

ECOLOGICAL QUALITY OBJECTIVES APPROACH TO THE ENVIRONMENTAL PROBLEMS IN THE NORTHWEST PACIFIC REGION

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Northwest Pacific including Sea of Japan and Yellow Sea is a transboundary region for several countries with very different socio-economical situations: China, Japan, Republic of Korea, North Korea and Russia. UNEP NOWPAP (Northwest Pacific Action Plan) is one of the UNEP Regional Seas programs with aims to support ecologically based management of coastal and marine environment. Development of the Ecological Quality Objectives (EQOs) is one of the NOWPAP activities for the time being and near future. Aims of this paper are to suggest the list of EQOs for the northwest Pacific, as well as targets and indicators, which can be used for the monitoring of the achievements of them. Another goal is to assess relevance for the northwest Pacific the proposed targets and indicators including analysis of the problems and limitations based on the experience of EQOs implementation in other regions. Main feature of the EQOs approach in the NOWPAP region is the absence of unified monitoring system for the countries and reliable legislative basis for the regional integration of the environmental data.

Key words: Ecological Quality Objectives (EQOs), ecological indicators, Sea of Japan, Yellow Sea, Northwest Pacific Region, NOWPAP

I. INTRODUCTION

Good environmental quality is necessary for the national economies and the wellbeing of the populations. The ecosystem based management with proper marine spatial planning seems to be the only approach ensuring sustainable use of the natural resources and services. Achievement of Good Environmental Status (GEnS) in marine areas through the development of the Ecological Quality Objectives (EQOs) is one of the major directions in the goal setting of modern society. In Europe EU Marine Strategy Framework Directive serves as legislative basis for the development of EQOs.

Northwest Pacific including Sea of Japan/East Sea and Yellow Sea is a transboundary region for several countries with very different socio-economical situations: China, Japan, Republic of Korea, North Korea and Russia (fig.1). The natural conditions are also quite diverse. There are many environmental problems in this region to be addressed, and many of them can be solved by joint efforts only. For the time being, there is not reliable legislative basis for the resolving of environmental issues on the regional level. Therefore, cooperation under supervision of international organizations is an appropriate way forward. UNEP NOWPAP (Northwest Pacific Action Plan) is one of the UNEP Regional Seas programs with aims to support ecologically based development and management of coastal and marine environment.

Development of the EQOs is one of the NOWPAP activities for the time being and in near future.

Aims of this paper are to present the list of EQOs for the northwest Pacific, as well as to suggest operational objectives (targets) and indicators, which can be used for the monitoring of the achievements of EQOs. Another goal is to analyze relevance for the northwest Pacific the suggested targets and indicators based on the problems and limitations observed at the implementation of EQOs in other regions, in the EU first.

II. ECOLOGICAL PROBLEMS IN NOWPAP REGION

Regardless of distinguishing method, targets and indicators have to correspond to the major ecological concerns of the region. Analysis of the status of marine environment within northwest Pacific by NOWPAP experts [1, 2, 15] allow to list the following serious ecological problems: 1) destruction of habitats and biodiversity decrease; 2) alien species increase; 3) eutrophication of estuaries and coastal waters; 4) chemical contamination of water, sediments and hydrobionts due to anthropogenic influence; 5) marine litter. There are several examples displaying some of the environmental issues in the region.

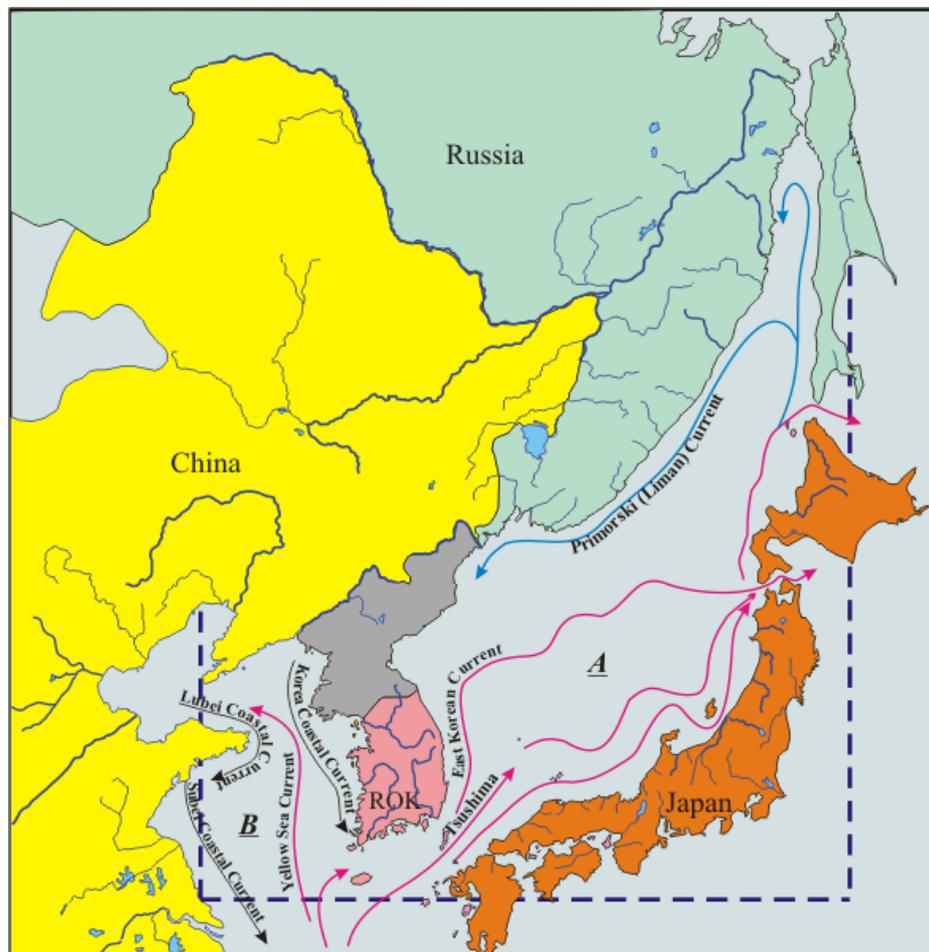


Fig. 1. NOWPAP Region with main marine currents.

Number and frequency of alien species, including invasive, increased in the entire region for the recent years. The basic reason for occurrence of alien species is discharge of ballast water by ships. Another important way is application of alien species in aquaculture and their further distribution in natural ecosystems. In 2013, experts from the four NOWPAP countries

provided data for compilation and publishing of Atlas of Marine Invasive Species in the NOWPAP region, including 80 hydrobiont species (15 plant species and 65 animal species) [3]. Impact of invasive species on natural biodiversity is displayed by predation and alteration of trophic chains and habitats. This may have a negative impact on fishery, shipping, and human life and health.

Eutrophication caused by human-mediated input of nutrients into marine water is a source of concern, especially in coastal areas near large rivers and/or cities. Consequences of eutrophication may be linked to Harmful Algal Blooms (HABs) and hypoxia, but as yet direct studies to confirm or refute this link are largely lacking. The direct socioeconomic impacts of eutrophication are related to the toxicity of or the damage to biological resources and the negative influence on recreational resources.

In the past years, there were about 50 red-tide events annually occurring in the NOWPAP member states (Fig. 2).

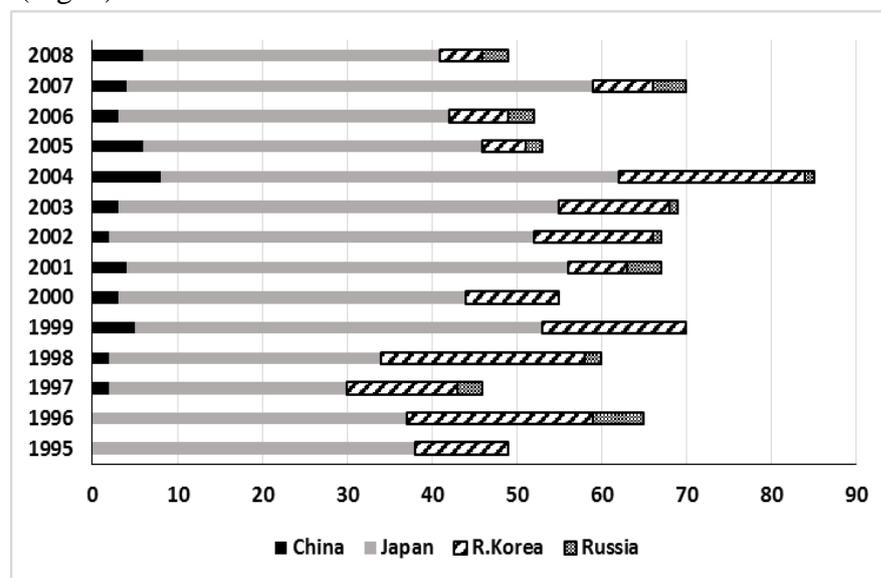


Fig.2. The number of red-tide occurrence in the NOWPAP member states [2]

Japan had the largest number of red-tide events, which have caused increasing damage to fisheries. 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. The most concerned species which induce damage to fisheries in the NOWPAP region are *Karenia mikimotoi*, *Cochlodinium polykrikoides* and *Chattonella antiqua* [2].

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, the abundance of the giant jellyfish, *Nemopilema nomurai*, massive green tides, hypoxia or anoxia, changes in phytoplankton communities and loss of marine biodiversity.

Chemical contamination of seawater, sediments and biota is caused by pollution from land-based sources through river and atmosphere transport. The source analysis of input of contaminants to the seawater revealed that atmospheric deposition is the main source of dust, nitrogen, phosphorus, cadmium and lead entering the Sea of Japan/East Sea, and lead entering the Yellow Sea, if compared to the river discharge. For the coastal water where the river discharge impact is evidently more important, the key factor is the size of the water area [4].

Environmental condition NOWPAP area improved for recent 5 years with regard to certain pollutants, such as tributyltin in Korea [5] or polychlorinated biphenyls (PCBs) in Japan [6], due to measures taken to decrease land based pollution of the marine environment. At the same time, contamination by hazardous substances, such as DDTs, remains a problem in many areas despite prohibition to produce or apply them.

III. ECOLOGICAL QUALITY OBJECTIVES (EQOs) FOR THE NORTHWEST PACIFIC

The environmental issues in the North-West Pacific can be efficiently solved only as a result of coordination among regional countries united by the common goals. The list of Ecological Quality Objectives for the Northwest Pacific is discussed as a part of UNEP NOWPAP international regional programme. Considering political, economic, and social peculiarities of the regional countries, we suggest the following ecological quality objectives corresponding to the good quality of seas and coastal areas in the North-West Pacific [7]:

- 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.

Achievement of the basic ecological quality objectives, defined in very general terms, is possible as a result of planned and phased solving of separate issues. It is obligatory to apply definite working parameters and criteria and the system of indicators, which could be monitored to trace and assess the progress of achievement of working and basic target parameters.

IV. DEVELOPMENT OF THE TARGETS AND INDICATORS FOR THE ECOLOGICAL QUALITY OBJECTIVES IN NORTHWEST PACIFIC

Definition and adoption by regional countries of the targets and indicators for the Ecological Quality Objectives is a separate difficult task. The first step in this direction was made in September 2014, when the regional workshop “Setting Ecological Quality Objectives for the NOWPAP Region” was held in Busan (Republic of Korea) back-to-back with the 12th Focal Points Meeting of NOWPAP Pollution Monitoring Regional Activity Centre (POMRAC). POMRAC Focal Points (representing NOWPAP member states), representatives of other NOWPAP Regional Activity Centres, OSPAR, PEMSEA, PICES and YSLME participated in the Workshop. The abovementioned Ecological Quality Objectives were approved.

Analysis of implementation mechanisms of MSFD law in EU [8] showed that the practical use of approved list of criteria and indicators is associated with numerous difficulties [9], which must be taken into account when discussing similar parameters and indicators in the North-West Pacific region. In particular, there is no available definition of principles of integration of indicators and benchmarks by individual descriptors in the overall assessment of the state of the environment in order to answer the basic question - whether or not a "good" state of the marine environment is achieved?

Another principal difficulty is necessary quantitative assessment of individual indicators and integrated indicators. This means the necessity of definite initial (background) condition, which can be compared to the actual or potential change in the situation. Therefore, the

definition of Good Environmental Status means such a status that was or may be correlated with anthropogenic changes. For many areas exposed to intense human pressure the correct selection of the comparative object is difficult or subjective.

The third principal difficulty is associated with the spatial heterogeneity of anthropogenic load, conducting of environmental studies on local areas, and the need for extrapolation of the estimates at the regional level. Among other things, it requires a coordinated monitoring between member countries, which should help in unification of the local assessment for the overall assessment of the region and in prevention of emerging transboundary "anomalies" in the obtained data.

An important circumstance in implementation of the assessment and environmental improvement programs is the overall lack of funding in the context of the economic crisis, which affects even comparatively wealthy EU countries, where numerous funding programs for environmental monitoring of the marine environment are being reduced [10]. This fact makes it unrealistic to obtain sufficient data to evaluate all indicators for all targets. Moreover, this fact must be taken into account in the Northwest Pacific region, where the ecosystem approach to the development of marine resources is not legally secured.

After analyzing of the system of indicators developed in the EU [8], we suggest to discuss 12 operational parameters and 24 groups of indicators for the monitoring of achievement of the five aforementioned ecological quality objectives and the general well-being of the marine environment in the Northwest Pacific region (Table 1). Detailed specification and applicable methods of monitoring must be based on analysis of actual data provided by the regional countries in terms of its use as indicators.

Table 1. List of Ecological Quality Objectives, operational criteria (targets) and indicators for the NOWPAP region

Ecological Quality Objectives	Operational Criteria (targets)	Indicators
1. Biological and habitat diversity are not changed significantly due to anthropogenic pressure	1.1. Species diversity of marine mammals and waterbirds	1.1.1. Abundance, distribution and population growth rates of marine mammals 1.1.2. Abundance and productivity of key waterbird species
	1.2. Species, age and size structure of fish stocks	1.2.1. Catch/biomass ratio 1.2.2. Spawning Stock Biomass (SSB) 1.2.3. Proportion of large fish (for selected species at the top of food webs)
	1.3. Distribution of benthic and pelagic communities and their status	1.3.1. Distribution 1.3.2. Condition of the typical species and communities 1.3.3. Hydrological and chemical conditions
2. Alien species are at levels that	2.1. Abundance and state characterization of alien species	2.1.1. Trends in spatial distribution and biomass of alien species

do not adversely alter the ecosystems	2.2. Environmental impact of alien species	2.2.1. Ratio between alien species and native species and their interaction at the level of ecosystem, habitats and species
3. Eutrophication adverse effects (such as loss of biodiversity, ecosystem degradation, harmful algal blooms, and oxygen deficiency in bottom waters) are absent	3.1. Nutrients concentration	3.1.1. Nutrients concentration in the water column 3.1.2. Nutrient ratios (silica, nitrogen and phosphorus)
	3.2. Direct effects of nutrient enrichment	3.2.1. Chlorophyll concentration in the water column 3.2.2. Species composition and abundance of toxic microalgae 3.2.3. Harmful algal blooms (HABs) 3.2.4. Abundance of opportunistic macroalgae
	3.3. Indirect effects of nutrient enrichment	3.3.1. Seasonal hypoxia, dissolved oxygen changes and size of the area concerned
4. Contaminants cause no significant impact on coastal and marine ecosystems and human health	4.1. Concentration of contaminants	4.1.1. Concentration of the contaminants in sediments, water and hydrobionts 4.1.2. Exceeding of MPC in aquatic organisms and frequency of such cases
	4.2. Effects of contaminants	4.2.1. Levels of pollution effects on the ecosystem components concerned, where a cause/effect relationship has been established
5. Marine litter does not adversely affect coastal and marine environments	5.1. Characteristics of litter in the marine and coastal environment	5.1.1. Trends in the amount and composition of litter washed ashore 5.1.2. Trends in the amount of litter in the water column and deposited on the seafloor 5.1.3. Trends in the amount, distribution and composition of micro-particles
	5.2. Impacts of litter on marine life	5.2.1. Trends in the amount and composition of litter ingested by marine animals

V. MAIN FEATURES AND POSSIBLE CHALLENGES OF APPLICATION OF THE MARINE ENVIRONMENT QUALITY INDICATORS IN THE NORTHWEST PACIFIC REGION

The main feature of the ecosystem approach implementation in the marine environmental management within the Northwest Pacific region, unlike the EU, is the lack of an international legal framework for the integration of environmental quality data. Implementation of the UNEP NOWPAP program allowed to compare monitoring systems in China, Korea, Japan and the Russian Federation, and open data obtained through national monitoring programs [2, 11, 12]. However, many challenges remain, resulting in the difficulty to observe actual state of environment in the region based on national data. In addition, the lack of sufficiently long-term data series interrupts reliable determination of the trends of changing environment and biota in many of the proposed groups of indicators.

An important unifying direction of international regional cooperation should be harmonization of the national monitoring systems. Some progress in this direction was achieved in the framework of large-scale activities on the international program of study and solving of environmental problems of the Yellow Sea. [13] However, complete harmonization of the national monitoring systems of China and the Republic of Korea participating in the implementation of this program has not been achieved yet despite numerous and long-term efforts.

Thus, unification of already applied methods and quality standards of water treatment in certain countries in the region is difficult to be expected in the near future. At the same time, an active international dialogue on similarities and differences in the monitoring methods is a way to seek consensus in the field of comprehensive and objective assessment of the state of the environment and biota in the NOWPAP region. On the other hand, methods for the determination of numerous biodiversity assessment indicators are still unsettled, and there is a certain hope to develop standardized methods through regional international cooperation.

Another feature of the Northwest Pacific region is a high diversity of climatic conditions from sub-tropical to sub-polar, and uneven socio-economic development of regional countries. It causes the unevenness of the quantitative characteristics of the monitoring network that requires consideration when assessing the spatial and temporal trends of environmental quality within the region. One example might be the use of biodiversity indicators, which values obviously depend on the intensity of observation, and therefore biodiversity assessment in relatively poorly studied and poorly developed coastal waters of northern Primorye, or the west coast of the Sakhalin Island is hardly comparable with the estimates obtained for densely populated coastal areas of Japan or Korea. Largely this applies to such eutrophication indicators as the number and characteristics of harmful algal blooms, the data range of which directly depends on the degree of development of aquaculture in the region. Overcoming of the environmental assessment difficulties associated with uneven socio-economic development is possible only through increased international cooperation and joint analysis of estimates obtained in different countries. It is unrealistic to expect obtaining of the full data set covering all parameters and indicators for the state of the environment assessment in the Northwest Pacific, allowing to map human impacts to display the status and press on marine ecosystems. An alternative approach might be borrowed from the international program for the protection of the Baltic Sea, providing three categories of ecosystem assessment: level of eutrophication, status of biodiversity, and level of pollution, jointly determining the "health" of the marine ecosystems [14].

Another alternative is to focus on the characteristic of human press using accessible data on the economic activities with related impact analysis for both natural and anthropogenic systems. In this case, the good state of the marine environment is determined by the absence of anthropogenic load, rather than values of selected environmental indicators. Quality parameters of any environmental element (individual, community, population, or ecosystem) in conjunction with assessment of anthropogenic load and consideration of the natural variability in the system requires detailed monitoring and is expensive, and in the context of the current economic crisis, the price can be daunting. [10] Therefore, the criterion of lack of pressure may be preferable as it is based on remote sensing data, as well as existing databases in the region, results of research projects, and simulations.

VI. CONCLUSION

The international program for the protection of the marine environment of UNEP NOWPAP (Northwest Pacific Action Plan) provides analysis of the regional environmental problems and related priority list contains 1) loss of biodiversity, 2) invasive species, 3) eutrophication, 4) chemical pollution, 5) marine litter.

Ecological Quality Objectives for the Northwest Pacific, as well as targets and indicators which can be used to monitor the progress, are determined through analysis of current environmental problems in the coastal areas and can serve as a basis for further regional discussion and development of targeted programs improving the state of the environment and biota of the East Sea/Sea of Japan and the Yellow Sea.

The main peculiarity of the ecosystem approach implementation in the marine nature management in the Northwest Pacific region is lack of common legal framework, which increases the importance of regional mechanisms for international cooperation, integrated in the process of joint quality assessment and environmental monitoring.

Among the most controversial problems of application of the suggested system of indicators are: 1) the principles of integrating assessments of various target parameters, 2) quantitative comparability of the estimates obtained in different countries.

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