# Present Status of Marine Pollution in the Sea around Japan

as based on data from Marine Environment Monitoring Survey results
Fiscal Years 1998 - 2007

October 2009

Ministry of the Environment

# Table of Contents



◎ Marine Environment Monitoring Survey Review Meeting

*Members*

*Note: the members and their affiliations listed above are as of March 2009*

| | |
|---|---|
| Mr. Satoru Futatsumachi | General Manager, Marine Pollution Research Laboratory, Environmental and Oceanographic Research Division, Hydrographic and Oceanographic Department, Japan Coast Guard |
| Prof. Joji Ishizaka | Professor, Faculty of Fisheries, Nagasaki University |
| Dr. Hideaki Maki | Research Fellow, Marine Environment Section, Water and Soil Environment Division, National Institute for Environmental Studies |
| Prof. Hideaki Nakata | Director, Graduate School of Science and Technology, Nagasaki University (Chairman) |
| Prof. Shuhei Nishida | Professor, Plankton Laboratory, Ocean Research Institute, Tokyo University |
| Dr. Yukihiro Nojiri | Vice Director, Center for Global Environmental Research, National Institute for Environmental Studies |
| Prof. Haruo Ogi | Professor Emeritus, Faculty of Fisheries Sciences, Hokkaido University |
| Prof. Yoshihisa Shirayama | Director, Field Science Education and Research Center, Kyoto University |
| Prof. Shinsuke Tanabe | Professor, Center for Marine Environmental Studies, Ehime University |


For the develop this report, cooperation from above members were obtained.

# 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. In response, the Ministry of the Environment launched new monitoring (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: Prof. Hideaki Nakata, Nagasaki University).

Given the immense sea areas targeted by this monitoring, it was anticipated that each round of this monitoring program would require from three to five years to fully complete. Thus far, two rounds of the survey (Phase I, Phase II) have been completed in the 10 years from Fiscal 1998 to 2007. In this monitoring program, comprehensive evaluation is expected to be performed on the actual condition of the marine environment, after every completion of one round of the monitoring cycle.

In recent years, status reports have been prepared by various international organizations, which summarize the existing conditions of the marine environment from regional and global aspects under the Northwest Pacific Action Plan (NOWPAP), the Global Marine Assessment (GMA), and so forth, and such broad-based information gathering has increasingly become more commonplace for assessing oceanic conditions worldwide. As a nation with a long history of experience and knowledge in effectively utilizing its ocean resources, such international contribution is also expected of Japan, through the active and continual provision of information on the condition of the marine environment.

In light of the above conditions, this report analyzed/assessed the extent of current pollution due to hazardous chemical substances such as heavy metals, PCBs, and dioxins from the coastal waters to offshore around Japan, chiefly with respect to the results of the "Marine Environment Monitoring Survey". The various survey results are then summarized as a status report.

## 2.1 Sea Areas and Ocean Currents around Japan

Japan is surrounded by the sea on all sides, with the Pacific Ocean (mean water depth: 4,282 m) located along Japan's eastern coastline. Shelf seas around Japan include the East China Sea, the Sea of Japan, and the Sea of Okhotsk. The East China Sea is generally an extremely shallow sea of 188 m in mean water depth, with a wide continental shelf, but it's maximum depth is relatively great, reaching 2,719 m. On the other hand, the Sea of Japan is an enclosed deep sea with a mean water depth of 1,350m and has deep regions of 3,796 m in maximum depth. The Sea of Okhotsk, extending northward from Hokkaido, has a mean water depth of 838 m, a small 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 mostly characterized by deep surrounding 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 area is generally small (Figure 2.1).

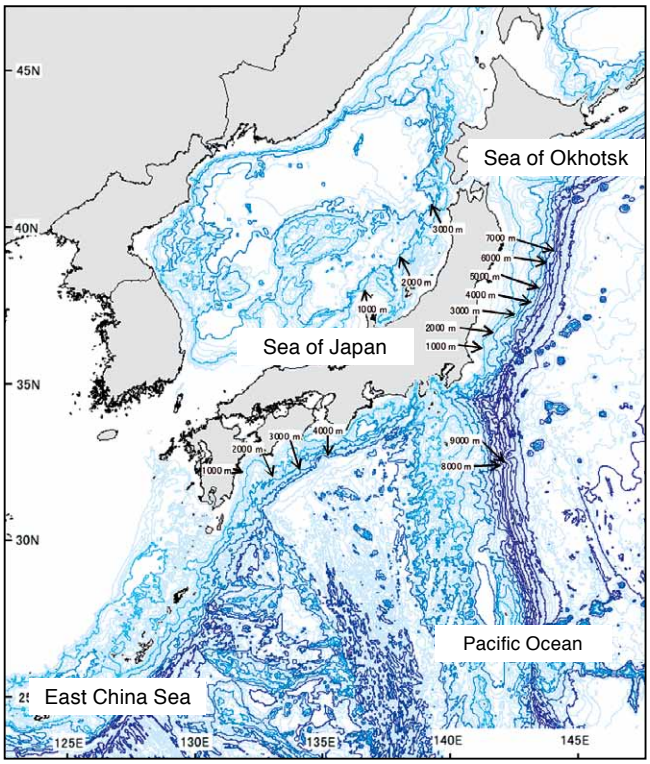


**Figure 2.1 Submarine Topography around Japan**
(Prepared based on the data of the Marine Information Research Center)
Note:depths depicted at a pitch of 200m

Major ocean currents in the sea areas around Japan include the Kuroshio Current and the Tsushima 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 of high-temperature oligotrophic seawater with high salinity, with a flow rate of as high as 50 million tons per second. It is known as one of the most rapid ocean currents in the world with highly transparent water due to the small plankton population. The Oyashio Current, which has its origin in the cold water of the Sea of Okhotsk and the Bering Sea, contains abundant nutrients. Due to a large population of plankton, 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, and it is one of the best fishing grounds in the world, attracting a great number of fish due to high water temperature and abundant nutrients (Japan Meteorological Agency website 2009).

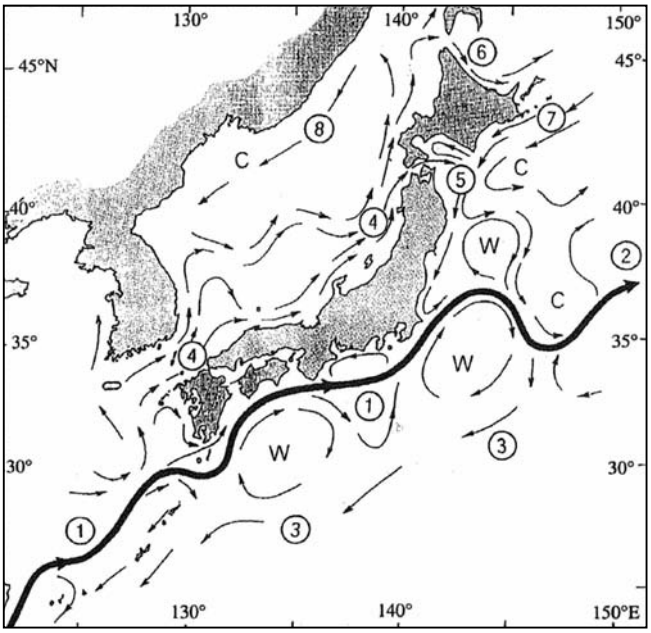


**Figure 2.2 Main Ocean Currents around Japan (Unoki and Kubota, 1996)**
W: Warm water, C: Cold water
(1) Kuroshio Current, (2) Kuroshio Extension, (3) Kuroshio Countercurrent, (4) Tsushima Current, (5) Tsugaru Warm Current, (6) Soya Warm Current, (7) Oyashio Current, (8) Liman Current

*The point of contact refers to a boundary between water masses that are different in temperature or nature such as the Kuroshio Current and the Oyashio Current.

## 2.2 Outline of the Marine Environment Monitoring Survey

In Japan, various monitoring programs are implemented by relevant organizations such as administrative bodies, research institutions, universities and junior colleges. Monitoring programs implemented by the Ministry of the Environment, in addition to the Marine Environment Monitoring Survey, include the Environment Survey of Chemical Contamination, the Public Waters Survey, and the Wide-area Comprehensive Water Quality Survey. The monitoring programs implemented by other ministries include the Ocean Pollution Surveys implemented by the Japan Coast Guard and the Atmospheric and Marine Environment Monitoring implemented by the Japan Meteorological Agency.

In the Marine Environment Monitoring Survey, surveys are performed on land-based pollution and on pollution caused by ocean dumping 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 especially significant pollution loads are likely to exist, to offshore.

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

Bioconcentration surveys and benthic community surveys are performed in consideration of the impacts that pollutants are likely to exert on marine organisms or the marine ecosystem at concentrations far below the environmental quality standards, from the perspective of protecting the marine ecosystem as well as from the conventional perspective of protecting human health or conserving the living environment.

This monitoring survey has the following characteristics:

- A comprehensive survey is performed on seawater (and water sampled from various layers for nutrients and heavy metals), sediments, marine organisms, benthic communities, floating plastic wastes, and so forth, not only with respect to coastal waters 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 PCBs, dioxins, and organotin compounds that are substances covered in the POPs Treaty.
- Although not subject to administrative control or not designated as mandatory monitoring items, coprostanol and linear alkylbenzenes (LABs) as marker substances for sewage sludge, are monitored as well.
- The pollution concentration levels of PCBs, dioxins, and so forth within the bodies of marine organisms populating sea areas ranging from the coastal area to the offshore area are monitored by sampling five types of marine organisms (mussels, benthic sharks in coastal areas, squids, cods and crustaceans in offshore areas).
- In addition to periodic surveys, in-depth follow-up surveys are also performed in proper response to highly concentrated pollution “hot spots” found in the process of the periodic surveys.
- Changes and trends in the findings of the monitored objects at the respective survey points are monitored and closely followed for several years.

# 3.Comprehensive Assessment of the Marine Environment

The present status and trends for the marine environment in the seas around Japan for the recent 10 years were comprehensively evaluated by experts, chiefly with respect to the results of the "Marine Environment Monitoring Survey," taking into account existing research survey results. A summary is shown in Table 3.1. The details are discussed below.

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

| Evaluation item | | | Evaluation of the present status | Effect of the current policy and prospect for future monitoring |
|---|---|---|---|---|
| Land-based pollution | Pollution concentration in sediments / marine organisms | Dioxins | • Loading from metropolitan areas exerts influence on the sediments in the coastal area. A low concentration level of dioxins remains detected within the sediments in the offshore area.<br>• Dioxins showed a downward trend in some sea areas and some marine organisms for the recent 10 years but not in a general and definite manner. | • The Law Concerning Special Measures against Dioxins (1999) and so forth contributed to a significant decrease in the emissions derived from incineration facilities, which has been one of the major sources in recent years. However, the impact of dioxins discharged in the past still remains due to low degradability and high bioaccumulation.<br>• With the reduction efforts promoted on a global scale according to the POPs Treaty (enforced in 2004), continuous monitoring will be required in future including the transboundary pollution from neighboring countries. |
| | | PCB | • Loading from metropolitan areas exerts influence on the sediments in the coastal area. A low concentration level of PCB remains detected within the sediments in the offshore area.<br>• No statistically significant downward trend has been observed in the concentration level within the bodies of marine organisms for the recent 10 years. | • The concentration of PCB in the environment decreased as a result of the in-principle prohibition of manufacturing, use, and import of PCB in 1974 by the Law Concerning the Examination and Regulation of Manufacture, etc. of Chemical Substances. The downward trend has become slow in recent years.<br>• With the treatment of PCB wastes started in 2004 associated with the Law Concerning Special Measures Against PCB Waste, the discharge of PCB into the environment may be about to decrease. However, the treatment has not taken effect yet in the form of decrease in the concentration level within sediments or marine organisms due to low degradability and high bioaccumulation.<br>• With the reduction efforts promoted on a global scale according to the POPs Treaty, continuous monitoring will be required in future including the transboundary pollution from neighboring countries. |
| | | Butyltin compounds | • Loading believed to be mainly due to the navigation by foreign vessels exerts influence on the sediments in the coastal area. A low concentration level of butyltin compounds remains detected within the sediments in the offshore area.<br>• Butyltin compounds showed a downward trend in some sea areas and some marine organisms for the recent 10 years but not in a general and definite manner. | • With the shipment amount of butyltin compounds intended for open system use estimated to 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 by industries, such efforts resulted in decrease of the concentration level within the bodies of the marine organisms. Given the slowing downward trend in recent years, however, the butyltin compounds pollution may remain relatively unchanged for the time being.<br>• With the AFS Treaty enforced in 2008, foreign vessels sailing into a port of Japan have been prohibited from using ship bottom antifouling paints including organotin compounds. The effect of the prohibition needs to be continuously verified in future. |
| | | Heavy metals | • Loading from metropolitan areas exerts influence on the sediments in the coastal area. Heavy metals originally exist in nature and were not observed at such a high load level as the man-caused load in the offshore area. | • While the heavy metal pollution of Japan origin decreased, there is a concern over the increase in transboundary pollution associated with the economic growth in neighboring countries. Thus, surveys need to be performed in response to such concerns. |
| | Influence on benthic communities | | • A change in composition of meiobenthos communities caused by the dysoxic environment was observed in some coastal waters. On the other hand, however, no relationships were observed between the pollution by hazardous chemical substances and the changes in population or composition of meiobenthos communities. | • Baseline data have been obtained for meiobenthos communities in sea areas around Japan from water depth to the order of 4,000 m. The influence of hazardous chemical substances on the benthic communities will be monitored in future by evaluating the chronological changes in the baseline data. |
| | Nutrients | | • The impacts of loadings from terrestrial origins were observed in some coastal waters. However, the impacts have not yet extended to the offshore area. | • Although monitoring needs to be continued in future, given that the loading has decreased as a result of effluent control measures including the Total Pollutant Load Control, the monitoring frequency may be decreased. |
| | Floating litter | | • It has been revealed that plastic wastes are distributed to the offshore area. Given that plastic wastes once discharged into the environment are not easily decomposed, they pose a concern over prolonged potential influence on organisms. | • In recent years, improvement has come to be seen in the discussion over the measures to reduce domestic plastic wastes and in the cooperation among member countries in the NOWPAP. The production of plastics is on an upward trend globally and attention needs to be given to it. |
| Pollution derived from ocean dumping | | | • A decrease was observed in the population of benthic communities at the ocean dumping point of bauxite residue compared with the background within the scope of the assumptions in the prior environmental impact assessment performed at the time of application for approval. No special impacts that may have been derived from legitimate ocean dumping on water quality or sediments were observed in the other ocean dumping point. | • A certain degree of effect was observed in the environ-mental conservation measures of Japan against ocean dumping. Although it is less likely that a significant pollution situation will arise in the future given the approval system for disposal at sea newly established (in 2007), it is important to continuously check the legitimacy of ocean dumping activities based on the law. |
| Detection of specific polluted sea areas (hot spots) | | | • High pollution concentrations for some offshore areas were detected in sediments after a limited number of surveys. Those sea areas were determined to have been artificially polluted. None of the above pollution cases was determined to have reached a level affecting human health. However, attention should be paid to those hot spots from the perspective of marine environment conservation. | • The hot spots so far detected need to be continuously monitored. In addition, monitoring should be performed as needed for sea areas that have not been surveyed yet in order to prevent such artificial pollution. |

## 3.1 Impacts of Land-based Pollution

### 3.1.1 Pollution concentration levels within sediments or marine organisms

**(1) General**

The impacts of land-based pollution loading on the marine environment can be studied by assessing the distribution and the concentration gradient of pollutants in sea areas ranging from the inner bay and coastal waters, where a major pollution load is likely to exist, to the offshore areas. With respect to sediments, the following pollutants showed a higher concentration in inner bays/coastal waters and a lower concentration in offshore areas: Given that such artificial chemical substances as PCBs and butyltin compounds do not originally exist in nature, the following pollutant distribution (except for butyltin compounds)may indicate impacts from land-based pollution loading:

- Sendai Bay-offshore area: Cadmium, total mercury, PCBs
- Tokyo Bay-offshore area: Cadmium, total mercury, lead, PCBs, dioxins, butyltin compounds
- Ise Bay-offshore area: Cadmium, PCBs
- Osaka Bay-offshore area: Total mercury, lead, PCBs, dioxins, butyltin compounds
- Toyama Bay-offshore area: Lead, PCBs, dioxins

Given that butyltin compounds are chiefly used for antifouling paints, the contamination from butyltins is likely to be derived from the heavy traffic of vessels, rather than from terrestrial origin. Taking these findings together, the impacts on coastal waters due to the various other pollutants listed above are likely to derive from pollution loading from metropolitan or large industrial areas.

The above substances were detected in offshore areas at low levels, but still were higher than the detection limits. They are thus assumed to have potential impacts on the environment, not only in coastal waters but also in offshore areas.

Dioxins, PCBs, and butyltin compounds will be discussed below as pollutants receiving particular attention with respect to trends noted during this long-term analysis. These pollutants will be outlined with respect to their various concentrations and trends for the recent ten years based on the Marine Environment Monitoring Survey data and then will be discussed with respect to the course of problems, long-term trends, countermeasures, and their effects (assessment) in light of the results of other monitoring and studies as well.

**(2) Dioxins**

*1) Results of the Marine Environment Monitoring Survey*

The Marine Environment Monitoring Survey data indicate that the dioxins within sediments show a higher concentration in inner bays/coastal areas with a metropolitan area located in the background and a lower concentration in offshore areas (Figure 3.1). This finding indicates that loadings from terrestrial origin have accumulated in the coastal areas.

In terms of the dioxin levels within marine organisms, dioxins showed a statistically significant downward trend ($P<0.05$) in some sea areas and some marine organisms (benthic sharks (liver, muscle) in Tokyo Bay, squids (liver) in the Kuroshio Current area, squids (muscle) in the Oyashio Current area, cods (liver) in the Sea of Japan area) but not in a general and definite manner for other regions and species (Figure 3.2).

*2) Evaluation of previous dioxin control measures*

In Japan, approximately 90% of the emissions of dioxins, especially of PCDD and PCDF, are estimated to be discharged from the incineration of industrial wastes (Ministry of the Environment, 2005). Accordingly, various preventive countermeasures have been implemented since December 1997, including regulations to control dioxins emitted from stacks of incineration facilities, etc. and

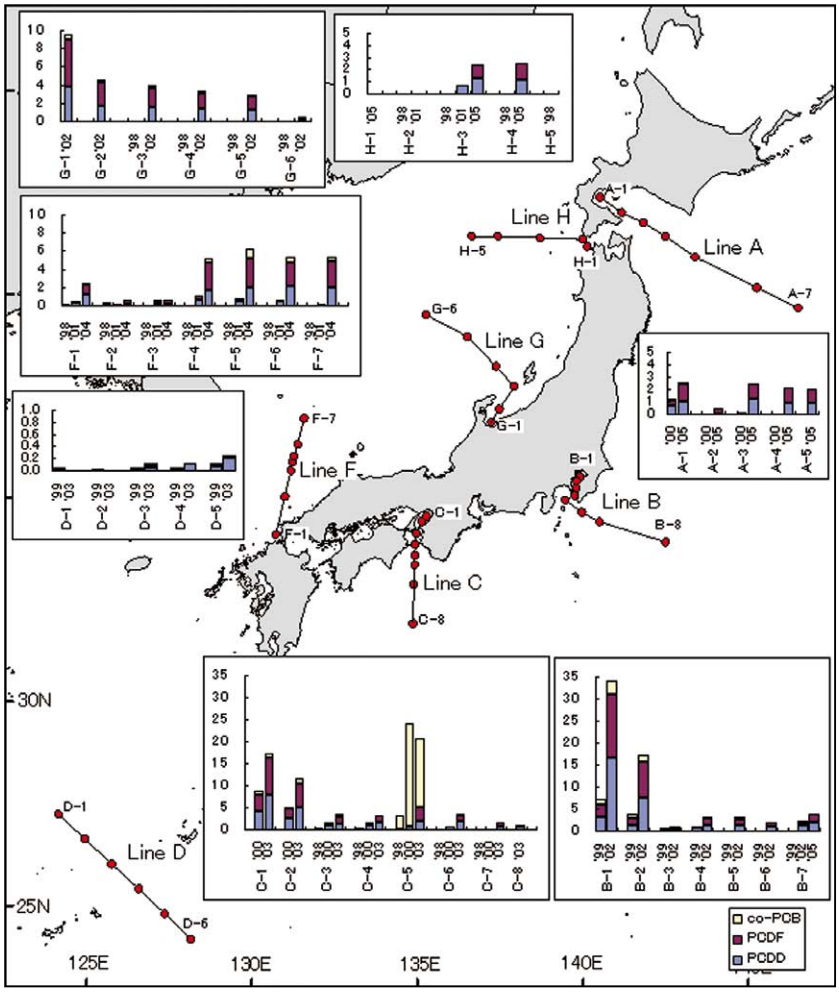


**Figure 3.1 Geographical Distribution of Dioxin Concentration within Surface Sediments**
(pg-TEQ/g dry wt)

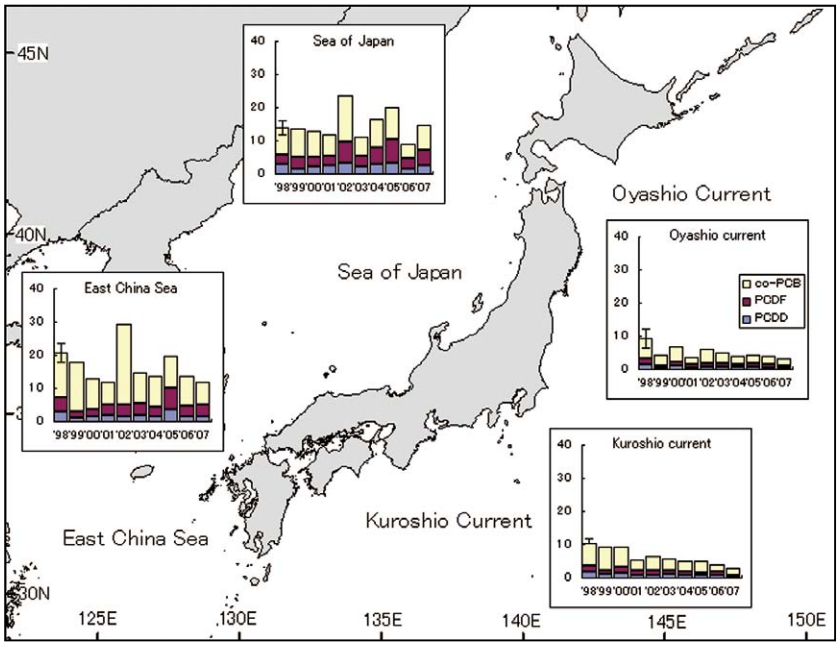


**Figure 3.2 Chronological Changes in Dioxin Concentration within Squids (Liver)**
(pg-TEQ/g wet wt)

the improvement of refuse incineration plants in accordance with the Air Pollution Control Law and the Waste Management and Public Cleaning 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 (Ministerial Conference on Dioxin Policy, 1999). In addition, the Law Concerning Special Measures against Dioxins was established in July 1999 and enforced in January 2000. Recently additional restrictions, etc., have been implemented for exhaust gases and wastewater.

As a result, the total emission of dioxins decreased by approximately 96% in 2007 from the 1997 levels. (Ministry of the Environment, 2008a). Associated with the above reduction, the dioxin concentration in the air, where the emission reduction is likely to take effect soonest, rapidly decreased by 92% during the period from 1997 to 2007 (Ministry of the Environment, 2008b) (Figure 3.3). On the other hand, in terms of the dioxin concentration within marine organisms, where emission reduction is likely to take effect latest, a downward trend was observed in some sea areas and some marine organisms but not in a general and definite manner, as mentioned above.

In terms of the changes in the dioxin concentrations as revealed from results of the analysis of a core sediment in Tokyo Bay (sampled in 1993), dioxin concentrations have decreased since around 1970, when concentrations peaked before the Law Concerning Special Measures against Dioxins went into effect in 2000 (Figure 3.4; Masunaga et al., 2001). It has also been reported in a recent major survey of Tokyo Bay, that dioxins, which had been included as an impurity substance in many pesticides commonly used during the 1960s and 1970s, exerted considerable adverse impacts on Tokyo Bay (Masunaga, 2004).

Because dioxins are slow to decompose (low degradability) and become concentrated within the bodies of organisms through the food chain (high bioaccumulation), the impacts of dioxins discharged in the past tend to remain. 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 in concurrent decline.

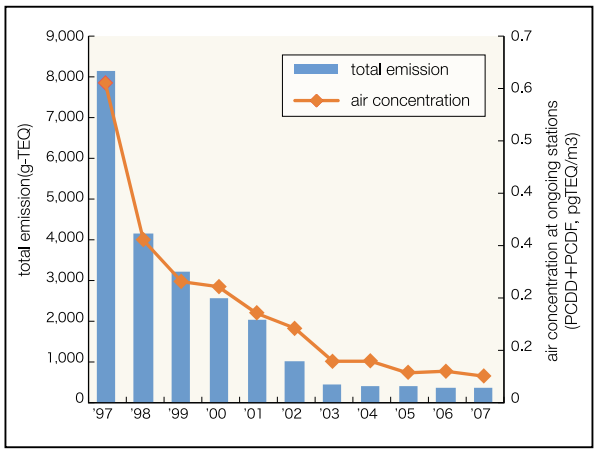


**Figure 3.3 Changes in the Total Emissions and Atmospheric Concent-ration of Dioxins**
(Prepared based on data from the Ministry of the Environment, 2008a and 2008b)

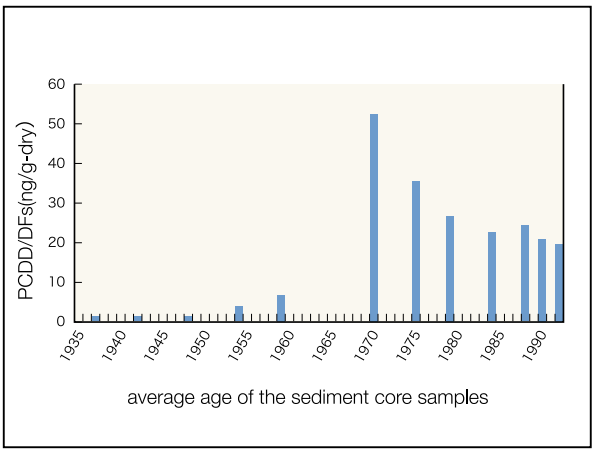


**Figure 3.4 Changes in Dioxin Concentration within Core Sediment in Tokyo Bay**
(Data altered from Masunaga et al., 2001)

### (3)PCBs

*1) Results of the Marine Environment Monitoring Survey*

The Marine Environment Monitoring Survey data indicate that PCBs within sediments show a higher concentration in inner bays/coastal areas with a metropolitan area located in the background and lower concentrations in offshore areas (Figure 3.5). This finding indicates that loadings from terrestrial origins are apt to accumulate in coastal areas.

No statistically significant downward trend has been observed in the PCB concentration levels within the bodies of marine organisms for the recent 10 years (P>0.05) (Figure 3.6).

*2) Evaluation of previous PCB control measures*

The industrial utilization /consumption of PCBs in Japan gradually increased after these compounds first started to be used in 1954 and peaked in 1970. Then

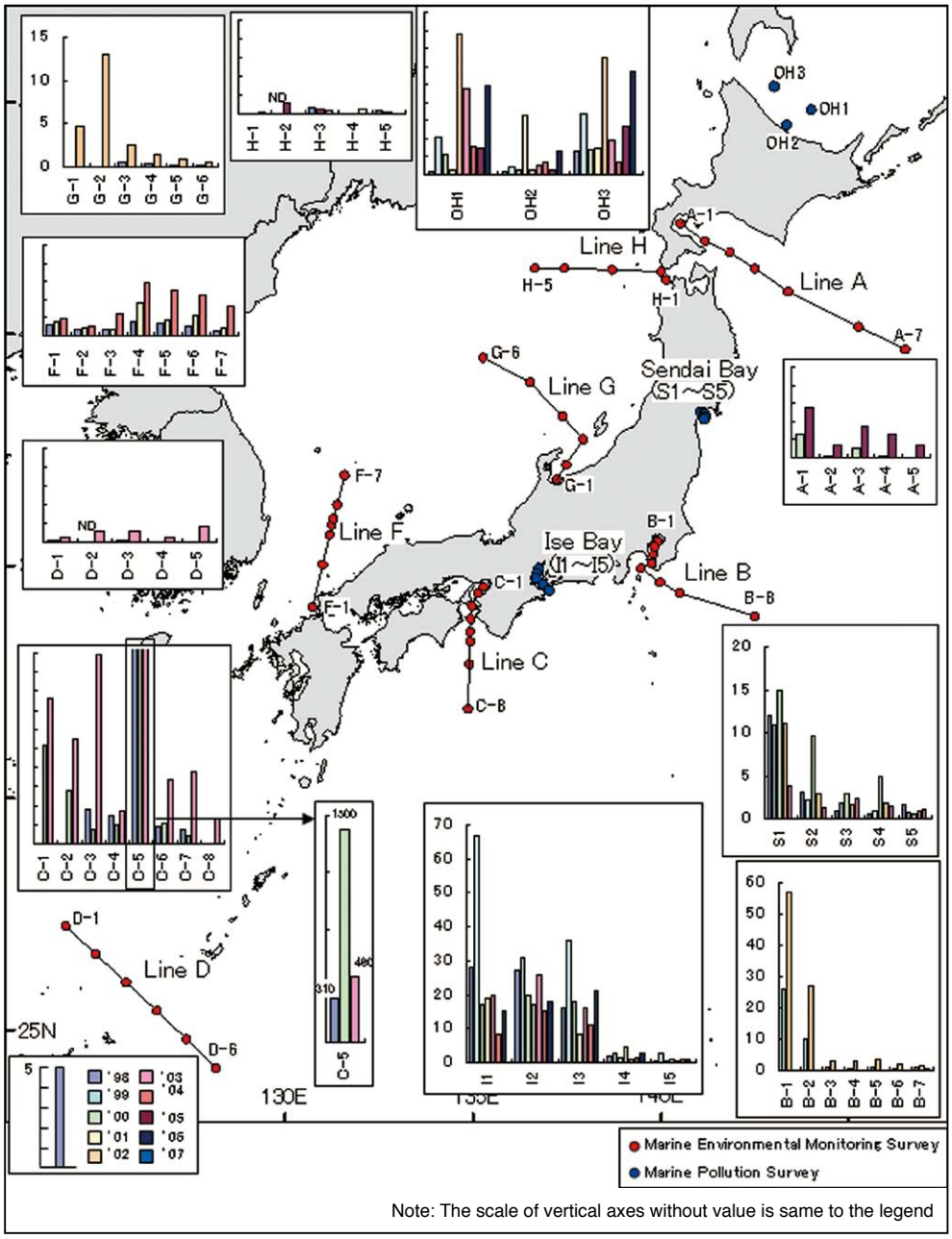


**Figure 3.5 Geographical Distribution of PCB Concentration within Surface Sediments (ng/g dry wt)**

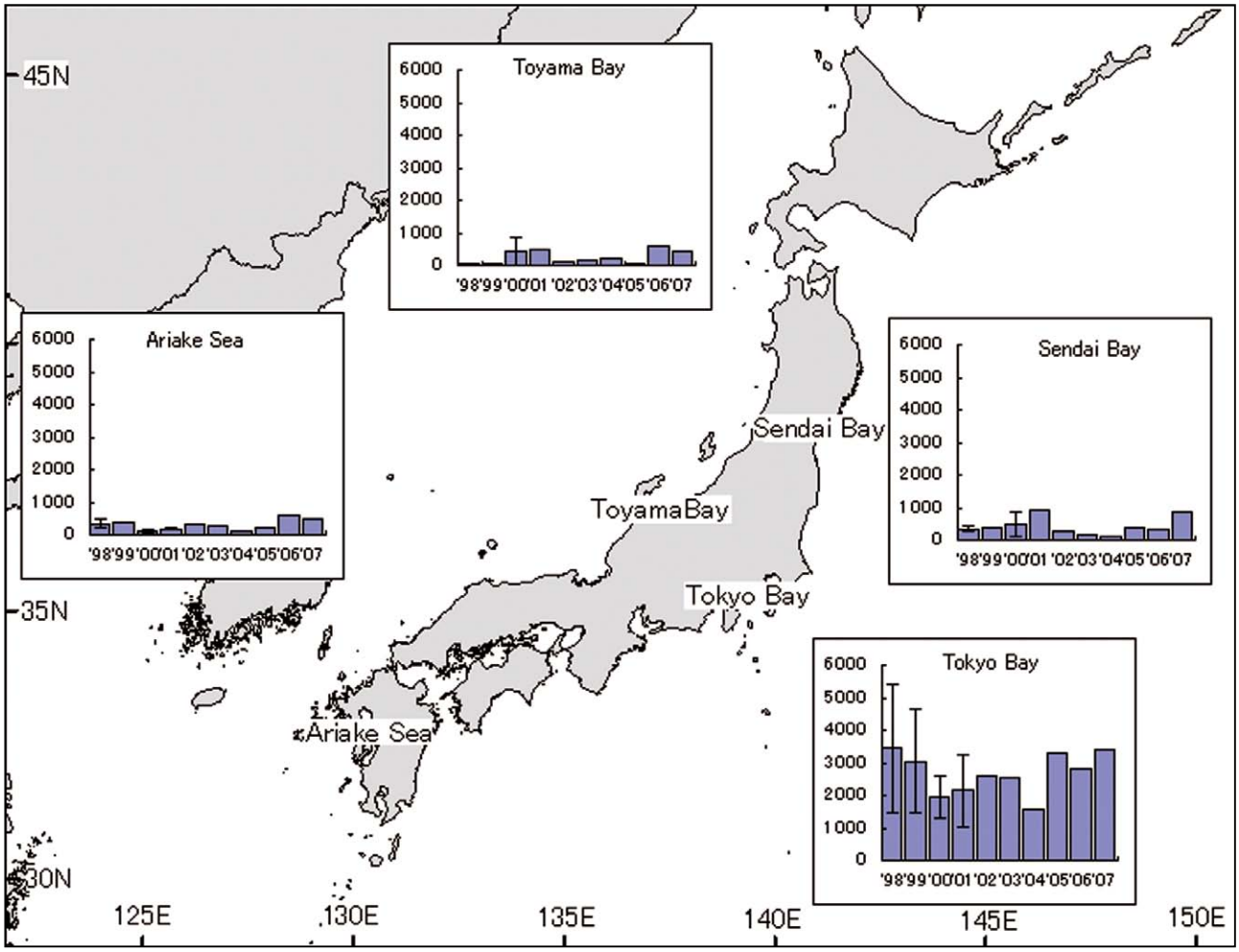


**Figure 3.6 Chronological Changes in PCB Concentration within Benthic Sharks (Liver) (ng/g wet wt)**

PCBs stopped being produced in 1972 (Figure 3.7) and were designated in 1974 as a class I specified chemical substance under the Law Concerning the Examination and Regulation of Manufacture, etc. of Chemical Substances. In principle, PCBs were at this time prohibited from being used.

Results of the analysis of core sediment from Tokyo Bay (sampled in 1993) (Okuda et al., 2000) indicate that the PCB concentrations 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 3.8). On the other hand, although PCB production stopped in 1972, the PCB sediment concentration levels remained at approximately 30% of the peak level from the mid 1980s to 1993. In addition, while the PCB concentration (national average) within fishes and shellfishes had been on a downward trend since the end of 1970s (Ministry of the Environment, 2007), it has leveled off in the 2000s (Figure 3.9).

After PCBs were designated as a class I specified chemical substance under the Law Concerning the Examination and Regulation of Manufacture, etc. of Chemical Substances, it was decided that PCBs and products containing PCBs that had already been produced would be recalled and stored. The disposal of the recalled PCBs did not progress smoothly. On the other hand, the prolonged storage of PCB wastes has unavoidably