NOWPAP POMRAC

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Pollution Monitoring
Regional Activity Centre

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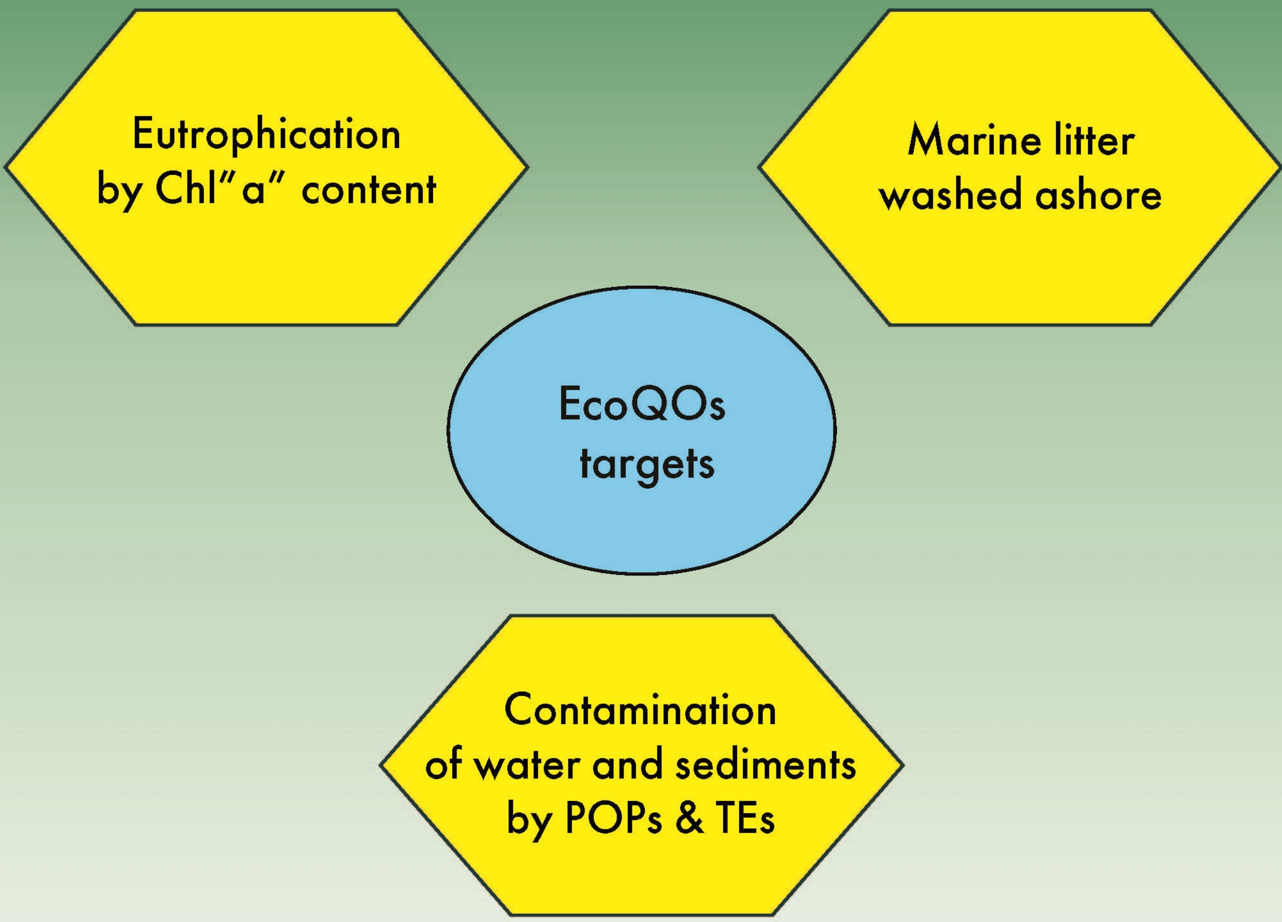
REGIONAL SYNTHESIS REPORT

Development of NOWPAP Ecological Quality Objective targets aligned (where possible) with SDG indicators, phase 2



POMRAC Technical Report No 16

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POMRAC, Vladivostok, Russian Federation
2021

POMRAC Technical Report No 16

Pollution Monitoring Regional Activity Center of UNEP Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of the Northwest Pacific Region (NOWPAP POMRAC)

Региональный Центр по мониторингу загрязнения окружающей среды Плана действий ЮНЕП по охране, управлению и развитию морской и прибрежной среды в регионе северо-западной Пацифики (NOWPAP POMRAC)

Pacific Geographical Institute,
Far Eastern Branch of the Russian Academy of Science

Федеральное государственное бюджетное учреждение науки
Тихоокеанский институт географии Дальневосточного отделения РАН

Development of NOWPAP Ecological Quality Objective targets aligned (where possible) with SDG indicators, phase 2. Regional synthesis report / Author: Alexander TKALIN, Yana BLINOVSKAYA, Hongjun LI, Masashi KIYOTA, Jeongseong RYU, Yi SUN, Vladimir SHULKIN, Yuri ZUENKO; Editor: Anatolii Kachur. – Vladivostok: PGI FEB RAS, 2022. – 56 pp.

Разработка целевых показателей для оценки качества морской среды в регионе северо-западной Пацифики в соответствии с индикаторами Целей Устойчивого Развития (SDG), 2 этап. Региональный обзор / авторы: А.В. Ткалин, Я.Ю. Блиновская, Х. Ли, М. Киота, Д.С. Рю, И. Сун, В.М. Шулькин, Ю.И. Зуенко; отв. редактор: А.Н. Качур. – Владивосток: ТИГ ДВО РАН, 2022. – 56 с.

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List of acronyms

CEARAC	– Special Monitoring and Coastal Environment Assessment Regional Activity Center
COD	– Chemical Oxygen Demand
CSBTS	– China State Bureau of Quality and Technical Supervision
DDT	– Dichlorodiphenyltrichloroethane
DIN	– Dissolved Inorganic Nitrogen
DIP	– Dissolved Inorganic Phosphorus
EcoQO	– Ecological Quality Objective
EQS	– Environmental Quality Standards
GESAMP	–IMO/FAO/UNESCO–IOC/UNIDO/WMO/IAEA/UN/UNEP/UNDP/ISA
HCH	– Hexachlorocyclohexane
HELCOM	– Helsinki Commission
IAEG–SDGs	– Inter–Agency and Expert Group on Sustainable Development Goal Indicators
ICC	– International Coastal Cleanup
ICEP	– Index of Coastal Eutrophication Potential
LMM	– Linear Mixed Model (statistical analysis)
IOC UNESCO	– Intergovernmental Oceanographic Commission of UNESCO
MAP	– Mediterranean Action Plan
ML	– Marine Litter
MLTM	– Ministry of Land, Transport and Maritime Affairs (of Korea)
MOF	– Ministry of Oceans and Fisheries (of Korea)
MPC	– Maximum Permissible Concentration
MSFD	– Marine Strategy Framework Directive
MTS	– Medium–term Strategy
NGO	– Non–government Organization
NOWPAP	– Northwest Pacific Action Plan
NPEC	– Northwest Pacific Region Environmental Cooperation Center
NSMSQ	– National Standard for Marine Sediment Quality (of China)
NSQS	– National Standard for Seawater Quality (of China)

OSPAR	– Oslo and Paris Conventions
PCB	– Polychlorinated Biphenyl
PEL	– Probable Effects Level
PEMSEA	– Partnerships in Environmental Management for the Seas of East Asia
PICES	– North Pacific Marine Science Organization
POMRAC	– Pollution Monitoring Regional Activity Center
PSU	– Practical Salinity Unit
RAC	– Regional Activity Center
SDGs	– Sustainable Development Goals
TEL	– Threshold Effects Level
TINRO	– Pacific Research Institute of Fisheries and Oceanography (in Russia)
TN	– Total Nitrogen
TP	– Total Phosphorus
UNEP	– United Nations Environment Programme
YSLME	– Yellow Sea Large Marine Ecosystem

Executive Summary

This regional synthesis has been prepared based on national inputs provided by the nominated experts from NOWPAP member states: People's Republic of China, Japan, Republic of Korea and Russian Federation (hereinafter referred to as China, Japan, Korea and Russia).

For each of four NOWPAP Ecological Quality Objective (EcoQO) targets agreed upon earlier, national experts were expected to consider available national standards, determine baseline values (when necessary), and use monitoring data for at least the last five years to test the applicability of those targets. In the subsequent chapters, the following is compiled from the four national reports: 1) brief description of designated areas in each NOWPAP member state; 2) baseline values and national standards used; and 3) brief assessment of applicability of NOWPAP EcoQO targets in each member state (within the specific designated areas).

According to the testing results, NOWPAP EcoQO targets are generally applicable within the designated areas. However, further discussion on defining the baseline values is needed among POMRAC and CEARAC experts. The regional workshop which has not been held in 2021 due to COVID-19 pandemic might be organized in the future in order to hold such a discussion. Further attention should be also paid to the developments of the global SDG indicators, in particular decisions of the Inter-Agency and Expert Group on SDG indicators (IAEG-SDG).

This regional synthesis was prepared by Dr. Alexander TKALIN based on the national inputs provided by the following experts nominated by the NOWPAP member states (in alphabetical order): Dr. Yana BLINOVSKAYA (Russia), Dr. Hongjun LI (China), Prof. Masashi KIYOTA (Japan), Dr. Vladimir SHULKIN (Russia), Dr. Yi SUN (China), Dr. Yuri ZUENKO (Russia).

1. Introduction

The Northwest pacific Action Plan (NOWPAP) has been adopted by four member states (China, Japan, Korea and Russia) in 1994. The overall goal of NOWPAP is "*the wise use, development and management of the coastal and marine environment so as to obtain the utmost long-term benefits for the human populations of the region, while protecting human health, ecological integrity and the region's sustainability for future generations*", i.e. sustainable development of the region (www.nowpap.org). Pollution Monitoring Regional Activity Center (POMRAC) is one of four NOWPAP RACs involved in the implementation of the Action Plan.

Based on the analysis of regional marine environmental problems, POMRAC has started working on the development of NOWPAP Ecological Quality Objectives (EcoQOs). During the initial stage (2014-2015), similar experience of other Regional Seas programmes (such as HELCOM, MAP and OSPAR) has been analyzed. As a result, a preliminary set of five EcoQOs has ben formulated and circulated among experts of NOWPAP member states and partner organizations (PEMSEA, PICES, YSLME and others). At the workshop held in 2014 in Busan (Korea), facilitated by a representative of OSPAR, experts from NOWPAP member states and partner organizations have agreed on the following EcoQOs for the NOWPAP region:

– Biological and habitat diversity are not changed significantly due to anthropogenic pressure;

– Alien species are at levels that do not adversely alter the ecosystems;

– Eutrophication adverse effects (such as loss of biodiversity, ecosystem degradation, harmful algal blooms, and oxygen deficiency in bottom waters) are absent;

– Contaminants cause no significant impact on coastal and marine ecosystems and human health;

– Marine litter does not adversely affect coastal and marine environments.

After the adoption of the Sustainable Development Goals (SDGs) in 2015, the work on Ecological Quality Objectives has become even more important and relevant for the NOWPAP member states. Achieving "Good Environmental Status" (the term from the Marine Strategy Framework Directive of the European Union, MSFD) in line with the five EcoQOs described above will contribute to the achievement of the SDG 14 on Oceans ("*Conserve and sustainably use the oceans, seas and marine resources for sustainable development*"), especially SDG 14.1 ("*By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution*").

In 2016, POMRAC has developed a preliminary list of 24 possible indicators to be used to monitor the progress of achieving the EcoQOs formulated earlier. In addition to experience from HELCOM, MAP, MSFD and OSPAR, recent developments related to the SDG 14.1 have been also taken into account. At that time, only two proxy indicators have been suggested by UNEP and IOC UNESCO for the SDG 14.1: *Chlorophyll a* concentration and the amount of marine debris washed ashore. The list of possible EcoQO indicators has been circulated among experts of NOWPAP member states and partner organizations and discussed at the workshop held in Vladivostok (Russia) in 2016. National experts have concluded that only six NOWPAP EcoQO indicators (out of 24 initially suggested) could be applied in all their countries. Details were later on described in the regional overview (POMRAC, 2017). These six indicators were as follows:

– Nutrient concentrations in the water column;
– Nutrient ratios (silica, nitrogen and phosphorus);
– *Chlorophyll a* concentration in the water column;
– Harmful algal blooms (HABs);
– Concentration of contaminants in water, sediments and organisms;
– Trends in the amount and composition of litter washed ashore.

In 2019, another regional workshop had been held in Vladivostok where nominated experts from NOWPAP member states discussed possible numerical targets to be used for those six indicators shown above. National reports prepared by nominated experts were summarized in the regional synthesis report (POMRAC, 2019). Experts have agreed to use initially certain "designated areas" for which targets could be set. It was also agreed that along with national water quality standards the so called "baseline values" (in fact median values) will be used to set the EcoQO targets when appropriate. Details could be found in the regional synthesis report (POMRAC, 2019) and the agreed upon four targets are shown in the Table 1.1 below. The designated areas selected were as follows:

– Jiaozhou Bay in China;
– Toyama Bay and/or Hakata Bay in Japan;
– Masan Bay and coastal area near Ulsan (for trace metals only) in Korea;
– Amursky Bay in Russia.

Table 1.1. NOWPAP EcoQO targets agreed upon in March 2019

Indicators	NOWPAP EcoQO targets
Nutrient concentrations in the water column	**Nutrient concentrations in the water column within the designated area do not exceed the baseline values or existing national standards.** **Note:** Baseline values could be decided by each country and will be confirmed by correspondence, taking into account past CEARAC studies on this issue to avoid unnecessary work.
Chlorophyll a concentration in the water column	***Chlorophyll a* concentrations within the designated areas do not exceed the baseline values.** **Note:** Baseline values will be decided by each country and will be confirmed by correspondence, taking into account past CEARAC studies on this issue. For this particular target, *in situ* data will be used.
Concentration of contaminants in water and sediments	**During the last 5 years, contaminant concentrations in water and surface sediments within the designated area do not exceed the existing national standards or baseline values.** **Note:** Spatial variability in surface sediments should be taken into account. If stations of different classes exist within the designated area, certain stations could be selected for testing this particular EcoQO target.
Trends in the amount and composition of litter washed ashore	**During the last 5 years, there is a decreasing trend (statistically significant) in the amount of marine litter washed ashore.** **Note:** In addition to regular monitoring results, data from annual International Coastal Cleanup (ICC) campaigns (held in the same area every year) might be used at the initial stage. Units might differ in different countries, i.e. it could be weight/volume/number of items per square meter or per 100 meters of shore length. Decreasing trend should be confirmed by common statistical tests.

In 2020-2021 biennium, nominated experts from NOWPAP member states were expected to prepare national reports where baseline values would be defined and suggested four EcoQO targets would be tested using monitoring data for the designated areas. The subsequent chapters summarize the findings of the four national reports of China, Japan, Korea and Russia. Unfortunately, due to COVID-19 pandemic, no regional workshop was held and the whole process was delayed significantly.

2. Brief description of designated areas

2.1. China (Jiaozhou Bay)

Jiaozhou Bay is located in the Yellow Sea, along the south coast of Shandong Peninsula, from about 35°55′ to 36°18′ N and from approximately 120°04′ to 120°23′ E (Figure 2.1), with an area of about 390 km^2 and an average water depth of 7 m. It is located in the temperate zone and therefore is ice-free all year around with a temperature varying from 2°C in winter to 28°C in summer. The salinity is around 32 PSU. Jiaozhou Bay is connected to the Yellow Sea proper via a narrow conduit (2.5 km). The narrow mouth gives Jiaozhou Bay an average water exchange time of about 52 days.

Jiaozhou Bay is surrounded by Qingdao City, Jiaozhou City, and Jiaonan City, forming a very dense industrial belt along the bay. The rapid economic development has brought environmental pollution and ecological damage to the Jiaozhou Bay, which has put unprecedented pressure on the bay ecosystem and reduced its service functions significantly. The sustainable development of the Jiaozhou Bay area has become a common concern of the government, scientific community and local citizens.

According to the differences in the geographical characteristics of Jiaozhou Bay and its water exchange capability (Liu, 2007), the area was sub-divided into three sub-areas. Inner Jiaozhou Bay (8 sampling sites in Fig. 2.1: SI 1 – SI 8) which has an average water exchange time of 50 days and is influenced by a large amount of riverine nutrient load. Then, the mouth of Jiaozhou Bay, which includes the narrow opening and has a shorter water exchange time of about 10 days (three sampling sites in Fig. 2.1: SM 1 – SM 3). And, finally, the area just outside the Jiaozhou Bay proper which is actually the coastal area of the northern Yellow Sea (two sampling sites in Fig. 2.1: SO 1 and SO 2). Although this last area is not actually a part of Jiaozhou Bay, it is adjacent to it, and thus its eutrophication status was included in consideration of the trophic status of the whole Jiaozhou Bay.

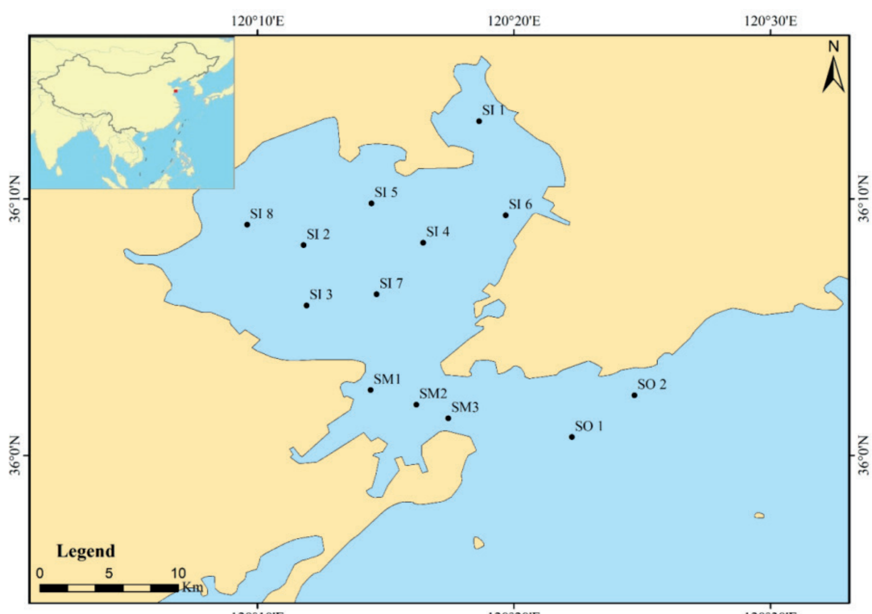


Figure 2.1. Jiaozhou Bay

2.2. Japan (Hakata Bay and Toyama Bay)

Two areas, Toyama Bay and Hakata Bay, were selected in Japan as designated areas for testing the feasibility of the four agreed EcoQO targets (Figure 2.2). The Japanese government (Ministry of the Environment) set the Environmental Quality Standards (EQS) for water pollution (available at https://www.env.go.jp/en/water/index.html), and many local governments in Japan monitor water quality and pollution levels specified by the EQS. Data relevant to the EcoQO targets have been collected and accumulated by the local governments or NGOs in the designated areas.

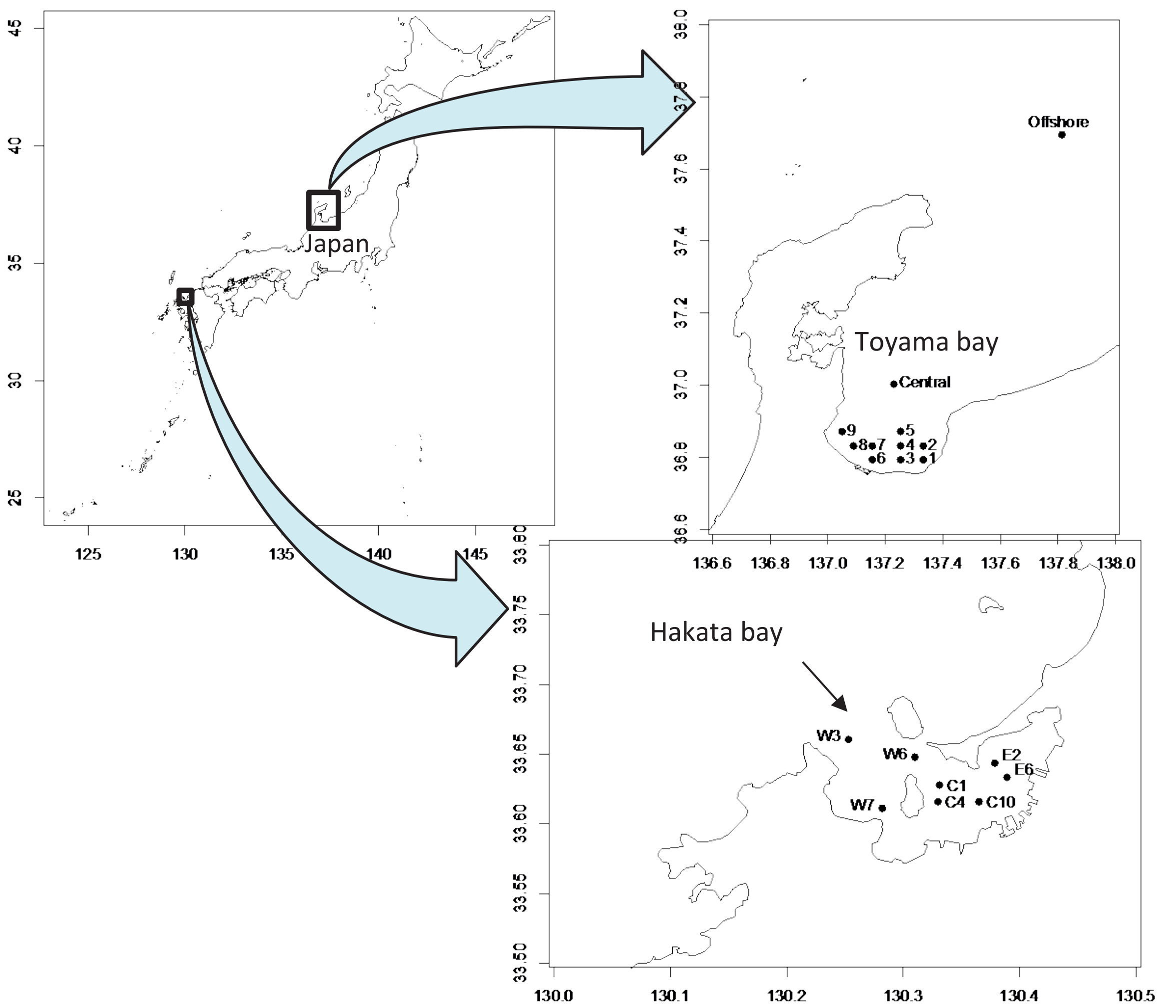


Figure 2.2. Toyama Bay and Hakata Bay with monitoring stations shown

Hakata Bay is a semi-enclosed water area surrounded by Fukuoka city on the northern coast of Kyushu island. The bay is approximately 130 km^2, 10 m deep on average, and 23 m at the deepest. The opening of the bay is only 7.7 km wide. The bay is affected by the industrial and household effluents from Fukuoka, Japan's 5^{th} largest city. Fukuoka city has been conducting regular sampling and analysis of sea water and bottom sediments in Hakata Bay. The resultant data are published annually as Fukuoka City Water Survey Debrief Reports (available at https://www.city.fukuoka.lg.jp/kankyo/k-hozen/hp/sokutei/index.html). Eight monitoring stations are located in Hakata Bay: two in the eastern part, three in the central, and three in the western part, as shown in Figure 2.2. Sea water samples are collected monthly in the surface, mid-water and bottom layers at each station. Nutrients, *Chlorophyll a*, and other items related to the EQS for conservation of the living environment are analyzed monthly, and annual average values are calculated. Items related to the EQS for human health are monitored once in three years. Sediment samples are collected once a year in August at each monitoring station, and items related to the EQS for conservation of the living environment are analyzed. Annual average data for sea-water nutrients for 2005-2009, *Chlorophyll a* and contaminants in sea water for 2010-2019, and bottom sediment contaminants for 2005-2019 were examined (Table 2.1). No marine debris data are available for Hakata Bay because routine monitoring surveys for marine debris have not been established in this area.

Table 2.1. Time-series data for Hakata Bay

Targets	Items	Data period	Source
Nutrients	Total N and total P in water column	2005-2019	Fukuoka City Water Survey Debrief Reports
Chlorophyll a	Surface, middle, bottom *Chlorophyll a* (annual average values)	2010-2019	
Contaminants	Heavy metals, organochlorines (annual average values)	2010-2019	
	Heavy metals (annual average values)	2005-2019	

Toyama Bay is the largest bay at the west coast of Japan. The bay is approximately 2,100 m^2, and 1,250 m at the deepest. The bay is characterized by the steep slope from the shore to the deep basin. Toyama prefecture regularly publishes White Paper on the Environment of Toyama Prefecture, which includes annual data on nutrients and contaminants in sea water and bottom sediment in Toyama Bay (available at https://www.pref.toyama.jp/1705/kurashi/kankyoushizen/kankyou/kj00009135/index.html). Data on sea water nutrients (1998-2019), heavy metals in bottom sediments (1974-2019), were extracted from the White Paper and analyzed (Table 2.2). Northwest Pacific Region Environmental Cooperation Center (NPEC) has been conducting surface *Chlorophyll a* monitoring at 11 stations shown in Figure 2.2. NPEC has also been conducting beach clean-up activities at five stations around Toyama bay since 2014 with the cooperation of local governments, NGOs and voluntary citizens. These data were provided by NPEC and analyzed.

Table 2.2. Time-series data for Toyama Bay

Targets	Items	Data period	Data source
Nutrients	Total N and total P in sea water	1998-2019	White Paper on the Environment of Toyama Prefecture
Chlorophyll a	Surface *Chlorophyll a*	2004-2019	NPEC
Contaminants	Heavy metals in bottom sediments	1974-2019	White Paper on the Environment of Toyama Prefecture
Beach litter	Plastic, rubber, Styrofoam, fabric, glass and pottery, metal, other	2014-2019	NPEC

2.3. Korea (Masan Bay and Ulsan Bay)

Masan Bay is semi-enclosed coastal embayment with limited water exchange located on the south coast of Korea and (Fig. 2.3). The mean depth of Masan Bay is 15 m and the water exchange rate of the inner bay and whole bay is 53.7 days and 23.2 days, respectively (Lee et al., 2009). Masan Bay is known as one of the most polluted areas in Korea due to high industrialization and urbanization during the last 50 years (Khim, Koh, 2011). Untreated waste, sewage, and wastewater have been discharged from industrial complexes and municipal areas in Masan Bay since the 1970s. As a result, eutrophication, harmful algal blooms, oxygen depletion, deterioration of water quality, and aesthetic problems occurred in Masan Bay (Chang et al., 2012). The Korean government has designated and managed Masan Bay as a special management coastal area since 1982 to respond to these problems. In particular, COD and TP are designated and managed as main contaminants subject to management (MOF, 2017). Thus, EcoQOs of nutrients, *Chlorophyll a*, and marine litter were assessed in Masan Bay.

Figure 2.3. Sampling sites in Masan Bay

Ulsan Bay is located on the east coast of Korea and is connected to the open sea (Fig. 2.4). Compared to Masan Bay, Ulsan Bay has a deeper water depth and was developed as a port city because of this geological feature. The area around Ulsan Bay was designated as a specific industrial zone in the 1960s. The marine environment of Ulsan Bay has been polluted since the 1970s, due to rapid industrialization (Choi et al., 2005). Accordingly, the Korean government designated Ulsan Bay as a special management coastal area in 1982 and is intensively managing environmental emissions of contaminants. Since the 2000s, contaminants flowing into Ulsan Bay have been evaluated by calculating pollutant emissions and measuring pollutant concentrations in sediments. Recently, management is in progress to reduce the concentration of copper, zinc, and mercury, which are contaminants subject to reducing below the "Probable Effect Level" (PEL) in sediment quality guideline (MOF, 2020). Thus, the relevant EcoQO on contaminants was assessed in Ulsan Bay.

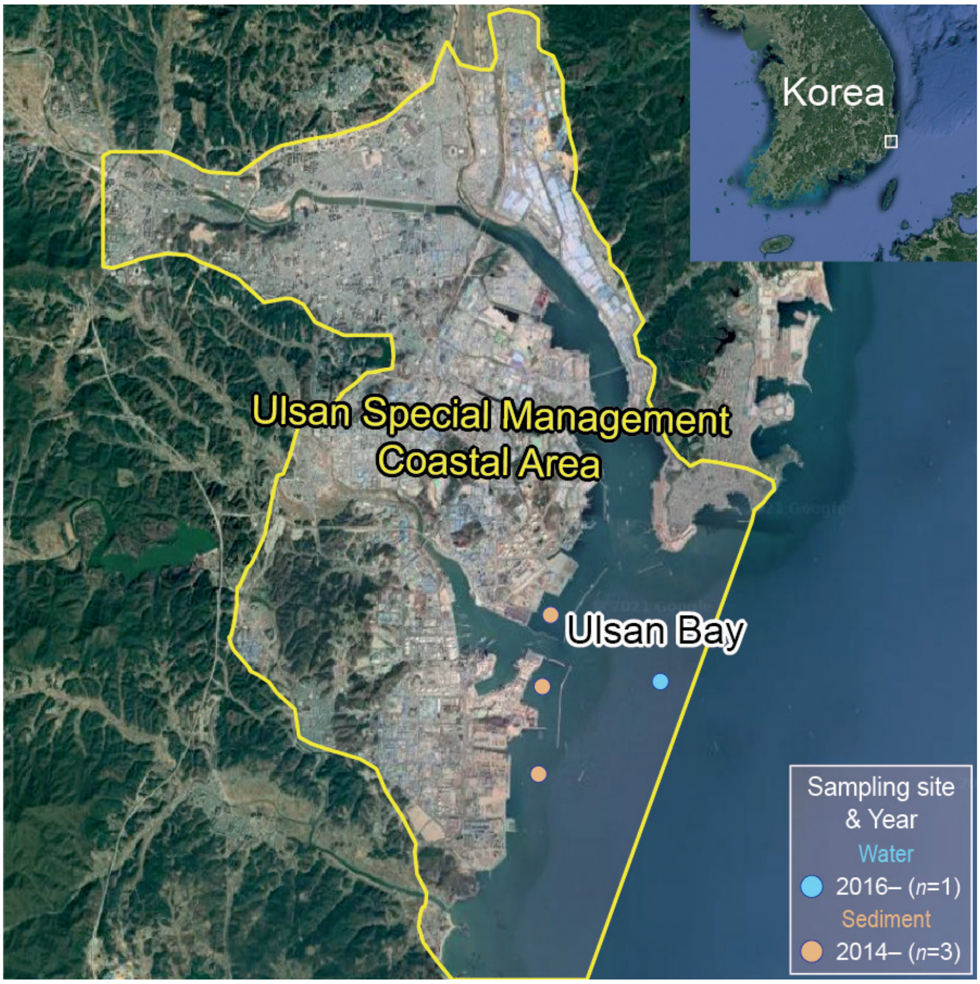


Figure 2.4. Sampling sites in Ulsan Bay

2.4. Russia (Amursky Bay)

Amursky Bay is the secondary bay of the large Peter the Great Bay, about 70 km long with the width of 10-20 km (from 42°50′ to 43°20′ N and from 131°22′ to 132°04′ E, Figure 2.5). Its area is 1,136 km^2 and the maximum depth 55 m. It is a semi-enclosed bay connected with Peter the Great Bay through the open southern boundary (9.7 km) and a series of narrow and shallow straits between islands along the eastern boundary. Rather big river (Razdolnaya, named Suifen in China) enters at the northern tip of the Bay, with mean annual fresh water discharge of 2.1 km^3, and freshens the northern part of the Bay, while salinity >32 PSU is typical for its southern areas. Temperature regime of the Amursky Bay is distinguished by extremely high amplitude: from minus 2°C in winter, when the whole area of the Bay is covered by sea ice, to plus 25-26°C in late summer. The northeastern coast of the bay is occupied by Vladivostok City, which is one of the main sources of the marine environment pollution. Another important source of pollution is the Razdolnaya river discharge that brings pollutants collected from its vast watershed located in both Russia and China and characterized by intense agricultural and industrial activity.

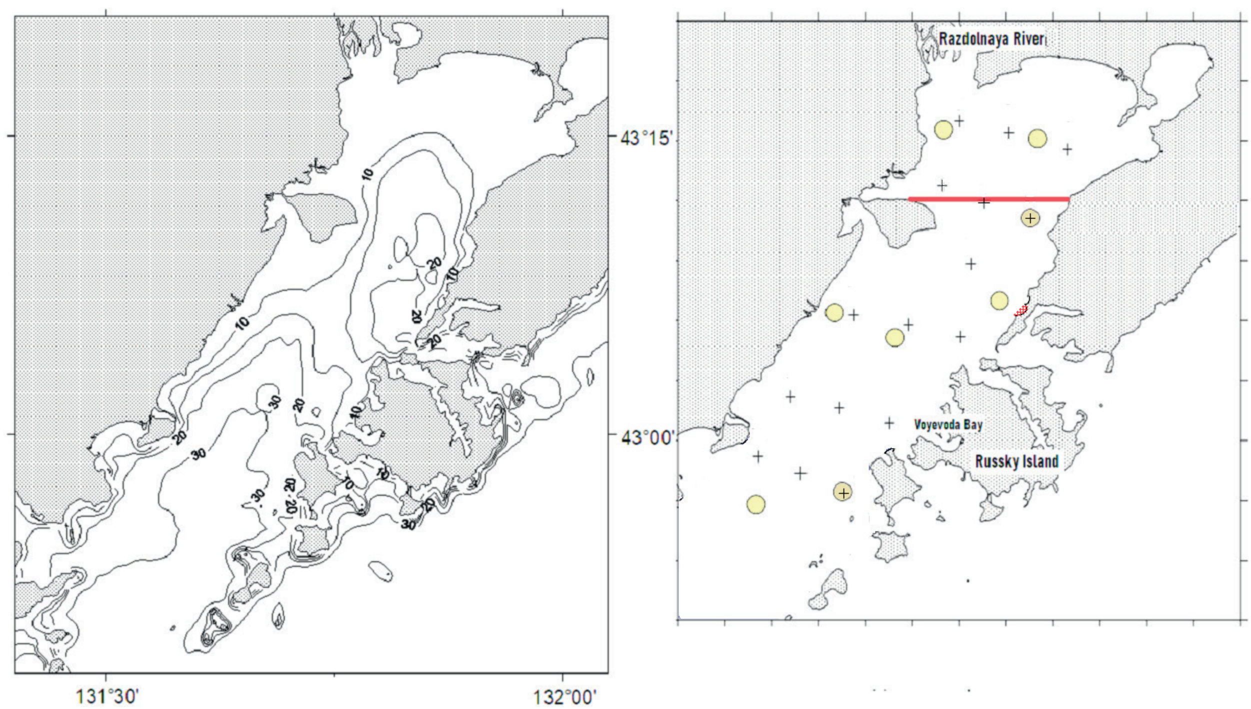


Figure 2.5. Amursky Bay sampling sites for nutrients and Chlorophyll a (crosses), water and bottom sediment contaminants (yellow circles). Red line (43°12 N) divides the northern and the southern parts of the bay

3. Setting baseline values for the designated areas

Obviously, using national water quality standards as targets could be the most logical approach. However, in some cases national standards are too high (e.g. in case of nutrients in Russia), so using such targets is simply not practical. This is why at the regional workshop held in March 2019 in Vladivostok nominated national experts have agreed to use "baseline values" (or median values) along with national water quality standards, depending on the situation in certain designated areas. Similar approach has been utilized by other Regional Seas Programmes: e.g. "assessment criteria" are being used in OSPAR, "reference conditions and thresholds/boundary values" in MAP, and "threshold values" in HELCOM (see, for example, http://helcom.fi/baltic-sea-trends/indicators/).

However, due to COVID-19 pandemic, regional workshop planned for 2021 has not been held and experts had no chance to further discuss the details of baseline value definition. As a result, reports submitted from NOWPAP member states have demonstrated quite different approaches (described in more detail below). In China, national standards were used and there was no need at all to consider baseline values. In Japan, national standards were also used and baseline values were considered only in the case of *Chlorophyll a*, where long-term average concentrations were considered as baseline values to detect recent trends. In Russia, background concentrations of nutrients and *Chlorophyll a* in the southern part of Amursky Bay (far from any anthropogenic sources) were considered as baseline values. On the contrary, in Korea, baseline values for nutrients and *Chlorophyll a* were calculated by adding one standard deviation to the maximum seasonal concentrations observed within the designated area. While setting NOWPAP EcoQO targets, it was advised (see Table 1.1) to take into account CEARAC findings on eutrophication. However, due to absence of regional workshop in 2021, CEARAC experts were unfortunately not involved in the process of baseline value determination for *Chlorophyll a* and nutrients.

3.1. Nutrient concentrations in the water column

3.1.1. China (Jiaozhou Bay)

China has four-level system of national water quality standards (National Standard for Seawater Quality of China, NSQS, 1997) applicable to different types and classes of water bodies. The first level is applicable to marine fisheries areas, marine nature reserves, nature reserves for rare and endangered species. The second level is applicable to aquaculture areas, seawater bathing areas, marine activities and recreation areas where human bodies are in direct contact with seawater, and industrial water areas directly related to human consumption. The third level is applicable to general industrial water areas and coastal scenic tourism areas. The fourth level is applicable to marine port waters, marine development operation areas.

The NOWPAP EcoQO target on nutrients implies that nutrient concentrations in the water column within the designated area do not exceed the baseline values or existing national standards. So, the baseline values of nutrients for the Jiaozhoy Bay were set as Class II according to NSQS (1997), i.e. waters suitable for aquaculture (Table 3.1.1). Jiaozhou Bay is indeed important for shellfish aquaculture and a fairly large part of the bay is covered by aquaculture farms.

Table 3.1.1. Baseline values used for the Jiaozhou Bay China

Assessment parameter	Baseline value	Reference
DIN concentration	0.300 mg/L	NSQS Class II
DIP concentration	0.030 mg/L	NSQS Class II

3.1.2. Japan (Hakata Bay and Toyama Bay)

The Basic Environment Law of Japan establishes two types of Environmental Quality Standards (EQS) related to water pollution: 1) EQS for protecting human health, and 2) EQS for protecting the living environment. Each type of standards designates reference levels for achieving the public water and water quality policy objectives. EQS for protecting the living environment for total nitrogen (TN) and total phosphorus (TP) are shown in Table 3.1.2. These standards were used as baseline values related to the NOWPAP EcoQO target.

Table 3.1.2. Standard values for TN and TP specified by EQS for protecting the living environment (cited from the webpage of the Ministry of the Environment, Japan)

Class	Water use	Standard value (mg/L)	
		TN	TP
I	Conservation of the natural environment	≤0.2	≤0.02
II	Fishery class 1, bathing	≤0.3	≤0.03
III	Fishery class 2	≤0.6	≤0.05
IV	Fishery class 3, industrial water, and conservation of habitable environment for marine biota	≤1.0	≤0.09

3.1.3. Korea (Masan Bay)

The baselines for nutrients in Masan Bay were calculated from the results of the national marine environmental monitoring network over the last 10 years, from 2011 to 2020 (MOF, 2021a). The baseline of DIN and DIP were determined by adding one standard deviation to the maximum value observed during this 10-year period. This method is currently used to set the marine environment standards in Korea (MLTM, 2010). Over the last 10 years, the maximum mean concentration for DIN and DIP was recorded in November 2015 (Fig. 3.1.1 and 3.1.2), and the baselines were calculated from these data.

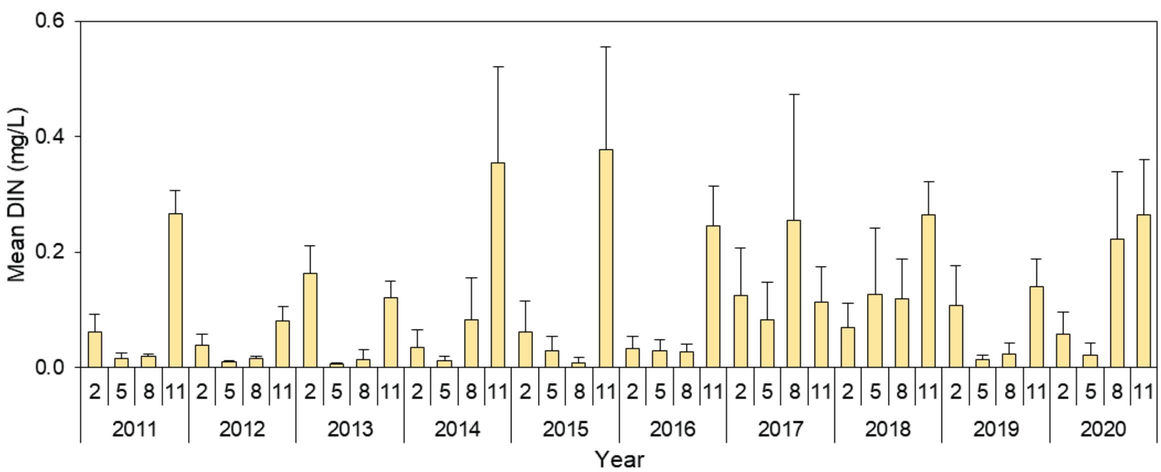


Figure 3.1.1. DIN (mean values and standard deviations) in Masan Bay from 2011 to 2020

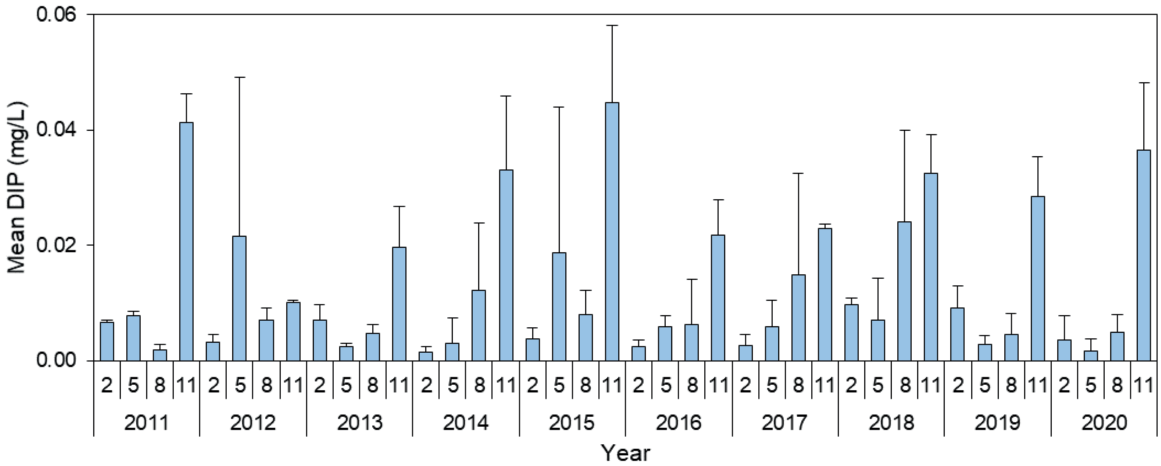


Figure 3.1.2. DIP (mean values and standard deviations) in Masan Bay from 2011 to 2020

The baselines of DIN and DIP were 0.555 mg/L and 0.058 mg/L, respectively. In previous report (CEARAC, 2013), the baselines of DIN and DIP in the Gijang area (near Busan) in winter were 0.20 and 0.02 mg/L, respectively because Gijang area, unlike Masan Bay, is directly connected to the open sea, with fewer pollution sources around, and only winter data were used for Gijang area.

3.1.4. Russia (Amursky Bay)

As mentioned earlier (POMRAC, 2017; POMRAC, 2019), national water quality standards in Russia are too high even for oligotrophic waters: about 9 mg/L for DIN and 0.05 mg/L for DIP. Therefore, the data from southern part of Amursky Bay (not affected by anthropogenic influence) were used to determine baseline values for nutrients. According to published data (Zuenko, Rachkov, 2015), baseline values for DIN and DIP were 26.1 µg/L and 18.0 µg/L respectively. These values, however, are much lower than recommended by CEARAC for Peter the Great Bay (Russia): 260-470 µg/L for DIN (in different seasons) and 34-65 µg/L for DIP (CEARAC, 2013).

3.2. *Chlorophyll a* concentration in the water column

3.2.1. China (Jiaozhou Bay)

While there are no official government standards for *Chlorophyll a* concentrations in China, the reference value of 5 µg/L presented in the CEARAC report of 2013 (http://www.cearac-project.org/cearacproject/integrated-report/eut_2013.pdf) was used as the baseline value.

3.2.2. Japan (Hakata Bay and Toyama Bay)

Long-tern data for *Chlorophyll a* are available only for Hakata Bay and long-term averages have been used as baseline values. For Toyama Bay, long-term data are only available for certain stations, so reliable baseline could not be established. Therefore, for testing NOWPAP EcoQO target on *Chlorophyll a*, baseline value was taken from CEARAC (2013): 5 µg/L for Toyama Bay.

3.2.3. Korea (Masan Bay)

As in the case of nutrients, the baseline for *Chlorophyll a* was determined by adding the standard deviation to the maximum of the 10-year seasonal mean values obtained from 2011 to 2020 in

Masan Bay (Fig. 3.2.1). Over the last 10 years, Chlorophyll a had the highest value in May 2015. The baseline calculated from this value was 72.9 µg/L. This baseline is higher than some previous estimates. For example, the mean value of Chlorophyll a for Jinhae Bay recommended by CEARAC was 5 µg/L (CEARAC, 2013). Baseline value for Masan Bay used in preparation of POMRAC regional overview was 11.4 µg/L (POMRAC, 2019). These differences might be explained by using more offshore stations in previous studies. Jinhae Bay is more open sea area compared with Masan Bay.

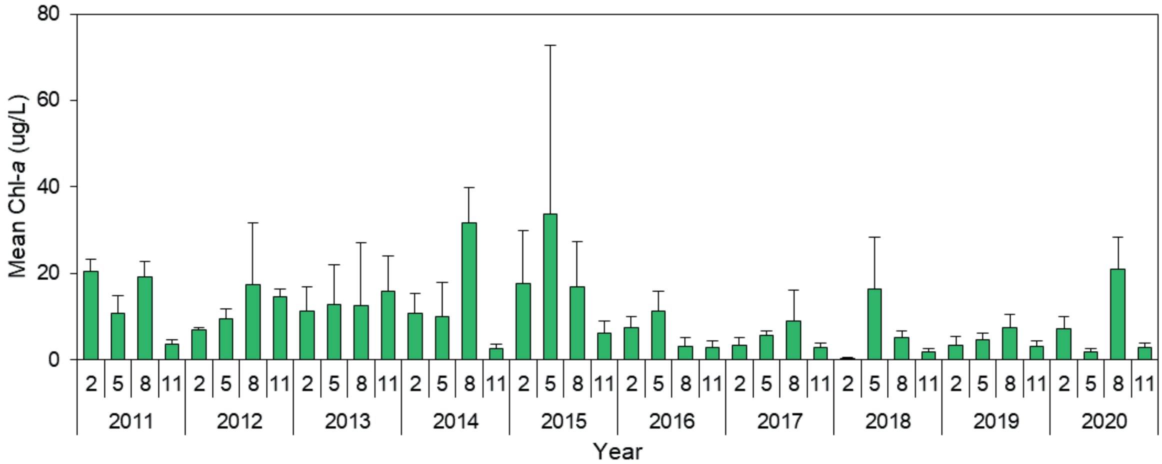


Figure 3.2.1. Mean and standard deviation of Chlorophyll a in Masan Bay from 2011 to 2020

3.2.4. Russia (Amursky Bay)

According to the results of long-term ecological monitoring conducted in the Amursky Bay by different government agencies and institutions, the southern part of the bay is considered as the water body with natural regime, without any significant anthropogenic impact. Therefore, the typical concentrations of Chlorophyll a in the southern part of the Amursky Bay (southward from 43°12’ N) were considered as baselines values. Using the published data (Zuenko, Rachkov, 2015; Zuenko, 2012; Zharova, Zuenko, 2018), baseline value for Chlorophyll a was calculated as 1.5 µg/L. It should be noted that this value is lower than the one recommended previously by CEARAC: 5 µg/L (CEARAC, 2013).

3.3. Concentration of contaminants in water and sediments

3.3.1. China (Jiaozhou Bay)

As mentioned earlier, China has four-level system of national standards for seawater (NSQS, 1997). For sediments, China has three-level system of national standards (National Standard for Marine Sediment Quality of China, NSMSQ, 2002). The first level is applicable to marine fishery areas, marine nature reserves, nature reserves for rare and endangered species, aquaculture areas, seawater bathing areas, marine activities, and recreation areas where human bodies come into direct contact with sediments, and industrial water areas directly related to human consumption. The second level is applicable to general industrial water areas, coastal scenic tourism areas. The third level is applicable to marine port waters, and special purpose marine development operation areas. National standards for contaminants (which were used for testing relevant EcoQO target) are shown in Table 3.3.1 and Table 3.3.2 below.

Table 3.3.1. National standards of China for some contaminants in seawater (maximum permissible concentration, mg/L)

<table>
<tr><th>Contaminant</th><th>First level</th><th>Second level</th><th>Third level</th><th>Fourth level</th></tr>
<tr><td>Hg</td><td>0.00005</td><td colspan="2">0.0002</td><td>0.0005</td></tr>
<tr><td>Cd</td><td>0.001</td><td>0.005</td><td colspan="2">0.010</td></tr>
<tr><td>Pb</td><td>0.001</td><td>0.005</td><td>0.010</td><td>0.050</td></tr>
<tr><td>Cr</td><td>0.05</td><td>0.10</td><td>0.20</td><td>0.50</td></tr>
<tr><td>As</td><td>0.020</td><td>0.030</td><td colspan="2">0.050</td></tr>
<tr><td>Zn</td><td>0.020</td><td>0.050</td><td>0.10</td><td>0.50</td></tr>
<tr><td>Cu</td><td>0.005</td><td>0.01</td><td colspan="2">0.050</td></tr>
<tr><td>DDTs</td><td>0.00005</td><td colspan="3">0.0001</td></tr>
<tr><td>HCHs</td><td>0.001</td><td>0.002</td><td>0.003</td><td>0.005</td></tr>
<tr><td>Oil</td><td colspan="2">0.05</td><td>0.30</td><td>0.50</td></tr>
</table>

Table 3.3.2. National standards of China for some contaminants in marine sediments (maximum permissible concentration, mg/kg)

Contaminant	The first level	The second level	The third level
Hg	0.20	0.50	1.00
Cd	0.50	1.50	5.00
Pb	60.0	130.0	250.0
Cr	80.0	150.0	270.0
As	20.0	65.0	93.0
Cu	35.0	100.0	200.0
Zn	150.0	350.0	600.0
DDTs	0.02	0.05	0.10
HCHs	0.50	1.00	1.50
Oil	500	1000	1500

3.3.2. Japan (Hakata Bay and Toyama Bay)

Environmental Quality Standards (EQS) for sea water have been used as baseline values related to EcoQO target on contaminants (Table 3.3.3). However, EQS do not cover contaminants in bottom sediments. In that case, long-term average values were used as baseline values.

Table 3.3.3. Environmental quality standards for contaminants in sea water related to human health (more data can be found at https://www.env.go.jp/en/water/index.html)

Item	Standard/guideline value (mg/L)
Cadmium	≤0.01
Total cyanide	Not detectable
Lead	≤0.01
Hexavalent chromium	≤0.05
Arsenic	≤0.01
Total mercury	≤0.0005
Alkyl mercury	Not detectable
PCBs	Not detectable
Dichloromethane	≤0.02

Table 3.3.3.

Continuation

Item	Standard/guideline value (mg/L)
Benzene	≤0.01
Selenium	≤0.01
Fluoride	≤0.8
Boron	≤1.0
Molybdenum	≤0.07
Antimony	≤0.02
Total manganese	≤0.2
Uranium	≤0.002

3.3.3. Korea (Ulsan Bay)

There are national guidelines for protecting human health and the living environment and for protecting the marine ecosystems in Korea (MOF, 2013). These guidelines for trace metals in seawater are shown in Table 3.3.4. These guidelines are based on eco-toxicity of these metals (MLTM, 2010). The acute guideline is a reference value when pollutant was measured once, and the chronic guideline is a mean value from at least four measurements per year.

Table 3.3.4. Seawater quality guidelines for selected metals in Korea

Contaminant	Acute (µg/L)*	Chronic (µg/L)**
As	9.4	3.4
Cd	19	2.2
Cr^{6+}	200	2.8
Cu	3.0	1.2
Hg	1.8	1.0
Ni	11	1.8
Pb	7.6	1.6
Zn	34	11

* Short-term basis (comparison with one-time observations)
** Comparison with the annual average value (data from four surveys per year, ideally one per season)

The sediment quality guidelines of Korea (shown in Table 3.3.5) consist of "Threshold Effect Level" (TEL) and "Probable Effect Level" (PEL) for eight heavy metals based on the eco-toxicity data (MLTM, 2012). TEL is the concentration expected to have a minimal negative ecological impact. PEL is the concentration with a very high probability of negative ecological impact. Because the concentration of heavy metals varies with particle size, Cu and Zn concentrations were corrected for differences in particle size using Li (MLTM, 2012). For other metals, concentrations were directly compared with guidelines. If the sample contained less than 33.1 mg/kg of Li, or the particle size correction concentration value was negative, Cu and Zn concentrations were directly compared with the guideline without implementing particle size correction.

Table 3.3.5. Sediment quality guidelines for selected metals in Korea

Contaminant	TEL (mg/kg)	PEL (mg/kg)
As	14.5	75.5
Cd	0.75	2.72
Cr	116	181
Cu*	20.6	64.4
Hg	0.11	0.62
Ni	47.2	80.5
Pb	44	119
Zn**	68.4	157

3.3.4. Russia (Amursky Bay)

As in the case of China, Russian national water quality standards were used as baseline values for this particular EcoQO target (contaminants in water), as shown in Table 3.3.6.

Table 3.3.6. National standards of Russia for contaminants in natural waters (maximum permissible concentrations, mg/L)

Parameter	"Public" waters	Waters for fisheries purposes	
		Sea water	Fresh water
Petroleum hydrocarbons	0.1	0.05	0.05
Detergents	0.5	0.1	0.1
Phenols	0.25	0.001	0.001
Al	0.5	0.04	0,04
Be	0.001	0.0003	0,0003
B	0.5	0.1	10
Fe	0.3	0.05	0.1
Cd	0.001	0.01	0,005
Mn	0.1	0.05	0.01
Ni	0.1	0.01	0.01
Cu	1.0	0.005	0.001
As	0.05	0.01	0.05
Se	0.01	0.002	0.002
Hg	0.0005 = 500 ng/l	0,0001	0.00001
Cr	$0.02Cr^{6+}$, $0.07Cr^{3+}$		
Zn	1.0	0.05	0.01
Pb	0.03	0.01	0.006
HCHs	0.02	0.00001	
DDTs	0.1	0.00001	
PCBs	0.001	0.0001	

National standards for contaminant concentrations in bottom sediments are absent in Russia, therefore it was decided to use Chinese national standards (CSBQTS, 2002) shown in Table 3.3.2 above (first level).

3.4. Trends in the amount and composition of litter washed ashore

In 2019, it was agreed that the 5-year decreasing trend in the amount of marine litter washed ashore would serve as the NOWPAP EcoQO target. Therefore, there was no need to establish any baseline values for this parameter. In case of China, due to lack of data for the Jiaozhou Bay proper, data for the Shilaoren Beach (outside the Jiaozhou Bay) have been used instead. Data from 2012 to 2018 were obtained from the "Bulletin of Marine Ecology and Environment Status of China". In Japan, no marine litter data were available for Hakata Bay. Therefore, relevant NOWPAP EcoQO target has been tested using Toyama Bay data only. In case of Korea, national onshore marine litter monitoring data for 2016-2020 have been used (MOF, 2021b). In Russia, out of 50 beaches where marine litter has been collected in recent years, three beaches were chosen with the most detailed data for analysis of temporal trends. One of these beaches is located within the Amursky Bay (designated area for Russia) and two other beaches are outside Amursky Bay.

4. Testing EcoQO targets agreed upon earlier

4.1. Nutrients concentration in the water column

4.1.1. China (Jiaozhou Bay)

Since there are national standards for DIN and DIP in seawater in China, the baseline values were set according to national standards (NSQS 1997), class II: 0.3 mg/L for DIN and 0.03 mg/L for DIP.

In the inner bay, during the period from 2011 to 2019, the annual concentrations of DIN ranged from 0.227 to 0.374 mg/L with an average of 0.277 mg/L. The maximum concentration was observed in 2013 and the minimum in 2019. Only in 2013 the mean annual concentrations of DIN was higher than the baseline value. According to Mann-Kendall test ($p < 0.05$), DIN concentrations have shown significant decreasing trend (except the outer part of the bay) from 2011 to 2019 (Figure 4.1.1).

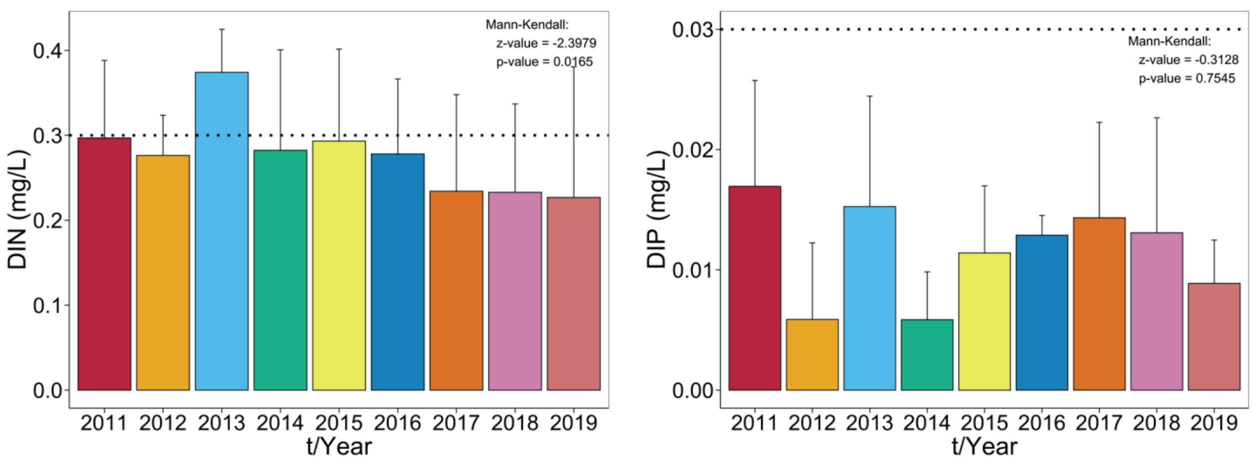


Figure 4.1.1. Mean concentrations (and standard deviations) of DIN and DIP in the inner sub-region of Jiaozhou Bay. The dash lines indicate the baseline concentrations

The annual mean concentrations of DIP ranged from 0.006 to 0.017 mg/L between 2011 and 2019, with an average of 0.012 mg/L. The maximum concentration occurred in 2011 and the minimum in 2014. The annual concentrations of DIP were lower than the baseline concentration for the whole period of 2011-2019. The DIP concentrations have not shown significant decreasing trend (Mann-Kendall test, $p > 0.05$) from 2011 to 2019 (Figure 4.1.1).

As for comparison of nutrients among the three sub-regions (inner bay, mouth of the bay and outer bay) of Jiaozhou Bay, both the DIN and DIP concentrations were highest in inner bay and lowest in the outer bay during the whole period (Figure 4.1.2). In conclusion, it is suitable to use NOWPAP EcoQO target on nutrient concentrations (DIN and DIP) in the Jiaozhou Bay of China.

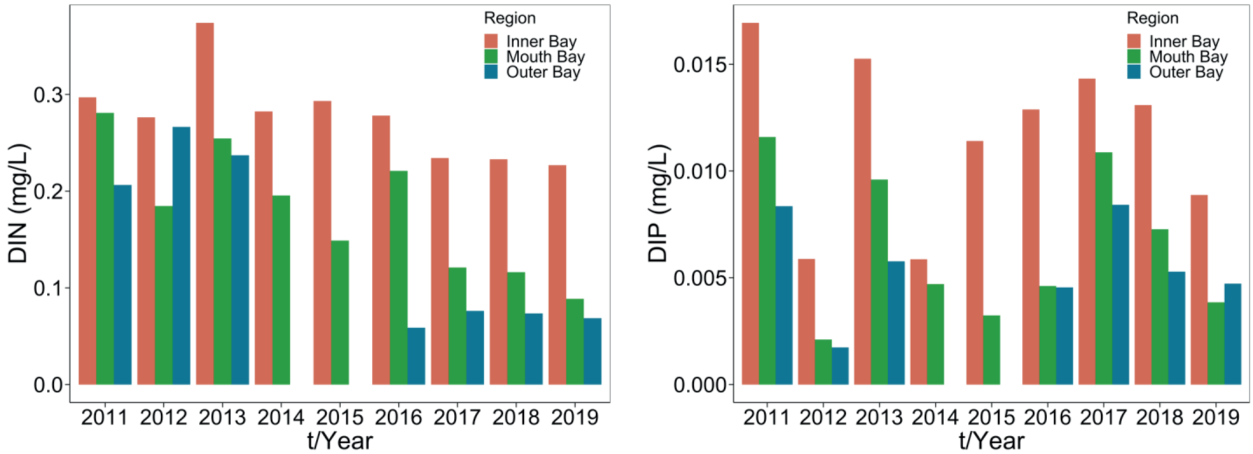


Figure 4.1.2. DIN and DIP concentrations in Jiaozhou Bay (inner bay, mouth of the bay and the outer bay) from 2011 to 2019

4.1.2. Japan (Hakata Bay and Toyama Bay)

In Hakata bay, Fukuoka city has been conducting a systematic monitoring program for the environmental quality of sea water and bottom sediment. Results of the monitoring program are regularly issued as Fukuoka City Water Survey Debrief Reports (available at https://www.city.fukuoka.lg.jp/kankyo/k-hozen/hp/sokutei/index.html). Surface, middle, and bottom sea water samples are collected monthly at eight stations. Concentrations of total nitrogen (TN) and total phosphorus (TP) are measured, and annual average values are calculated for each station. According to Fukuoka city, the western area of Hakata Bay is categorized into class II (suitable for Fishery class 1). The eastern and central areas of Hakata bay are categorized into class III (suitable for Fishery class 3). Therefore, baseline values of TN and TP in the eastern and central areas are ≤ 0.6 mg/L and ≤ 0.05 mg/L, and those in the western part are ≤ 0.3 mg/L and ≤ 0.03 mg/L, respectively (Table 3.1.2).

Figures 4.1.3 and 4.1.4 are boxplots showing intra-annual variations and inter-annual changes of TP and TN at stations in the whole area or in the eastern, central, and western areas of Hakata Bay. Standard values specified by EQS for conservation of living environment are indicated by dotted lines. Annual average TN values at stations in the eastern and central area are lower than the standard value (≤ 0.6 mg/L) in most years. Average TN values at stations in the western area are higher than the standard value (≤ 0.3 mg/L) only from 2005 to 2011. Annual average TP values are lower than the standard values at stations both in the eastern and central areas (≤ 0.05 mg/L) and in the western area (≤ 0.6 mg/L) for the entire period (2005-2019).

In Toyama Bay, White Paper on the Environment of Toyama Prefecture shows values of TN and TP in sea water measured at regular monitoring stations from 1998 to 2019. Since Toyama prefecture does not specify the classes of sampling areas, EQS standard values for class II area (suitable for Fishery class 1) are tentatively applied to all sampling stations, that is, ≤ 0.3 mg/L for TN and ≤ 0.03 mg/L for TP.

Figure 4.1.5 shows inter-annual changes in TN and TP values at regular monitoring stations in Toyama Bay. TN values are lower than the standard value in most station except a few stations located in a river mouth or in ports. These areas may be categorized into class III for which standard value is 0.6 mg/L. TP values are lower than the standard value (0.03 mg/L) for class II area.

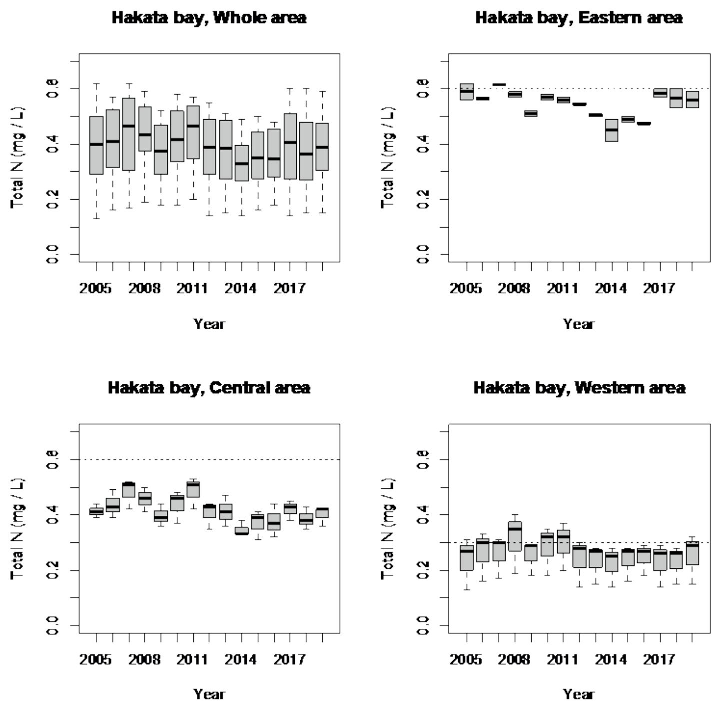


Figure 4.1.3. Boxplots showing the variation of average TN values in Hakata Bay

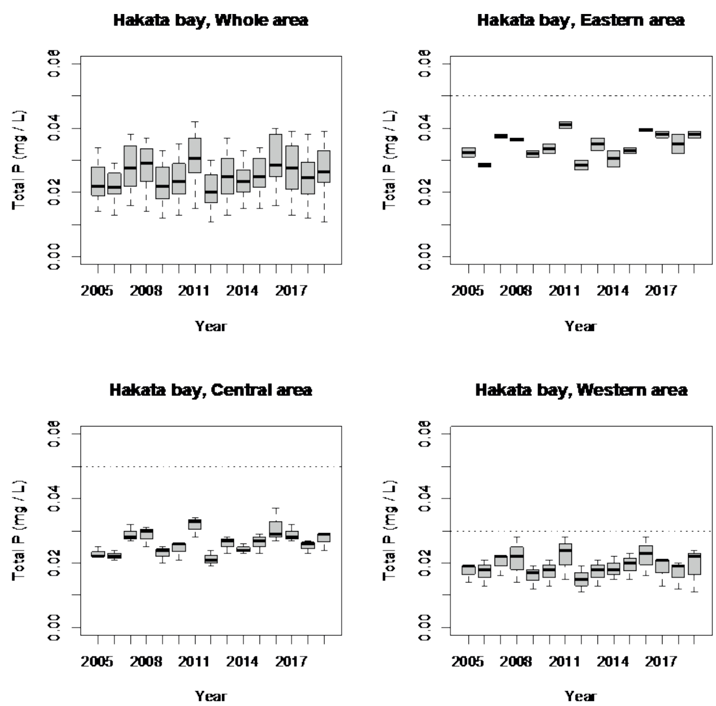


Figure 4.1.4. Boxplots showing the variation of average TP values in Hakata Bay

These results demonstrate that TN and TP values in Hakata Bay and Toyama Bay are generally maintained below the standard levels specified by EQS.

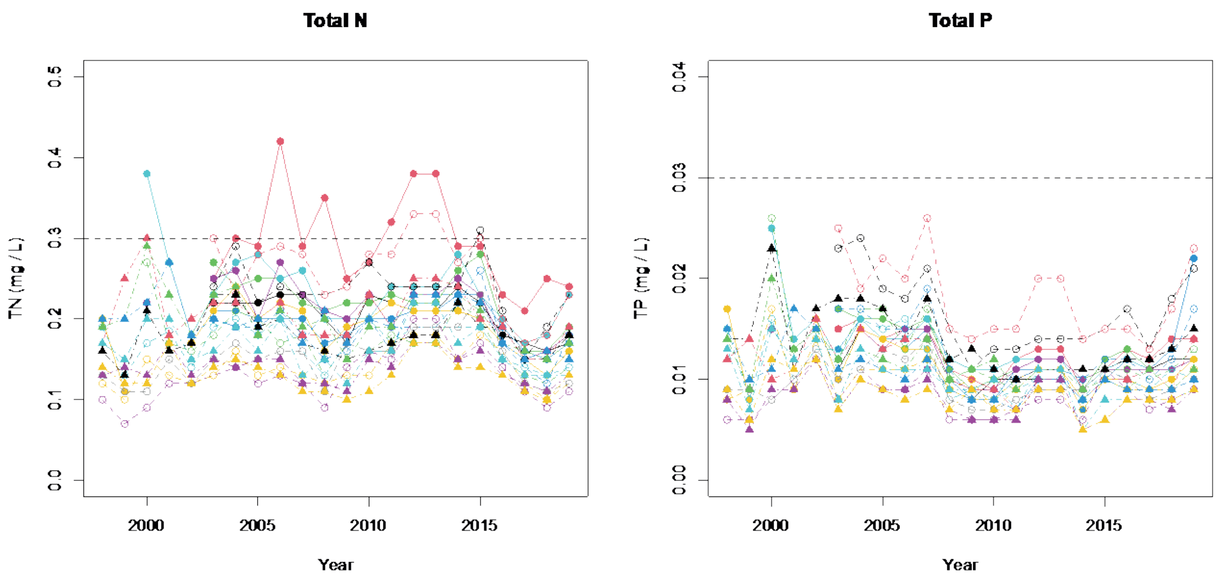


Figure 4.1.5. Inter-annual changes in TN and TP values in Toyama bay

4.1.3. Korea (Masan Bay)

Based on the national coastal monitoring data (MOF, 2021a), concentrations of DIN in Masan Bay were generally similar over the last 5 years (Fig. 4.1.6). The annual mean of DIN ranged from 0.071 to 0.145 mg/L, which was about four times lower than the baseline. However, concentrations exceeding the baseline were detected at some sites (about 25% of samples in August 2017). Values exceeding the baseline were mainly recorded in the inner part of the bay, where freshwater flows from terrestrial sources. Overall, the concentrations of DIN can be used as NOWPAP EcoQO target for Masan Bay.

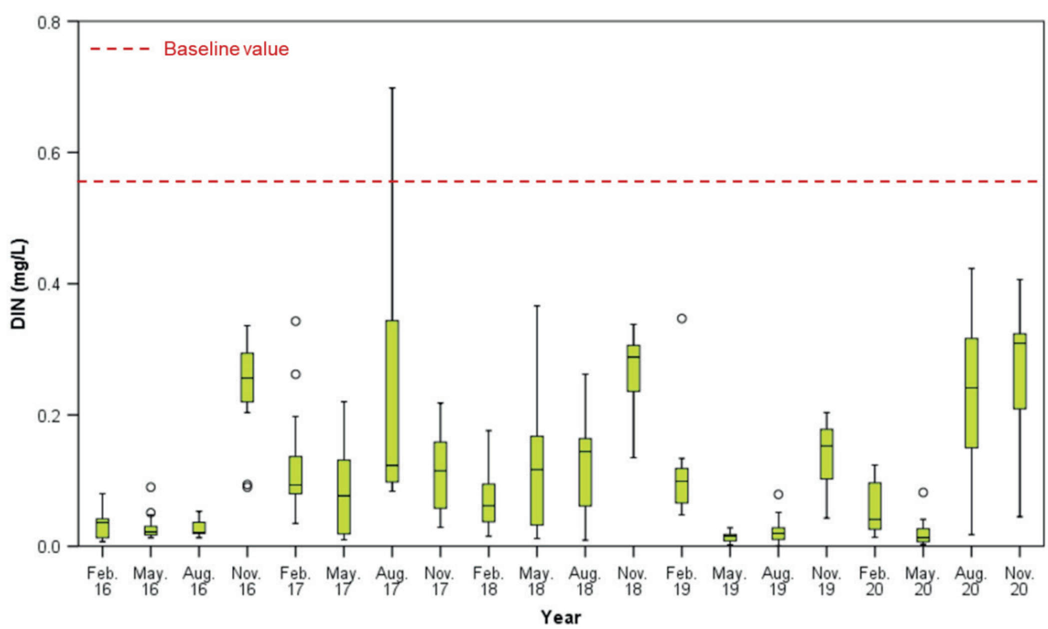


Figure 4.1.6. Concentrations of DIN in Masan Bay from 2016 to 2020

Based on the national coastal monitoring data (MOF, 2021a), concentrations of DIP in Masan Bay were generally similar over the last 5 years (Fig. 4.1.7). The annual mean of DIP varied from 0.009 to 0.018 mg/L, which was about 3 times lower than the baseline. Only occasionally (no more than 7% in August 2017, August 2018 and November 2020, respectively) concentrations exceeding the baseline were detected at some sites. As in the case with DIN, values exceeding the baseline were mainly recorded in the inner part of the bay, where freshwater flow occurs. Overall, concentrations of DIP could be used as NOWPAP EcoQO target for Masan Bay.

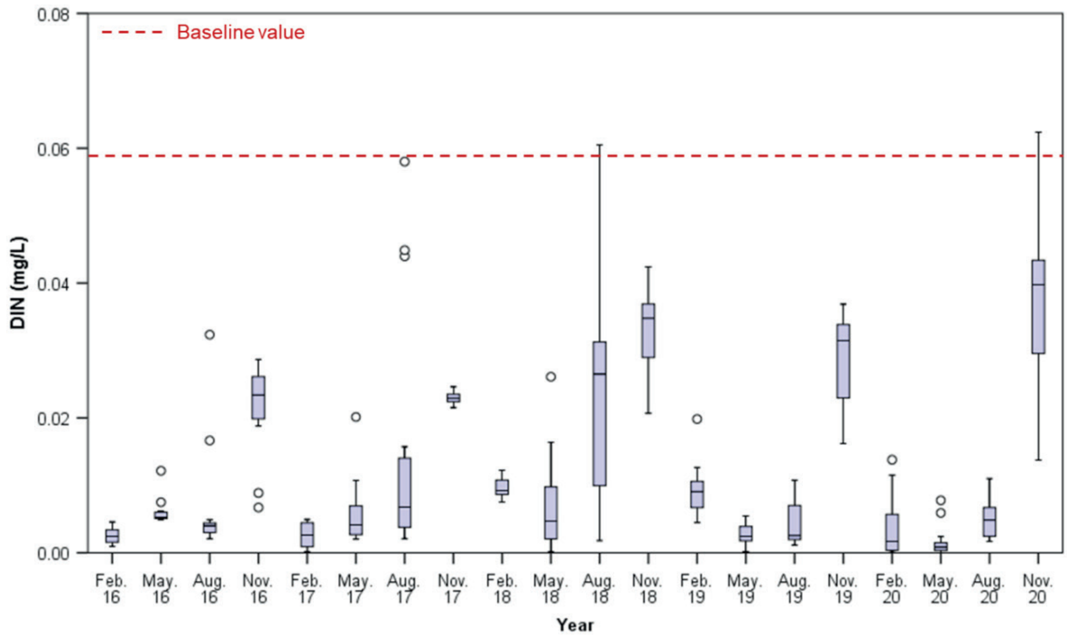
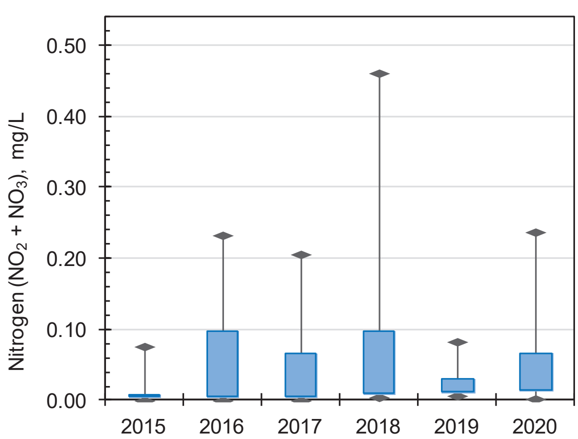


Figure 4.1.7. Concentrations of DIP in Masan Bay from 2016 to 2020

4.1.4. Russia (Amursky Bay)

The period of 2015-2020 was chosen for testing of NOWPAP EcoQO targets in the Amursky Bay which was rather well surveyed in this period three different research institutions. All parameters were highly spatially variable, with the most prominent difference between the northern and southern parts of the Amursky Bay (northern part, northward from 43°12 N, is usually occupied by the highly eutrophic estuarine waters). Seasonal variability of studied parameters was also high. Therefore, statistical analysis was performed for two parts of Amursky Bay and also for different seasons. Statistical significance of the trends was evaluated using Mann-Kendall ranking test. DIN was considered as a sum of nitrite and nitrate nitrogen, neglecting the ammonium component which was insignificant.

Figures 4.1.8 and 4.1.9 show inter-annual variations of DIN and DIP in the southern and northern parts of Amursky Bay, respectively. As baseline values have been set at 26.1 µg/L (0.026 mg/L) for DIN and 18.0 µg/L (0.018 mg/L) for DIP, it is obvious that monitoring data in the northern part of the bay exceed those baselines. It should be noted that those baselines were determined using data from the southern part of Amursky Bay, not affected by anthropogenic influence. However, monitoring data for DIN exceed baseline even in the southern part of the bay.



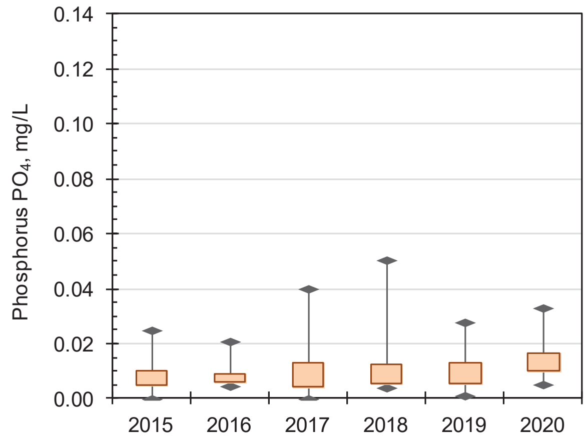
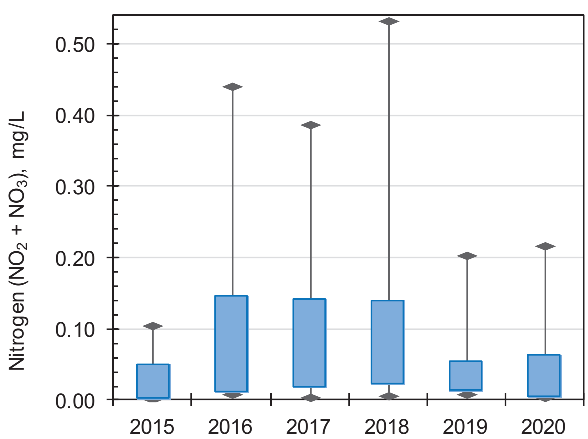


Figure 4.1.8. Boxplots (quartiles and ranges) DIN and DIP concentrations at the surface of the southern part of Amursky Bay in May-October of 2015-2020



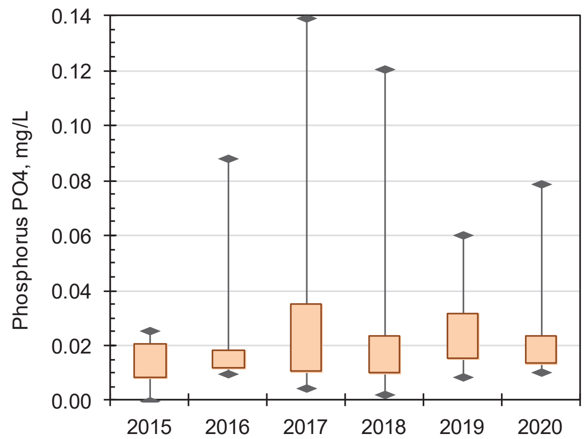


Figure 4.1.9. Boxplots (quartiles and ranges) DIN and DIP concentrations at the surface of the northern part of Amursky Bay in May-October of 2015-2020

Figure 4.1.10 below shows DIN data for different seasons in the northern part of Amursky Bay as an example. No significant trends were found for the period of 2015-2020 in both parts of the Amursky Bay and for both DIN and DIP. Overall, looks like using baseline data determined from background concentrations measured in unaffected part of the bay is not appropriate approach to test NOWPAP EcoQO target on nutrients.

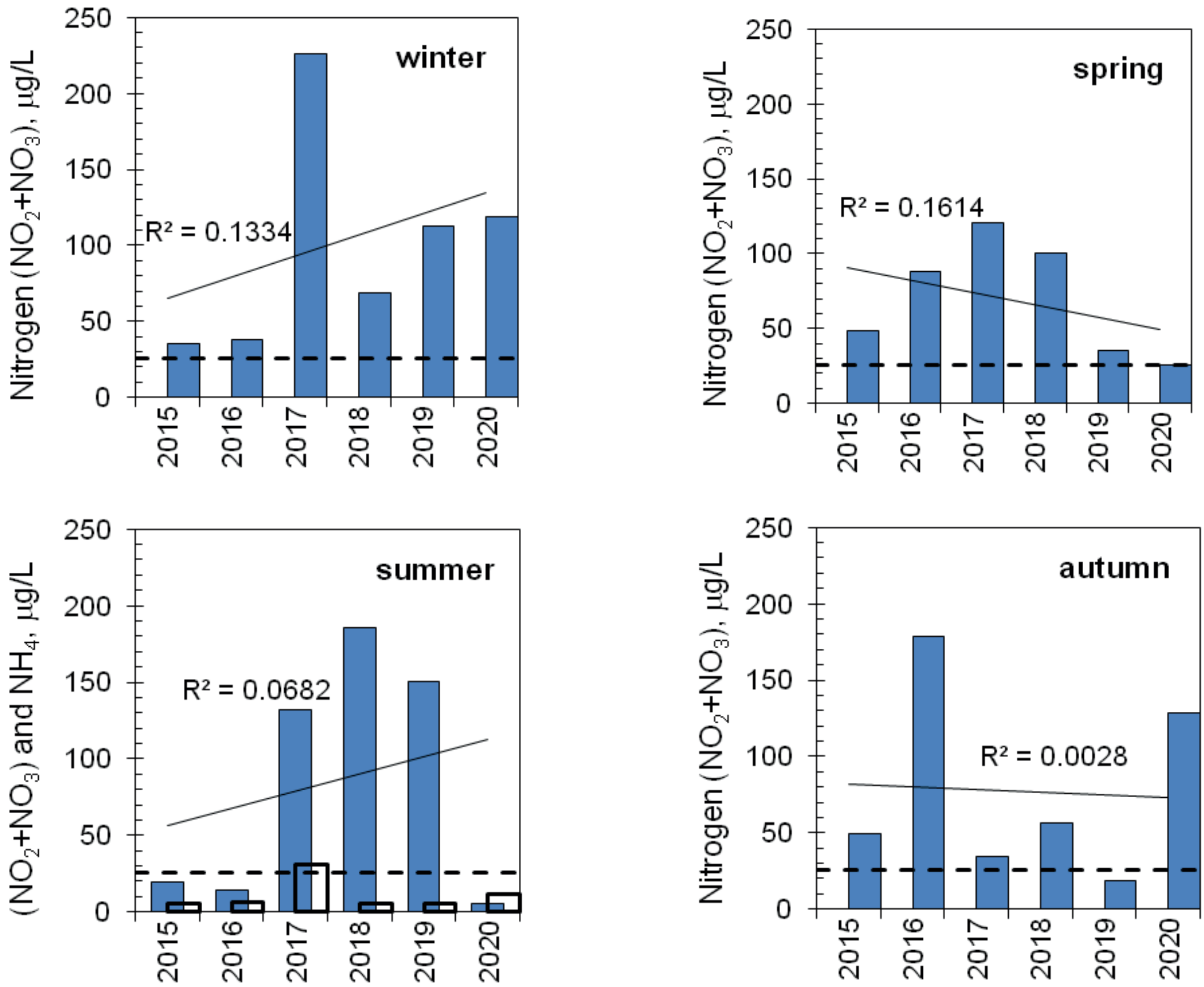


Figure 4.1.10. DIN concentrations at the surface of the northern part of Amursky Bay in 2015-2020 showing linear trend (solid line), baseline (dotted line) and trend coefficients (R^2); concentration of ammonium nitrogen is shown for summer season by transparent bars

4.2. *Chlorophyll a* concentration in the water column

4.2.1. China (Jiaozhou Bay)

As stated earlier, the baseline value used in this study was 5 µg/L of *Chlorophyll a*. From 2011 to 2018, the annual value of *Chlorophyll a* ranged from 2.503 to 6.416, with an average of 4.067 (Figure 4.2.1 below). The annual mean value was higher than the baseline value only in the inner part of the bay in 2011 and in 2013. In conclusion, mean concentration of 5 µg/L is suitable target to assess the status of *Chlorophyll a* in the Jiaozhou Bay of China. However this baseline value cannot be applied to other regions considering the high variation of *Chlorophyll a*.

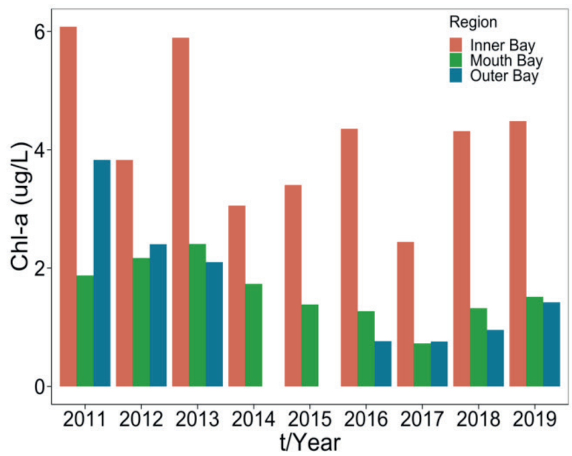


Figure 4.2.1. Temporal variations of <u>*Chlorophyll a*</u> concentrations in three different areas of Jiaozhou Bay of China from 2011 to 2019.

4.2.2. Japan (Hakata Bay and Toyama Bay)

<u>*Chlorophyll a*</u> concentrations in sea water in Hakata Bay are systematically monitored by Fukuoka city. Surface, middle, and bottom sea water samples are collected monthly at stations in the eastern, central, and western areas of the bay. These values are published in Fukuoka City Water Survey Debrief Reports. Annual average concentrations of <u>*Chlorophyll a*</u> at each station from 2010 to 2019 were analyzed.

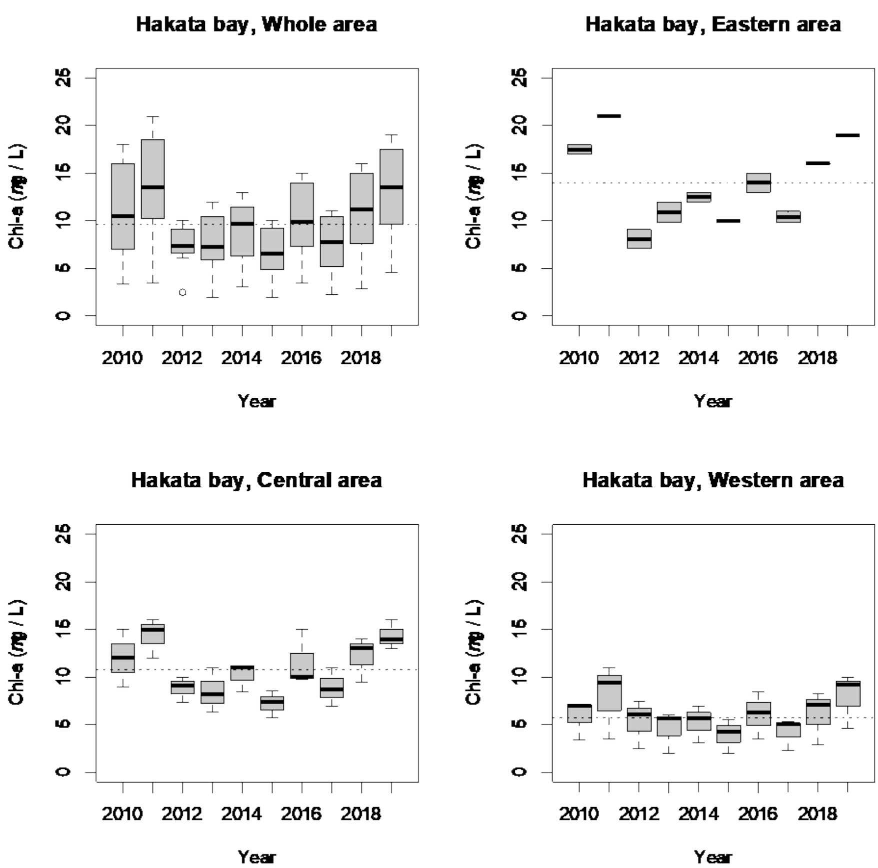


Figure 4.2.2. Boxplots showing the variation of average <u>*Chlorophyll a*</u> concentrations in Hakata Bay (dotted lines indicate average levels in each area)

Figures 4.2.2 shows boxplots of annual average *Chlorophyll a* concentrations for the whole bay and separately for the eastern, central, and western areas of the bay. Linear Mixed Model (LMM) analysis, in which each station is treated as a random effect, does not detect significant linear trends in each area during the entire period (2010-2019). However, since increases in *Chlorophyll a* concentrations in recent years are visually recognizable in Figure 4.2.2, LMM analysis is also applied separately to the first five years (2010-2014) and to the next five years (2015-2019). The results suggested that *Chlorophyll a* concentrations remained at low levels until 2015 but increased in recent years, exceeding the baseline values.

In Toyama Bay, monitoring is conducted by NPEC on a monthly basis, but missing observations occur irregularly in some months and stations. Therefore, the resultant data cannot be treated as monthly time series data. As an alternative, average quarterly *Chlorophyll a* concentrations were calculated for each station and their temporal changes are plotted in Figure 4.2.3. Figure 4.2.3 clearly demonstrates large seasonal fluctuations of *Chlorophyll a* concentrations, being higher in the second and/or third quarter(s). Since long-term changes are masked by large seasonal fluctuations, inter-annual trends of the average quarterly *Chlorophyll a* concentrations are plotted by each quarter in Figure 4.2.4. Figure 4.2.4 demonstrates that *Chlorophyll a* concentrations are generally higher in the second and third quarters (exceeding the baseline value of 5 µg/L) and that decreasing trends may be detectable in the average values for second and third quarters. Figures 4.2.3 and 4.2.4 also indicate that long-term continuous data are only available for stations 3 and 5. Temporal changes in quarterly or annual average *Chlorophyll a* concentrations at stations 3 and 5 were analyzed and significant decreasing trend has been detected from 2004 to 2010 (p-values = 0.011 and 0.012 for stations 3 and 5, respectively). No significant inter-annual trends were detected for recent years from 2011 to 2019 (p-values = 0.139 and 0.786, for stations 3 and 5, respectively).

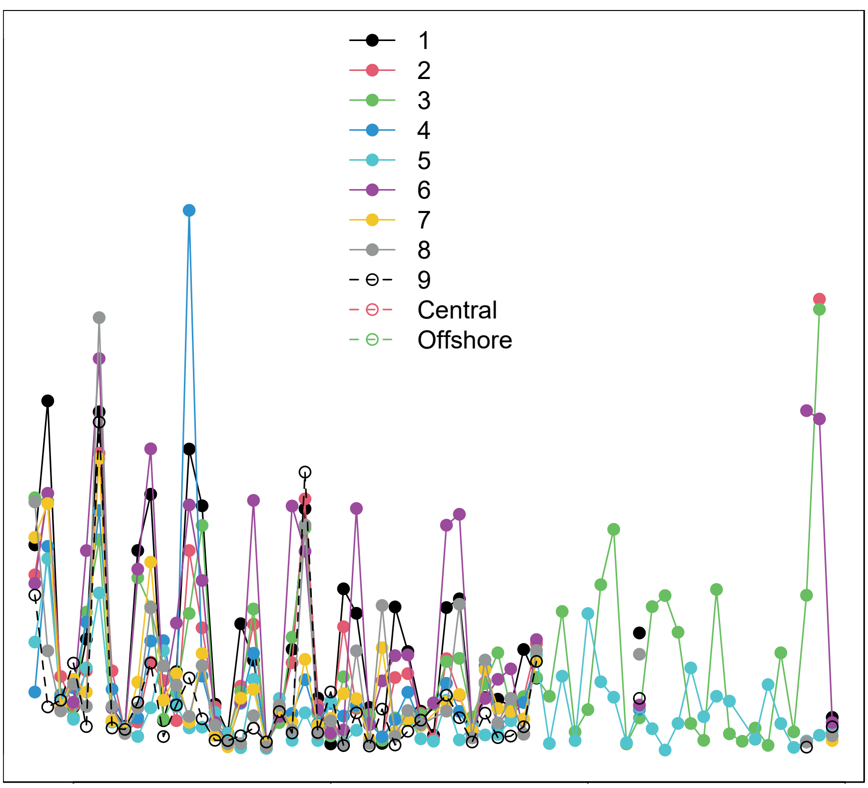


Figure 4.2.3. Temporal changes in average quarterly *Chlorophyll a* concentrations for each station in Toyama Bay

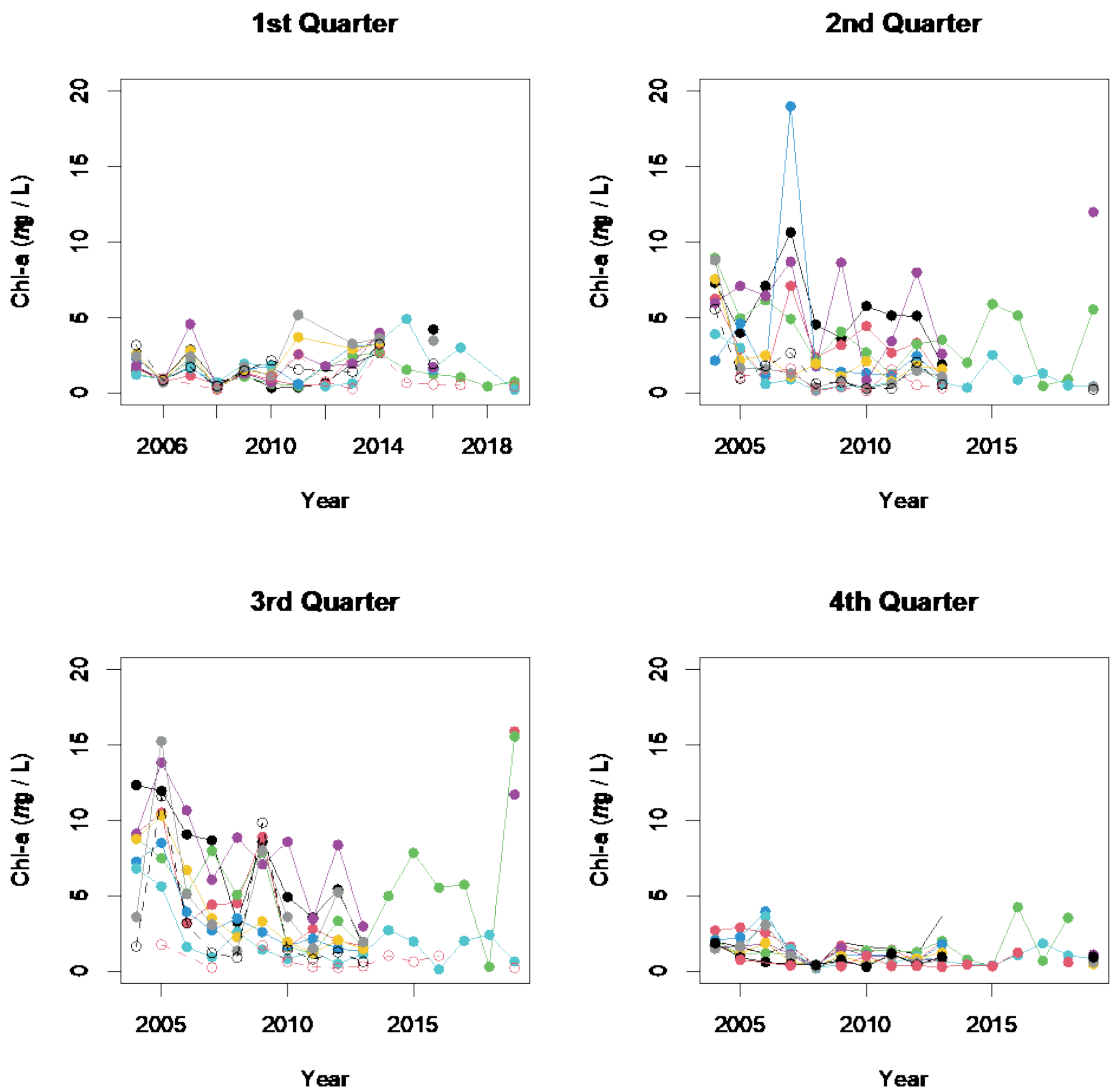


Figure 4.2.4. Inter-annual changes in average quarterly *Chlorophyll a* concentrations in Toyama Bay for different quarters

4.2.3. Korea (Masan Bay)

Based on the national coastal monitoring data from 2016 to 2020 (MOF, 2021a), the concentration of *Chlorophyll a* in Masan Bay was generally similar over the last 5 years (Fig. 4.2.5). The annual mean *Chlorophyll a* ranged from 4.61 to 8.16 μg/L, which was about nine times lower than the baseline value. As in the case of nutrients, the concentration of *Chlorophyll a* was relatively high in the inner part of the estuary, into which freshwater flows. Overall, the concentration of *Chlorophyll a* met the suggested NOWPASP EcoQO target.

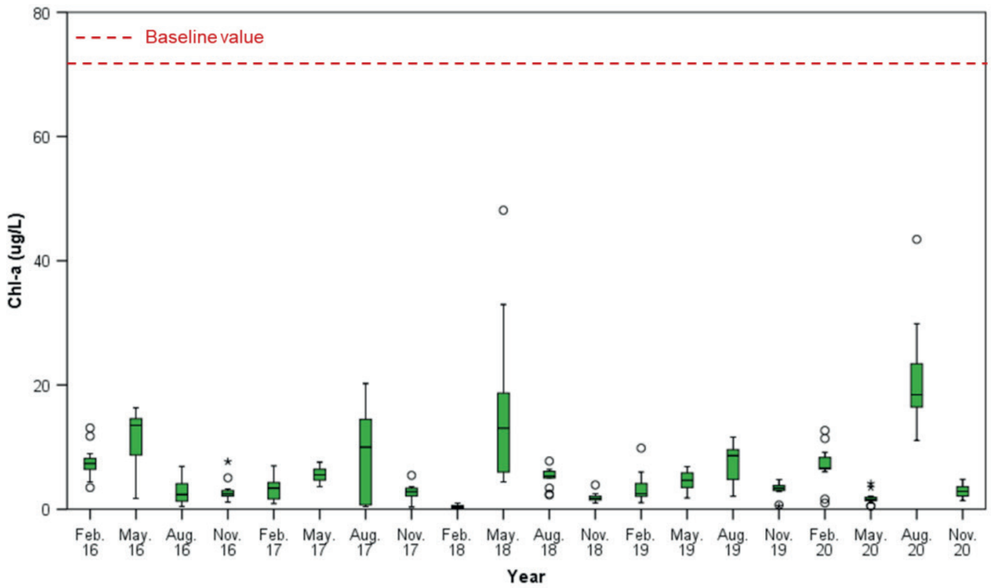


Figure 4.2.5. Temporal variations of *Chlorophyll a* in Masan Bay from 2016 to 2020

4.2.4. Russia (Amursky Bay)

To assess eutrophication of the Amursky Bay, mean seasonal *in situ* values of *Chlorophyll a* above the thermocline (measured by fluorimeter and corrected) were compared with the baseline: 1.5 µg/L (Figures 4.2.6 and 4.2.7). It should be noted again that this baseline value is considerably lower than the level 5 µg/L of *Chlorophyll a* recommended by CEARAC (CEARAC, 2013).

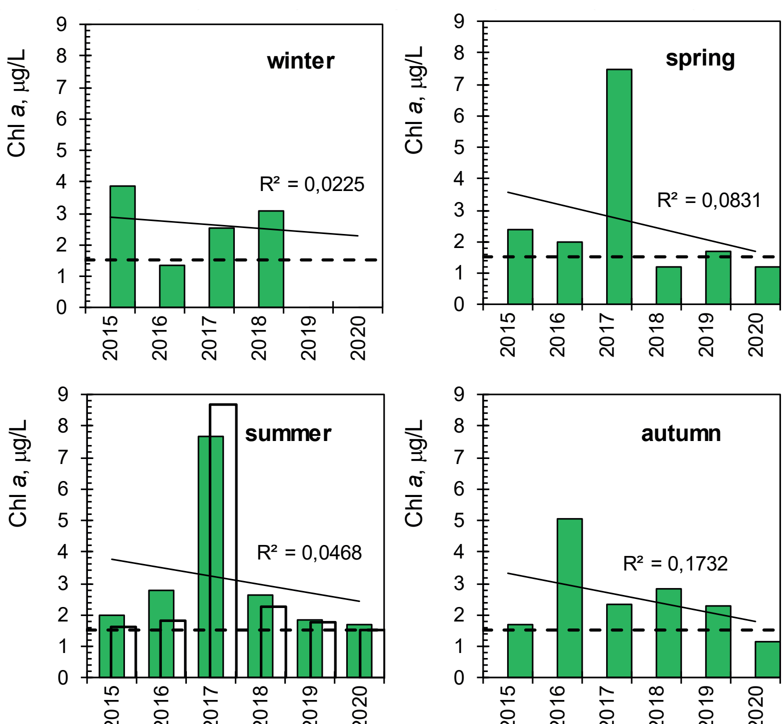


Figure 4.2.6. *Chlorophyll a* concentrations in the upper layer of the southern Amursky Bay, showing trend (solid line), baseline (dotted line), values for the whole water column in summer (transparent bars) and trend coefficients (R^2)

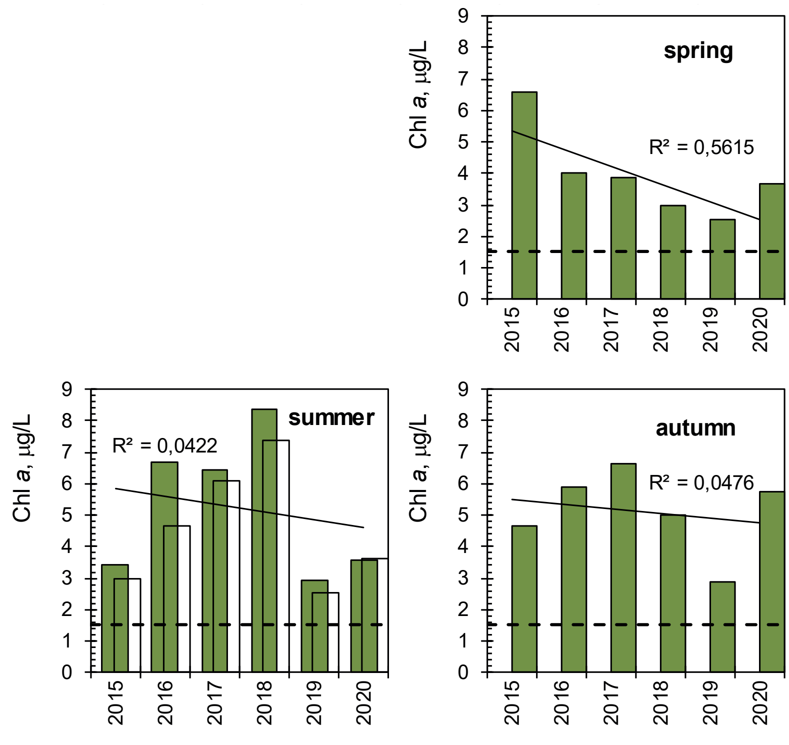


Figure 4.2.7. *Chlorophyll a* concentrations in the upper layer of the northern Amursky Bay, showing trend (solid line), baseline value (dotted line), values for the whole water column in summer (transparent bars) and trend coefficients (R^2)

Chlorophyll a concentrations decreased in both southern and northern areas of the Amursky Bay in all seasons, the trend for spring in the northern area was statistically significant. Overall, available data have shown that NOWPAP EcoQO target for *Chlorophyll a* was not achieved: monitoring results were higher than baseline value in many cases (even if using baseline of 5 µg/L, as recommended by CEARAC).

4.3. Concentration of contaminants in water and sediments

4.3.1. China (Jiaozhou Bay)

The following eight parameters are being routinely monitored in seawater in China: Hg, Cd, Pb, Cr, As, Zn, Cu and Oil. National standards for these parameters (NSQS 1997) were used as baseline values. Considering that Jiaozhou Bay is used for shellfish aquaculture and a sizable part of the bay is covered by aquaculture farms, class II standards were used. For contaminants in sediments, class I standards were used (NSMSQ, 2002).

As shown in Figures 4.3.1 and 4.3.2 below, concentrations of all contaminants during the period from 2011 to 2019 were lower than the baseline values (baseline values are shown as dashed lines). No statistically significant trends were observed during that period. Therefore, it is possible to use national standards as the baseline values for the relevant NOWPAP EcoQO target in Jiaozhou Bay.

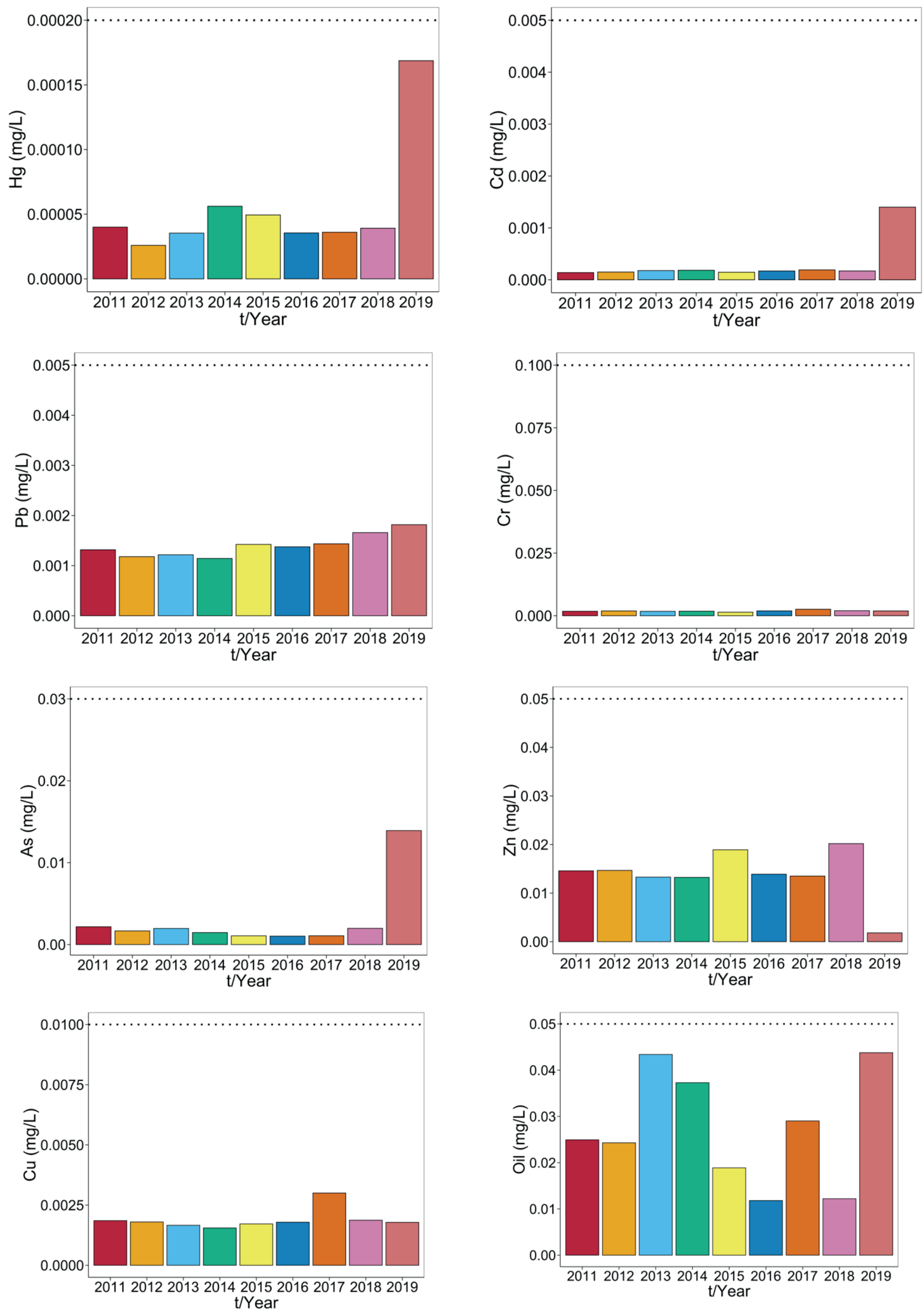


Figure 4.3.1. Annual mean concentrations of contaminants in sea water of Jiaozhou Bay

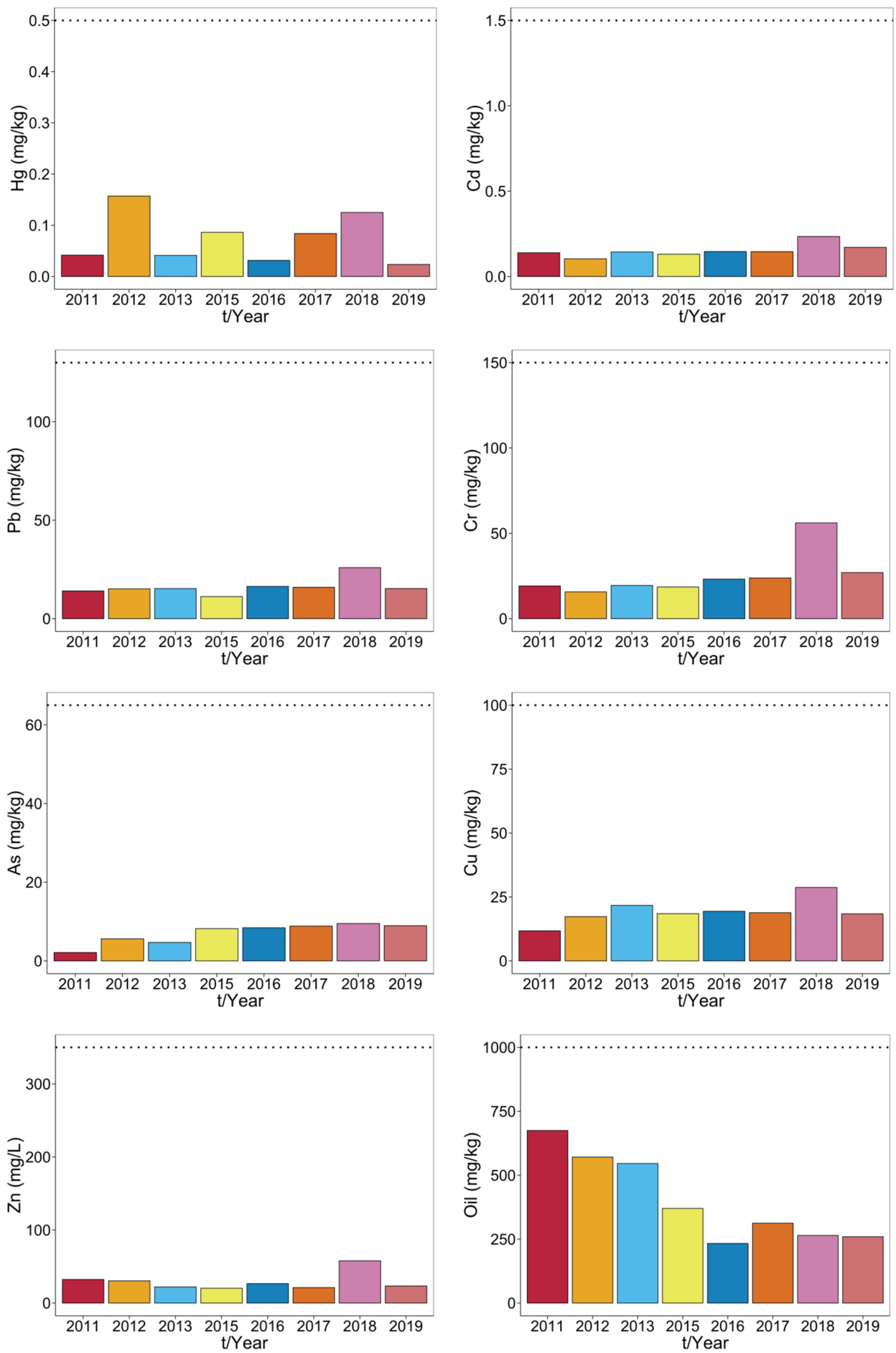


Figure 4.3.2. Annual mean concentrations of contaminants in sediments of Jiaozhou Bay

4.3.2. Japan (Hakata Bay and Toyama Bay)

Seawater contaminants in Hakata Bay

As mentioned above, Environmental Quality Standards (EQS) are established in Japan on the basis of the legal framework. Many local governments in Japan conduct regular monitoring of sea water and bottom sediment quality to assess environmental conditions in their administrative areas. In Hakata Bay, Fukuoka city conducts regular sampling of sea water and bottom sediment at eight stations. Several basic items such as arsenic, nickel, and molybdenum are measured every year on a monthly basis, but other items are measured in some stations once in three years. Figure 4.3.3 shows inter-annual variations in arsenic, hexavalent chromium, molybdenum and uranium in sea water from 2010 to 2019. Concentrations of most items were below the EQS or below the detection limit. Exceptionally, uranium concentrations in sea water are higher than the guideline value. However, the higher uranium concentrations are not caused by artificial contamination, but reflect the higher natural level in the area.

Bottom sediment contaminants in Hakata Bay

Fukuoka city has been conducting regular sampling of bottom sediment annually in August at eight stations where heavy metals and PCBs are measured. Figure 4.3.4 shows inter-annual variations in lead (Pb), total chromium (TCr), total mercury (THg) and PCBs in bottom sediments observed from 2005 to 2019. Since there are no EQS for bottom sediment contaminants, average values are shown with dotted lines as baseline levels to detect recent trends. Pb shows significant linear increasing trends both for the entire period and for the recent five years (LMM, p values <0.001 for both 2005-2019 and 2015-2019, respectively). TCr shows significant linear decreasing trends both for the entire period and for recent five years (LMM, $p <0.001$ and $p = 0.002$ for 2005-2019 and 2015-2019, respectively). THg does not show significant increasing trends for the entire period but increases significantly in recent years ($p = 0.479$ and 0.008 for 2005-2019 and 2015-2019, respectively). PCBs are detected sporadically in some years before 2011, but are lower than the detection limit in recent years.

Toyama Bay

Concentrations of heavy metals in bottom sediments are reported in White Paper on the Environment of Toyama Prefecture. Heavy metal concentrations in bottom sediments are generally higher from the 1970s to 2000, but remain at lower levels after 2000 (Figure 4.3.5). Results of the LMM analysis detect significant decreasing trends only for cadmium. No significant linear trends are detected for all the heavy metal elements for the recent five years ($p = 0.248$, 0.616, 0.889, 0.187, 0.189 for THg, Cd, Pb, As, and TCr, respectively).

These results demonstrate that contaminant levels are generally maintained below the national standard/guideline levels. Long-term data for Toyama Bay suggest that heavy metal levels in bottom sediments are maintained at low levels after 2000.

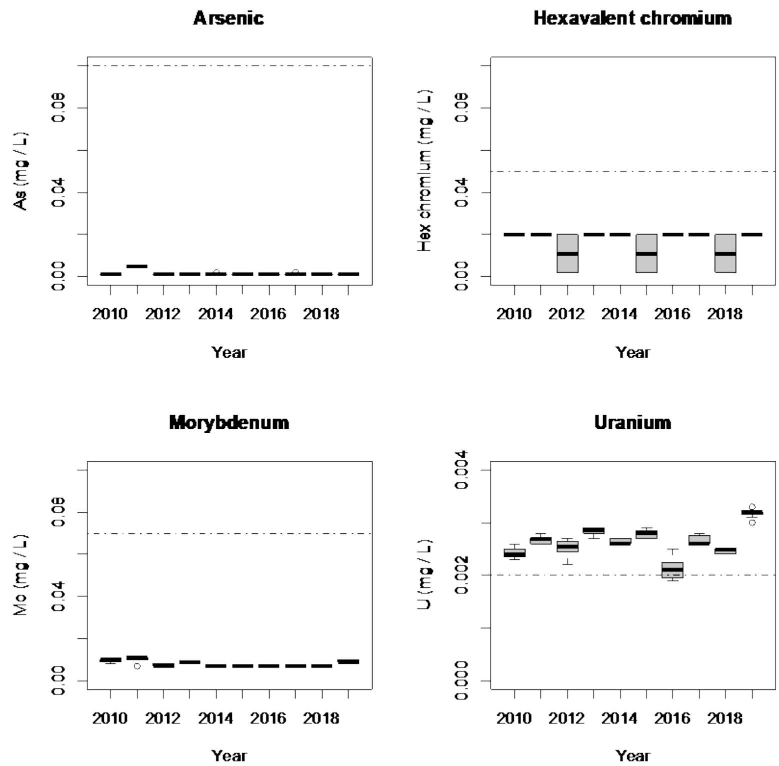


Figure 4.3.3. Boxplots showing concentrations of some contaminants in sea water of Hakata Bay (dotted lines indicate EQS)

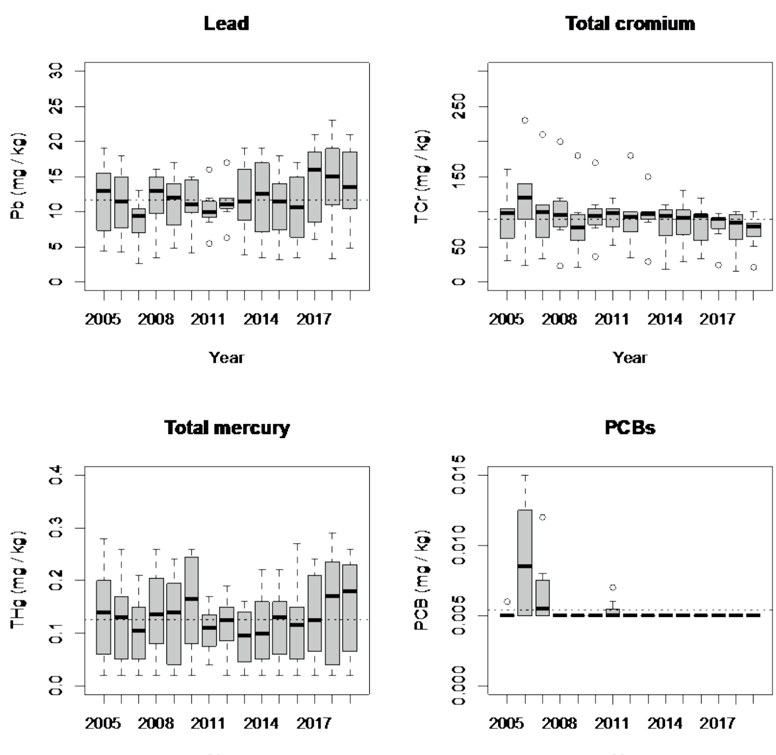


Figure 4.3.4. Boxplots showing concentrations of some contaminants in bottom sediments of Hakata Bay (dotted lines indicate average values)

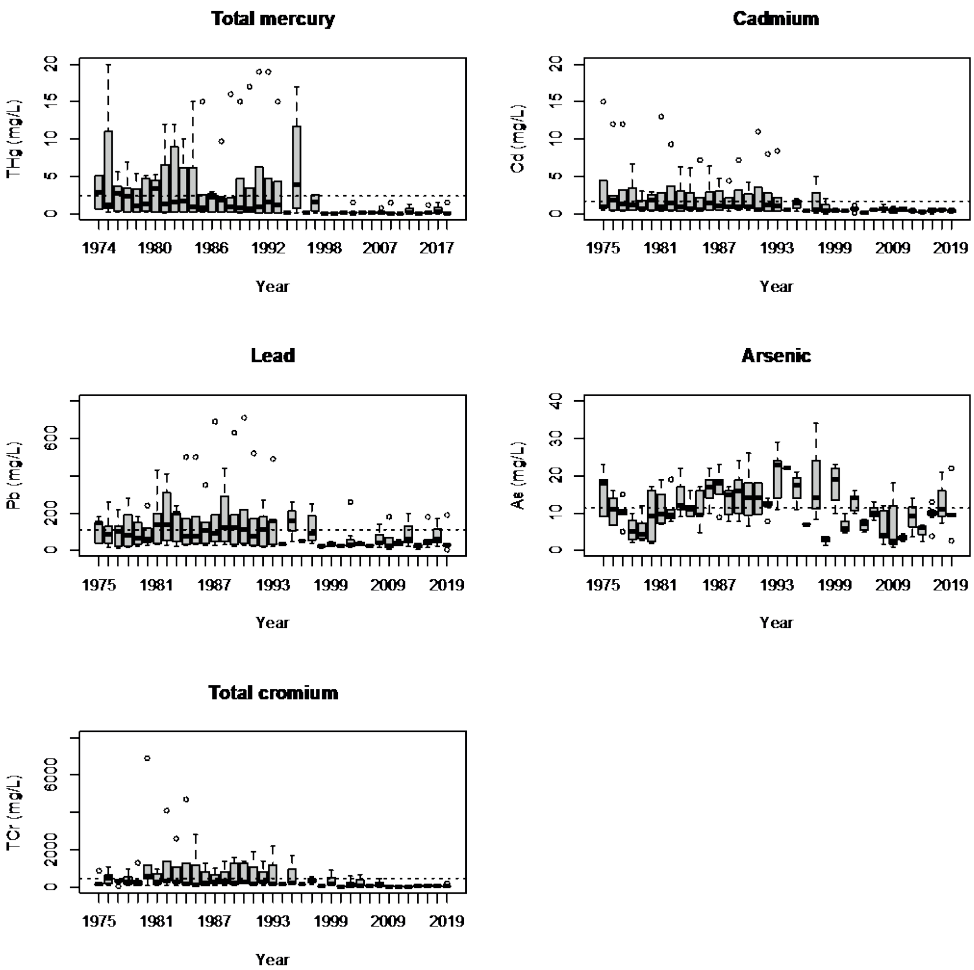


Figure 4.3.5. Boxplots showing heavy metal concentrations in bottom sediments of Toyama Bay (dotted lines indicate average levels of each substance)

4.3.3. Korea (Ulsan bay)

Seawater contaminants

Based on the results of the national marine ecosystem comprehensive survey over the last 5 years, from 2016 to 2020 (MOF, 2020), the annual mean concentrations for each metal varied as follows: As (0.25–0.85 µg/L), Cd (0.02–0.24 µg/L), Cr (0.15–0.53 µg/L), Cu (0.16–0.25 µg/L), Hg (0.04–2.17 ng/L), Ni (0.03–0.23 µg/L), Pb (0.03–2.17 µg/L), and Zn (0.02–0.93 µg/L). The annual mean concentrations of metals did not exceed chronic and acute guidelines (Fig. 4.3.6 and 4.3.7). Overall, the EcoQO target for contaminants seems suitable for Ulsan Bay.

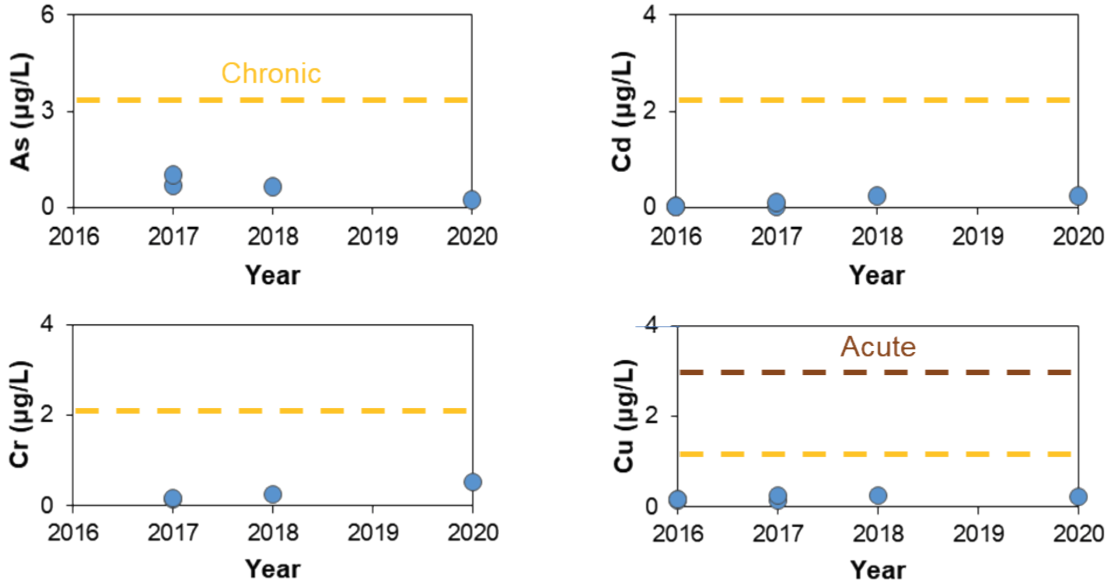


Figure 4.3.6. Concentrations of As, Cd, Cr, and Cu in seawater of Ulsan Bay from 2016 to 2020; yellow and brown lines represent chronic and acute guidelines, respectively

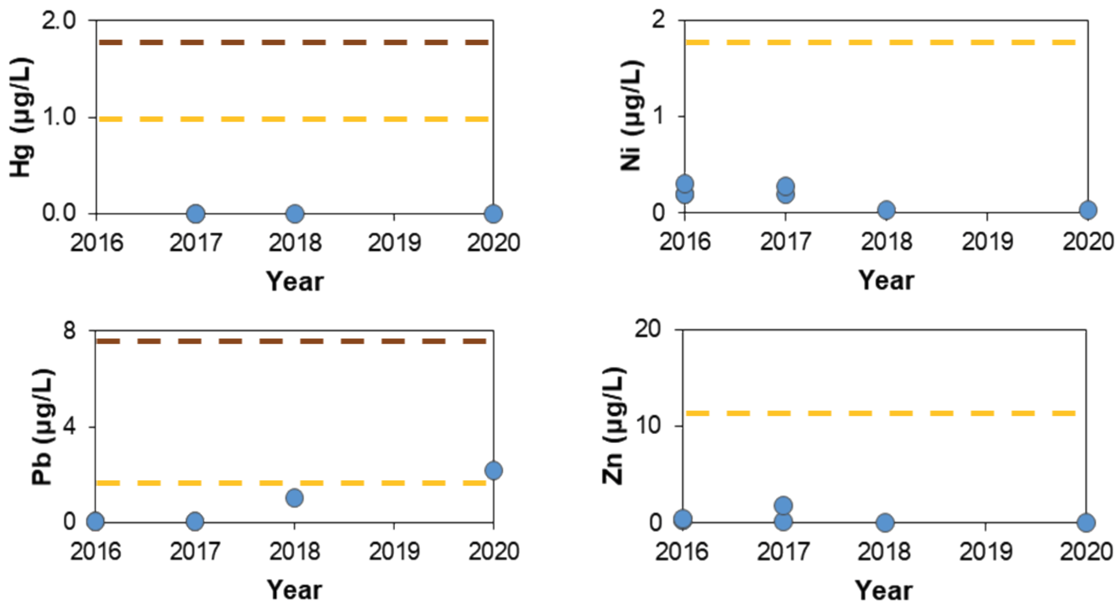


Figure 4.3.7. Concentrations of Hg, Ni, Pb, and Zn in seawater of Ulsan Bay from 2016 to 2020; yellow and brown lines represent chronic and acute guidelines, respectively

<u>Bottom sediment contaminants</u>

Because the concentration of heavy metals varies with particle size, metal concentrations corrected for differences in particle size using Li were used. For As, Cd, Cr, Hg, Ni and Pb, measured concentrations were directly compared with standards (TEL and PEL, see earlier). For Cu and Zn, the measured concentration of Li was corrected for particle size, and compared with the standards (MLTM, 2012). If the sample was less than 33.1 mg/kg of Li or the particle size corrected concentration was negative, it was directly compared with the standards without implementing particle size correction.

The annual mean concentrations measured from 2016 to 2020 for each metal were as follows: As (10.6–12.2 mg/kg), Cd (0.43–0.54 mg/kg), Cr (67.5–82.2 mg/kg), Cu (20.8–22.6 mg/kg), Hg (0.10–0.30 mg/kg), Ni (30.4–33.4 mg/kg), Pb (54.2–65.2 mg/kg), and Zn (70.9–75.2 mg/kg), respectively. These data are plotted in Fig. 4.3.8 and 4.3.9. Relatively high concentrations of metals in sediments were found near the industrial and estuarine areas. The concentration of As, Cd, Cu, Hg, Pb, and Zn often exceeded the TEL, but did not exceed PEL. Overall, concentrations of metals in the coastal sediments of Ulsan Bay can be used for testing of NOWPAP EcoQO target.

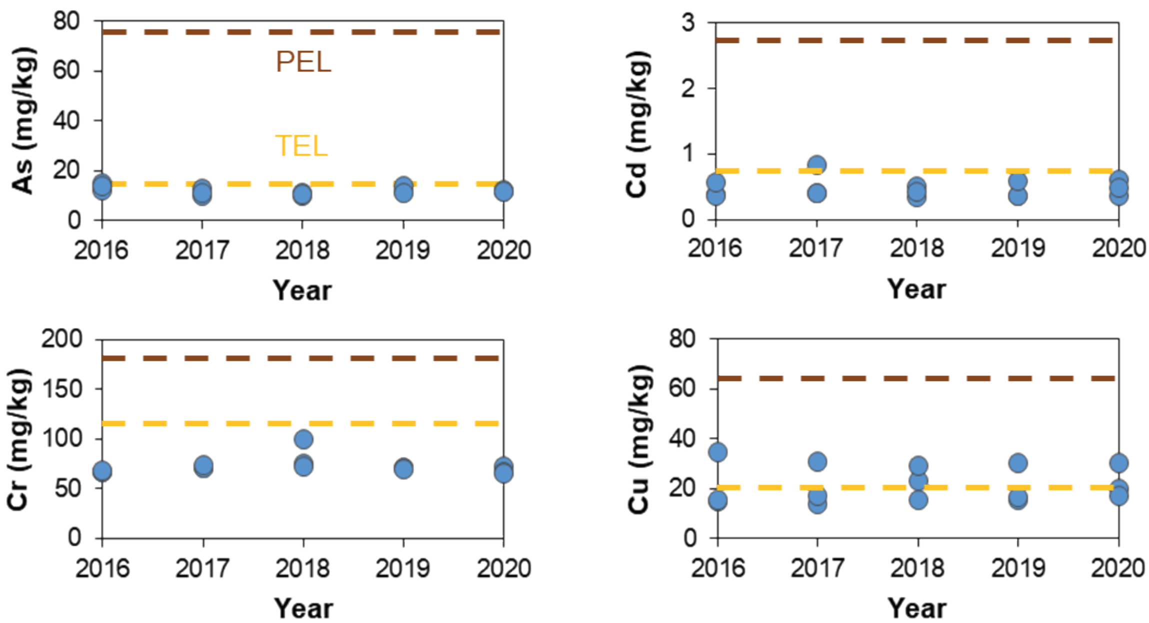


Figure 4.3.8. Concentrations of As, Cd, Cr, and Cu in bottom sediment of Ulsan Bay; yellow and brown lines represent TEL and PEL, respectively

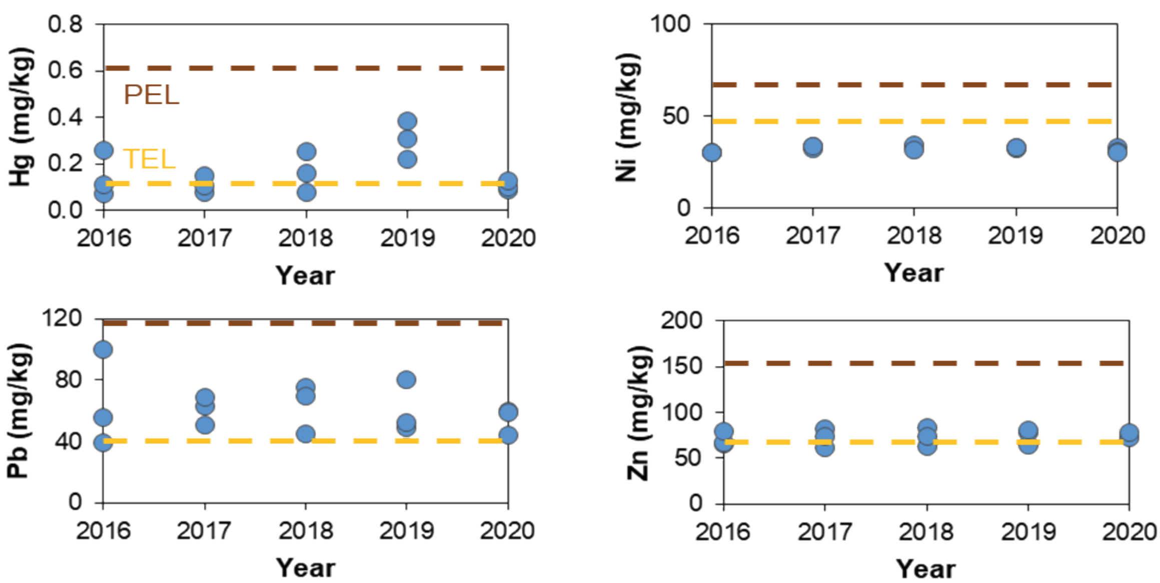


Figure 4.3.9. Concentrations of Hg, Ni, Pb, and Zn in bottom sediment of Ulsan Bay; yellow and brown lines represent TEL and PEL, respectively

3.3.4. Russia (Amursky Bay)

As mentioned earlier, Russian national standards were used for contaminants in sea water (Hg, Ni, Cu, Pb, Cd, Zn, Mn, Fe, and oil) and Chinese national standards (first class) were used for contaminants in bottom sediments (Hg, Cu, Pb, Cd, Zn, Mn, Fe, Co, Nl, Cr, oil, and phenols). Data on contaminants were taken from annual reports published in Moscow (Quality of marine waters by chemical parameters, in Russian).

In 2014-2019, the mean annual values of all contaminants in water were lower than the baseline values, except of the oil and iron (Fe) in several years, though single samples showed the maximum values of pollution by all contaminants above the baselines (Figure 4.3.10). High iron content in the natural waters is a regional feature of Primorye caused by mineral composition of soils. Year-to-year changes of contaminant concentrations had shown no significant trend.

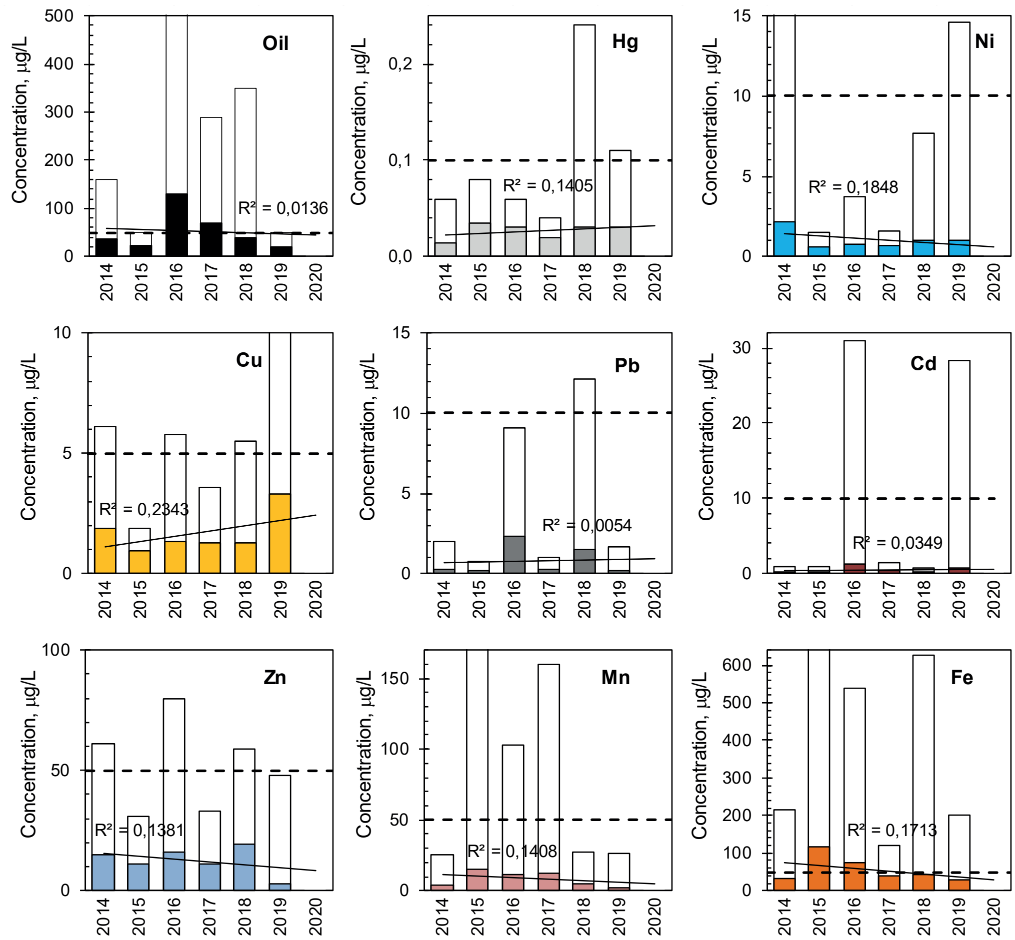


Figure 4.3.10. Mean annual concentrations of contaminants in the Amursky Bay water showing linear trends (solid lines), baseline values (dotted lines) and trend coefficients (R^2). Maximum annual values are shown by white bars

Mean values of bottom sediments contamination exceeded occasionally the baseline values for Hg and Cd (the baseline was not available for Fe and phenols). However, for other contaminants (Cu, Pb, Zn, and Cr) even the maximum concentrations did not exceed the baseline values (Figure 4.3.11). Negative trends were observed for year-to-year changes of almost all contaminants, except of Pb and Zn with zero trends. However, all trends except Fe were statistically insignificant.

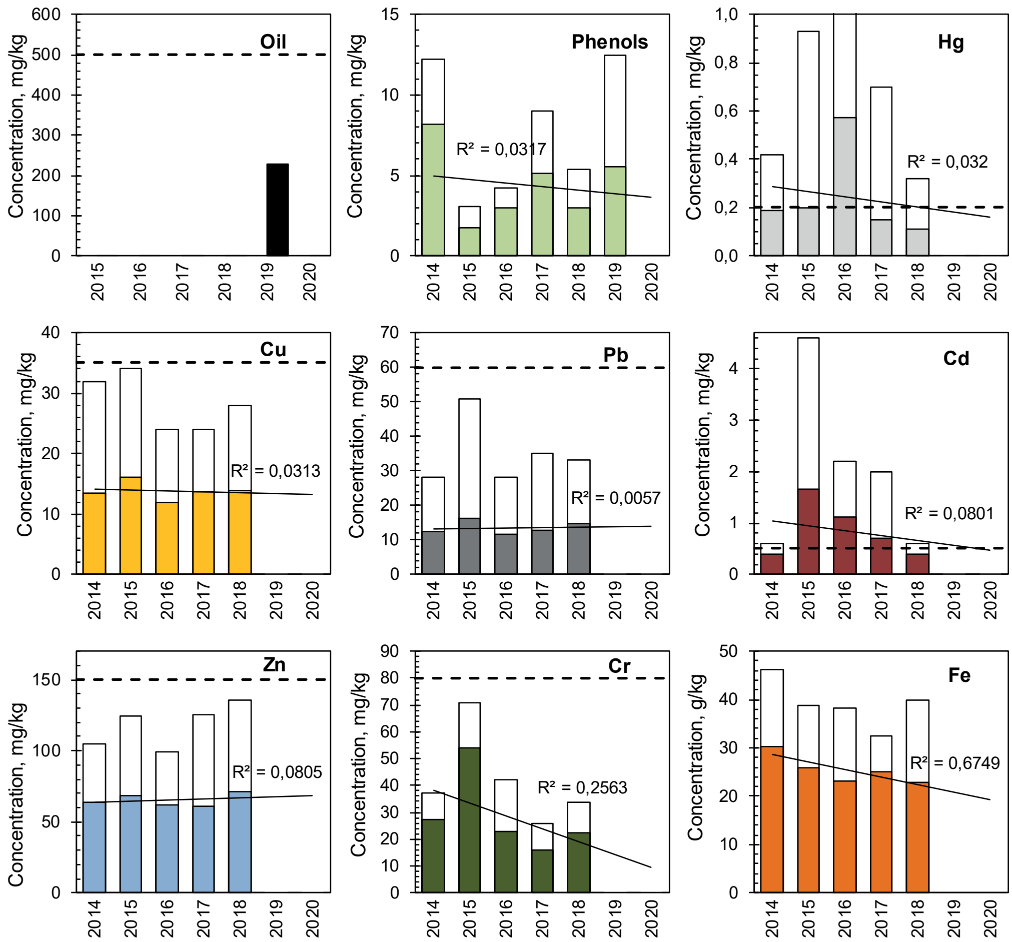


Figure 4.3.11. Mean annual concentrations of contaminants in sediments of the Amursky Bay showing linear trends (solid lines), baseline values (dotted lines) and trend coefficients (R^2). Maximum annual values are shown by white bars

4.4. Trends in the amount and composition of litter washed ashore

4.4.1. China

As mentioned earlier, due to data deficiency, the Shilaoren Beach outside the Jiaozhou Bay has been selected as the study area. From 2012 to 2018, the average amount of litter washed ashore was 286,190 pieces/km^2. The highest value was observed in 2012, and the lowest value in 2018 (Figure 4.4.1). There is a significant decreasing trend (Mann-Kendall test, $p < 0.05$) in the amount of litter washed ashore in the Shilaoren Beach. Therefore, the suggested NOWPAP EcoQO target for marine litter washed ashore is suitable for China.

The conclusion about the decreasing trend of marine litter washed ashore is confirmed by the findings within the second phase of the Yellow Sea Large Marine Ecosystem (YSLME) project. Figure 4.4.2 below shows the results of marine litter monitoring on 11 beaches in China from 2010 to 2018: (http://www.yslmep.org/wp-content/uploads/2020/08/YSLME-Fact-Sheet-Marine-Litter-FINAL-08102020.pdf).

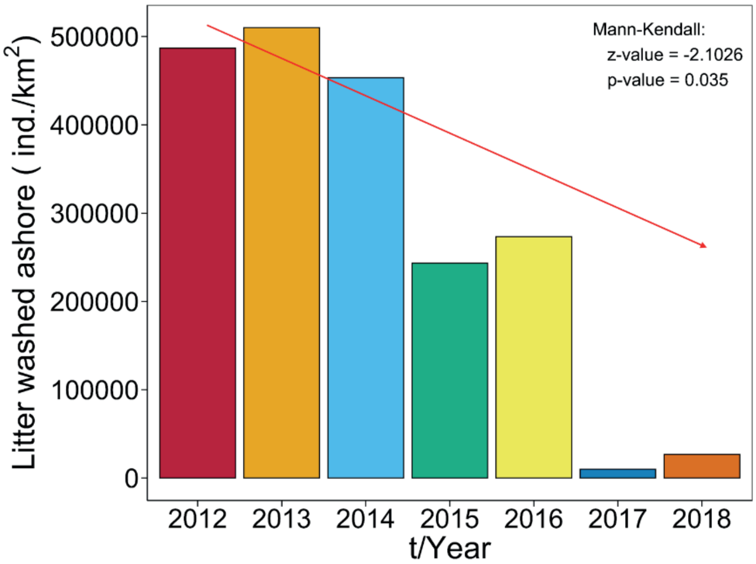


Figure 4.4.1. Annual values of litter washed ashore in the Shilaoren Beach from 2012 to 2018

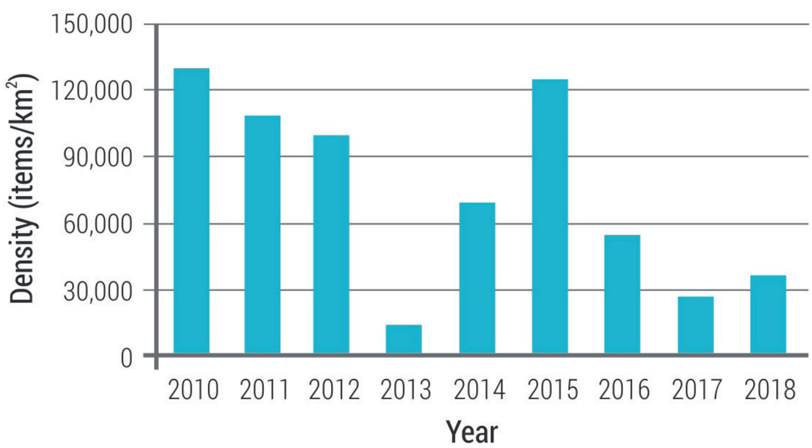


Figure 4.4.2. Beach litter at 11 monitoring sites along the Yellow Sea coast of China from 2010 to 2018

4.4.2. Japan (Toyama Bay only)

As indicated earlier, there is no detailed beach litter data for Hakata Bay. In Toyama Bay, NPEC has been conducting beach clean-up surveys at five locations since 2008 with the cooperation of local governments, elementary schools, universities, NGOs, and voluntary citizens. Five beaches were surveyed once a year in September or October. Beach litter was collected, classified into eight categories (plastic, rubber, styrofoam, fabric, glass and pottery, metal, and other), and recorded. Data on the density of each debris category in weight per unit area (g /100m^2) from 2014 to 2019 were analyzed.

Figure 4.4.3 shows Inter-annual fluctuations in the amount and composition of beach litter at five beaches along Toyama Bay from 2014 to 2019. Total amount (density) of beach litter shows very large inter-annual fluctuations, and no decreasing or increasing trends are discernible. In most locations and years, plastic occupied majority of the beach litter.

Since beach litter surveys cover only six years and litter density data have very large inter-annual variations, simple average and/or normal approximation of confidence intervals are not appropriate

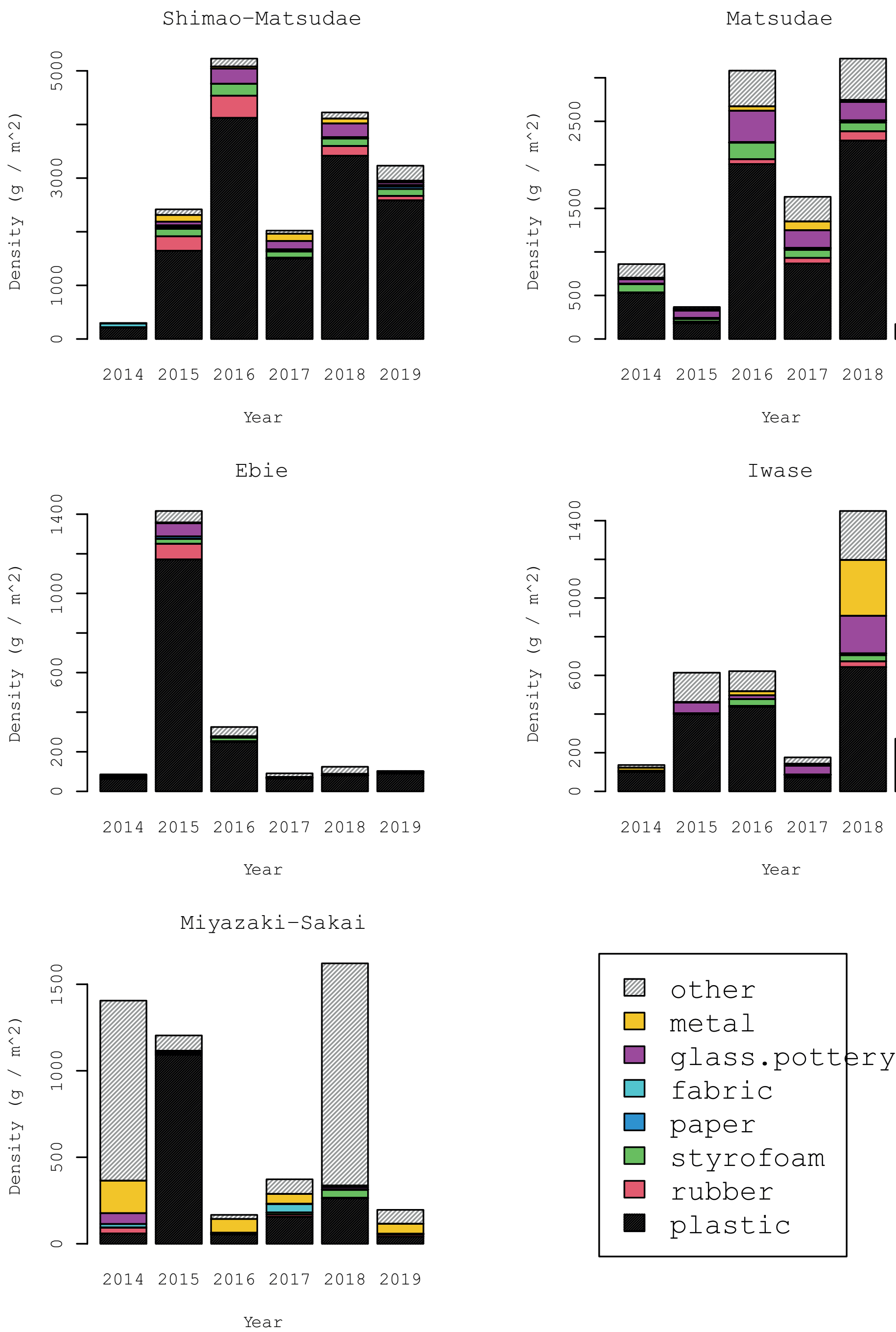


Figure 4.4.3. Inter-annual changes in beach litter composition collected along Toyama Bay (dark-shaded color indicates plastic)

as a benchmark for beach litter density. There are many possible reasons for the large inter-annual variations of beach litter density: oceanographic conditions such as currents and waves, meteorological conditions such as wind and precipitation, and anthropogenic factors such as dumping and clean-up activities before the survey (Forsberg et al., 2020; Hinate et al., 2020; Isobe et al., 2014; Ryan et al., 2009; Schwarz et al., 2019). In Toyama Bay, currents are supposed to have minor effects since Noto peninsula protects Toyama Bay against the Tsushima current (which flows basically from the west to the east), and most beach litter in Toyama Bay is supposed to originate from the near-by area (NPEC, personal communication). Precipitation may well have a large impact on the influx of litter through rivers. Figure 4.4.4 demonstrates the patterns of total beach litter densities and monthly precipitation observed at the nearby meteorological stations in the western and eastern areas of Toyama bay. In both areas, precipitation was higher in 2016 and 2018 and lower in 2017. Beach litter densities in Shimao-Matsudae, Matsudae and Iwase typically showed a pattern similar with precipitation. It is likely that precipitation is an important factor that determines the influx of litter from land through rivers.

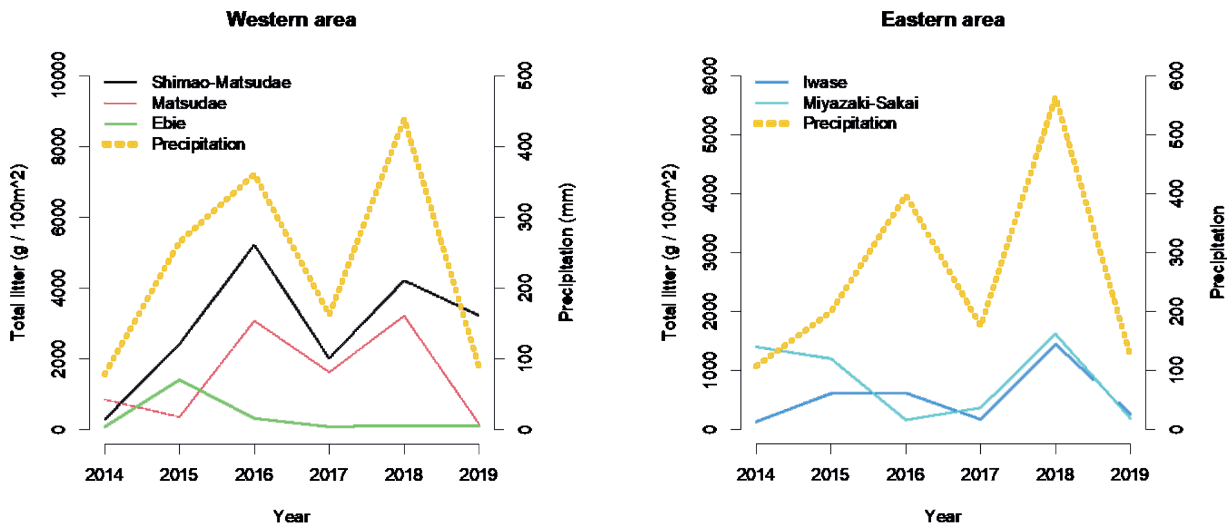


Figure 4.4.4. Relationships between total beach litter density and monthly precipitation in the western and eastern areas of Toyama Bay. Yellow dotted lines indicate precipitation observed at the nearby metrological station in September of the survey year

These results suggest that amounts of beach litter have large temporal fluctuations and therefore it is difficult to determine the inter-annual trends of beach litter amounts. One option to overcome this problem is to continue surveys at the same location for a long period. Another option is to collect relevant data on meteorological, oceanographic and anthropogenic factors for better interpretation of the trends and variations.

4.4.3. Korea (Masan Bay)

Based on the national onshore marine litter monitoring data over the last 5 years from 2016 to 2020 (MOF, 2021b), it was confirmed that the amount of marine litter washed ashore in Masan Bay significantly decreased ($P < 0.01$) over the study period (Fig. 4.4.5). From 2016 to 2020, the annual mean number of marine litter items found ashore in Masan Bay of Korea ranged from 107 to 927 count/100m, which decreased significantly in 2018, 2019, and 2020 compared to 2016 and 2017. Most marine litter in 2016–2017 was plastic (53.4%). However, proportion of plastic increased to 94.7% in 2018–2020. Overall, the amount of marine litter in the onshore coastal areas of Korea showed a statistically significant decrease, meeting NOWPAP EcoQO target.

The conclusion of decreasing trend in beached marine litter is confirmed (as in the case of China) by the findings within the second phase of the Yellow Sea Large Marine Ecosystem (YSLME) project. Figure 4.4.6 below shows the results of marine litter surveys on the beaches of Korea from 2008 to 2017: (http://www.yslmep.org/wp-content/uploads/2020/08/YSLME-Fact-Sheet-Marine-Litter-FINAL-08102020.pdf).

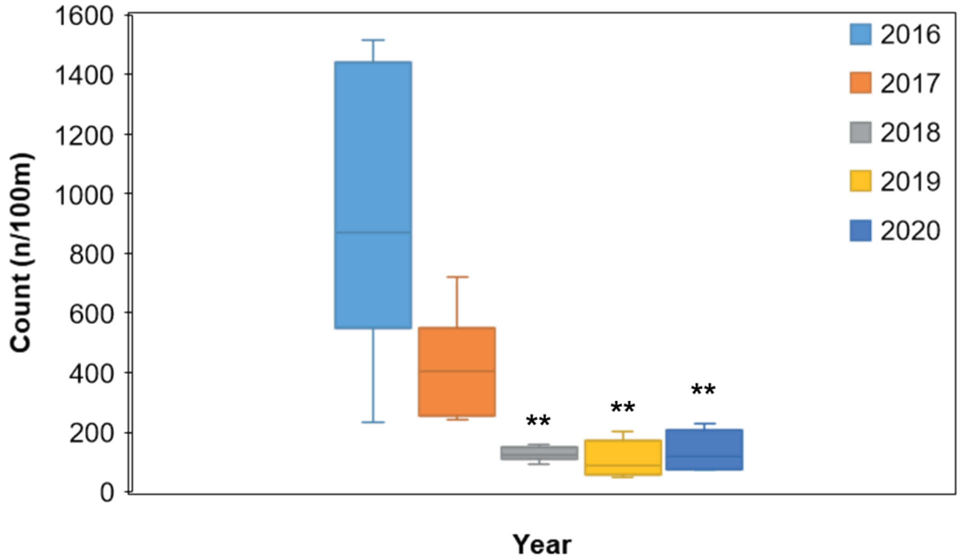


Figure 4.4.5. Temporal variation of the amount of marine litter washed ashore in Masan Bay **Indicates statistically significant difference (P < 0.01)

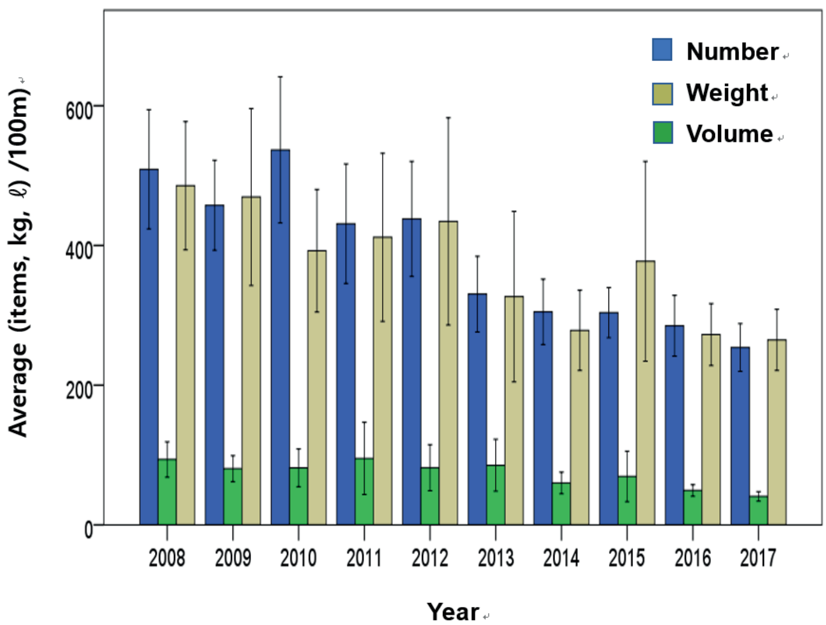


Figure 4.4.6. Temporal distribution of macro litter from 2008 to 2017 in Korea

The weight of marine litter washed ashore in Masan Bay has also significantly decreased ($P < 0.01$) over the last five years, from 2016 to 2020 (Fig. 4.4.7). The annual mean weight of marine litter ranged from 2.5 to 39.8 kg/100m, which decreased significantly in 2018 and 2019 compared to 2016, 2017, and 2020. In 2016–2017, marine litter by weight was primarily plastics (39.3%). In 2018–2020, the proportion of wood was the highest (32.4%), followed by glass (29.1%), plastic (25.3%), and other kinds of litter. Overall, the weight of marine litter washed ashore significantly decreased, meeting NOWPAP EcoQO target.

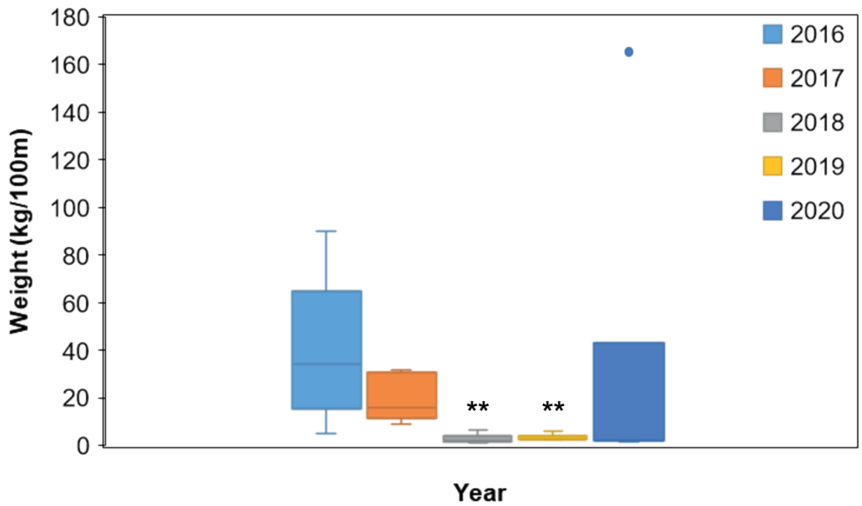


Figure 4.4.7. Temporal variation of the weight of marine litter in Masan Bay
**Indicates statistically significant difference ($P < 0.01$)

4.4.4. Russia (Amursky Bay and other locations)

Monitoring of marine litter on beaches in the Russian Far East is performed mainly through the International Coastal Cleanup (ICC) campaigns being held since 2007. For the period from 2007 to 2020, about 50 beaches of Primorsky Kray were investigated.

For testing the NOWPAP EcoQO target on marine litter, three beaches were selected with more detailed data available in recent years. One of these beaches (Fedorova Bay) is within the Amursky Bay, two others – outside Amursky Bay, in less industrialized and less populated areas.

Fedorova Bay. Study area was 1,250 square meters. During the years from 2016 to 2020, the average amount of marine litter washed ashore was 1.0 pieces/m^2. The highest value was observed in 2017, the lowest value in 2020 (Fig. 4.4.8).

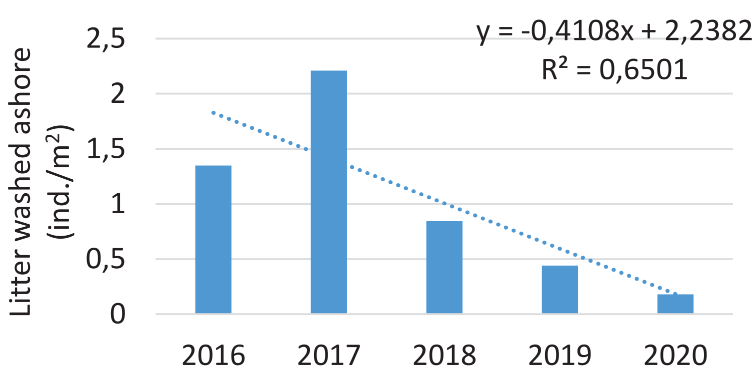


Figure 4.4.8. Marine litter washed ashore in the Fedorova Bay. The exponent test is applied to test the trend statistically

Baclan Bay. Study area was 1,280 square meters. During the years from 2016 to 2020, the average amount of marine litter washed ashore was 0.22 pieces/m^2. The highest value was observed in 2016, the lowest value in 2019 (Fig. 4.4.9).

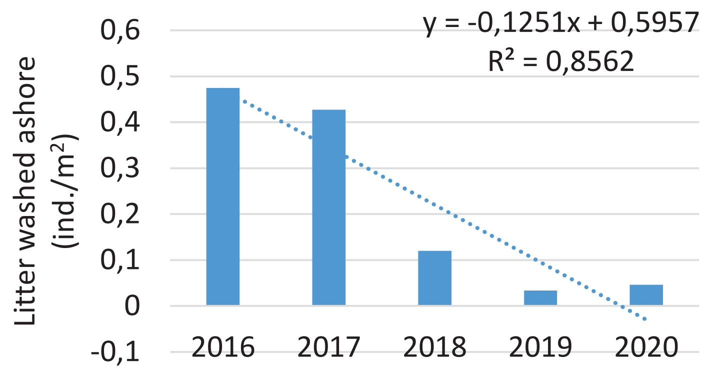


Figure 4.4.9. Marine litter washed ashore in the Baclan Bay. The exponent test is applied to test the trend statistically

Olga Bay. Study area was 5,250 square meters. During the years from 2016 to 2020, the average amount of marine litter washed ashore was 0.10 pieces/m^2. The highest value was observed in 2016, the lowest value in 2020 (Fig. 4.4.10).

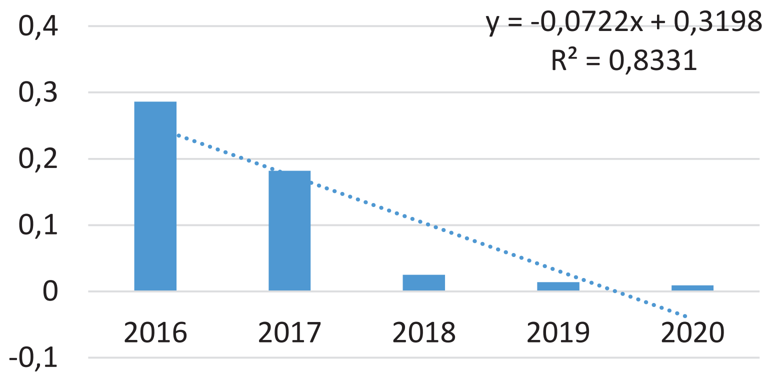


Figure 4.4.10. Marine litter washed ashore in the Olga Bay. The exponent test is applied to test the trend statistically

Despite obvious differences in the nature of these three beaches (two of them located far from industrialized and heavily populated areas), there is a clear decreasing trend in the amount of marine litter washed ashore, i.e. NOWPAP EcoQO target is applicable.

5. Conclusions

The main goal of this activity (phase 2) was to test the four NOWPAP EcoQO targets agreed upon in 2019. Table 5.1 below shows the results of this testing. The cells shaded in green do not mean that NOWPAP EcoQO targets have been actually met. Rather it means that the suggested EcoQO targets could be applied in NOWPAP member states. Of course, further studies are necessary (including outside the designated areas). Further research is also needed for some targets where the results of testing were not conclusive (e.g., marine litter in Japan or *Chlorophyll a* in Russia). Unfortunately, due to COVID-19 pandemic, the regional workshop planned for 2021 has not been held. As a result, experts did not have a chance to discuss and agree on common procedures to establish baseline values (when necessary). It could be seen from Table 5.1 that for testing some NOWPAP EcoQO targets experts used national standards while for testing other targets baseline values were applied. In the latter case, some experts used background values observed within the designated areas (i.e. very low concentrations) and monitoring data in recent 5 years often exceeded such baseline values. Other experts have used maximum concentrations plus one standard deviation and in such cases monitoring data during the last 5 years were mostly below such baselines. Obviously, further discussions among experts from NOWPAP member states are needed, including CEARAC experts dealing with eutrophication (i.e. concentrations of nutrients and *Chlorophyll a*).

Table 5.1. Applicability of suggested EcoQO targets in the designated areas of the NOWPAP member states

Indicators	NOWPAP EcoQO targets	China	Japan	Korea	Russia
Nutrients	Nutrient concentrations in the water column within the designated area do not exceed the baseline values or existing national standards	**Yes (DIN, DIP) Nat. St.**	**Yes (TN, TP) Nat. St.**	**Yes (DIN, DIP) BL**	**Yes (DIN, DIP) BL**
Chlorophyll a	*Chlorophyll a* concentrations within the designated areas do not exceed the baseline values	**Yes BL**	**Yes BL**	**Yes BL**	**Not conclusive (BL)**
Contaminants	During the last 5 years, contaminant concentrations in water and surface sediments within the designated area do not exceed the existing national standards or baseline values	**Yes Nat. St.**	**Yes Nat. St.**	**Yes Nat. St.**	**Yes Nat. St.**
Marine litter	During the last 5 years, there is a decreasing trend (statistically significant) in the amount of marine litter washed ashore	**Yes**	**Not conclusive**	**Yes**	**Yes**

Nat. St. – National Standards

BL – baseline values

One more goal of this activity was possible alignment with relevant SDG indicators. It was expected (from decisions of the IAEG-SDG) that after 2021 two SDG 14.1.1 indicators will be used: index of coastal eutrophication potential (ICEP) and floating plastic debris density. Before that "deadline", two proxy indicators have been used instead: *Chlorophyll a* and beach litter density, respectively. However, during 2020-2021, the following developments took place:

- The word "floating" has been removed from SDG indicator;
- Due to the fact that many Regional Seas programmes around the world use *Chlorophyll a* data as well as beach litter data (including plastic), these two parameters might be used by the IAEG-SDG even after 2021 (final decision has not been made yet by the IAEG-SDG as of December 2021).
- While at the global level mostly modeling data will be used (for both ICEP and plastic debris), at the national level more *in situ* data will be compiled: *Chlorophyll a*, nutrients, beach litter, visual observations, trawling for litter, etc. (see https://wedocs.unep.org/20.500.11822/35086).

Some suggestions included in the national reports submitted by nominated experts from NOWPAP member states are compiled below. As indicated earlier, the regional workshop planned in 2021 has not been held due to COVID-19 pandemic. Discussion of such suggestions and further way forward (including possible alignment of NOWPAP EcoQO targets with global SDG indicators) could be organized in the future, with involvement of POMRAC and CEARAC experts.

Some suggestions from nominated national experts

From China

The eutrophication is a common phenomenon in the NOWPAP member states. It is necessary to develop a unified tool to assess and compare the eutrophication status for NOWPAP member states. In China, the central government uses the eutrophication index (E) to classify the eutrophication status:

$$E = \mathrm{COD_{Cr}} \times \text{inorganic nitrogen} \times \text{active phosphate} \times 106/4500$$

$E \geq 1$ indicates eutrophication, $1 \leq E \leq 3$ indicates mild eutrophication, $3 < E \leq 9$ indicates moderate eutrophication, and $E > 9$ indicates severe eutrophication. Such approach is user-friendly for environmental managers and general public. We recommend the development of a standard and simplified tool such as E to compare the eutrophication status in the NOWPAP member states.

From Japan

Chlorophyll a concentrations in water column have very large seasonal fluctuations which can obscure the inter-annual trends. Collection of monthly *Chlorophyll a* data is needed in this regard. If monthly monitoring is too demanding, time-series analysis of satellite image data validated by regular *in situ* observation could be a practical alternative.

Analysis of beach litter data also revealed very large fluctuations in the amount and composition of beach litter. It is difficult to detect the inter-annual trends of beach litter amount and composition due to their large fluctuations. One option to overcome this problem is to continue the beach monitoring at the same location for a long period. Another option is to collect relevant meteorological, oceanographic and anthropogenic factors and apply these data for better understanding the trends and variations (see e.g. Hardesy et al. 2017). Beach litter data expressed in weight are likely to be affected by the occurrence of a large object, whereas beach litter data expressed in numbers can be affected by the occurrence of numerous small fragments. Proper design of survey and data analysis should be determined in accordance with the purpose of monitoring (GESAMP 2019).

From Korea

The results of this report should be considered as positive, because designated areas included hotspots with the concentrated industrial areas, as well as estuaries that are primarily affected by terrestrial input. Concentrations of nutrients exceeded the baselines in only a small fraction of all observations, and contaminants did not exceed the guidelines at all. In addition, since this report evaluated special management areas in Korea, the ecological quality on the national scale is expected to be excellent. Overall, the national monitoring system and evaluation network in Korea are relatively well established and could contribute to the achieving the UN SDG 14.1 goal.

From Russia

To enhance the feasibility of chosen NOWPAP EcoQO targets, more clear recommendations for the establishing baselines could be recommended. If the baselines for contaminants will be established equal to the maximum permissible concentrations (MPC), then their *in situ* values would be assessed as "high" in many cases. From the other hand, if the baselines for nutrients and chlorophyll will be established above the natural levels, then their *in situ* values would be more frequently assessed as "low". As a compromise, something between MPC and natural level (NL) could be considered:

$$\text{Baseline level} = (\text{MPC} + \text{NL})/2$$

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