWPAP and by the individual member states.

In the first SOMER for the NOWPAP region [SOMER, 2007], the following main environmental impacts affecting marine and coastal areas were identified: a) land-based sources (LBS) of pollution accompanied by eutrophication, hypoxia and HABs; b) oil spills; c) coastal modification, including land reclamation; and d) over exploitation of biologic resources. The major drivers and impacts keep on to be the same until now: NOWPAP sea area continues to be under significant pressure. Human activities and natural changes are influencing and damaging many aspects of the marine environment. There is a strong need to deal with several challenges.

Good environmental quality is necessary for the national economies and the wellbeing of the populations. Governments should ensure that the marine and coastal environment could support economic and social benefits including food provision, usage of mineral and energy resources, recreation and tourism. There is a need to have better understanding and more information to help in the management and protection of coastal and marine environment. The ecosystem based management with proper marine spatial planning seems to be the only approach ensuring sustainable use of the natural resources and services.

This second State of the Marine Environment Report (SOMER-2) synthesizes available knowledge about major drivers and pressures affecting the NOWPAP sea and coastal areas, the environmental conditions, and the current impacts of human activities. This report hopefully will support future application of the ecosystem based approach.

Major Issues

Pressures, state and known impacts of the major issues identified in this report can be briefly summarized as follows:

1) Coastal changes due to urban and tourist development lead to fragmentation, degradation and loss of habitats and landscapes, including the erosion of the shoreline. Special attention should be paid to the degradation of transitional areas, including deltas, estuaries and coastal lagoons, which serve as critical nursery areas for commercial fisheries and support unique assemblages of species.

2) Chemical contamination of waters, sediments and biota is caused by pollution from land-based sources through river and atmosphere transport. Environmental conditions are improving with regard to certain pollutants in some NOWPAP areas, due to decrease of land based pollution. At the same time, contamination linked to hazardous substances remains a problem in many areas.

3) The NOWPAP region is especially vulnerable to marine pollution incidents due to its high shipping density along with industrial development and economic growth. Furthermore, the NOWPAP members have extensive coastline and the high density of transport activity among them, accordingly they are exposed to high risk of oil and Hazardous and Noxious Substances (HNS) pollution incidents.

4) Eutrophication caused by human-mediated input of nutrients into marine waters is a source of concern, especially in coastal areas near large rivers and/or cities. Consequences of eutrophication may be linked to HABs and hypoxia, but as yet directed studies to confirm or refute this link are largely lacking. The direct socioeconomic impacts are related to the toxicity of or the damage to biological resources and the negative influence on recreational resources. The SOMER-2 data suggest that eutrophication is still a localised phenomenon in the NOWPAP region. Better monitoring schemes allowing to forecast more reliable trends

of environmental quality will give opportunity to assess the effect of eutrophication on the supporting and provisioning ecosystem services.

5) The impacts of marine litter, concentrated especially in bays and shallow areas, is increasingly regarded as a matter of concern.

6) The number and occurrence frequency of invasive non-indigenous species have increased in recent years in the whole NOWPAP region. Impacts on natural biodiversity include predation, alteration of the food chains, and modification of habitats with subsequent negative influence on fishing, aquaculture, shipping and human wellbeing and health.

7) Overfishing and destructive fishing practices lead to the changes in community structure, the food chain and the delivery of ecosystem services. Fisheries pressure has led to the reduction in the fish catches and reduced abundance of large predator species. The state of biodiversity reflects the cumulative effects of the pressures affecting the NOWPAP sea areas.

8) Changes in freshwater fluxes and the sediment delivery to the sea due to human activities on watersheds and hydro engineering constructions or climate change affect mainly the near shore areas, including impacts on coastline stability, but offshore regions are also under influence.

There is a deficit of information about some ecological issues, and insufficient information to establish reliable trends for other issues. Where quantification is possible, it often remains difficult to connect ecological impacts with particular pressures. But existing monitoring data are the only starting point for developing a systematic observations that will provide necessary information for the future assessment and management actions, and NOWPAP countries have to use available data. There are also gaps in understanding of the impacts of human activity on marine and coastal biodiversity.

The Way Forward

In the future the application of the Ecosystem Based Management (EBM) or Ecosystem Approach (EA) or any other management approach must take into account and be based on the ecosystem features of the sea area considered. To apply ecosystem approach, the set of indicators connecting pressures, impacts and responses and reflecting the progress in managerial actions is needed. The Ecological Quality Objectives (EQO) as broadly formulated general goals have been suggested for this purpose by some Regional Seas programs (such as HELCOM, OSPAR and MAP). These programs have already developed the Ecological Quality Objectives based on their vision, strategic goals and assessment of ecological status and pressures in their regions. The Ecological Objectives describe, for each of the major environmental issue identified, the desired results pursued by the application of the Ecosystem Approach to the management of human activities.

Suggestions to develop Ecological Quality Objectives for the NOWPAP region were included in the NOWPAP Medium-term Strategy 2012-2017 (MTS) already approved by

NOWPAP member states in 2012. One of main MTS goals is to develop and adopt a harmonious approach towards coastal and marine environmental planning on an integrated basis and in a pre-emptive, predictive and precautionary manner. NOWPAP POMRAC Focal Points Meeting in 2013 has approved the development of the set of Ecological Quality Objectives in close cooperation with other RACs as one of the main activities for the 2014-2015.

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