Present Status of Marine Pollution in the Sea around Japan

as based on data from Marine Environment Monitoring Survey results
Fiscal Years 1998 – 2016

Ministry of the Environment, Japan

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1. Objective

With the enforcement of the United Nations Convention on the Law of the Sea in July 1996, it was decided that Japan would assume responsibility for environmental conservation in its exclusive economic zone (EEZ). In response, the Ministry of the Environment launched a new monitoring survey (the Marine Environment Monitoring Survey) in fiscal 1998 based on the "Marine Environment Monitoring Review Guideline" (Environment Agency, 1998) under the guidance of the Marine Environment Monitoring Survey Review Meeting (Chairman: Hideaki Nakata, Professor Emeritus at Nagasaki University).

Given the immense sea areas targeted by this monitoring survey, the initial plan was to perform the first round of the monitoring survey in the target area in three to five years, which was revised to eight years in recent years. Over the past 19 years, from fiscal 1998 to 2016, three rounds of the survey (phase 1 to phase 3) have been conducted.

Based on the results of this long-term continuous survey, it became possible to capture temporal trends of the marine environment around Japan. In this report, the status of marine environment influenced by the input of pollutants from lands and disposal of the wastes to the ocean at survey sites around Japan was comprehensively evaluated. Focusing on the results of the Marine Environment Monitoring Survey from phase 1 to phase 3, this report summarized temporal changes of status of the marine environment from the coastal areas to oceanic areas around Japan, caused mainly by contamination of harmful chemical substances.

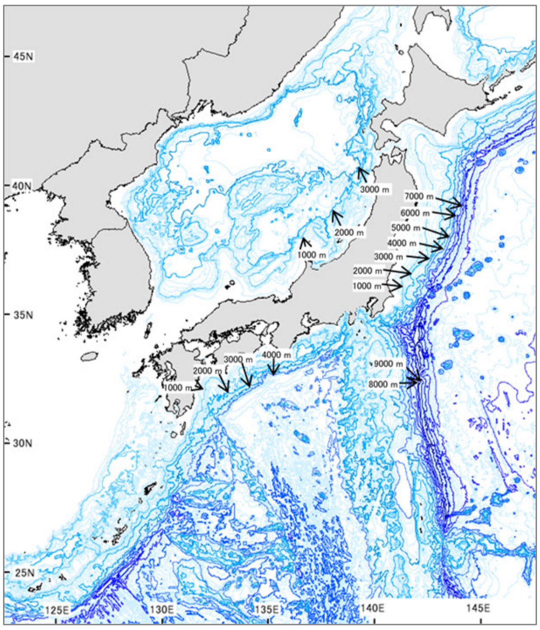
2. Current conditions of the marine environment around Japan

2.1. Characteristics of oceans around Japan

Japan is surrounded by the sea on all sides, with the Pacific Ocean having half the mass of all seawater on earth (mean water depth: 4,282 m) located along Japan's eastern coastline. Epicontinental seas around Japan include the East China Sea, the Sea of Japan, and the Sea of Okhotsk. The East China Sea has large continental shelves. While the maximum depth is 2,719 m, which is quite deep, it is a shallow sea where the average depth is only 188 m. Meanwhile, the Sea of Japan is a deep and closed sea area where the maximum depth is 3,796 m with an average depth of 1,350 m. The Sea of Okhotsk has a mean water depth of 838 m, a continental shelf along the areas of the coast, and a maximum water depth of 3,372 m (Ministry of Education, Culture, Sports, Science and Technology, 2002). Thus, the sea areas around Japan are surrounded by deep waters with almost no shallow seas except for bays. Continental shelves have developed in some of the marginal sea areas adjacent to Japan, but the areas are generally narrow (Figure 2.1).

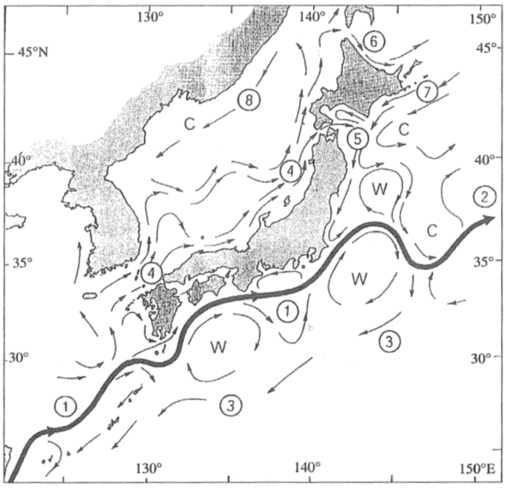
Major ocean currents in the sea areas around Japan include the Kuroshio Current and the Tsushima Warm Current, which are warm currents, and the Oyashio Current and the Liman Current, which are cold currents (Figure 2.2).The Kuroshio Current is a stream with a flow rate of as high as 50 million tons per second, and it is known as one of the strongest oceanic currents in the world. Due to its high temperature and oligotrophic environment with high salinity, plankton density is low, and the water transparency is high. The Oyashio Current has its origin in the cold water of the Sea of Okhotsk and the Bering Sea. Due to its nutrient-rich seawater, plankton density is high, and the water transparency is relatively low. The point of contact* between the Kuroshio Current and the Oyashio Current is located at a sea area to the east of Japan, where the biological productivity is extremely high and attracts a great number of fish which makes the area one of the best fishing grounds in the world.

* The point of contact refers to a boundary between water masses with different temperatures and characteristics such as the Kuroshio Current and the Oyashio Current.



*The isobath is 200-m contour (in principle)

Figure 2.1 Submarine Topography around Japan (Prepared based on the data of the Marine Information Research Center)



(1) Kuroshio Current; (2) Kuroshio Extension; (3) Kuroshio Counter-Current; (4) Tsushima Warm Current; (5) Tusgaru Warm Current; (6) Soya Warm Current; (7) Oyashio Current; (8) Liman Current

W: Warm water; C: Cold water

Figure 2.2 Major Ocean Currents around Japan (Unoki and Kubota, 1996)

2.2. Outline of the Marine Environment Monitoring Survey

In Japan, various marine environment monitoring programs are implemented by relevant organizations such as administrative bodies, research institutions, and researchers of colleges, etc. The Ministry of the Environment implements monitoring programs including the Marine Environment Monitoring Survey, which this report is based on, the Environment Survey of Chemical Contamination, the Public Waters Survey, and the Wide-area Comprehensive Water Quality Survey. In addition, other ministries individually implement monitoring programs such as the Ocean Pollution Surveys by the Japan Coast Guard, and the Atmospheric and Marine Environment Monitoring by the Japan Meteorological Agency.

In the Marine Environment Monitoring Survey, surveys on land-based pollution and on pollution caused by ocean dumping of wastes are performed, with attention paid to the emission sources.

The surveys for land-based pollution are designed to identify the impacts of the land-based pollution load on the marine environment by determining the distribution and the concentration gradient of pollutants in areas ranging from inner bays and coastal waters, where significant pollution loads are likely to exist, to offshore areas.

The surveys on pollution caused by ocean dumping of wastes are focused upon understanding the pollution status of seawater, marine sediments, and marine organisms caused by ocean dumping in Wastes Disposal Sea Areas (Sea Area II, III and IV), where considerable amounts of wastes have been disposed of in recent years.

This monitoring survey is performed from the conventional perspective of protecting human health or conserving the living environment, and also from the perspective of protecting the marine ecosystem, by considering the possibility of the impacts that pollutants are likely to exert on marine organisms or the marine ecosystem even at concentrations far below the environmental quality standards.

In addition to the above, this monitoring survey has the following characteristics:

- ◆ A comprehensive, continuous survey is performed on seawater (water sampled from various layers for nutrient salts and heavy metals), marine sediments, marine organisms, benthic communities and marine plastic wastes, not only with respect to coastal areas but also offshore sea areas with water depth to the order of 4,000 m.
- ◆ In addition to heavy metals, various hazardous chemical substances are included in the survey target such as organotin compounds and substances covered in the Stockholm Convention on Persistent Organic Pollutants (e.g. PCBs, dioxins).
- ◆ Coprostanol and linear alkylbenzenes (LABs), which are marker substances that are likely derived from sewage sludge, are monitored as well, even though they are not subject to administrative control or not designated as mandatory monitoring items.
- ◆ The pollution concentration levels for substances such as PCBs and dioxins within the bodies of five types of marine organisms populating in sea areas, from the coastal area to the offshore area, are monitored. The target marine organisms are mussels, benthic sharks, squids, cods and crabs.
- ◆ In addition to periodic surveys, in-depth follow-up surveys are also performed in proper response at the sites where highly concentrated pollutions were found during the consideration of the survey results. These sites are called “hot spots,” hereafter.

* “Wastes Disposal Sea Areas” are sea areas where wastes could be disposed of, defined in “Law Relating to the Prevention of Marine Pollution and Maritime Disaster .” Type of wastes which could be disposed of into the sea, methods for the disposal, etc. are specified according to the sea areas.

3. Comprehensive Assessment of the Marine Environment

The present status and trends for the marine environment in the sea areas around Japan for the past 20 years (approximately 40 years for long-term trend analysis) were comprehensively evaluated by experts. Table 3.1 shows the summary of the evaluations. The details are discussed in subsequent sections.

Table 3.1 Assessment Results of the Marine Environment in Seas around Japan

Evaluation Items			Evaluation of the present status	Effects of the current policy and prospect for future monitoring
Impacts of Land-based Pollution	Nutrient Salts		The impacts of loadings from terrestrial origins were observed as high levels of nutrient salts in some coastal waters. However, the impacts have not yet extended to the offshore area. The nutrient salts tend to decrease by year in inner bay.	The loading has decreased as a result of effluent control measures including Total Pollutant Load Control.
	Pollutant concentrations	Heavy metals	Concentrations of heavy metals in marine sediments were generally higher in inner bays and coastal areas, where it lies in the hinterland of metropolitan areas, and these might be the result of land-based loading. Since heavy metals originally exist in nature, heavy metals detected in the offshore area may be also from natural origin such as geological features besides anthropogenic load. The concentrations in marine organisms showed a downward trend in some sea areas and some organisms, but not in a general and definite manner.	With entry into force of the Minamata Convention on Mercury in August 2017, the reduction of anthropogenic load of mercury is expected through reinforced regulations.
		PCBs	Levels of PCBs in marine sediments were higher in inner bays and coastal areas, where it lies in the hinterland of metropolitan areas, and these might be the results of land-based loading. Furthermore, even though PCB levels were lower in offshore areas, PCBs were continuously detected. No statistically significant downward trend has been observed in the concentration levels in marine organisms.	The concentration of PCBs in the environment matrices decreased after the manufacturing, use, and import of PCBs were basically prohibited in 1974 by the Law Concerning the Examination and Regulation of Manufacture, etc. of Chemical Substances. In recent years, the downward trend has slowed down. With the treatment of PCB wastes started in 2004 associated with the Law Concerning Special Measures for Promotion of Proper Treatment of PCB Wastes (PCB Special Measures Law), it is assumed that the reduction of PCB discharges into the environment has been enhanced further. However, the treatment has not taken effect yet in the form of decrease in the concentrations in marine sediments or marine organisms due to its low degradability and high bioaccumulation. The treatment of PCB wastes is expected to accelerate toward 2027, and the emissions into the sea areas are expected to decrease in the future.
		Dioxins	Levels of dioxins in marine sediments were higher in inner bays and coastal areas, where it lies in the hinterland of metropolitan areas, and these might be the results of land-based loading. Furthermore, even though dioxin levels were lower in offshore area, dioxins were continuously detected. The concentrations in marine organisms showed a downward trend in some sea areas and some organisms, but not in a general and definite manner.	Control measures such as the Law Concerning Special Measures against Dioxins (1999) contributed to a significant decrease in the emissions derived from incineration facilities, which has been one of the major emission sources in recent years. However, the impact of dioxins discharged in the past still remains in the marine environment due to its low degradability and high bioaccumulation. Therefore, the trends of dioxins in the marine environment need to be continuously monitored.

Table 3.1 Assessment Results of the Marine Environment in Seas around Japan (Continue)

Evaluation Items			Evaluation of the present status	Effects of the current policy and prospect for future monitoring
Impacts of Land-based Pollution	Pollutant concentrations	Butyltin compounds	Concentrations of butyltin compounds in marine sediments were higher in inner bays and coastal areas, where it lies in the hinterland of metropolitan areas, and these might be due to the navigation of foreign vessels. Furthermore, a low concentration level of butyltin compounds remains detected in the offshore area. The concentrations in marine organisms showed a downward trend in some sea areas and some organisms, but not in a general and definite manner.	It is estimated that the shipment amount of butyltin compounds intended for open system use have decreased associated with the restriction by the Law Concerning the Examination and Regulation of Manufacture, etc. of Chemical Substances (1988-1990) and the voluntary control measures by industries. Such efforts may have resulted in decrease of the concentration levels within the bodies of marine organisms. Furthermore, with the AFS Convention enforced in 2008, usage of ship bottom antifouling paints including organotin compounds has been prohibited on foreign vessels sailing into ports of Japan. Although the concentration levels are decreasing, the downward trend is gradual in recent years. Therefore, it may take time for the butyltin compounds to become undetected, and continuous monitoring is necessary.
	Impacts on benthic communities		A change in composition of meiobenthos communities caused by the dysoxic environment was observed in some inner bay areas. On the other hand, however, no significant correlations were observed between the pollution by hazardous chemical substances and the changes in population or composition of meiobenthos communities.	The N/C ratio, which indicates the improvement of the dysoxic environment at the bottom layer, decreased in some sea areas. The status needs to be monitored continuously.
	Marine plastic wastes		It has been revealed that plastic wastes are distributed to the offshore area. Given that plastic wastes once discharged into the environment do not easily decompose, they pose a concern over prolonged potential influence on organisms.	Globally, such as in G7 meetings, leaders have recognized the plastic wastes as a problem, and it is expected that each country starts implementing measures to reduce plastic wastes and generate good effects. The distribution of plastic wastes in sea areas is inhomogeneous in spatial-temporal terms, thus monitoring with higher density is necessary.
Pollution derived from ocean dumping			The population of benthic communities at the ocean dumping point of bauxite residue had decreased compared with the background site, but it was within the range of assumptions from the prior environmental impact assessment performed at the time of application for approval. In addition, changes in the sediments characteristics and seafloor topography derived from dumping acts were observed at the ocean dumping points at the offshore area of the Niigata Port, and the composition of benthic communities were different from other survey points. However, the changes were limited to the ocean dumping points. Except for the cases above, no special impacts that may have been derived from legitimate ocean dumping activities were observed at other ocean dumping points.	A certain degree of effect was determined from the environmental conservation measures implemented against ocean dumping in Japan. It is less likely that a significant pollution situation will arise in the future according to the approval system for disposal at sea, newly established in 2007. However, it is required that the ocean dumping activities are legitimately conducted, and continuously checked by monitoring the sea areas.
Detection of specific polluted sea areas (hot spots)			In some of the results of the survey to date, the concentrations of pollutants in the sediments, which were relatively high for offshore areas, were observed. It was determined that these results were from anthropogenic land-based pollutants.	Concerning the hot spots so far detected, the concentrations have not reached a level affecting human health, however, continuous monitoring is required in terms of protection of marine environment and ecosystem. In addition, monitoring should be performed as needed for sea areas where surveys have not been implemented regularly, in order to prevent such anthropogenic pollution.
Analysis of long-term trends			Concentrations of PCBs in marine sediments of some inner bays and coastal areas, where it lies in the hinterland of metropolitan areas, showed significant decrease trends for the past 40 years. In addition, the decreasing trend of total mercury in seawater, and increasing trends of lead and copper in sediments were also significant.	There is a possibility that the concentration of PCBs in marine sediments has decreased due to the reduction of anthropogenic load through regulations in Japan and overseas. On the other hand, there is a possibility that analytical methods and impacts from natural origins may have affected the concentration trends of other substances. Therefore, continuous monitoring is necessary.

3.1. Impacts of Land-based Pollution

3.1.1. Nutrient salts

In major water bodies like Tokyo Bay and Osaka Bay, under high levels of nutrient loadings from terrestrial origins. sea water of coastal areas showed high level of nutrient salts. However, direct impact in the coastal areas did not appear to have extended out to the offshore region. The concentration of nutrient salts has decreased over time in inner bays. This might be the result of effluent control measures including the Total Pollutant Load Control.

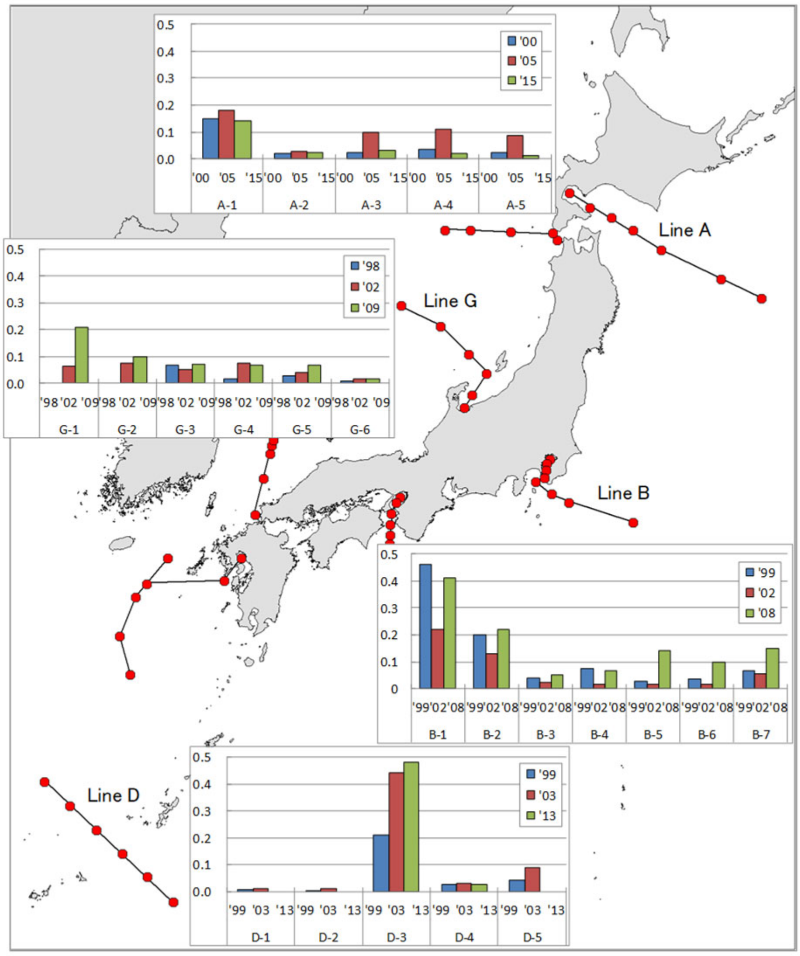
3.1.2. Pollutant concentration in the marine environment

(1) Heavy metals

The concentrations of heavy metals in marine sediments were generally high in inner bays and coastal areas, where it lies in the hinterland of metropolitan areas, while they were lower in offshore areas. This indicates that loadings from terrestrial origins are affecting coastal areas (Figure 3.1). In addition, the concentrations of heavy metals in the offshore areas generally tended to be higher than the existing measurement results of concentration in the North Pacific (open ocean) (Nozaki, 1995, Mawji et al., 2015), indicating that the impact of loadings from terrestrial origins had extended out to the offshore areas, although the impact was not as high as coastal areas. Meanwhile, at the survey points of some sea areas such as off the coast of Okinawa and in the southwestern part of Hokkaido, heavy metals in the marine sediments were relatively high due to the effects of natural origins such as geological conditions. The baseline data of concentrations of heavy metals in sea areas around Japan were thus accumulated.

In terms of heavy metal levels within marine organisms, statistically significant decreasing trends ($p<0.05$) were seen in some sea areas and species [copper in crabs (muscles) in the Sea of Japan, and total mercury in squids (livers) in sea areas of Oyashio Current and cods (livers) in the Sea of Japan] but not in a definite manner in general (Figure 3.2).

There is no clear decreasing trend for the concentrations of mercury neither in sediments nor in organisms at this point. However, the anthropogenic load of mercury on the marine environment is expected to decrease, based on the reinforcement of regulations on the use and emission of mercury into the environment under the Laws to Prevent Environmental Contamination with Mercury and the Air Pollution Control Act, to comply with the Minamata Convention on Mercury adopted in 2013 and entered into force in August 2017.



Note: Colors of the bars correspond to the difference in survey years.

Figure 3.1 Geographical Distribution of Total Mercury Concentrations within Surface Marine Sediments (μg/g dry wt)

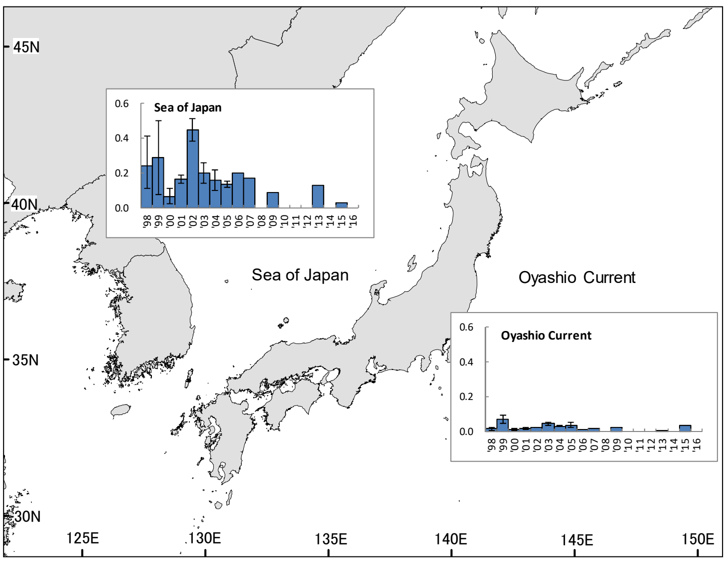


Figure 3.2 Chronological Changes in Total Mercury Concentrations within Cods (μg/g dry wt)

(2) PCBs

The concentrations of PCBs in sediments were high in inner bays and coastal areas, where it lies in the hinterland of metropolitan areas, while they were lower in offshore areas (Figure 3.3). This finding indicates that loadings from terrestrial origins are highly affecting coastal areas.

No statistically significant downward trend was observed in the PCB levels within marine organisms for the recent years ($P>0.05$; Figure 3.4).

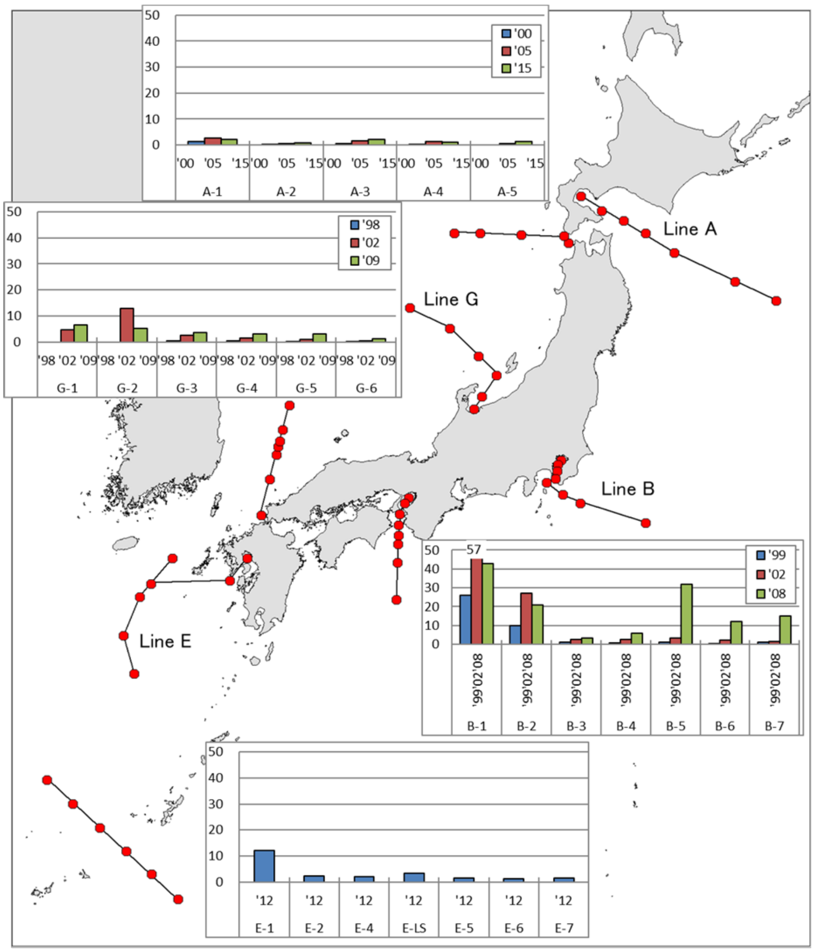
The consumption of PCBs in Japan gradually increased after these compounds first started to be used in 1954 and peaked in 1970. Then the production of PCBs was stopped in 1972 (Figure 3.5), and PCBs were designated as a class I specified chemical substance under the Act on the Evaluation of Chemical Substances and Regulation of Their Manufacture, etc. (Chemical Substances Act) in 1974, that prohibited the use of PCBs in principle. (The uses of PCBs in some purposes in closed-systems are still allowed.)

Results of the analysis of sediment cores from the head of Tokyo Bay (sampled in 1993) (Okuda et al., 2000) indicated that the concentrations of PCBs rapidly increased in the 1960s until peaking around 1970, and then began to decline in reasonable accordance with the concurrent declining patterns of industrial utilization/consumption (Figure 3.6). On the other hand, although production of PCBs stopped in 1972, the concentration levels of PCBs in sediment cores remained at approximately 30% of the peak level from the mid 1980s to 1993. The concentrations of PCBs in marine sediment cores collected at the head of Tokyo Bay in this monitoring survey in recent years shifted near the concentrations found around 1993 by Okuda et al. (2000). This indicates that PCBs still remain in the environment even after the production and uses were stopped.

In addition, while the PCB concentrations (national averages) within fishes and shellfishes had been on a downward trend since the end of the 1970s (Ministry of the Environment, 2017a), it has leveled off in the 2000s for the fishes (Figure 3.7). This trend mostly consists with the finding of this monitoring survey.

After PCBs were designated as a class I specified chemical substance under the Chemical Substances Act, it was decided that PCBs that had already been produced and products containing PCBs would be recalled and stored. However, the disposal of the recalled PCBs did not progress smoothly. Furthermore, the prolonged storage of PCB wastes has resulted in missing and lost cases of stored PCBs, and there is concern over the discharge of such missing or lost PCBs into the environment (Deliberation Committee on PCB Waste Treatment Project, 2003).

Because the parties to the Stockholm Convention on Persistent Organic Pollutants are obliged to complete the proper treatment of PCBs by 2028, Law concerning Special Measures for Promotion of Proper Treatment of PCB Wastes (PCB Special Measures Law) was established in 2001 and detoxification of PCBs has been in progress in Japan since December 2004 with the objective of completing the treatment of PCB wastes by March 2027. Because PCBs are slow to decompose in the environment (low degradability) and are apt to be concentrated/accumulated within the bodies of organisms through the food chain (high bioaccumulation), the reduction of outflow of PCBs into the environment associated with the treatment of PCB wastes has not taken effect yet in the form of decreases in the concentration levels within marine sediments or marine organisms. However, as the treatment of PCB wastes is assumed to accelerate toward March 2027, it is expected that the concentrations of PCBs in the marine environment will decrease.



Note: Colors of the bars correspond to the difference in survey years.

Figure 3.3 Geographical Distribution of PCB Concentrations within Marine Surface Sediments (ng/g dry wt)

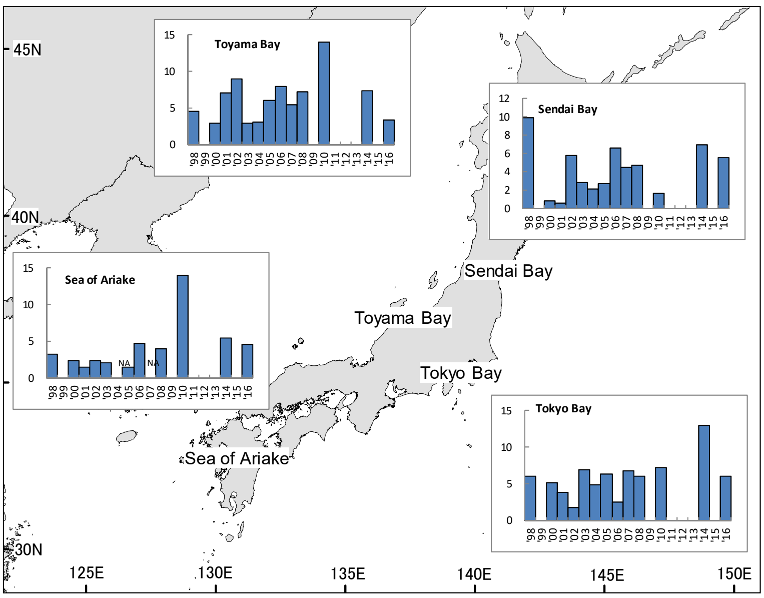


Figure 3.4 Chronological Changes in PCB Concentrations within Mussels (molluscous part) (ng/g dry wt)

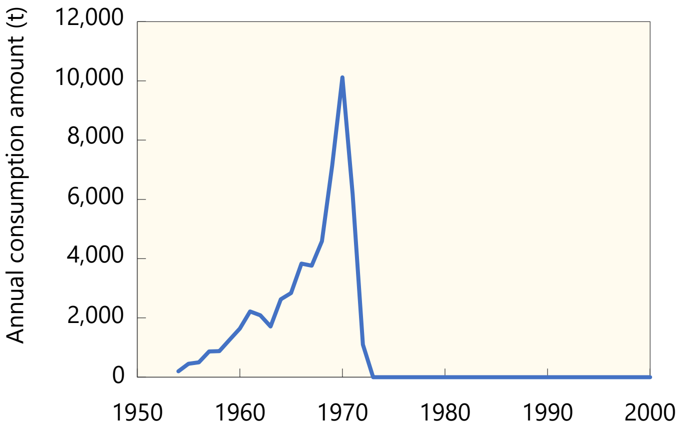


Figure 3.5 Changes in PCB Consumption in Japan (Prepared from data based on Isono, 1975)

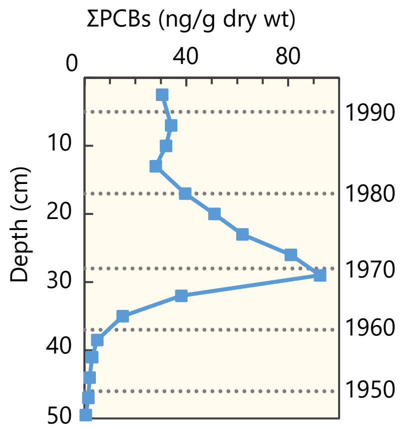


Figure 3.6 Vertical distribution of PCBs in the sediment core of Tokyo Bay (Changed from Okuda et al., 2000)

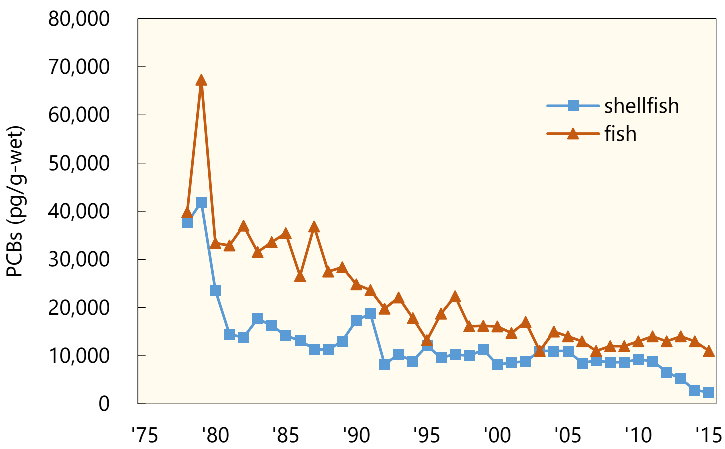


Figure 3.7 Long-term changes in the PCB concentration in organisms in Japan (geometric mean) (prepared based on data from the Ministry of the Environment, 2017a)

(3) Dioxins

The concentrations of dioxins in marine sediments were high in inner bays and coastal areas, where it lies in the hinterland of metropolitan areas, while they were lower in offshore areas (Figure 3.8). This indicates that loadings from terrestrial origins are highly affecting coastal areas.

In terms of dioxins levels within marine organisms, statistically significant decreasing trends ($p<0.05$) were seen in the concentrations of dioxins in some sea areas and species [PCDDs/PCDFs and co-PCBs in sharks (livers) in Tokyo Bay, PCDDs/PCDFs and co-PCBs in squids (livers) in sea areas of the Kuroshio Current, co-PCBs in squids (livers) in sea areas of the Oyashio Current and co-PCBs in cods (livers) in the Sea of Japan] but not in a definite manner in general (Figure 3.9).

In Japan, approximately 90% of the emissions of dioxins, especially of PCDDs and PCDFs, are estimated to be released from the incineration of municipal and industrial wastes (Ministry of the Environment, 2012a). Accordingly, various preventive countermeasures have been

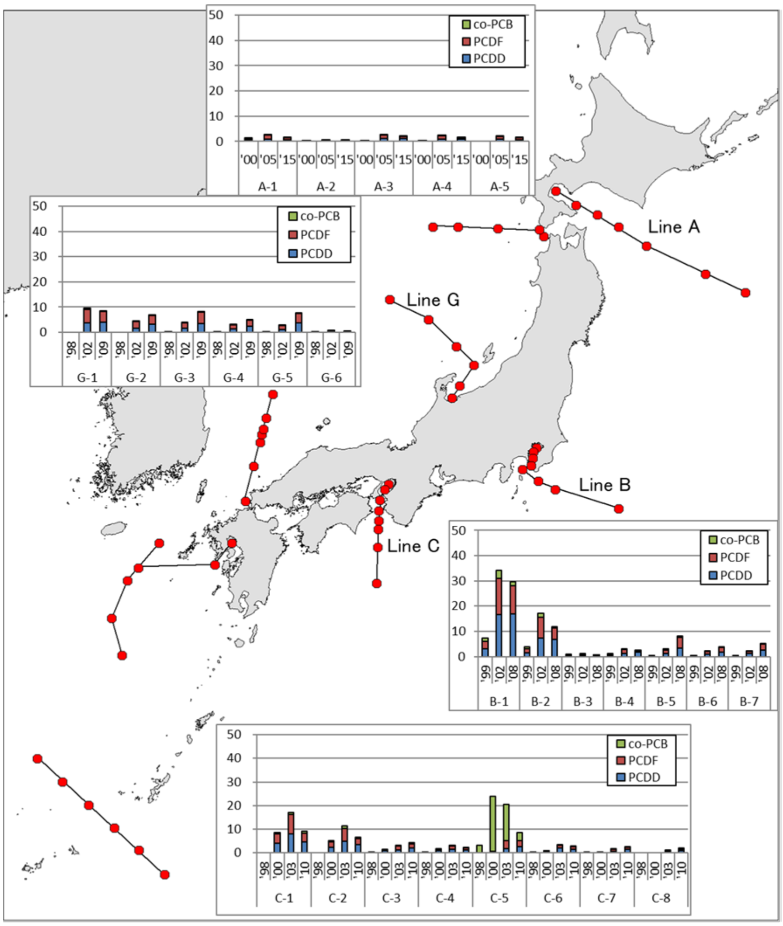


Figure 3.8 Geographical Distribution of Dioxin Concentration within Marine Sediments (pg-TEQ/g dry wt)

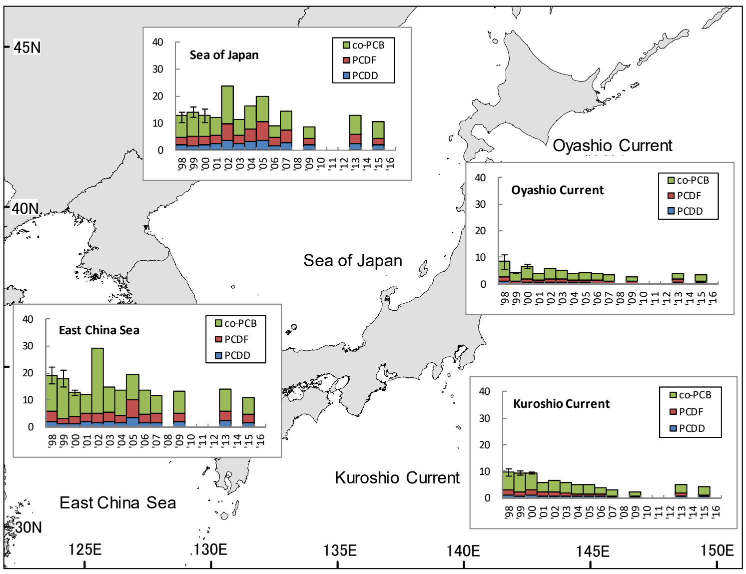


Figure 3.9 Chronological Changes in Dioxin Concentration within Squids (livers) (pg-TEQ/g wet wt)

implemented since December 1997, including regulations to control dioxins emitted from stacks of incineration facilities, etc. and the improvement of refuse incineration plants in accordance with the Air Pollution Control Law and the Waste Management and Public Cleansing Law. Later, with the Basic Guidelines of Japan for the Promotion of Measures against Dioxins formulated in March 1999, the policy of “reducing the total amount of national dioxin emissions by approximately 90% from the 1997 level within 4 years” was launched. In addition, the Law Concerning Special Measures against Dioxins was established in July 1999 and enforced in January 2000, and restrictions, etc., have been implemented for exhaust gases and wastewater.

As a result, the total emission of dioxins in Japan decreased by approximately 98% in 2015 from the 1997 level (Ministry of the Environment, 2017b). Associated with the above reduction, the dioxin concentration in the air, where the emission reduction is likely to take effect soonest, rapidly decreased by about 97% from the 1997 level in 2015 (Ministry of the Environment, 2017c) (Figure 3.10). On the other hand, in terms of the dioxin concentration within marine organisms, where the effect of emission reduction is likely to show slowly, a downward trend was not observed in a definite manner in general, as mentioned above.

Because dioxins are slow to decompose (low degradability) and easily are concentrated within the bodies of organisms through the food chain (high bioaccumulation), the dioxins discharged in the past tend to remain in the marine environment. Hence, the concentration of dioxins within the bodies of marine organisms may not decrease immediately even if the emissions of dioxins derived from incineration facilities, which is one of the chief sources of dioxins in recent years, are declining.

According to the analysis of sediment cores of Tokyo Bay sampled in 2011, the concentration of dioxins peaked around 1970, before the Act on Special Measures against Dioxins became effective in 2000, and gradually decreased. The concentration of dioxins around 2010 was about 1/8 of the peak concentration (Figure 3.11; Nozawa et al., 2014, Yamazaki, 2014). The concentration of dioxins at the surface layer of the sediment cores mentioned above was about the same as the concentration detected at the survey point at the head of Tokyo Bay in the Marine Environment Monitoring Survey. Furthermore, it has been reported that pesticides were assumed as a major source of the dioxins in Tokyo Bay, as dioxins were contained in many pesticides as impurities used around the 1960s to the 1970s (Masunaga, 2004).

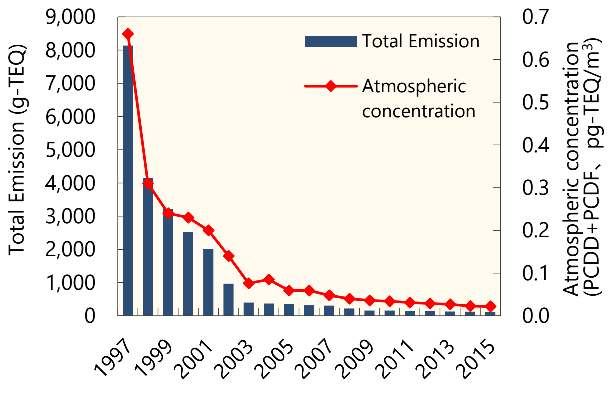


Figure 3.10 Changes in the total amount of dioxin emissions and concentration in the atmosphere (prepared based on data from the Ministry of the Environment, 2017b; 2017c)

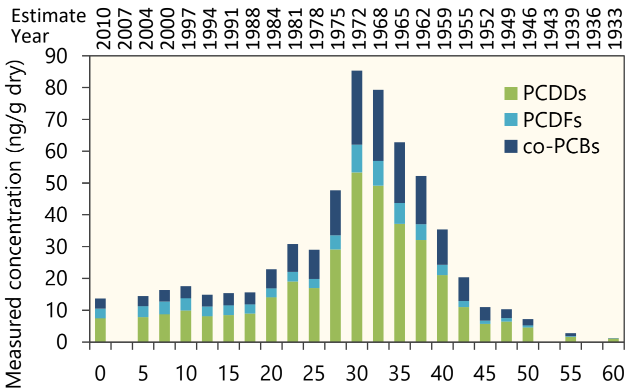


Figure 3.11 The concentration of dioxins by depths of the sediment core collected at Tokyo Bay (Yamazaki, 2014)

(4) Butyltin compounds

The concentrations of butyltin compounds in marine sediments were high in inner bays and coastal areas, where it lies in the hinterland of metropolitan areas, while they were lower in offshore areas (Figure 3.12). Given the fact that butyltin compounds were mainly used in antifouling paints, the contamination was likely to be derived from the heavy traffic of vessels in affected sea areas rather than from terrestrial origins. In addition, given that the use of antifouling paints containing butyltin compounds had already been prohibited in Japan around 1990 as discussed below, the major loading source might have been due to the navigation of foreign vessels.

In terms of butyltin compound levels within marine organisms, statistically significant decreasing trends ($p<0.05$) were seen in some species and some sea areas [TBT in mussels (molluscous part) in Sendai Bay and Tokyo Bay, TBT in squids (livers) in sea areas of Oyashio Current, DBT in squids (livers) in the East China Sea, and TBT and DBT in squids (livers) in the Sea of Japan] but not in a definite manner in general (Figure 3.13).

Since the 1960s, butyltin compounds have been widely used in antifouling coatings (for ship bottom paints or fish net antifouling paints). In the mid 1980s, however, marine pollution from organotin compounds became a social issue in Japan. In association with the issue, one of the members of this pollutant group, tributyltin oxide (TBTO) was designated as a class I specified chemical substance under the Chemical Substances Act in January 1990 in Japan, and manufacturing, using, or importing of this substance was prohibited in principle. In September of the same year, other tributyltin (TBT) compounds were designated as a class II specified chemical substance that requires prior notification of quantities of production or importation, and the quantities of the production or importation was restricted accordingly. At about the same time, the production and use of antifouling paints were voluntarily controlled by various relevant industries. Shipment amounts of TBT for open system use have rapidly decreased after peaking at the end of the 1980s (Figure 3.14), assumably due to the effect of the above restrictions.

Additionally, the International Convention on the Control of Harmful Anti-fouling Systems on Ships (AFS Convention) went into effect in 2008. As outlined under this convention, foreign vessels entering into Japanese ports are prohibited from using antifouling paints for ship bottoms which contain organotin compounds. Therefore, the loading of butyltin compounds in sea areas around Japan is expected to decrease.

The concentrations of TBT in fishes and shellfishes show a long-term decreasing trend since 1985 when the environmental survey for the status of TBTs by the Ministry of Environment started (Figure 3.15), assumably due to the effect of the various above-mentioned control measures in Japan. On the other hand, the downward trend has slowed down since 1998. In addition, as stated above, in terms of the Marine Environment Monitoring Survey, TBT concentrations within the bodies of marine organisms show a significant downward trend in some sea areas and some species but not in a definite manner in general. Putting these findings together, it may take time until the accumulation of tributyltin compounds within the bodies of marine organisms will be unrecognizable.

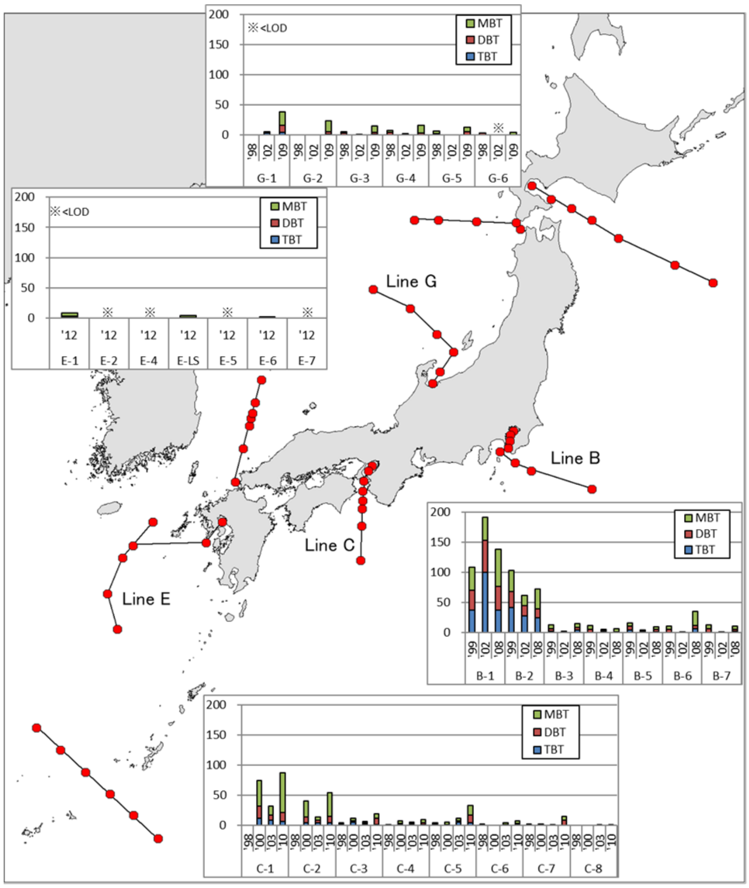


Figure 3.12 Geographical Distribution of Butyltin Compound Concentration within Surface Sediments (ng/g dry wt)

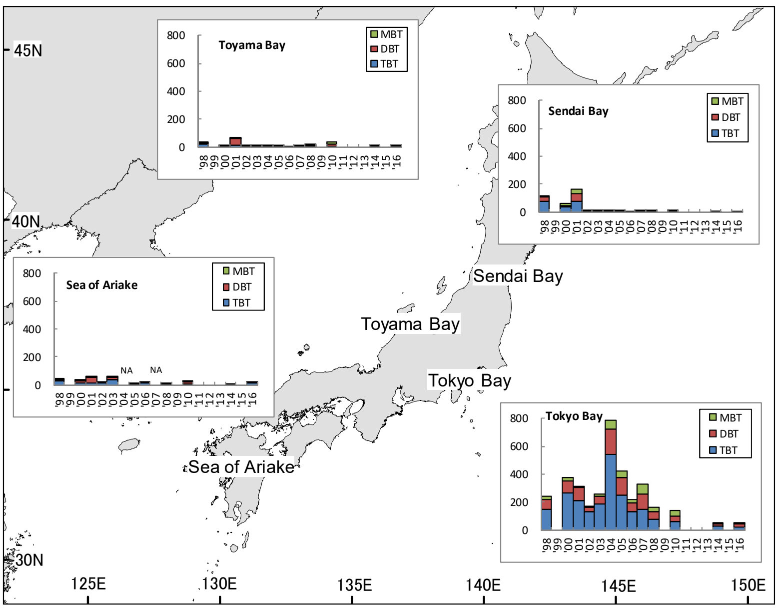
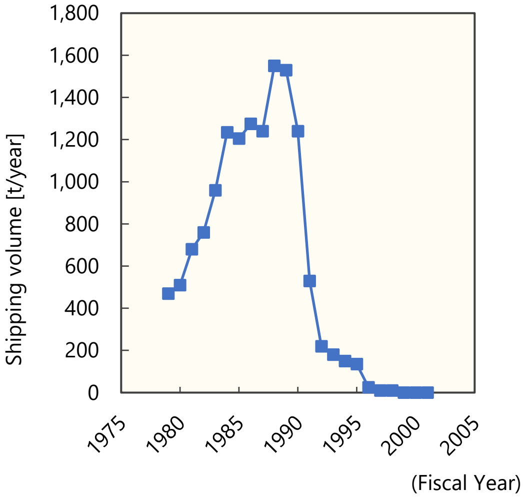


Figure 3.13 Chronological Changes in Butyltin Compound Concentration within Mussels (ng/g wet wt)



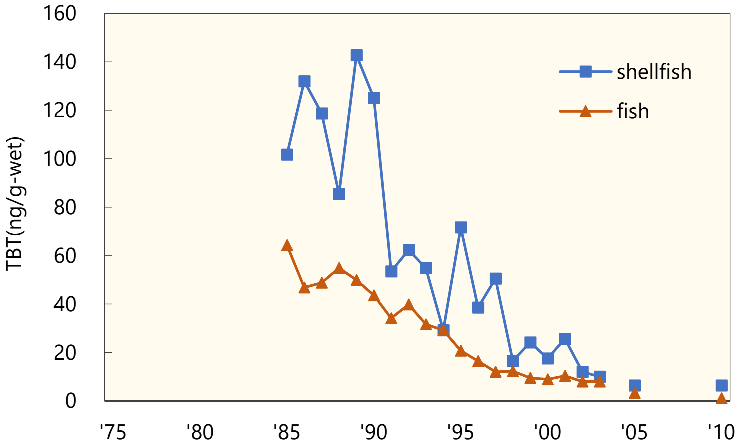


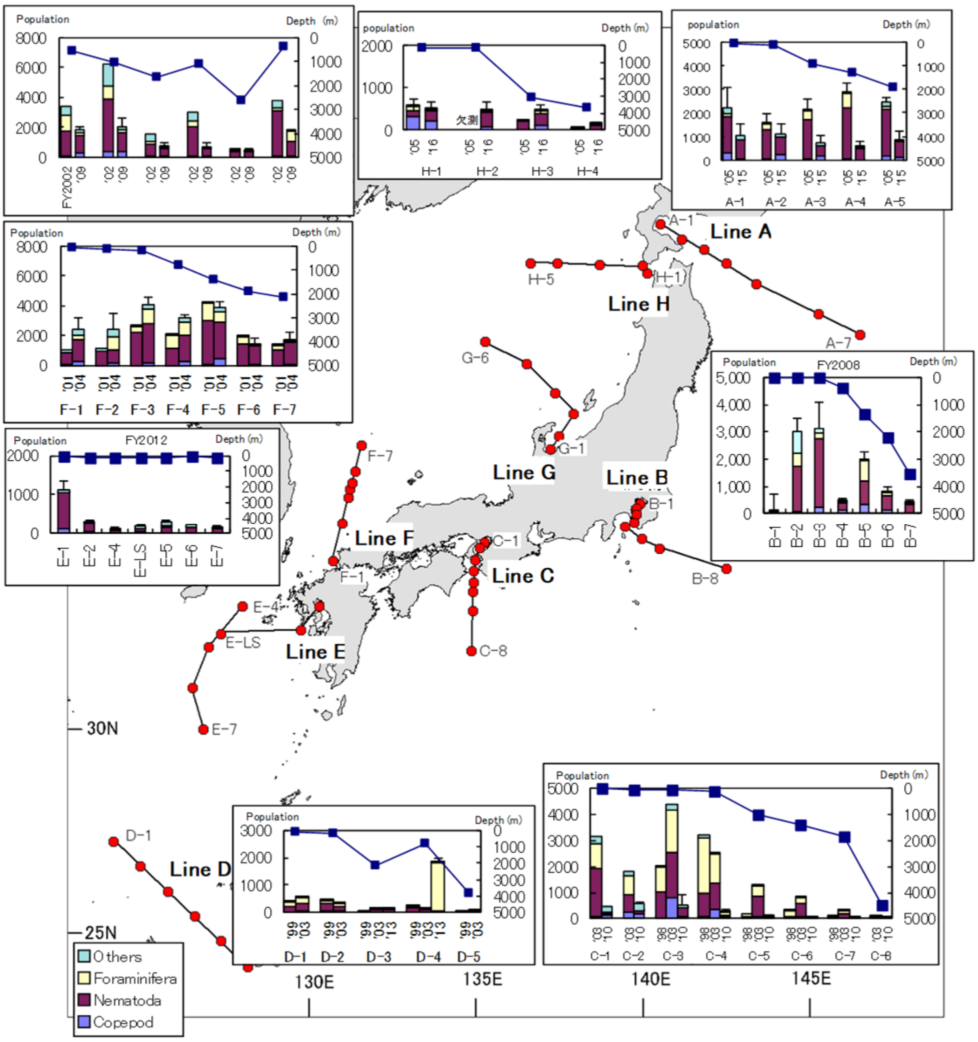
Figure 3.14 Estimated Shipment Amounts of TBT for Open System Uses in Japan (Except for shipment amounts for chemical raw materials; TBT-based equivalent value) (Nakanishi and Horiguchi, 2006)

Figure 3.15 Long-term changes in the TBT concentration inside the bodies of organisms in Japan (prepared based on data from the Ministry of the Environment, 2012b)

3.1.3. Impacts of hazardous substances on benthic communities

The impacts of various human activities on the marine environment may cause changes in the marine ecosystem. In the Marine Environment Monitoring Survey, surveys on meiobenthos communities were performed in an attempt to better assess this perspective. As a result, data were accumulated from survey points at water depths of up to approximately 5,000 m (Figure 3.16).

In some inner bay areas, changes in the composition of meiobenthos communities were observed, which were most likely to be a result of dysoxic environment. Still, no significant correlations were observed between the pollution by hazardous chemical substances and the observable changes in population or composition of meiobenthos communities. This result indicates that the concentrations of the hazardous chemical substances were not so high as to affect the meiobenthos communities. The ratio of population of Nematode to Copepod (N/C ratio) is used as an indicator of environment deteriorations such as hypoxia. At some survey points, the high values in the N/C ratio, which have been confirmed in the early 2000s, were no longer detected in recent years. This result might indicate the improvement of the dysoxic environment at the bottom layer.



Note: the bar graphs show the population of the Meiobenthos and the line graphs shows the water depth

Figure 3.16 Distribution of Meiobenthos Population (Population/10cm²)

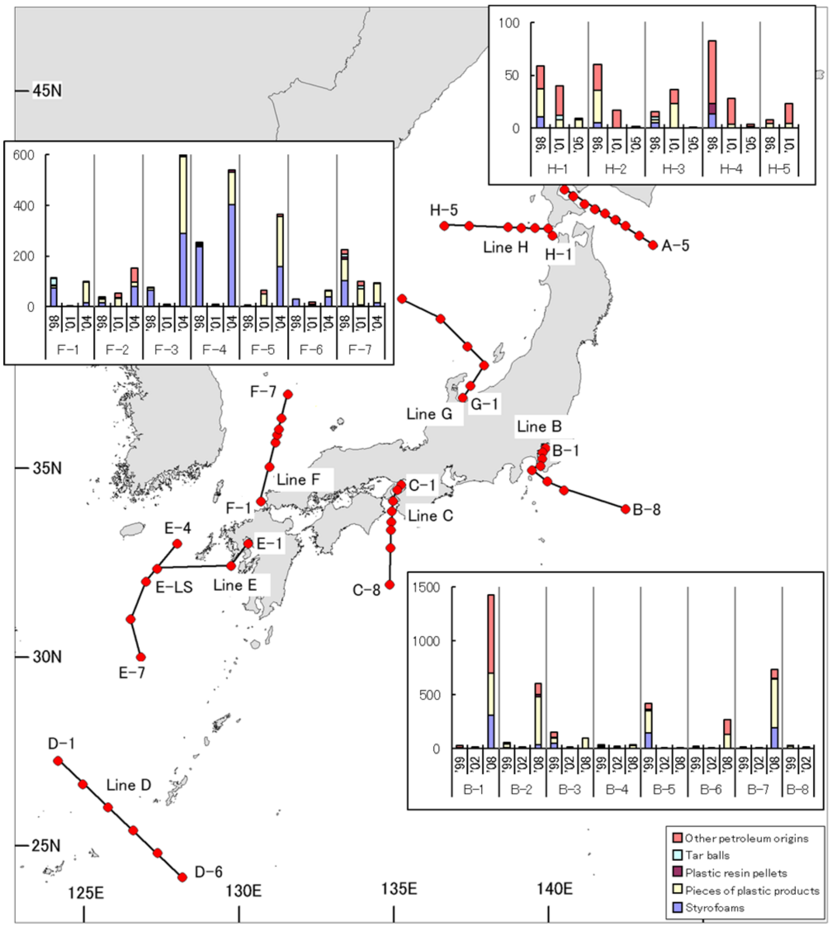
3.1.4. Marine plastic wastes

The results of the Marine Environment Monitoring Survey revealed that marine plastic wastes are widely distributed not only in coastal areas but also in offshore areas. Some sea areas showed a higher concentration of plastic wastes in the coastal areas, with a lower concentration in offshore areas. However, few data show such trends in a definite manner. In addition, the data were inhomogeneous in spatial-temporal terms, and survey points with large quantities of marine plastic wastes were localized. Moreover, the distributed quantities at a survey point varied significantly from year to year (Figure 3.17).

Among marine plastic wastes, small pieces of plastics (microplastics) such as resin pellets and plastic fragments are likely to be ingested accidentally by marine organisms such as seabirds. In addition, impacts of microplastics on marine organisms are not only limited to direct effects, but also to effects caused by chemical substances adhered on the microplastics from the marine environment, such as seawater. Given that plastic wastes once discharged into the environment are slow to decompose and as plastic wastes are distributed across a wide stretch of ocean around Japan, potential long-term influences on marine organisms are concerned.

Ogi and Fukumoto (2000) reported that 490,000 pieces/km^2 of plastic particles on average (with a range of 0 to 9,890,000 pieces/km^2) had been distributed in the coastal areas off Southeast Hokkaido during 1994 to 1995. However, according to the results of the Marine Environment Monitoring Survey, the distribution quantity at a survey point varied significantly among survey years. Therefore, continuous monitoring surveys are required in order to grasp the trend of chronological changes in the plastic waste distribution.

The issue of marine plastic wastes is being discussed globally such as in summit meetings. The Leaders' Declaration at the G7 Summit held in Elmau in 2015 contained a commitment to work on this issue together. They also agreed on preventing the outflow of microplastics such as pellets and microbeads into the ocean and limiting their uses. On the other hand, the amount of plastic productions around the world has been increasing (Figure 3.18), which may also result in the increase of the inflow of plastic wastes into the marine environment. Thus, the continuous monitoring system needs to be further enhanced through domestic and international cooperation.



Note: The data prior to 2004 are reference values (the collection method was modified in 2004).

Figure 3.17 Distribution of Marine Plastic Wastes in or before fiscal 2014 (1,000 pieces/km^2)

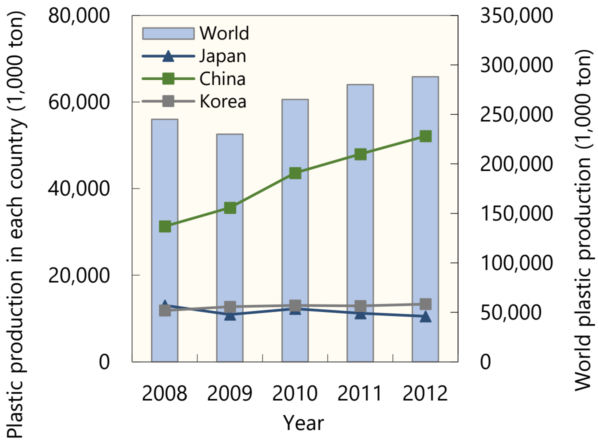


Figure 3.18 Changes in the amount of plastic productions (Prepared from data furnished via the website of the Japan Plastics Industry Federation, 2017)

3.2. Effects of pollution caused by ocean dumping of wastes

Ocean dumping of wastes in Japan is regulated by the Law Relating to the Prevention of Marine Pollution and Maritime Disaster (Marine Pollution Prevention Law), and by the Waste Management and Public Cleansing Law as an effort to comply with the requirements specified in the international treaties, Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention), and 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (1996 Protocol).

In or before April 2007, Disposal Sea Areas A, B, C, and F had been specified as sea areas where ocean dumping was permitted in Japan. The wastes mentioned below were specified for the respective sea areas, and identified as wastes permitted to be dumped for disposal: Disposal Sea Area B includes Disposal Sea Area A, Disposal Sea Area C includes Disposal Sea Area B, and Disposal Sea Area F includes substantially all sea areas.

Disposal Sea Area A (current Disposal Sea Area I) had been a sea area where dumping and disposal were permitted for solidified wastes with high harmful effects in or before 2007. The ocean dumping of such highly hazardous wastes, however, has not been practically conducted in Japan since 1981, and it has been prohibited after the amendment of Marine Pollution Prevention Law in 2007. The wastes which had been dumped into Disposal Sea Area B (current Disposal Sea Area II) were mainly water-insoluble inorganic sludge such as bauxite residue and construction sludge. In Disposal Sea Area C (current Disposal Sea Area III), organic wastes had been permitted to be dumped for disposal. Various types of specific waste items dumped in Disposal Sea Area C included human wastes, sludge from facilities of human waste treatment, organic sludge, waste acid, waste alkali, animal and plant residues, and cattle manure. In Disposal Sea Area F (current Disposal Sea Area IV), ocean dumping of dredged soil had been permitted.

In the ocean dumping process, decision criteria are established for industrial wastes likely to be contaminated by hazardous chemical substances, and only wastes meeting those criteria are permitted to be dumped for disposal. Under the Marine Pollution Prevention Law in or before 2007, the wastes permitted for ocean dumping were defined, but performance of environmental impact assessments prior to the dumping and monitoring after the dumping were not required to the waste- generating companies.

After April 1, 2007, a new approval system for the ocean dumping of wastes was established in association with the partial amendment of the Marine Pollution Prevention Law in response to the 1996 Protocol to the London Convention. Associated with the above system, it was decided that waste-generating companies were obligated to perform a prior assessment of the impact of ocean dumping on the marine environment.

According to the results of the Marine Environment Monitoring Survey, substances originating in the bauxite residues, and decrease in meiobenthos communities were observed at the survey point in Disposal Sea Area II located off Boso and Izu. However, the impacts observed were within the range of assumptions from the prior environmental impact assessments for these areas. Furthermore, the composition of benthic communities in Disposal Sea Area IV located off Niigata Port, were different from other survey points due to changes in the characteristics (particle sizes) of sediments and seafloor topography caused by ocean dumping. However, these effects were limited to ocean dumping points. In most sea areas other than the areas mentioned above, no impact was observed by the legitimate ocean dumping activities. However, pollution from unknown origins has been detected in some of these ocean dumping areas. Illegal waste dumping may be the cause of such pollution, and further identification of the pollution source(s) is required.

Although it is less likely that significant pollution will arise in the future, owing to the approval system for ocean dumping under the Marine Pollution Prevention Law, it is important to continuously check the impacts of the ocean dumping through methods such as environment monitoring.

3.3. Detection and follow-up survey of specific polluted sea areas (hot spots)

The Marine Environment Monitoring Survey detected relatively high concentrations of pollution in marine sediments, rarely seen in the offshore areas, in the following three sea areas. In these sea areas, detailed follow-up surveys have been properly performed.

(1) Sea areas around the Kii Channel

PCBs higher than the background levels were detected within sediments in the sea area around the Kii Channel. The survey indicated continuous loading of PCBs since around 1970 to at least recent years with a PCB loading source present near the seafloor. In addition, the survey indicated that it was highly possible that the loading source was not likely to be from a single property source but possibly from a mixture of various devices.

(2) Offshore of Kii/Shikoku

High concentrations of butyltin and phenyltin compounds were detected in sediments located in Disposal Sea Area II and Disposal Sea Area III (at a water depth of approximately 4,000 m to 4,500 m) off Kii/Shikoku. The source of this pollution is unspecified at this point.

(3) Western part of the Sea of Japan

High concentrations of butyltin compounds and brominated flame retardants were detected within sediments in a wide-scale sea area around the Disposal Sea Area III located in the western part of the Sea of Japan. The source of this pollution is unspecified at this point.

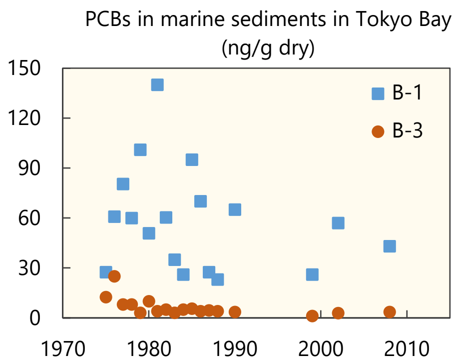
Although none of the above sea area cases were determined to have reached a level to affect human health, these cases indicate that the impacts of anthropogenic activities have extended to the offshore areas. Accordingly, continuous monitoring is necessary from the perspective of conserving the marine environment and ecosystem.

Although the areas of the monitoring surveys were limited, pollution in deep seafloors has been detected as mentioned. Therefore, in terms of preventing anthropogenic pollution in the future, an extensive monitoring survey needs to be continuously performed, including sea areas where ocean dumping had been conducted but have not yet been surveyed.

3.4. Findings of the analysis of long-term trends

In addition to the findings of the Marine Environment Monitoring Survey since 1998, results from some survey points of the Japan Coastal Pollution Survey from 1975 are also available. Thus, an analysis on the temporal trend of the concentration of pollutants in the marine environment around Japan over the past 40 years was implemented. As a result, a significant decreasing trend of PCB concentrations in sediments in some inner bays and coastal areas such as Tokyo Bay and Osaka Bay, where it lies in the hinterland of metropolitan areas, was observed (Figure 3.19). This indicates that the effects of regulations on PCB production and uses in Japan have appeared as a decrease in PCB concentrations in marine sediments at a certain degree.

Furthermore, the decreasing trend of total mercury in seawater and the increasing trends of lead and copper in marine sediments were statistically significant. However, there are possibilities that these may relate to the use of different analytical methods or effects of natural origins, which makes it difficult to accurately analyze long-term trends. Additionally, in recent years, the data have been obtained at a frequency of surveying one round of the sea areas around Japan in about eight years, thus, this difference in survey frequency also makes the long-term analysis difficult. The implementation of continuous monitoring surveys with proper frequency are important to clearly understand the long-term trends of pollutants in the marine environment.



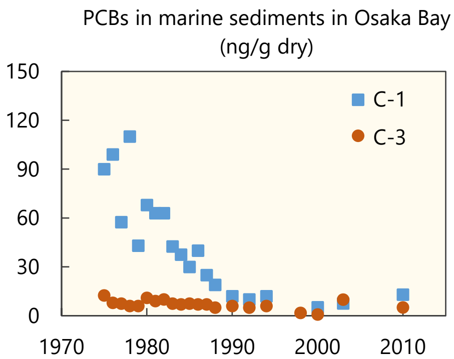


Figure 3.19 Temporal trends of PCB concentrations in marine sediments in Tokyo Bay (figure on the left) and Osaka Bay (figure on the right)

3.5. Toward Future Countermeasures

Through the implementation of the Marine Environment Monitoring Survey over approximately 20 years, the baseline data of pollutants in the marine environment around Japan was compiled. Such a long-term environment monitoring survey is unique at the global level, and is highly valuable in terms of protection of the environment around Japan, where land areas are surrounded by oceans.

As discussed earlier, emissions of dioxins over the last 20 years have decreased to 1/10 or less of prior levels as a result of the laws and regulations. Atmospheric concentrations of dioxins have rapidly decreased, in close association with the decrease in the emissions. On the other hand, although dioxins showed a partial downward trend in terms of the concentrations within the bodies of several marine organisms and sea areas, this downward trend is not definite or clearly characterized in general.

Thus, once a pollutant is discharged into the marine environment, restrictions on these sorts will not readily have observable effects. Considering such characteristics of the sea, continuous conservation measures from a preventive perspective strongly need to be taken in order to prevent marine pollution. Including such perspectives, the issues to be addressed in the Marine Environment Monitoring Survey in the future are summarized below:

(1) The expansion of survey areas within the EEZ of Japan

In the United Convention on the Law of the Sea, “the protection and conservation of the marine environment” are prescribed as one of sovereign rights of the coastal state of an exclusive economic zone (EEZ), and the Marine Environment Monitoring Survey is being implemented as a part of such regulations. The survey is performed continuously by using some survey points of the previous Japan Coastal Pollution Survey and covering from inner bays and coastal areas, where major pollutant loads are likely to be present, to offshore of these areas. Meanwhile, no survey data have been obtained from further offshore areas within the EEZ. Thus, the expansion of survey areas and implementation of surveys at such areas in order to obtain baseline data need to be considered.

(2) The implementation of surveys suited to wastes to be dumped into the ocean

A new approval system for ocean dumping of wastes was established associated with a partial amendment of the Marine Pollution Prevention Law in 2007. Accordingly, it has now become possible to accurately grasp in advance the types, quantities, and locations of wastes being dumped into the ocean for disposal. In addition, with the monitoring report obligations now required for waste-generating companies, a field survey by the waste-generating companies are performed for wastes being dumped into the ocean for disposal in large quantities.

It is assumed that the wastes mainly dumped into the ocean in the future would be dredged soil, therefore, consideration may be required to set survey categories focusing on the effects of dredged soil repeatedly dumped into the ocean at coastal areas for the surveys in ocean dumping sea areas. In addition, it is necessary for the national government to continuously examine the adequacy of monitoring reports prepared by waste-generating companies, that is, to verify that no significant effect has been occurring on the marine environment.

(3) Continuous monitoring of specific polluted sea areas (hot spots)

Based on the findings of past surveys, continuous monitoring needs to be performed for PCBs within the sediments in the sea area around the Kii Channel, as well as for the organotin compounds within the sediments at the offshore of Kii/Shikoku, and for the butyltin compounds and brominated flame retardants within the sediments in the western part of Sea of Japan. In addition, monitoring areas should be expanded as needed in order to prevent such anthropogenic pollution, including sea areas where ocean dumping had been conducted but have not yet been surveyed.

(4) Implementation of the periodic assessment of the marine environment and the introduction of proper evaluation indexes

The Marine Environment Monitoring Survey is planned to survey sea areas (currently eight transect lines are available) around Japan in about eight years. The period needed to perform one round of the survey is called "one phase." In principle, a periodic evaluation for the respective phases is expected to be performed on the current conditions of the marine environment, effects of policies, and other relevant aspects using data obtained so far and other data obtained through relevant monitoring surveys inside and outside of Japan. Phase 1 was from fiscal 1998 to 2001, phase 2 from fiscal 2002 to 2007, and phase 3 from fiscal 2008 to 2016. This report is a summary of data up to phase 3. The survey shifts to phase 4 in fiscal 2018.

The evaluation results of the monitoring surveys need to be used for the proposal and reevaluation of measures for the conservation of marine environment of Japan. In addition, the results should be considered to be shared and utilized in the activities of the Northwest Pacific Action Plan (NOWPAP) and the Global Marine Assessment (GMA).

Further, in order to publish the scientific evaluation results regarding the current status of the marine environment obtained by the Marine Environment Monitoring Survey, including impacts of the concentration of hazardous chemicals in the environment on organisms, in an easily understood manner, it is necessary to further discuss the evaluation method of the marine environment by considering various indexes used for the evaluations of the marine environment in other countries.

(5) Frequent transmission of the results

In the Marine Environment Monitoring Survey so far, information concerning the outcomes of monitoring surveys have been transmitted through methods such as compilation of survey results for each year, preparation of report assessing the status of the marine environment around Japan, development of a database to distribute the survey data, and presentation at international conferences. While the worldwide recognition toward the conservation of the marine environment is increasing, active introduction of the survey results at international conferences and academic conferences by Japan is required to widely increase the recognition toward the purpose of the Marine Environment Monitoring Survey, and to make further use of the findings of the monitoring survey.

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The data on Marine Environmental Monitoring Survey can be downloaded from following (only in Japanese): http://envgis.nies.go.jp/kaiyo/

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