Chapter 3 Biodiversity in the ocean and its ecosystem service

In this chapter, functions of the ocean and the current status of the marine biodiversity at the global level and for water around Japan will be identified and summarized to provide prerequisites for preparation of the basic concepts for conservation and sustainable use of marine biodiversity.

1. What are the biodiversity and the ecosystem service?

Ever since beginning of its primitive form, life has repeated adaptation, evolution and extinction in response to various changes of environment on the Earth, to create the present diversity of as many as 30 million species[4] and their associations. "Biodiversity" could be referred to as the "character" and "interconnection" of life created through the long history of evolution. Human being is one of the species which constitute the biodiversity, and the biodiversity provides foundation for its survival.

In the Convention on Biological Diversity, "biodiversity" is defined as the variability among all organisms. Included are not only "species diversity" which is occurrence of various species of fauna and flora, but also "intra-species (genetic) diversity" which is variation in a single species according to localities, etc., and "ecosystem diversity" which refers to the variety of ecosystems such as forests, rivers, tidal flats and coral reefs, which are composed of the interrelation between various fauna and flora.

The blessings people can obtain from such ecosystems where various organisms interact are called "ecosystem services." They include "provisioning services" of resources such as seafood and the genetic resources for medicine, "regulating services" for stable climate and clean water, "cultural services" to provide recreational and mental benefits such as sea bathing, and "supporting services" such as nutrient circulation and photosynthesis[5].

Facilitation of the objectives of the Convention on Biological Diversity, or conservation and sustainable use of the biodiversity requires understanding of the fact that there are multiple levels of the biodiversity as mentioned above, and it is important to address all levels rather than any single level.

2. Functions of the ocean and characteristics of its ecosystems

(1) Physical functions and blessings from the ocean

Ocean covers an extensive part of the Earth, and large-scale horizontal and vertical circulations occur there. Evaporation of water from the ocean plays a major role in sustaining the atmosphere-to-land circulation of water. Along with water, the ocean transports heat, it mitigates drastic changes of the climate through its interactions with the atmosphere, and maintains the temperature within the acceptable range for occurrence and growth of organisms. The ocean is deeply involved in the weather around the world and the climate kinetics. There occur and grow a variety of organisms in the ocean, and diverse ecosystems are established there.

In recent years, there is increasing attention on relationship between the ocean and the climate change. The ocean has not only a lot of water but also a plenty of carbon as a "carbon reservoir". Annual net primary production of marine phytoplankton would be around 50 billion tons of carbon equivalent. This would be almost equal to that of terrestrial plants, and the ocean is very important as a sink for carbon dioxide.

Human life has been closely related to the ocean with multi-functions ever since the

4 Millennium Ecosystem Assessment (2005) Ecosystem and Human Well-being Vol.1.

5 Field, C. B., M. J. Behrenfeld, J. T. Randerson and P. Falkowski (1998) Primary production of the biosphere: Integrating terrestrial and oceanic components. Science 281: 237-240.

ancient times. As the quantity and quality of human activities increase, there occurs more utilization of the ocean.

Direct blessings from the ocean to human beings include means for transportation, supply of food, water, mineral and energy, and space for recreation and mental stability. In particular, unexploited energy and mineral resources have been recently identified in the ocean through various surveys and researches on the ocean. When such resources are utilized, efforts have to be made to accomplish their sustainable development, and to establish and maintain an international order on the use of energy and mineral resources.

(2) Characteristics of marine ecosystems

Important in consideration on the marine environment and the ecosystems there is the existence of an extensive water body. In the ocean, there are layers with different water flow at different depths, and organisms and ecosystems distribute three-dimensionally. Plants with photosynthesis as primary producers occur in photic zones down to about 200m from the water surface, and on sea bottoms of the shallow coastal water. There occur completely different ecosystems in the deep sea.

In the ocean, many organisms migrate for a long distance during their life history. In addition, water, or where they occur and grow, also moves around. These lead to very high mobility of organisms. In other words, there is a highly continuous space from the polar region to the tropics, and complex interactions among organisms exist over a wide area.

Microscopic phytoplankton is the major primary producer in the ocean, and this is quite different from the terrestrial ecosystem where large plants such as trees are the major producer. In the ocean, turnover of the primary production occurs quickly and the material circulation rate through the grazing food chain and microbial food chain is high. Materials, therefore, do not stay for a long time in the form of the primary producers as on land.

For example, at transition regions where different ocean currents or water bodies are in contact, cold seawater with rich nutrients mixes with warm surface water to stimulate productions of phytoplankton and attract many organisms of higher trophic levels in the food web. However, one must keep in mind that the status of ecosystems changes drastically with changes of physicochemical conditions. For instance, environmental changes due to the global-scale climate change, such as the regime shift with intervals of several decades and El Niño and La Niña, significantly alter productions and distributions of organisms.

Approximately 230 thousand species[6] have been identified for marine organisms, but our knowledge on marine species is limited compared to terrestrial ones. Many new species are still discovered even in shallow waters, and it is expected that there are many unknown species. As for higher taxa, among all of the 35 animal phyla[7], 34 of them include species occurring in the ocean, and 16 phyla are found only in the ocean. It could be said that there are more morphological variations among marine organisms than terrestrial ones.

(3) Characteristics of the marine environment and ecosystems around Japan

Japan is surrounded on its four sides by the Pacific Ocean, the East China Sea, the Sea of Japan and the Sea of Okhotsk. Consisting of approximately 6,000 islands including Hokkaido, Honshu, Shikoku, Kyushu and Okinawa, Japan has one of the world's widest closed sea and exclusive economic zone of approximately 4.47 million km^2 around it.

Approximately a half of the world's ocean is ocean flats, or flat bottoms. However, four plates collide to each other in marine areas around the Japanese Archipelago on the eastern edge of the Eurasian Continent, and their submersions have created marine trenches and the diverse and complex bottom topography with drastic changes in water depth. It is characteristic to Japan that the majority of its exclusive economic zone is deep water, with limited shallow water over the continental shelf and within the inland sea and bay.

As for the average water depth around Japan, the East China Sea is shallow and around 300m deep, but the Sea of Japan and the Sea of Okhotsk are about 1700m deep, and the Pacific Ocean is around 4200m deep[8]. A relatively gentle continental shelf of 0 to 200m deep extends out from the continent in the East China Sea southwest to the line between the Korean Peninsula and the Noto Peninsula and in water west to Hokkaido and coastal water of the Sea of Okhotsk. On the Pacific side, there are very steep bottom topographies down to the depth of 4,000 to 6,000m, such as the Japan Trench and the Izu-Ogasawara Trench running south from Honshu and the Nansei Islands Trench (Ryukyu Trench) from Kyushu to Okinawa. There are also a series of seamounts such as the Nansei Islands Ridge (Ryukyu Ridge) and the Izu-Ogasawara Ridge on the Pacific side. There are relatively wide undersea basins at the depth of about 2,000m, such as the Japan Basin in the Sea of Japan and the Kuril Basin in the Sea of Okhotsk.

Diverse environment is created in Japanese water due to many warm and cold currents such as the Kuroshio Current (warm current)

6 Fujikura et al, (2010) Marine Biodiversity in Japanese Waters. PLoS ONE
7 According to the classification by The Union of Japanese Societies for Systematic Biology
8 National Institutes of Natural Sciences, National Astronomical Observatory of Japan (2009) Chronological Scientific Tables 2010

and the Oyashio Current (cold current) flowing along Japan, and the Japanese Archipelago of numerous islands extending from the south to north with a wide range of climate zones from subarctic to tropical ones. In the north, drift ice covers the Sea of Okhotsk in winter, and unique habitat and environment are created by sea ice. In the south, various organisms are transported from the south by the Kuroshio Current. Under influences of the Kuroshio Current, or the world's largest warm current, Japanese water is warm even at the high latitude, and this allows the world's northernmost distribution of coral reefs and provides many marine organisms with their spawning and feeding grounds and the larvae and juveniles of fish with their nursing grounds. In addition, there are many fish and good fishing grounds in the transition region where the Kuroshio Current contacts the Oyashio Current. The Tsushima Warm Current flows in the surface layer of around 200m, and below is a water body with low temperature and relatively high dissolved oxygen content called the "Japan Sea Proper Water".

Unique fauna and flora occur along the long and complex coastline of approximately 35,000km in total length, depending on local topographies such as sand dunes and cliffs. Distributed in the shallow coastal water, where land, inland water and sea join, are seaweed beds[9], tidal flats and coral reefs, and diverse habitats and environment are provided to marine organisms for their reproduction, growth and feeding. In the vast ocean on the Pacific side, there are remote islands, such as the Izu-Ogasawara Islands, Okinotori Island, Minamitori Island and the Daito Islands, and seamounts, and water shallower than its surrounding induces the upwelling current to provide habitats for various organisms.

Coastal water is closely linked with its adjoining land, and nutrient salts are supplied from rivers and the springs on the sea bottom. Ecotone, or a transitional zone from the land to its adjoining water beyond the shoreline, is rich in biodiversity. For example, the "intertidal zone" between the high tide and low tide lines repeatedly emerges and submerges with the tidal rhythm. Duration of time under seawater varies depending on the height to produce differences in environmental factors such as dryness, temperature, and salinity, and multiple species adapted to each environment are thriving there. In brackish water at the river mouth, where seawater mixes with freshwater, many organisms with resistance to changes in salinity occur, and mangrove forests are established in the tropical and subtropical zones. A unique ecosystem develops at each environment. On sandy beaches, landing of sea turtles and breeding of little terns are observed. Enormous numbers of species and biomass of benthic organisms occur on tidal flats in the inland bay to provide food to many migrating birds such as sandpipers and plovers, and they fly to these tidal flats for food and rest. Seaweed beds are called the "cradle in the sea", and they have an important role as a place for spawning and growth of organisms. In coastal ecosystems such as tidal flats and seaweed beds, organic matters in municipal effluents from the land are removed through decomposition by bacteria and meiobenthos and the filtration by shellfish, and nitrogen and phosphate are also taken away as parts of organic matters by their storage in seaweeds and removal by birds and fish, to produce clean water. Through their function to produce clean water, coastal ecosystems maintain habitats and environment for organisms, and they contribute significantly to the protection of biodiversity.

Under unique environments such as the deep sea and the hydrothermal vent, there occur organisms completely different from those in coastal and surface water.

In water around Japan, such diverse environments allow occurrences of 50 out of 127 species of marine mammals in the world (40 species of whales and dolphins, 8 species of seals and sea lions, sea otters and dugongs)[10], 122[11] out of about 300 species of sea birds in the world, and around 3,700[12] out of about 15,000 species, or about 25% of marine fish in the world, to produce a rich species diversity. Surveys on marine organisms occurring in our exclusive economic zone, or water under our jurisdiction, reported around 34,000 species[13], which account for about 15% of around 230 thousand species known in the world. Among these, about 1,900 species are identified as endemic to Japan. As for marine organisms, it should be noticed that except for certain taxa, their taxonomy is still under development, with many organisms yet to be discovered.

3. The current status of marine biodiversity

(1) Global marine biodiversity outlook

Various measures have been taken on both international and national scales to assess the variety and complexity of biodiversity.

9 In this Strategy, "seaweed beds" refer to areas where communities of large size benthic plants (seaweed and sea grass) are established.
10 Jefferson et al, (2008) Marine mammals of the world. & Ohdachi et al, (2009) The wild mammals of Japan.
11 Peter Harrison (1985) Seabirds: An Identification Guide. & The Ornithological Society of Japan ed. (2000) Check-List of Japanese Birds (6th ed.).
12 Taki et al, (2005) Colored Fish Guide (New ed.). & Ueno and Sakamoto (2009) Fish Classification Guide (New ed.)
13 Result of the research under the international joint research network "Census of Marine Life (CoML)", done by

We gradually understand the loss of marine biodiversity.

"Millennium Ecosystem Assessment" (MA) was the first large-scale action to assess the biodiversity and ecosystem at the global scale, and 1,360 experts from 95 countries were involved from 2001 to 2005.

The Millennium Ecosystem Assessment has revealed that human beings have significantly altered the structure of terrestrial ecosystems. We have accelerated the rate of species extinction by approximately 1,000 times in the past few hundred years, and we are changing the fundamental biodiversity on the Earth. For the ocean, it has been pointed out that coastal ecosystems rich in biodiversity have been significantly affected by human activities and threatened for loss. For example, about 20% of coral reefs in the world have been lost during the last few decades of the 20th century, and in countries with available data, around 35% of mangrove forests have also disappeared in the last 20 years. As for marine fishery resources, global demands on them are on the rise. However, the same assessment reported that a quarter of species targeted for the scientific resource assessment were depleted by overfishing. Stock of fish species, especially those in higher trophic levels in the food chain (large fish-eating fish such as certain species of tunas and Atlantic cods) is declining, and losses of marine biodiversity have been revealed.

Secretariat of the Convention on Biological Diversity edited and published the "Global Biodiversity Outlook (GBO)" in 2001, 2006, and 2010. Its third edition (GBO3) published in May 2010, evaluates the status of achievements of the objectives agreed by the Parties for 2010, and points out that on the global scale, none of these 21 individual objectives has been met. As for the status of coastal and marine ecosystems, it is reported that the mangrove forests and coral reefs are declining continuously, and 80% of marine fishery resources in the world have been exploited to the limit or even overexploited.

Recently, a global-scale research entitled "Census of Marine Life" (CoML) had been conducted since 2000 as a 10-year project to study the biodiversities, distributions and populations of marine organisms in the world for the past, present and future. Researchers from more than 80 countries including Japan participated in this Census, and data were registered and accumulated on the global-scale Ocean Biogeographic Information System (OBIS).

(2) Status of the marine biodiversity in Japan

For assessment on the status of the biodiversity in Japan, the Ministry of the Environment established the Japan Biodiversity Outlook Science Committee, and with contributions by 208 experts, released the "Comprehensive Assessment of Biodiversity in Japan" (JBO: Japan Biodiversity Outlook) in May 2010. Japan Biodiversity Outlook states that developments and alterations, especially those during the high economic growth period, significantly diminished tidal flats and natural coastlines. Although demands for developments and alterations are decreasing now, coastal erosions, invasions of alien species and impacts of the global warming are listed as new concerns.

Specifically, the Outlook identifies followings as indicators to represent the status of biodiversity losses in the coastal and marine ecosystems: (1) size and quality of the coastal ecosystems; (2) number of individuals and distributions for species in shallow water; and (3) status of valuable fish stocks. All of these indicators trend to decrease.

As for (1) size and quality of the coastal ecosystems, the Outlook points out that coastal ecosystems such as tidal flats, seaweed beds, coral reefs, and sandy beaches have shrank in size due to the developments and alternations of lands, such as dredging and reclamation, sea gravel extraction, and creation of artificial shorelines during the high economic growth period after the war. Especially, tidal flats tend to be in inner bays, and it is easy to develop them. Tidal flats shrank drastically during the high economic growth period, and around 40% of sandy beaches had disappeared in 50 years since 1945. More than 50% of natural coastlines have also disappeared along the main island. Shore erosions on sandy beaches are getting worse under the reduced supply of sediments due to gravel extractions from rivers and the sea and the river development projects in the upstream, and under influences by structures on coastlines to change the sand drift system. In addition, various changes in the ecosystems, such as rocky-shore denudation, and coral bleaching are observed. Rocky-shore denudation is a critical decline of dense sea jungles with large seaweeds. Changes or degradations of corals, sea grasses and seaweeds are attributed to increases of the seawater temperature, and there is a concern over impacts of the global warming.

As for (2) number of individuals and distributions for species in shallow water, numbers of individuals of birds like snipes and plovers and the shellfish like short-necked clams and hard clams, with a part of their life history in shallow water, are decreasing due to deterioration of the environment, water pollution and less tidal flats and sandy beaches.

For (3) status of valuable fish stocks, about 40% of the fishery resources already evaluated are at low levels now.

While the Comprehensive Biodiversity Evaluation reports that relationship between the biodiversity and ecosystem service is yet to be studied, the loss of biodiversity in Japan is suggested to have impacts on the supply of ecosystem services. In the Seto Inland Sea, decreases in sand eel stock level is attributed to the loss of sandbanks by actions such as dredging of the sea sand, and this is suggested to have resulted in less loons, or winter birds there. Decreases of clams lead to not only less food supplies but also less cultural services,

or opportunities for recreational shellfish gathering.

In recent years, changes in the marine ecosystem and their impacts on ecosystem services including fishery have been observed. For example, outbreaks of Nomura's jellyfish occurred frequently in the Sea of Japan.

4. Impacts of human activities on marine biodiversity

For effective and efficient conservation and sustainable use of marine biodiversity, it is important to systematically and comprehensively understand problems in the target water.

(1) Factors affecting marine biodiversity

Major anthropogenic factors that affect or may affect the biodiversity in Japan are (1) physical alterations that reduce habitats for organisms, (2) pollution of marine environment that deteriorates the quality of ecosystems, including releases of effluent, waste material, oil and chemical substances, (3) excessive harvests (including those of non-target species, or their bycatch), (4) introduction of alien species that may disturb ecosystems, and (5) impacts of the climate change that may affect the physicochemical environment or system of the ocean. Human activities are intensive especially in coastal water, and these factors are involved intricately.

1) Physical alterations to reduce habitats for organisms

Physical alterations of inland areas, such as river basins, coastal areas and sea bottoms may have impacts on habitats of marine organisms depending on where and how they occur.

Development projects in river basins may increase the influx of sediments and nutrients into rivers excessively due to the runoff of surface soil. This may increase turbidity in the estuary and coastal water, or it may lead to changes in the marine environment, such as eutrophication. Alterations to prevent the river flow may divide a habitat of migratory (diadromous) fish between the river and sea, to pose a problem against their reproduction and reduce their population size. Such alterations may also facilitate erosions on the sandy beach

due to the reduced supply of sediments.

Development projects in the coastal area usually involve physical alterations of the coastline to lead to changes in topography of the coastal area, losses of ecosystems in shallow water, and changes in the flow regime. Losses of seaweed beds, tidal flats, coral reefs and sandy beaches will not only deprive marine organisms of their habitats, but also contribute to eutrophication through reduction of the function of ecosystems to clean water. As for thermal effluents from power plants, there are growing concerns about impacts of changes in the temperature on marine organisms. Depending on their siting, bird strikes at wind power stations would be concerns about migratory birds.

Exploitations of energy and mineral resources on the sea bottom may also deprive organisms in the unique chemosynthetic ecosystem thriving without solar energy in the deep sea of their habitats through physical alterations.

2) Pollution of the marine environment that deteriorates the quality of ecosystems

i. Pollution from land-based sources and activities

Influx of pollution loads, such as the hazardous substances and nutrient salts in the industrial and municipal effluents generated by the industrial activity and daily life of human beings, increased especially during the high economic growth period, and caused problems such as accumulations of sludge, or deposits of polluted soft mud on the sea bottom, and outbreaks of red tides associated with eutrophication, to produce significant adverse impacts on the occurrences and habitats of organisms especially in coastal water. It is also among concerns that chemical substances with unknown hazard may have impacts on ecosystems.

ii. Pollution from marine based sources and activities

Among the pollution loads on the marine environment from activities on the sea surface, such as navigation, are marine pollution by spills of oil and chemical substances from ships, discharge of the wastes and contaminated water generated from activities within ships, and pollution by oil from boating disasters. Adverse impacts by ship-bottom antifouling paints with organotin compounds such as tributyltin (TBT) on marine organisms have posed problems since late 1980s.

In April 2010, an oil spill accident occurred at the oil drilling facility in the Bay of Mexico, and tons of crude oil was released over the whole bay from the underwater oilfield. Causes of the accident are presently under investigation, but oil was released at deep water and the pressure of crude oil to blow out was

extremely strong, so that the oil spill could not be stopped easily and extensive damages were made.

3) Fishery-related problems

Fishery is an environment-dependent industry and it is based on rich blessings from the sea. It is necessary to maintain sound ecosystems to support its productivity, and it is essential to protect the biodiversity for this. On the other hand, if fishery or aquaculture is managed improperly, it may pose a threat of significant impacts on the marine ecosystem. Excessive harvests of fish and shellfish (including their bycatch) will not only reduce the population size of fisheries resources but also change the species composition of their preys and predators, and even balance in the whole food web. In addition to these, it is also required to pay attentions to impacts of actions such as the dumping of harvested organisms and the ghost fishing, or entanglements of organisms in abandoned fishing gears, on the ecosystem. Aquacultures could provide indirect effects to recover fisheries resources through reductions of the dependency on them. However, majority of juveniles for the aquaculture of Japanese eels and bluefin tunas are supplied from natural resources, and there is a concern over impacts on the resources of such species. Aquacultures may also lead to marine pollution if the rearing density and feed dosage are not properly managed, and their impacts on the genetic biodiversity need to be considered.

Fishers living in the coastal communities are conducting environmental conservation activities for stable supply of the safe and quality products. However, in recent years, depopulation in coastal fishing communities and advanced aging are posing concerns over declines in such conservation activities.

4) Disturbance of ecosystems by alien species

Alien species are introduced intentionally or unintentionally through human actions from abroad or the other areas of Japan beyond the natural potential for migration of wildlife. Alien species may feed on indigenous organisms to damage fishery, eliminate indigenous organisms through competition with them, damage ecosystems through genetic contaminations by their crossing with indigenous organisms, and harm the human body and life through their biting and poison. Countermeasures against such alien species are required. In our ocean and coastal water, 76 species which did not occur in Japan originally are known to occur, and it is recognized that about 20 species have been introduced apparently from abroad while they distribute naturally in Japan. More than 100 species would have been introduced from the other parts of Japan. For example, organisms such as Mediterranean green crabs are confirmed to have settled in water around Japan, and there is a concern on their impacts.

As pathways for introduction of alien species, recent studies have clarified that entrainment of organisms in the ballast water of ships or their attachment to the body of ships allows their transportation to water far away, and upon discharges of the ballast water, they will settle there to disrupt the local ecosystem, for example through reduction of indigenous species, and damage the local fishery.

Species which has not been occurring at the site may be introduced for its aquaculture, but potential impacts on the local ecosystem in the case of its escape are also concerns. Furthermore, in addition to impacts by the introduced species, outbreaks of organisms coming along with it or its parasites at new habitats may also be concerns. For example, Sakigurotamatsumeta snails that feed on molluscs used to occur only in limited parts of Japan, such as the Sea of Ariake. Recently, however, it has been reported that snails of foreign origin came to marine areas new to them together with imported clams and reproduced themselves there to feed on bivalves, such as short-neck clam, and damage their aquafarming and shellfish gathering[14].

5) Effect of the climate change

In recent years, there are growing concerns on impacts of the climate change for both coastal water and the open sea. In coastal water, there would be impacts on the coastal ecosystem through the sea level rise, stronger tropical cyclone and frequent high tides. Coral reefs are suggested to be vulnerable to the climate change, and their large-scale bleaching by the increased seawater temperature has been observed frequently in recent years around the world. Furthermore, increasing ambient concentrations of carbon dioxide will lead to more carbon dioxide dissolved into seawater and subsequent aggravation of its acidification. Acidification of seawater will then suppress calcification to produce calcium carbonate for the skeleton of corals and the shell of plankton. Some species may not be able to form its

14 The Plankton Society of Japan, Japanese Association of Benthology ed. (2009) Alien species in the sea - The Earth's oceans disturbed by human beings.

skeleton or shell, and balance of the ecosystem may be lost due to changes in the species composition.

Recent studies have revealed decreases in the production of phytoplankton, or the major producer in the open ocean, and it is suggested that the reduced supply of nutrient salts to the euphotic zone due to more stratification in the ocean by the global warming is responsible for this[15].

In the north-western part of the Sea of Okhotsk, formation of sea ice produces dense cold seawater with high salinity to sink and flow out of the continental shelf and carry iron from the Amur River to the southern part of the Sea of Okhotsk and the North Pacific Ocean. It is suggested that the seawater circulation triggered by chilled sea surface in winter allows this iron to go up again to the surface layer, lead to growth of phytoplankton, and support the marine and terrestrial ecosystems. If the formation of sea ice is reduced due to the global warming, there would be extensive impacts on biological production of the associated marine ecosystems.

As for fishery, extension of the distribution of target species to the north may change their fishing grounds and seasons. Surveys on sea urchins catches around Hokkaido since 1985 revealed that Kitamurasakiuni sea urchins which used to be harvested in substantial volumes at the southern part of Hokkaido, are now caught also in substantial volumes at further north along Soya region. Longheaded eagle rays, which used to distribute in coastal water in the subtropical and tropical zones, are now occurring in large numbers in Ariake Sea and the Seto Inland Sea, and damages on the fishery of short-neck clams and pen shells caused by the rays have been reported. Extension to the north of the distribution of organisms with adverse impacts on fisheries is suggested.

(2) Impact factors in each type of water

In order to understand impact factors, it is necessary to treat “coastal water” and “open ocean” differently. Coastal water is closely related to land, and there are unique ecosystems such as those where the primary producers like algae occur. Open ocean receives less influence from land, and there are different ecosystems from those in coastal water.

While coastal water is usually rich in nutrient salts from land, it is subject to impacts by human activities. In terms of ecosystems, coastal water is not clearly separated from the open ocean, and both are closely related to each other. However, in this Conservation Strategy, coastal water is defined as “water from the intertidal zone to the continental shelf of less than 200m in depth, to be subject to significant impacts by human activities”, and the other water as the open ocean.

1) Coastal water subject to significant impacts by human activities

In coastal areas, there have been formed many flat lands suitable for the agriculture. They have been densely populated since the ancient times, and major cities have developed there. During the economic growth after the war, industries also had concentrated on the coastal areas, such as the pacific belt zone, for better access to imported material and water resources. In Japan, flat coastal areas with populations and industries are often subject to heavy environmental loads. Coastal areas adjacent to shorelines have been under pressures of human activities, such as reclamations, creations of artificial coastline and dredging to collect sea sand, and the habitats for marine organisms and coastal

vegetations, such as seaweed beds, tidelands, coral reefs, sandy beaches and sandbanks, have decreased, environmental conditions have been deteriorated, and links between the land and sea have been destructed there. There is less daily involvement with the sea. In recent years, drastic development does not occur as it used to do, and coastal areas reclaimed in a year remain no more than around 800ha. New development projects, however, are still under way. In coastal water, apart from the development projects, its recreational uses, such as diving, could disrupt ecosystems if proper consideration is not taken for the marine ecosystem.

Not only physical alterations of the coast, but also discharges of various substances from daily life and industrial activities have impacts on ecosystems by their pollution of seawater through rivers and groundwater. In the past (1950’s), the Minamata disease, or a toxic neurological disorder, occurred through intakes of fish and shellfish contaminated with organic mercury discharged into water, and became a serious social problem as one of the four major pollution diseases in Japan. With aggravation of the water pollution by industrial

15 Gregg et al, (2005) Global Chlorophyll-a Trends During 1998-2003: Geophys. Res. Lett.

and municipal effluents, dissolved oxygen contents in water decreased, and more water became unsuitable for the organisms that used to occur there. In recent years, serious pollution has been improved, but water mass with low oxygen contents and red tides are still observed especially in the enclosed water, and there occur problems such as decreases in fish and shellfish and subsequent impacts on fishery. Sediment discharges not only from natural disasters but also from farmlands, devastated forestlands and construction sites have been also reported to have impacts on coastal ecosystems such as coral reefs and seaweed beds.

Large volumes of debris are drifting out from Japan and the countries and regions around it to have washed up to beaches including those along the Sea of Japan, and damages such as deterioration of the coastal environment including ecosystems there, losses of scenic beaches with “white sand and green pines”, reduced functions as the coast, and impacts on fishery have been reported. Drifting debris on the sea, such as plastic wastes from human activities, are washed up to beaches or accumulated on the sea floor. Apart from adverse impacts on scenery and fishery, turtles and sea birds may swallow them, and life of organisms would be threatened.

Fishery utilizes biological resources in the ocean, and if it is not properly managed, it will have impacts on the marine ecosystem by overfishing or bycatch. Among 84 populations of 52 fish species under the stock assessment of individual fish species and subpopulation, 40% of them are evaluated to be at low level. Apart from impacts of changes in the marine environment, excessive fishing on certain species overwhelming their ability to recover, in addition to reductions of the seaweed beds and tidal flats as the spawning and nursery grounds in the coastal water, is suggested to be responsible for this. Aquaculture is also conducted in coastal water, and attentions for its appropriate management is required as mentioned above. It is a concern that alien species intentionally introduced in recent years for food supply may have impacts on the original ecosystem.

2) Human pressure on the open ocean

When compared with coastal water, the open ocean is less likely to be subject to direct impacts of human activities. Currently, the open ocean is used mainly for navigation, fishing and ocean dumping of wastes. Its new development and utilization, such as exploitation of ocean bottom resources and the development of natural energy including wave power and tidal power, are envisaged for future.

Among impacts on the ocean by vessels are discharges of oil and hazardous substances, and especially oil spills at the time of an accident have significant impacts on the marine ecosystem. After the war, Japan has developed economically through trades with many countries around the world. Today, Japan relies almost all of its international trade and about 40% of its internal transport on the marine transport. Along with globalization and the global scale economic development, volumes of the marine transport in the world are increasing, growing with and Japan is involved in around one-seventh of such volumes.

As for fishery, even in the open ocean, significant reductions in size of particular species or population, for example by overfishing would pose a threat of impacts on populations of the organisms associated with such species, or balance of the whole food web. Bycatch and ghost fishing are also concerns.

Wastes and pollutants released to the sea from human activities in coastal water or the open ocean are transported extensively by ocean currents, atmospheric circulations and the movements of organisms, and it is observed that they are accumulated in the body of organisms even in the open ocean. It is known that floating debris in the North Pacific is accumulated to particular water by ocean currents[16]. Debris from Japan has been reported to have washed up to beaches of the Midway Islands. Marine environment monitoring by the Ministry of the Environment[17] has clarified that floating plastics distribute extensively even in the open ocean of around 4,000m deep. Deep-sea surveys have identified plastic debris even on the deep-sea bottom as well. Once released to the environment, plastics are not easily decomposed, and there is a concern that they may have impacts on organisms for a long time.

16 M. Kubota (1994) A mechanism for the accumulation of floating marine debris North of Hawaii. Journal of Physical Oceanography. 24, : 1059-1064.

17 The Ministry of the Environment (2009) Present Status of Marine Pollution in the Sea around Japan - as based on data from Marine Environment Monitoring Survey results (Fiscal Years 1998 - 2007). (http://www.env.go.jp/press/press.php?serial=11688)