A Brief Review of Studies Related to Research on Effects of Environmental Changes on Cetaceans in the JARPA Survey

Yoshihiro Fujise
The Institute of Cetacean Research,
4-18, Toyomi-cho, Chuo-ku, Tokyo 104, Japan.

ABSTRACT

This paper outlines the surveys to evaluate the effects of environmental changes on cetaceans, conducted under the JARPA. The survey includes the analyses of oceanographic data, estimation of the accumulation level of pollutants such as organochlorines and heavy metals in minke whales, and marine debris. Pollution studies have revealed the following: although the organochlorine levels accumulated in the body of Antarctic minke whales are lower than those in Northern Hemisphere, a series of these studies suggested an increasing trend of accumulation levels of PCB's in the minke whales in the Antarctic. Heavy metal studies suggest that the accumulation levels of hepatic Hg in minke whales increased until 1980's, suggesting possible environment changes such as changes of food availability.

INTRODUCTION

The Japanese Whale Research Program Under Special Permit in the Antarctic (JARPA) commenced in the 1987/88 austral season as a feasible survey in the Antarctic Area IV, and has been carried out every year since the 1989/90 season as a full-scale program to cover the entire area of south of 60°S in Antarctic Areas IV and V. At present, the 10th JARPA survey is being carried out. To date, samples and data have been collected to estimate biological parameters in the minke whale and elucidate the role of cetaceans in the Antarctic ecosystem, which are the major objectives of the survey. In addition to these, an extensive set of other kind of samples and data have been collected from the first survey in order to address many other questions.

In 1992, the International Whaling Commission (IWC) decided to establish a regular agenda item for research on effects of environmental change on cetaceans in the Scientific Committee, SC (IWC, 1993). In the following year, the Commission adopted a Resolution recommending that the SC should 'give priority to research on the effects of environmental changes on cetaceans in order to provide the best scientific advice for the Commission to determine appropriate response strategies to these new challenges' (IWC, 1994). In response to this Resolution, the SC focused on several factors to be considered in the context of cetaceans: (1) global warming; (2) ozone depletion; (3) pollution; (4) direct (intentional and incidental mortality) effects of fisheries and indirect (ecological ramifications) effects of fisheries; (5) noise; and (6) other human activities (e.g. tourism, coastal developments). The Committee decided to hold two workshops (IWC, 1995). As a result, the Workshop on Chemical Pollution and Cetaceans was held in Bergen, Norway, in March 1995, and the Workshop on Climate Change and Cetaceans was held in Kahuku, Hawaii in March 1996. In response to the reports of these Workshops (Anon, 1995; 1996), the Committee agreed to establish a Standing Working Group on effects of environmental change on cetaceans from 1997. In this way, the topic of the effects of environmental change on cetaceans has become a great concern in the IWC (IWC, 1997).

Although the JARPA has already designed to cover this item by collecting related samples and data from the beginning of the program, to response to a growing concern over environmental changes, Japan decided to give this item more priority and started to treat this item as one of the research objective: 'elucidation of the effect of environmental changes on cetaceans' from the 1995/96 JARPA survey and provide adequate resources for studies and analyses (Government of Japan, 1995).

This paper outlines the survey on effects of environmental change on cetaceans conducted under the JARPA and summarizes the status on the studies on pollutants in the Antarctic among others.

OCEANOGRAPHIC SURVEY

Since the 1987/88 season, JARPA has recorded surface water temperature and the vertical distribution of sea water temperature by the XBT device at 50 to 90 observation points every year (Table 1). The JARPA surveys also have recorded ice edge information.

Figs. 1 and 2 show the means of air and surface temperatures, respectively in a zone between 60°S and 63°S in January and February in Areas IV and V, for several years. No yearly trend of these temperatures are observed.

The data of vertical distribution of sea water temperature by the XBT device are now being analyzed. Naganobu *et al.* (1989, 1993, 1994, 1995, 1996) studied the correlation between the oceanographic structure and the distribution of minke whales by means of two environmental gradient indices (Q_{50}, Q_{200}). They reported that a high density area tends to be formed in the upwelling of shelf water or the area bordering on warm water advection. Further analyses incorporating other factors such as the availability of food (i.e. Antarctic krill), are required.

The oceanographic data are also used as indices for status of prey species of whales in the Antarctic ecosystem (Ichii, 1990; Ichii and Kato, 1990; 1991). These analyses revealed that the food availability tends to change with variation of sea ice coverage by year (Ichii *et al.*, in prep.). These studies could provide useful information to address questions raised by the Workshop on Climate Change.

POLLUTANTS

Organochlorine compounds

During the 1989/90 JARPA survey, 26 samples of air and sea water were collected to monitor the level of organochlorines (HCHs, DDTs, chlordanes and PCBs) in the atmosphere and sea water. The result of this monitoring was reported together with other oceanographic data by Iwata *et al.* (1993). The atmospheric and sea water concentrations of organochlorines such as PCB's (Fig. 3) in the Southern Hemisphere were lower than in the Northern Hemisphere, although the distribution pattern suggested a shift or expansion of the major sources from the mid or low latitudes during the last decade. In surface water, HCHs was higher in the north of 40°N, whereas DDTs were higher near tropical Asia. Chlordanes (CHLs) and PCBs exhibited rather uniform distribution in both hemispheres. Estimations of fluxes by gas exchange across the air-water interface gave insight into the dispersal of organochlorines through oceanic atmosphere depending on their Henry's law constants and the tendency of more transportable substances to deposit into the cold waters as an ultimate sink (Iwata *et al.*, 1993).

In the meantime, from 1992 to 1996, the Government of Japan carried out the Project on Global Environment Monitoring with Fishing Vessels Network. As a part of this project, JARPA collected air and sea water samples for analysis on levels of organochlorines in the atmosphere and the sea water of the Antarctic (Fisheries Agency, Government of Japan, 1995).

With regard to the accumulation level of organochlorines in Antarctic minke whales, Tanabe *et al.* (1995) reported on the levels of organochlorines in the blubber of minke whales taken in the 1984/85 season (commercial whaling) and in the 1990/91 season (JARPA survey). They detected five organochlorine compounds (PCBs, DDTs, HCBs, CHLs and HCHs), and the levels of concentration of these compounds were lower than these reported for Northern Hemisphere baleen whales. Also they reported that the levels of DDTs showed no yearly variation. However, even taking into consideration of difference in age-characteristic accumulation, the level of PCB concentration was higher in 1990/91 than in 1984/85. These results were presented in the Workshop on Chemical Pollution and Cetaceans (Tanabe *et al.*, 1995).

In addition, the levels of the above four organochlorine compounds other than HCB were lower in Antarctic minke whales than those levels in the North Pacific (Table 2), by direct comparison with minke whales taken from the North Pacific (Aono *et al.*, 1996; in prep.). This can be explained by higher level of chemical compounds emission in the Northern Hemisphere and/or by the difference in trophic levels of minke whales between Northern and

Southern Hemispheres, e.g. Antarctic minke whales feeds on lower trophic organisms primarily euphausiids and North Pacific minke feeds on fish species such as Pacific saury. The composition of HCH isomers showed higher ratio of γ-HCH in the Southern minke whales as it was also observed in their food, which indicated different compositions of HCHs used in both hemispheres were reflected in minke whales (maybe used lindane in the Southern Hemisphere). In the Antarctic, increasing trend of PCBs residue levels were noted during a period of 1984 to 1993 (Table 3), implying the continuous discharge of PCBs in the Southern Hemisphere (Aono *et al.*, 1996; in prep.).

Heavy metals

Studies on concentration levels of heavy metals in minke whale bodies and the ecosystem in the Antarctic were conducted by Honda *et al.* (1987) and Yamamoto (1988) in the days of commercial whaling. According to these studies, southern minke whales were showed lower concentration level of Hg and higher level of Cd than cetaceans in the Northern Hemisphere. Honda *et al.* (1987) also reported that the concentration level of Hg and Cd in livers of minke whales taken in 1980/81 season from commercial whaling showed no increase trend with age as has been reported in other whale species, possibly because of change in the ecosystem due to overexploitation of other large whale species. Watanabe *et al.* (in prep.) re-examined this trend using samples taken from the 1984/85 and 1985/86 seasons, and reported that such changes might have continued until the first half of 1980's. Further analysis has been made using samples taken from the JARPA survey, and it was found that the level of Hg concentration in minke whales taken in recent years increased with age (Fig. 4). The increase trend of Hg, due to change of the ecosystem, was reflected for all age groups (Fujise *et al.*, in prep.). They also suggested a possibility that the increased Hg intake started to decrease in early 1980's (Fig. 5).

It has reported that renal Cd levels of human begin to decrease if hepatic Cd are attained to about 40ppm and 50% of the specimen showed the abnormal value of β_2-microglobulin in those urine at this level or more, although the renal Cd levels are correlated positively to hepatic Cd levels upto this level (Ellis *et al.*, 1984). Honda (1985) suggested that, in the light of relation between levels of Cd concentration in liver and kidney of multi-species animals (Fig. 6), it has a possibility of renal dysfunction for wildlife animals such as cetaceans. He also suggested that these thresholds are 20ppm for cetaceans and 10ppm for sea birds. In Antarctic minke whales, maximum levels of hepatic Cd was 40.4 ppm (Yamamoto, 1988). This suggests that Antarctic minke whales with the level of Cd concentration in livers of more than 20 μ g/g possibly showed incidence of renal dysfunction. Similar possibility were suggested by Yamamoto (1988) from analysis of metallothionein in kidney of minke whales. However, no new reports on this subject have been presented since then.

OTHER STUDIES

In addition to the studies outlined above, the JARPA has conducted surveys on marine debris since it was started. An outline of the marine debris survey is shown in Table 4. In the Antarctic sea, plastics, styrene form, buoys and drums were observed, but the number of such drifting materials was found to be smaller than in the lower and mid latitudinal waters. In addition to observation on marine debris, JARPA has recorded artifacts mingled in the stomach content of minke whales taken from the survey area, and so far six artifacts were found in the stomach of out of 2,887 whales (Table 5). The same survey has been carried out in the minke whale research program in the North Pacific (JARPN)(Fujise *et al.* 1995, 1996), and the encounter rate of artifacts in the Antarctic is being found to be lower than in the North Pacific.

CONCLUSION

Studies on environmental changes in the JARPA survey were reinforced since 1995 as one of the major objectives of the survey, and the analyses in this area has started only recently. Results of the studies introduced in this paper are preliminary and ongoing. However, it can be concluded that they can provide useful information on the effects of environmental change on cetaceans.

A series of studies on dynamic of organochlorines and their accumulation levels in minke whales suggest that the current level of organochlorines in the Antarctic are lower than those in other areas (Table 2). It seems that there is no serious threat to the health of the minke whales. However, it is important to continue this kind of monitoring to detect trend of accumulation levels of PCBs in the minke whales in the Antarctic. Furthermore these monitoring are also needed to estimate the fate of organochlorines in the global circulation system because the high latitude waters such as Antarctic are likely to serve as a major sink of organochlorines.

Also, the heavy metal studies suggest that the accumulation levels of Hg increased in the minke whale until early 1980's. A recent study also suggested a decreasing pattern of hepatic Hg after that. These results suggest the possibility of environmental changes, perhaps suggesting change of availability of food of minke whales. The possibility of changes of food availability are also supported by the studies on biological parameters, body fattyness and blubber thickness of minke whales (Zenitani *et al.*, in prep; Ohsumi *et al.*, in prep.). At this moment, no study was made to determine whether it was due to changes of abundance of food species by environmental change or due to the interrelationship between minke whales and other species. However, this question could be solved by continuation of the monitoring survey.

Furthermore, it was also suggested the existence of renal dysfunction on minke whales in the Antarctic region. It is hoped to see further studies on this subject as soon as possible.

Finally, it should be noted that most of the above pollutant studies requires the use of internal tissues which can be obtained only from the lethal sampling method. Furthermore, these analyses requires biological information such as age, sex and sexual maturity of the specimen.

As two workshops of the IWC have pointed out, presently not much is known about effects of environmental change on cetaceans. Therefore, it is necessary not only to continue these studies but also to promote collaboration with other expert organizations to address this challenge.

REFERENCES

Anon, 1995. Report of the workshop on chemical pollution and cetaceans. Paper SC/47/Rep2 presented to the IWC Scientific Committee, May 1995 (unpublished). 34pp.

Anon, 1996. Report of the IWC workshop on climate change and cetaceans. Paper SC/48/Rep2 presented to the IWC Scientific Committee, June 1996 (unpublished). 26pp.

Aono, S., Tanabe, S., Fujise, Y. and Tatsukawa, R. 1996. Specific accumulation of persistent organochlorines in minke whale (*Balaenoptera acutorostrata*) and their prey species from the Antarctic and the North Pacific. Paper SC/48/O22 presented to the IWC Scientific Committee, June 1996 (unpublished). 10pp.

Borrell, A. 1993. PCBs and DDTs in blubber of cetaceans from the Northeastern North Atlantic. *Mar. Pollut. Bull.* 26 (3): 146-51.

Ellis, K.J., Yuen, K., Yasumura, S., Cohn, S.H. 1984. Dose-response analysis of cadmium in man : Body burden *vs* kidney dysfunction. *Environ. Res.* 33: 216-26.

Fisheries Agency, Government of Japan. 1995. Project of global environment monitoring with fishing vessel network. Paper SC/M95/P14 presented to the Workshop on Chemical Pollution and Cetaceans. Bergen, 1995 (unpublished). 2pp.

Fujise, Y., Yamamura, K., Zenitani, R., Ishikawa, H., Yamamoto, Y., Kimura, K. and Komaba, M. 1990. Cruise report of the research on southern minke whales in 1989/90 under the Japanese proposal to the scientific permit. Paper SC/42/SHMi25 presented to the IWC Scientific Committee, June 1990 (unpublished). 56pp.

Fujise, Y., Ishikawa, H., Saino, S., Nagano, M., Ishii, K., Kawaguchi, S., Tanifuji, S., Kawashima, S. and Miyakoshi H. 1993a. Cruise report of the 1991/92 Japanese research in Area IV under the special permit for Southern Hemisphere minke whales. *Rep. int. Whal. Commn* 43:357-71.

Fujise, Y., Zenitani, R., Saino, S., Itoh, S., Kawasaki, M., Matsuoka, K. and Tamura, T. 1993b. Cruise report of the 1992/93 Japanese research under the special permit for Southern Hemisphere minke whales. Paper SC/45/SHB12 presented to the IWC Scientific Committee, April 1993 (unpublished). 39pp.

Fujise, Y., Kishiro, T., Zenitani, R., Matsuoka, K., Kawasaki, M. and Shimamoto, K. 1995. Cruise report of the Japanese whale research program under a special permit for North Pacific minke whales in 1994. Paper SC/47/NP3 presented to the IWC Scientific

Committee, May 1995 (unpublished). 29pp.

Fujise, Y., Iwasaki, T., Zenitani, R., Araki, J., Matsuoka, K., Tamura, T., Aono, S., Yoshida, T., Hidaka, H., Nibe, T. and Tohyama, D. 1996. Cruise Report of the Japanese Whale Research Program Under a Special Permit for North Pacific Minke Whales in 1995 with the result of a preliminary analysis of data collected. Paper SC/48/NP13 presented to the IWC Scientific Committee, June 1996 (unpublished). 39pp.

Government of Japan. 1995. The 1995/96 research plan of Japanese whale research programme under special permit in the Antarctic. Paper SC/47/SH3 presented to the IWC Scientific Committee, May 1995 (unpublished). 9pp.

Henry, J. and Best, P.B. 1983. Organochlorine residues in Whales Landed at Durban, South Africa. *Mar. Pollut. Bull.* 14(6): 223-7.

Honda, K. 1985. Studies on bioaccumulations of heavy metals in marine mammals. Doctoral thesis of Tokyo University, 101pp.

Honda, K., Y. Yamamoto, H. Kato and R. Tatsukawa. 1987. Heavy metal accumulations and their recent changes in southern minke whales Balaenoptera acutorostrata. *Arch. Environ. Contam. Toxicol.*, 16: 209-16.

Ichii, T. 1990. Distribution of Antarctic krill concentrations exploited by Japanese krill trawlers and minke whales. *Proc. NIPR Symp. Polar Biol.* 3:36-56.

Ichii, T. and Kato, H. 1990. Food of southern minke whales from Japanese research take in 1987/88. Paper SC/42/SHMi14 presented to the IWC Scientific Committee, June 1990 (unpublished). 15pp.

Ichii, T. and Kato, H. 1991. Food and daily food consumption of southern minke whales in the Antarctic. *Polar Biology*.11:479-87.

Iwata, H., Tanabe, S., Sakai, N., and Tatsukawa, R. 1993. Distribution of persistent organochlorines in the oceanic air and surface seawater and the role of ocean on their global transport and fate. *Environ. Sci. Technol.* 27:1080-98.

IWC. 1993. Chairman's report of the forty-fourth annual meeting. *Rep. int. Whal. Commn* 43:39.

IWC. 1994. Chairman's report of the forty-fifth annual meeting. *Rep. int. Whal. Commn* 44:35.

IWC. 1995. Report of the Scientific Committee. *Rep. int. Whal. Commn* 45:55-9.

IWC. 1997. Report of the Scientific Committee. *Rep. int. Whal. Commn* 47:xx-xx.

Kasamatsu, F., Yamamoto, Y., Zenitani, R., Ishikawa, H., Ishibashi, T., Sato, H., Takashima, K. and Tanifuji, S. 1993. Report of the 1990/91 southern minke whale research cruise under scientific permit in Area V. *Rep. int. Whal. Commn* 43:505-22.

Kato, H., Hiroyama, H., Fujise, Y. and Ono, K. 1989. Preliminary report of the 1987/88 Japanese feasibility study of the special permit proposal for Southern Hemisphere minke whales. *Rep. int. Whal. Commn* 39: 235-48.

Kato, H., Fujise, Y., Yoshida, H., Nakagawa, S., Ishida, M. and Tanifuji, S. 1990. Cruise report and preliminary analysis of the 1988/89 Japanese feasibility study of the special permit proposal for southern hemisphere minke whales. *Rep. int. Whal. Commn* 40: 289-300.

Kawano, M., Inoue, T., Wada, T., Hidaka, H. and Tatsukawa, R. 1988. Bioconcentration and residue patterns of chlordane compounds in Marine Animals: Invertebrates, Fish, Mammals, and Seabirds. *Environ. Sci. Technol.* 22:792-7.

Muir, D.C.G., Wagemann, R., Hargrave, B.T., Thomas, D.J., Peakall, D.B. and Norstrom, R.J. 1992. Arctic marine ecosystem contamination. *The Science of the Total Environment* 122:75-134.

Naganobu, N., Shimamoto, K. and Kato, H. 1989. Oceanographical analysis on the southern minke whale distribution based on the data during Japanese research take in 1987/88. Paper SC/41/SHMi18 presented to the IWC Scientific Committee, June 1989 (unpublished).9pp.

Naganobu, M., Kano, H., Fujise, Y. and Kato, H. 1993. Preliminary oceanographical analyses on the southern minke whale distribution based on the data during Japanese research take in 1988/89. Paper SC/45/SHBa15 presented to the IWC Scientific Committee, May 1993 (unpublished). 13pp.

Naganobu, M., Kano, H., Fujise, Y. and Kato, H. 1994. Relationship between oceanographic condition and minke whale density in the Ross Sea based on the data from the 1992/93 cruise of Japanese whale research programme under special permit. Paper SC/46/SH17 presented to the IWC Scientific Committee, May 1994 (unpublished). 21pp.

Naganobu, M., Kano, H., Fujise, Y., Nishiwaki, S. and Kato, H. 1995. Relation-ship between oceanographic condition and minke whale density in the Antarctic Ocean based on the data from the Japanese scientific permit cruise in 1989/90, 1991/92 and 1993/94. Paper SC/47/SH11 presented to the IWC Scientific Committee, May 1995 (unpublished). 22pp.

Naganobu, M., Kano, H., Itoh, K., Nishiwaki, S. and Kato, H. 1996. Relationship between oceanographic conditions and minke whale density in and around the Ross Sea based on the data from the Japanese scientific permit cruise in 1994/95. Paper SC/48/SH19 presented to the IWC Scientific Committee, May 1996 (unpublished). 25pp.

Nishiwaki, S., Ishikawa, H., Itoh, S., Matsuoka, K., Yuzu, S., Nagatome, I., Yamagiwa, D., Murase, H., Tanifuji, S., Miyakoshi, H. and Ono, K. 1994. Report of the 1993/94 cruise of the Japanese whale research programme under special permit in the Antarctic Area IV. Paper SC/46/SH15 presented to the IWC Scientific Committee, May 1994 (unpublished). 42pp.

Nishiwaki, S., Ishikawa, H., Itoh, S., Shimamoto, K., Mogoe, T., Kawazu, H., Machida, S., Yamane, T., Ono, K. and Ohkoshi, C. 1995. Report of the 1994/95 cruise of the Japanese whale research programme under special permit (JARPA) in the Antarctic Area V. Paper SC/47/SH5 presented to the IWC Scientific Committee, May 1995 (unpublished). 38pp.

Nishiwaki, S., Ishikawa, H., Tohyama, D., Kawasaki, M., Shimamoto, K., Yuzu, S., Tamura, T., Mogoe, T., Hishii, T., Toshida, T., Hidaka, H., Nibe, H., Yamashiro, K., Ono, K. and Taguchi, F. 1996. Report of the 1995/96 Japanese whale research program under special permit in the Antarctic (JARPA) IN Area IV and eastern part of Area III. Paper SC/48/SH12 presented to the IWC Scientific Committee, May 1996 (unpublished). 48pp.

Sergeant, D.E. 1980. Levels of mercury and organochlorine residues in tissues of sea mammals from the St. Lawrence estuary. *International Council for the Exploration of the Sea.*, Doc. Cm/B 55: 10pp.

Stern, G.A., Muir, D.C.G., Segstro, M.D., Dietz, R. and Heide-Jorgensen, M.P. 1994. PCB's and other organochlorine contaminants in White Whales (*Delphinapterus leucas*) from West Greenland variations with age and sex. *Meddeleser om Gronland, Bioscience* 39: 245-59.

Tanabe, S., Subramanian, AN., Ramesh, A., Kumaran, P.L., Miyazaki, N. and Tatsukawa, R. 1993. Persistent organochlorine residues in dolphins from the Bay of Bengal, South India. *Mar. Pollut. Bull.* 26 (6):311-6.

Tanabe, S., Aono, S., Fujise, Y., Kato, H. and Tatsukawa, R. 1995. Persistent organochlorine residues in the Antarctic minke whale, *Balaenoptera acutorostrata.*

Paper SC/M95/P13 presented to the Workshop on Chemical Pollution and Cetaceans, Bergen, 1995 (unpublished). 6pp.
Yamamoto, Y. 1988. Heavy metal accumulation and toxicology of the Southern minke whale. Doctoral thesis of Ehime University, 127pp.

Table 1. Outline of the oceanographic research (surface temperature and vertical thermal distribution) conducted in the JARPA surveys

Season	Area	Period	Depth observed (m)	XBT point	Reference
1987/88	IV	Jan.17-Mar.26	0-400	67	Kato *et al.*, 1989
1988/89	V	Jan.12-Mar.30	0-750	56	Kato *et al.*, 1990
1989/90	IV	Dec.12-Mar.1	0-750	78	Fujise *et al.*, 1990
1990/91	V	Dec.16-Mar.14	0-750	81	Kasamatsu *et al.*, 1993
1991/92	IV	Dec.4-Mar.24	0-750	86	Fujise *et al.*, 1993a
1992/93	V	Dec.3-Mar.24	0-750	95	Fujise *et al.*, 1993b
1993/94	IV	Dec.3-Mar.15	0-750	97	Nishiwaki *et al.*, 1994
1994/95	V	Dec.3-Mar.21	0-750	93	Nishiwaki *et al.*, 1995
1995/96	IIIE-IV	Nov.11-Mar.14	0-750	98	Nishiwaki *et al.*, 1996

Table.2. Concentrations (μg/g on wet weight) of organochlorine compounds in the blubber of cetaceans from Northern and Southern Hemispheres (after Aono *et al.*, in prep.). *: From JARPN survey; **: From JARPA surveys.

Location	Species	Type of whale	Sampling year	n	PCBs	DDTs	CHLs	HCHs	HCB	References
Northern Hemisphere										
S.E. Greenland	Fin whale	Baleen	1975	3	3.6	2.8	NA	NA	NA	1
North Atlantic	Fin whale	Baleen	1982,85,86	48	1.3	0.85	NA	NA	NA	2
North Atlantic	Sei whale	Baleen	1982,85	14	0.46	0.4	NA	NA	NA	2
St. Lawrence River	Minke whale	Baleen	-	1	28	1.1	NA	NA	NA	3
West Greenland	Minke whale	Baleen	1972	6	0.61	1.4	NA	NA	NA	1
North Pacific	Minke whale	Baleen	1987	10	2.2	2.2	0.41	0.42	0.2	4
North Pacific	Minke whale	Baleen	1994*	18	2.3	1.7	0.44	0.33	0.14	4
South India	Humpback dolphin	Toothed	1990-91	3	1.2	12	NA	0.51	0.0026	5
West Greenland	White whale	Toothed	1989-90	71	5.3	4.1	2.4	NA	NA	6
South India	Spinner dolphin	Toothed	1990-91	5	0.53	17	NA	0.35	0.0082	5
South India	Bottlenose dolphin	Toothed	1990-91	4	0.51	7.3	NA	0.51	0.0026	5
North Pacific	Dall's porpoise	Toothed	1980-82	3	NA	9.1	28	0.8	NA	7
Off Iki Island Japan	Pacific white-sided dolphin	Toothed	1981	5	38	76	NA	14	NA	5
Southern Hemisphere										
South African coast	Minke whale	Baleen	1974	29	ND	ND-0.82	NA	NA	NA	8
South African coast	Fin whale	Baleen	1974	6	ND	ND-0.33	NA	NA	NA	8
South African coast	Sei whale	Baleen	1974	1	ND	0.13	NA	NA	NA	8
Antarctic	Minke whale	Baleen	1984-85	20	0.038	0.11	0.027	0.0037	0.11	4
Antarctic	Minke whale	Baleen	1988-89**	20	0.076	0.12	0.029	0.0018	0.10	4
Antarctic	Minke whale	Baleen	1990-91**	19	0.097	0.13	0.031	0.0021	0.092	4
Antarctic	Minke whale	Baleen	1992-93**	20	0.096	0.18	0.041	0.0027	0.13	4
South Atlantic	Sperm whale	Toothed	1986		0.13	0.39	NA	NA	NA	5

NA: Not analyzed, ND: Not detected.

References: 1: Muir *et al.* (1992), 2: Borrell (1993), 3: Sergeant (1980), 4: Aono *et al.* (in prep.), 5: Tanabe *et al.* (1993), 6: Stern *et al.* (1994), 7: Kawano *et al.* (1988), 8: Henry and Best (1983).

Table 3. Concentrations of organochlorine residues (ng/g on wet weight basis) in the blubber of male minke whales (after Aono *et al.*, in prep.). *: Data from JARPA surveys, **: data from JARPN surveys.

Location	Year	n	Fat (%)	PCBs	DDTs	CHLs	HCHs	HCB
Antarctic+	1984/85	20	80	38	110	27	3.7	110
			(54-93)	(13-95)	(32-300)	(11-57)	(2.4-5.7)	(39-290)
	1988/89*	15	80	69	98	25	1.8	92
			(64-96)	(34-118)	(27-220)	(9.6-48)	(0.67-4.2)	(45-162)
	1990/91*	13	79	86	110	28	1.9	85
			(73-90)	(38-180)	(54-250)	(18-52)	(0.92-2.9)	(46-130)
	1992/93*	12	87	61	140	34	2.3	120
			(77-98)	(35-120)	(77-270)	(21-55)	(0.95-4.3)	(73-180)
North Pacific	1987	10	74	2200	2200	410	420	200
			(69-79)	(1500-3000)	(350-1000)	(250-530)	(280-670)	(120-240)
	1994**	18	74	2300	1700	440	330	140
			(53-87)	(620-3100)	(230-2600)	(98-640)	(140-660)	(66-320)

( ) : Range, +: used samples which age is less than 25 years old.

Table 4: Marine debris surveys conducted during the JARPA cruises (1987/88-1995/96)

Season	Searching hours*	Observed no. of items	Type of debris found in the research area (south of 60 S)
1987/88	422.8	2	plastic bottle, polystyrene box
1988/89	164.5		
1989/90	57.0		
1990/91	52day		
1991/92	425.9	1	buoy
1992/93	342.0	0	
1993/94	178.2	1	drum can
1994/95	545.3	1	dram can
1995/96	434.7	8	polystyrene box, buoy, steel can

*: include survey conducted between Japan and the research area.

Table 5. List of marine debris found in stomachs of minke whales sampled during the JARPA surveys

Season	Examined	Observed	Type of debris
1987/88	273	1	plastic bag
1988/89	241	0	
1989/90	329	0	
1990/91	327	0	
1991/92	288	2	wood piece, plastic cap
1992/93	330	2	wood piece, plastic cap
1993/94	330	1	plastic cap
1994/95	330	0	
1995/96	439	0	

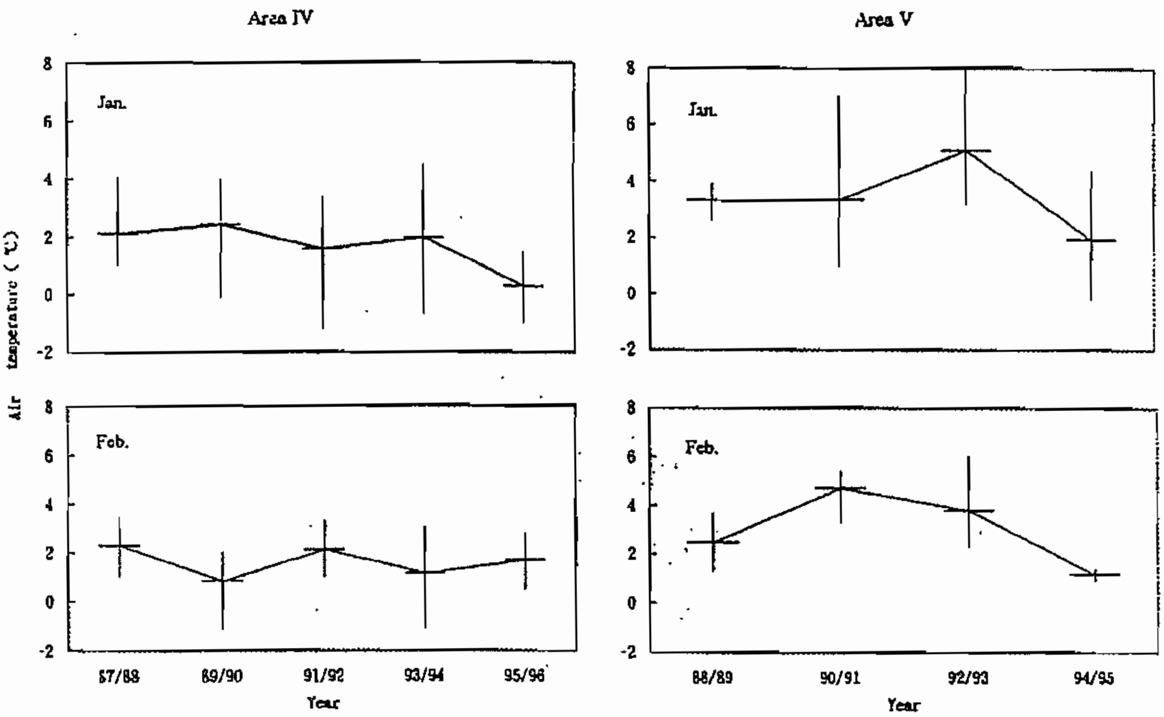


Fig. 1. Yearly changes of air temperatures in a zone between 60°S-63°S in January and February.

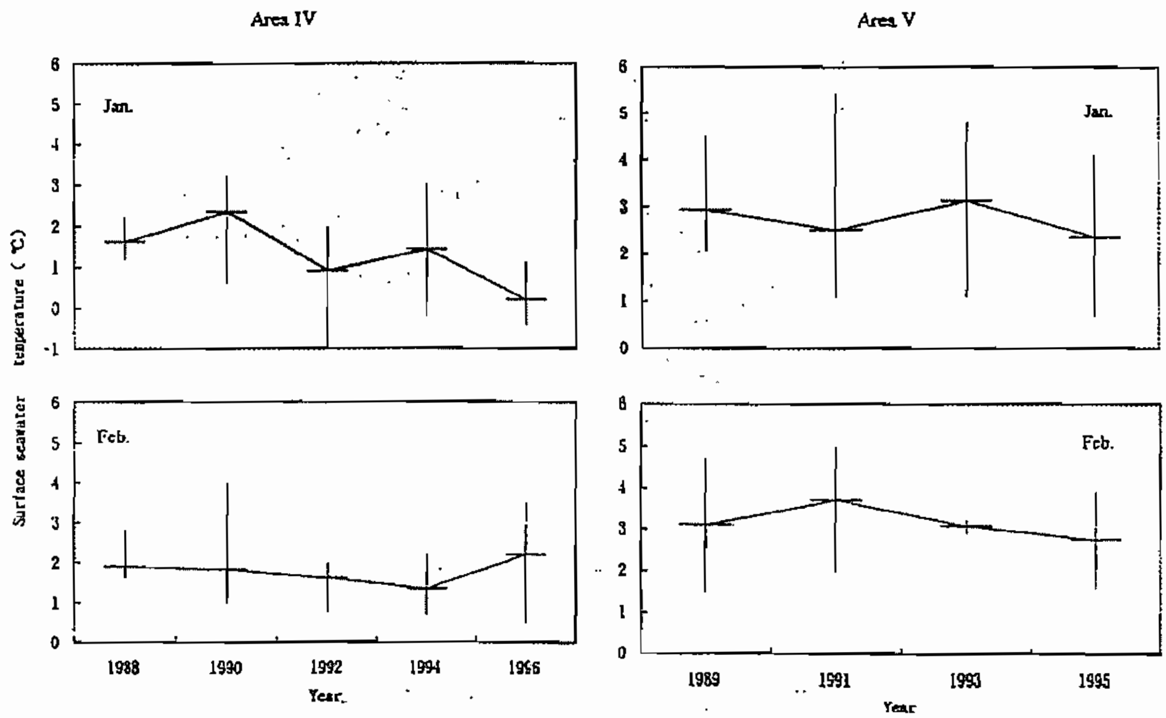


Fig. 2. Yearly changes of surface seawater temperatures in a zone between 60°S-63°S in January and February.

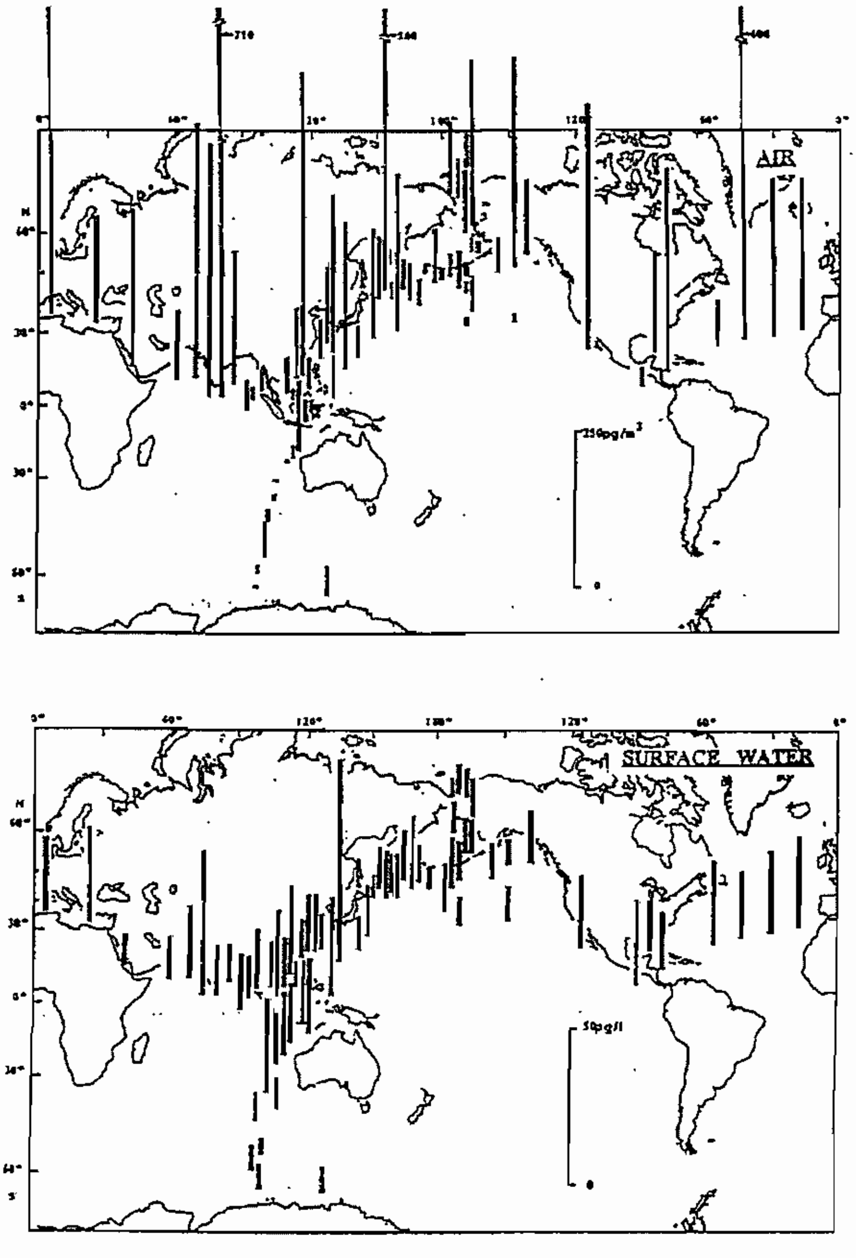


Fig. 3. Distribution of PCB concentrations in air and surface seawater (after Iwata *et al.*, 1993). Data for the Southern Hemisphere were from the 1989/90 JARPA survey (Fujise *et al.*, 1990).

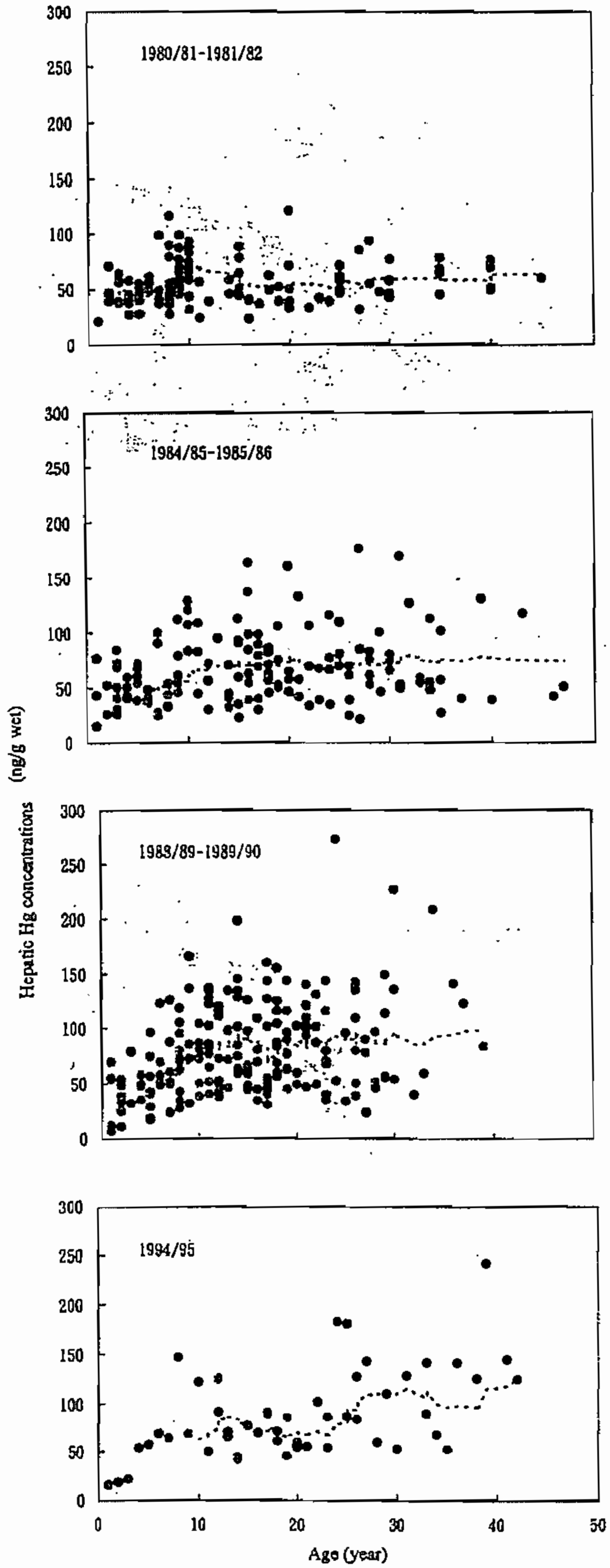


Fig. 4. Age trends of hepatic Hg concentrations of minke whale by survey season. Broken line was drown by running mean method (after Fujise *et al.*, in prep.).

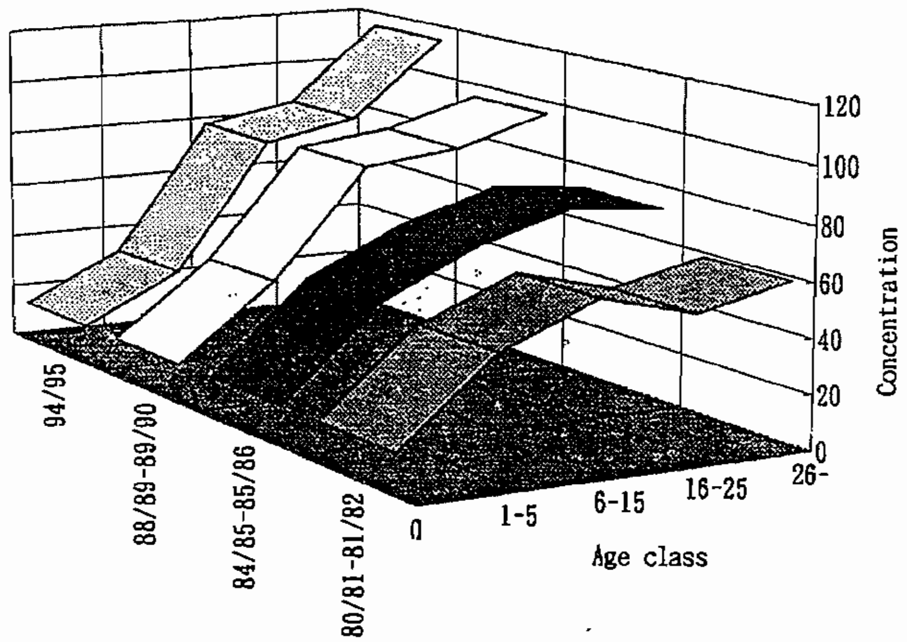
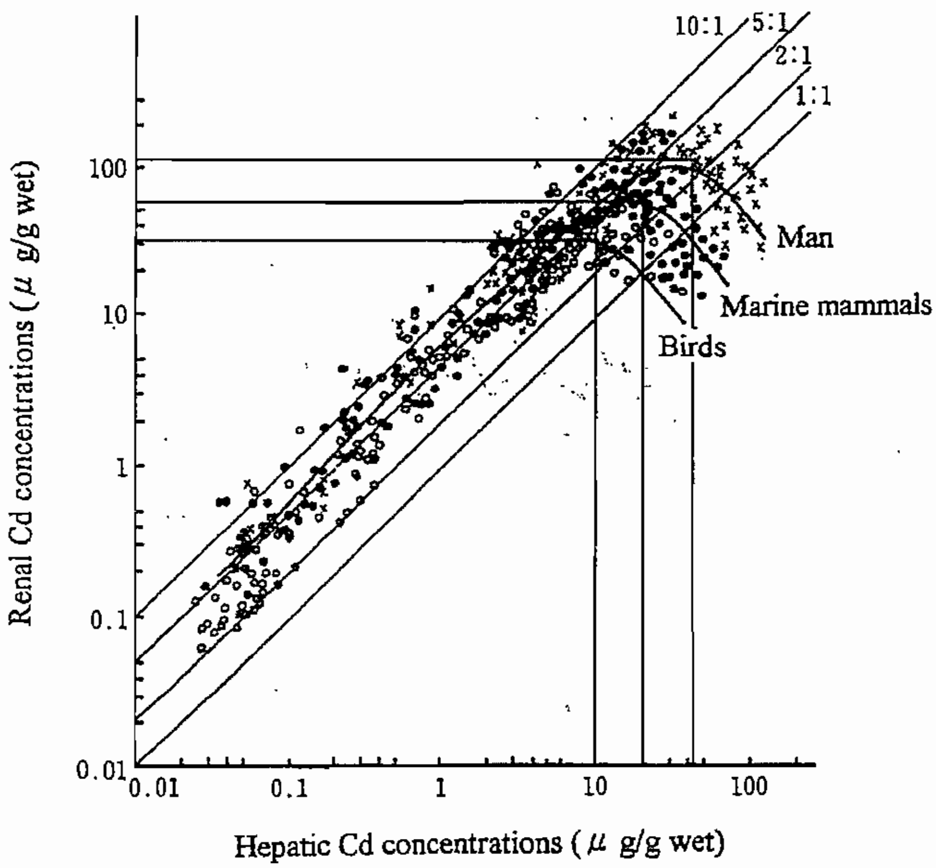


Fig.5. Comparison of age trends of hepatic Hg concentrations of minke whales by servey season (after Fujise *et al.*, in prep.).



Fig, 6. Relationship between hepatic and renal concentrations of Cd in animals (after Honda, 1985). ×: man (Ellis *et al.*, 1984), ●: marine mammals, ○: birds.

APPENDIX

Scientific works related on the environmental changes on cetaceans and other work related on chemical pollution, based on JARPA data and material, presented in symposium and other scientific meetings.

Aono, S., Tanabe, S., Fujise, Y. and Tatsukawa, R. 1995. Specific Accumulation of persistent organochlorines in minke whale (*Balaenoptera acutorostrata*) from the Antarctic and the North Pacific. The 1995 Spring Meeting of the Japanese Society of Fisheries Science, April, 1995, Nihon University. Supplement p.120.

Hasunuma, R., Urano, I., Ogawa, T., Kawanishi, Y. and Fujise, Y. 1992. Analysis of selenium compounds in mammals. The 63th Spring Meeting of the Chemical Society of Japan. March, 1992, Osaka. Proceedings II p.2060.

Hasunuma, R., Arai, K., Ogawa, T., Kawanishi, Y., Fujimoto, A. and Fujise, Y. 1992. Analysis of urinary selenium compounds in marine mammals. The 65th Meeting of the Japanese Biochemical Society. October, 1992, Fukuoka. Seikagaku 64(8):658.

Hasunuma, R., Miyanishi, T., Iwasaki, K., Ogawa, T., Fujise, Y. and Kawanishi, Y. 1994. Selenium compounds in urine of minke whales. The 67th Meeting of the Japanese Biochemical Society. September, 1994, Osaka. Seikagaku 66(7):988.

Hasunuma, R., Iwasaki, Y., Ogawa, T., Fujise, Y. and Kawanishi, Y. 1995. Purification of selenium-containing components in whale urine. The 69th Spring Meeting of the Chemical Society of Japan. March, 1995, Kyoto. Proceedings II p.1010.

Hasunuma, R., Ogawa, T., Kawanishi, Y., Fujise, Y. Fujimoto, A. and Ohike, T. 1995. Selenium metabolites in mammalian urine. The 68th Meeting of the Japanese Biochemical Society. September, 1995, Sendai. Seikagaku 67(7):951.

Hasunuma, R., Ogawa, T., Fujise, Y. Fujimoto, A., Ohike, T. and Kawanishi, Y. 1996. Selenium compounds in mammalian urine. The 70th Spring Meeting of the Chemical Society of Japan. March, 1996. Tokyo. Proceedings II p.618.

Ichii, T., Yamazaki, A., Kato, H. and Fujise, Y.1992. Feeding habit and food consumption of southern minke whales in the Ross Sea and its offshore region. The 15th Symposium on Polar Biology. December, 1992, Tokyo. Supplement p.92.

Iwata, H., Tanabe, S., Yamamoto, Y., Fujise, Y. and Tatsukawa, R. 1991. Latitudinal distribution of oceanic air and seawater contaminations by organochlorines and their feature. The 1991 Spring Meeting of the Japanese Society of Fisheries Science. April, 1991, Tokyo. Supplement p.55.

Kashima, Y., Honda, K., Yamamoto, Y. and Tatsukawa, R. 1989. Occurrence and species differences of cadmium thionein in marine mammals. The 1989 Spring Meeting of the Japanese Society of Fisheries Science, April, 1989, Tokyo. Supplement p.191.

Kashima, Y., Honda, K., Yamamoto, Y. Sang Jung Beak and Tatsukawa, R. 1989. Behavior *in vivo* of cadmium in marine mammals. The 1989 Spring Meeting of the Japanese Society of Fisheries Science, April, 1989, Tokyo. Supplement p.191.

Naganobu, M., Shimamoto, K. and Kato, H. 1988. Analysis of temperature (XBT) data in the feasibility study on Southern minke whale in 1987 /88. The 11th Symposium on Polar Biology. December, 1988, Tokyo. Supplement p.19.

Naganobu, M., Shimamoto, K. and Kato, H. 1989. Analysis of Temperature (XBT) Data in the feasibility study on Southern minke whale in 1987 /88. The 1989 Spring Meeting of the Japanese Society of Fisheries Science, Tokyo. Supplement p.129.

Naganobu, M., Kano, H. and Kato, H. 1989. Oceanographical analysis on the southern minke whale distribution based on the data during Japanese research take in 1988/89. The 12th Symposium on Polar Biology. December, 1989, Tokyo. Supplement p.62.

Naganobu, M., Kano, H. and Kato, H. 1990. Oceanographical analysis on the southern minke whale distribution based on the data during Japanese research take in 1988/89. The 1990 Spring Meeting of the Japanese Society of Fisheries Science, April, 1990. Tokyo. Supplement p.29.

Naganobu, M., Kano, H. and Fujise, Y. 1990. Oceanographical analysis on the southern minke whale distribution based on the data during Japanese research take in 1989/90. The 13th Symposium on Polar Biology. December, 1990, Tokyo. Supplement p.49.

Naganobu, M., Kano, H. and Fujise, Y. 1991. Oceanographical analysis on the southern minke whale distribution based on the data during Japanese research take in 1989/90. The 1991 Spring Meeting of Japanese Fisheries Society. April, 1991, Tokyo. Supplement p.192.

Naganobu, M., Kano, H. and Fujise, Y. 1991. Oceanographical analysis on the southern minke whale distribution based on the data during Japanese research take in 1990/91. The 14th Symposium on Polar Biology. December, 1991, Tokyo. Supplement p.60.

Naganobu, M., Kano, H. and Fujise, Y. 1992. Oceanographical analysis on the southern minke whale distribution based on the data during Japanese research take in 1990/91. The 1992 Spring Meeting of Japanese Fisheries Society. April, 1992, Tokyo. Supplement p.56.

Naganobu, M., Kano, H. and Fujise, Y. 1992. Oceanographical analysis on the southern minke whale distribution based on the data during Japanese research take in 1991/92. The 15th Symposium on Polar Biology. December, 1992, Tokyo. Supplement p.49.

Naganobu, M., Kano, H. and Fujise, Y. 1993. Oceanographical analysis on the southern minke whale distribution based on the data during Japanese research take in 1991/92. The 1993 Spring Meeting of Japanese Fisheries Society. April, 1993, Tokyo. Supplement p.122.

Naganobu, M., Kano, H. and Fujise, Y. 1993. Oceanographical analysis on the southern minke whale distribution based on the data during Japanese research take in 1992/93. The 16th Symposium on Polar Biology. December, 1993, Tokyo. Supplement p.77.

Naganobu, M., Kano, H. and Fujise, Y. 1994. Oceanographical analysis on the southern minke whale distribution based on the data during Japanese research take in 1992/93. The 1994 Spring Meeting of Japanese Fisheries Society. April 1994, Tokyo. Supplement p.186.

Naganobu, M., Kano, H., Fujise, Y. and Nishiwaki, S. 1994. Oceanographical analysis on the southern minke whale distribution based on the data during Japanese research take in 1993/94. The 17th Symposium on Polar Biology. December, 1994, Tokyo. Supplement p.54.

Naganobu, M., Kano, H. Fujise, Y. and Nishiwaki, S. 1995. Oceanographical analysis on the southern minke whale distribution based on the data during Japanese research take in 1993/94. The 1995 Spring Meeting of Japanese Fisheries Society. April 1995, Tokyo. Supplement p.224.

Naganobu, M., Kano, H., Fujise, Y. and Nishiwaki, S. 1995. Oceanographical analysis on the southern minke whale distribution based on the data during Japanese research take in 1994/95. The 18th Symposium on Polar Biology. December, 1995, Tokyo. Supplement p.87.

Tamura, T., Shimazaki, K., Ichii, T. and Fujise, Y. 1995. The distribution of minke whales and their prey in the Antarctic Ocean. The 1995 Spring Meeting of the Japanese Society of Fisheries Science, April, 1995, Tokyo. Supplement p.86.

Tanabe, S., Aono, S., Fujise, Y. and Tatsukawa, R. 1995. Persistent organochlorine residues in minke whale (*Balaenoptera acutorostrata*) from Antarctic Ocean. 4th Symposium on Environmental Chemistry. June, 1995, Tokyo.

Tsuda, M., Hasunuma, R., Fujise, Y., Fujimoto, A. and Kawanishi, Y. 1993. The concentration of selenium and heavy metals in urine of marine mammals. The 66th meeting of Japanese Biochemical Society. October, 1993, Tokyo. Seikagaku 65(8):881.

Yamamoto, Y., Honda, K., Kashima, Y. and Tatsukawa, R. 1989. Metallothionein in fetus and mature minke whales. The 1989 Spring Meeting of the Japanese Society of Fisheries Science, April, 1989, Tokyo. Supplement p.190.