Methodology and procedures of cetacean prey surveys in JARPN II -Offshore component-

HIROTO MURASE[1], HIKARU WATANABE[2], SHIROH YONHEZAKI[1] TSUTOMU TAMURA[1], KOJI MATSUOKA[1], YOSHIHIRO FUJISE[1] AND SHIGEYUKI KAWAHARA[3]

[1] *The Institute of Cetacean Research, 4-5 Toyomi-cho, Chuo-ku, Tokyo, 104-0055, Japan*
[2] *National Research Institute of Far Seas Fisheries, 2-12-4 Fukuura, Kanazawa, Yokohama, Kanagawa 236-8648, Japan*
[3] *National Research Institute of Far Seas Fisheries, 5-7-1, Orido, Shimizu, Shizuoka, Shizuoka, 424-8633, Japan*

ABSTRACT

Cetacean prey species surveys have been conducted every year since 2002 (except 2006) as a part of the full scale surveys of offshore component of JARPN II. The main objective of the prey species surveys were estimation of prey preference of cetaceans which is one of the most important parameters of ecosystem models. Prey preference of cetaceans can only be studied by comparing species compositions of prey in stomachs of cetaceans with species compositions of prey in sea. Prey of common minke, sei and Bryde's whales which are target sampling species of JARPN II were studied in the prey surveys. Five vessels (a research base vessel, three sighting and sampling vessels and a prey survey vessel) were engaged in the cooperative surveys of cetacean sampling and prey. In each year, one to three small blocks (cooperative survey blocks) were established within the entire survey area of the offshore component of JARPN II. Cetacean and prey surveys were conducted in the cooperative survey blocks in the same spatiotemporal scale. A trawler type fisheries survey vessel conducted prey surveys including net sampling and acoustic data recording by quantitative echosounders. Four types of nets (NORPAC, IKMT, MOCNESS and midwater trawl) were used to sample various prey species from zooplankton to fish. A quantitative echo sounders, either EK500 or EK60 (Simrad, Norway) which is commonly used in fisheries research worldwide, was used in the prey surveys. Oceanographic observations using CTD and XCTD were also conducted in the prey surveys. At the same time of prey surveys, cetaceans were sampled and their stomach contents were investigated. Using data acquired by the prey surveys, distribution patterns and biomasses of copepods, krill, Japanese anchovy, and Pacific saury were studied. Such a large scale multidisciplinary surveys in the marine ecosystem have not been conducted in the offshore region of the North Pacific or other boreal regions of world. The data collected by the surveys were used to estimates the prey preferences of cetaceans and results are presented to this workshop (Murase, *et al.*, 2009). Climatic and biological regime shifts have been observed in the Pacific Ocean (Overland *et al.*, 2008) though they have not been reported from 2000 to 2007. Regime shifts affect both fisheries and the marine ecosystem substantially in negative and positive directions. Long term cetacean prey survey program is critically important to detect how cetaceans and their prey respond to regime shifts.

INTRODUCTION

The first phase of the Japanese Whale Research Program under Special Permit in the North Pacific (JARPN) was conducted between 1994 and 1999. The main objective was to clarify the stock structure of minke whales in the western North Pacific. As it proved that minke whales feed on a good deal of fisheries resources such as Japanese anchovy and Pacific saury (Tamura *et al.*, 1998; Tamura and Fujise, 2002), the feeding ecology was added in 1996 as a feasibility study. At the JARPN review meeting held by IWC/SC in February 2000, the workshop agreed that the sampling regime must be designed to allow for a more quantitative estimation of temporal and geographical variation in diet, and recommended that acoustic and trawl surveys should be conducted concurrently with future whale surveys (IWC, 2001). The government of Japan submitted the Research Plan for Cetacean Studies in the Western North

Pacific under Special Permit (JARPN II) (Feasibility Study Plan for 2000 and 2001) to the 52nd IWC/SC (Government of Japan, 2000). The overall goal is to contribute to the conservation and sustainable use of marine living resources including whales in the western North Pacific, especially within Japan's economic exclusive zone (EEZ). The priority in this second phase is on feeding ecology, involving the studies on prey consumption by cetaceans, prey preference of cetaceans and ecosystem modelling. Prey preference of cetaceans is inevitable to most ecosystem models and estimated with the cooperative whale and prey surveys. As the cooperative whale and prey surveys had never been conducted in the western North Pacific, a two-year feasibility study was conducted in 2000 and 2001. Prey distribution and biomass data of common minke (*Balaenoptera acutorostrata*) and Bryde's (*B. edeni*) whales were collected by the cetacean prey survey in the feasibility study. The results of the feasibility study in 2000 and 2001 were reviewed in the 54th IWC/SC (IWC, 2003). Some results of feasibility study related to feeding ecology of cetacean were published in peer reviewed scientific journal (Murase *et al.*, 2007). Based on successful results of the feasibility study, the study was expanded to full scale in 2002 (Government of Japan, 2002). Sei whales (*B. borealis*) was added as a target cetacean species in addition to minke and Bryde's whales. Although sperm whales (*Physeter macrocephalus*) have been a target species of the offshore component of JARPN II since 2000, prey of sperm whales have not been studies in the prey species survey. There are three spatiotemporal scale to link feeding ecology of cetaceans with distribution pattern of them and the definitions are follows; at the macro scale, cetaceans migrate seasonally between feeding and breeding grounds; at the meso scale, cetaceans move over days and weeks in search of preferred local abundance of food; and at the micro scale, whales dive and search for food within localised areas (IWC, 2003). In JARPN II, prey preference of whales is considered as one of the input parameter of ecosystem models not at individual level but at population level in the feeding area. Thus, the main focus is to study feeding ecology of cetaceans at meso scale in JARPN II. It was planned that the results of full scale JARPN II will be review every six years. First six years period was 2002-2007. In the full scale survey, JARPN II has three components (three regional survey areas) namely off Sanriku, off Kushiro and offshore. In this paper, methodologies and procedures of cetacean prey surveys in first six years of full scale JARPN II offshore component were reviewed.

SURVEY AREA

The survey area of the cetacean prey surveys was in the western North Pacific. Southern, northern, eastern and western boundaries of the survey area were 35°N, boundary of EEZ claimed by a foreign country, 170°E and eastern coast line of Japan, respectively. Continental shelf region of Japan (shallower than 200 m water depth) was not included. The survey area corresponds to Sub-areas 7, 8 and 9 which are set for the Implementation Simulation Trials of common minke whale in the North Pacific (IWC, 1994). Although the most of survey area of offshore component of JARPN II is out of EEZ of Japan, the area is migration corridors for many pelagic fish including Japanese anchovy (*Engraulis japonicus*), Japanese pilchard (*Sardinops melanostictus*), Pacific saury (*Cololabis saira*) and chub mackerel (*Scomber japonicus*). Because those pelagic fishes show seasonal migration between inside and outside of Japanese EEZ, investigation of feeding impact of cetaceans on those species is important.

Within the survey area, one to three small blocks were set for cooperative whale and prey surveys every year (Fig. 1). Ideally, cooperative survey should be conducted in the entire survey area. However, because availability of fisheries research vessel for prey survey was limited, small blocks were established within the survey area. Small blocks were set considering the oceanographic conditions such as positions of fronts and water masses as well

as anticipated distribution pattern of the target cetacean species so that small blocks could be treated as representative of the entire survey area.

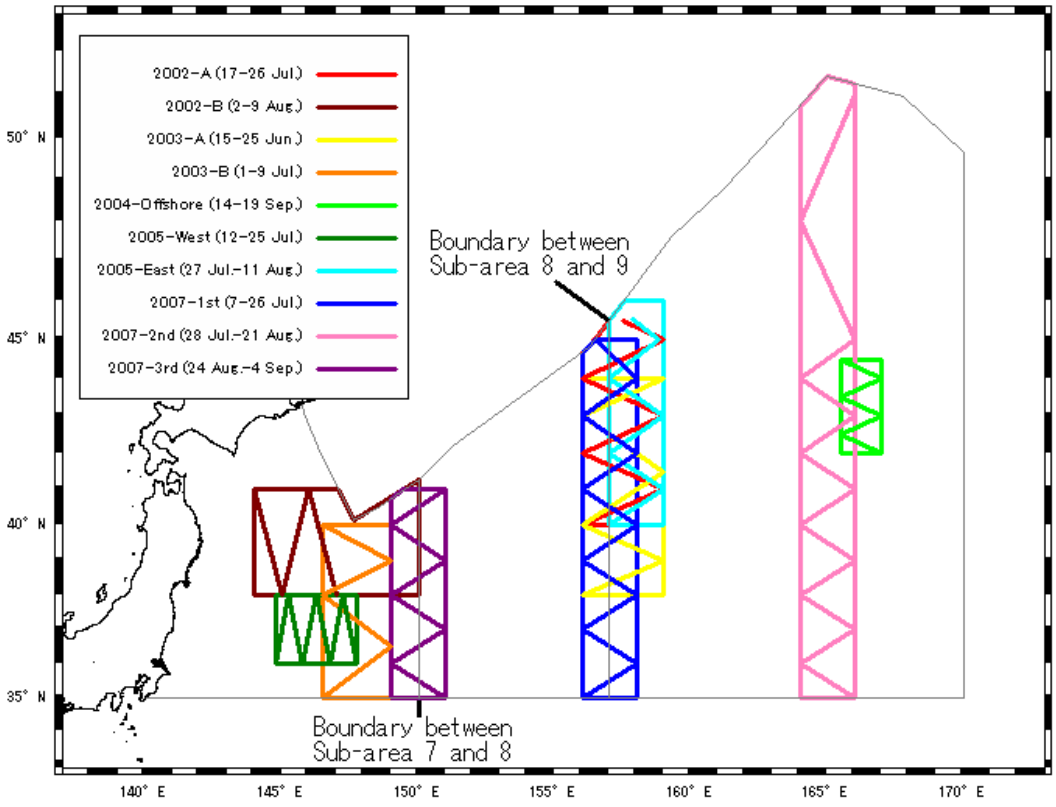


Fig. 1. Survey blocks for cooprative whale and prey surveys in JARPN II offshore component from 2002 to 2007. Each colour represents boundary of surveyed blocks. Zigzag line within each block represent planned trackline.

For monitoring purpose, two regions were selected to set blocks: a region around boundary between Sub-areas 7 and 8 and a region around boundary between Sub-areas 8 and 9. Surveys were also conducted in Sub-area 9. The region around boundary between Sub-areas 7 and 8 is under the influence of Kuroshio extension. Because positions and shapes of Kuroshio extension are highly variable both seasonally and yearly, positions of small blocks were different from year to year according to the position and shape of Kuroshio extension. Bryde's whales were main target species in the region around boundary between Sub-area 7 and 8. Although there are seasonal as well as yearly changes in oceanographic conditions in meridional (latitudinal) direction in a region around boundary between Sub-areas 8 and 9, the change is relatively moderate in comparison with the region around Kuroshio extension. Minke and sei whales are mainly distributed in the northern part of the region around boundary between Sub-area 8 and 9 while Bryde's whales are mainly distributed in southern part of it.

TIMING OF SURVEYS

Timing of cooprative whale and prey surveys from 2002 to 2007 was summarized in Table 1. Both whale and prey surveys were conducted simultaneously in the survey blocks so that data were collected at same spatiotemporal scale. As mentioned in *Introduction* section, scale of

the interest of JARPN II is meso scale (cetaceans move over days and weeks in search of preferred local abundance of food). Each block was surveyed within one to three weeks. Because no prey survey vessel was available, cooprative whale and prey survey was not conducted in 2006.

Table 1. Timing of cooprative whale and prey surveys from 2002 to 2007.

Year	Block	(Abbreviation)	Prey Survey			Whale Survey	
			Vessel	Start	End	Start	End
2002	Special Block A	2002-A	SYO	17-Jul	26-Jul	18-Jul	1-Aug
	Special Block B	2002-B	SYO	2-Aug	9-Aug	7-Aug	17-Aug
2003	Block A	2003-A	SYO	15-Jun	25-Jun	10-Jun	22-Jun
	Block B	2003-B	SYO	1-Jul	9-Jul	26-Jun	29-Jun
						1-Jul	7-Jul
2004	Offshore	2004-O	SYO	14-Sep	19-Sep	5-Sep	8-Sep
2005	Western Block	2005-W	SYO	12-Jul	25-Jul	8-Jul	15-Jul
	Eastern Block	2005-E	SYO	27-Jul	11-Aug	25-Jul	4-Aug
2007	Block 1	2007-1	KK1	7-Jul	26-Jul	9-Jul	22-Jul
	Block 2	2007-2	KK1	28-Jul	21-Aug	23-Jul	2-Aug
	Block 3	2007-3	KK1	24-Aug	4-Sep	11-Aug	13-Aug

TRACKLINE DESIGN

Zigzag tracklines were constructed for prey survey in all cooprative survey blocks (Fig. 1). The survey vessel steamed on planned zigzag tracklines. Spacing between waypoint were decided based on avirable days of prey survey vessels.

RESEARCH VESSEL

Two trawler type fisheries research vessels(RVs), *Shunyo-maru* (Fisheries Research Agency of Japan, 887 GT, SYO) and *Kaiko-maru* (Kaiko Senpaku, 860 GT, KK1), conducted prey surveys (Fig.2). SYO was used from 2002 to 2005 while KK1 was used in 2007. Net sampling, acoustic data recording using quantitative echosoudners and oceanographic observations were conducted by RVs.


(a)

(b)

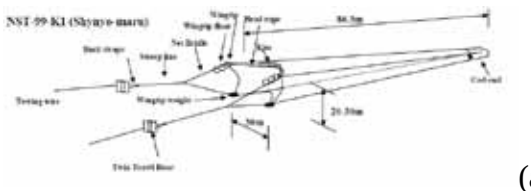
Fig.2. Prey survey vessels. (a) Syunyo-maru (SYO) and (b) Kaiko-Maru (KK1)

Four vessels were engaged in whale surveys in cooperative survey blocks. Three vessels were engaged in the whale survey consisting of sighting and sampling of whales. Those three

vessels were termed as sighting and sampling vessels (SSVs). Sampling of whales is legal according to Japanese national regulation and the International Convention for the Regulation of Whaling (ICRW). Stomach contents of sampled minke, Bryde's and sei whales were examined on the research base ship, *Nisshin Maru* (NM: 7,659GT). In 2002 and 2007 dedicated sighting vessels (SVs) conducted sighiting survey of cetaceans in cooperative survey blocks. Details of whale surveys were described in Tamura *et al.* (2009).

NET SAMPLING

Four types of nets (NORPAC, IKMT, MOCNESS and midwater trawl) were used to sample various prey species from zooplankton to fish (Fig.3).


(a)


(c)


(b)


(d)

Fig.3. Four types of nets used in the prey surveys: (a) midwater trawl (Fig.1 of Ueno *et al.*, 2004), (b) MOCNESS, (c) IKMT and (d) NORPAC.

The midwater trawl (NST-99, Nichiomo, Japan) was 86.3 m long with a mouth opening of 900 m^2 and a 6.0 m cod end with a 17.5 x 17.5 mm mesh inner. Details of specification of the midwater trawl are described in Ueno *et al.* (2004). The sampling depth and, the height and width of the mouth of the net were monitored with either by Scanmar net monitoring system (Scanmar, Norway) or PI32 Catch Monitoring System (Simrad, Norway). Towing speed of the trawl net was 4-5 knots. Surface and midwater trawl was towed at predetermined and targeted stations. Surface trawls were conducted using the midwater trawl net with the floats attached to the bridle so that the trawl could be towed at the surface. Surface trawl was designed for collecting Pacific saury which distributes near surface layer (Ueno *et al.*, 2004). Targeted trawls were conducted to identify the species and size compositions of biological backscattering detected by the quantitative echosounder. The purpose of the predetermined trawls was to estimate the abundance and distribution patterns of cephalopods and neustnic

organisms such as Pacific saury that are difficult to detect by the echosounder. Two different depth layers were sampled at predetermined trawl stations; 0-30m (surface) and 0-100m (midwater). In general, midwater predetermined trawl was towed for 10 minutes at each depth layer (0-30 m, 30-60 m, and 60-100 m) whereas surface predetermined trawl was towed for 30 minutes. All samples were identified to the species as much as possible and wet weight of each species was measured aboard the ship. For the major species, length of 100 individuals was measured to examine their size composition.

MOCNESS (Multiple Opening / Closing Net and Environmental Sampling System) was used to collect vertical distribution and biomass data of copepods. Because specialized equipments were required to tow the MOCNESS, it was only used onboard SYO. MOCNESS was used from 2003 to 2005. The mouth opening size and mesh size were 1 m^2 and 0.33 mm x 0.33 mm, respectively. At the predetermined station, following depth layers were towed; 0-20 m, 20-40 m, 40-60 m, 60-80 m, 80-100 m, 100-150 m, 150-200 m and 200-250 m. In some cases, target towing was also made to identify species and size compositions of biological backscattering detected by the quantitative echo sounder. The samples were preserved in 10 % formalin for species identification at the laboratory.

IKMT (Isaacs-Kidd Midwater Trawl) was mainly used to sample krill. IKMT was used in 2002 and 2007. IKMT with mouth opening of 1 m^2 was used in 2002 while IKMT with mouth opening of 9 m^2 was used in 2007. IKMT was mainly used to investigate species identification and size compositions of backscattering from krill detected by the quantitative echo sounder. The samples were preserved in 10 % formalin for species identification at the laboratory.

A small plankton net, NORPAC (North Pacific standard net), equipped with flow meter was towed at most of trawl stations to estimate abundance of copepods in 2002 and 2007. The mouth opening and mesh size of NORPAC are 45 cm and 0.35 mm, respectively. NORPAC was towed from 150 m to surface but it was towed various depth range in some cases to identify species compositions of acoustical backscattering. The samples were preserved in 10 % formalin for species identification at the laboratory.

Number of net hauls was summarized in Table 2.

Table 2. Number of net hauls in cooperative survey blocks form 2002 to 2007.

Block	Midwater trawl		MOCNESS		IKMT	NORPAC
	Predetermined	Targeted	Predetermined	Targeted	Targeted	Predetermined
2002-A	7	5	-	-	11	6
2002-B	6	4	-	-	7	7
2003-A	11	2	3	0	-	-
2003-B	5	1	3	4	-	-
2004-O	6	0	3	0	-	-
2005-W	9	4	7	0	-	-
2005-E	12	3	4	0	-	-
2007-1	21	5	-	-	8	21
2007-2	26	0	-	-	4	27
2007-3	13	1	-	-	0	14

QUANTITATIVE ECHOSOUNDER

Quantitative echosounders were used in prey surveys to collect distribution pattern and biomass data of prey species. EK60 (Simrad, Norway) was used onboard SYO while EK500 (Simrad, Norway) was used onboard KK1 (Fig.4). Both EK60 and EK500 are commonly used

for surveys on fisheries resources worldwide. Data recorded by 38 and 120kHz transceivers were used for analysis. Only EK60 raw data were saved in 2002 and 2004 while data were recorded with an aid of a software Echoview (Myriax, Australia) in other years. A calibration was conducted within the survey area every year.


(a)


(b)

Fig.4. Quantitative echosounders; (a) EK60 and (b) EK500.

OCEANOGRAPHIC OBSERVATION

Water temperature and salinity profiles were recorded using Conductivity-Temperature-Depth profiler (CTD, SBE-19, Seabird, USA) and expendable CTD (XCTD, Tsurumi Seiki Co., Japan) (Fig.5). CTD and XCTD casts were made most of net haul stations. Details of oceanographic observations were described in Okazaki *et al.* (2009).

Fig.5. Oceanographic observation using CTD.

DISCUSSION

The cetacean prey surveys in offshore component of JARPN II took multidisciplinary approach to collect oceanographic and prey species data. Such a large scale multidisciplinary surveys in marine ecosystem have not been conducted in offshore region of the North Pacific or other boreal regions of world. The data collected by the surveys were used to estimates the prey preferences of cetaceans and results are presented to this workshop (Murase, *et al.*, 2009). Norway conducted several concurrent minke whale sampling and prey surveys in the polar region of Norwegian waters (e.g. Haug *et al.*, 1995; 1996; Lindstrøm *et al.*, 2001). Prey preferences of three baleen whale species, minke, Bryde's and sei whales, were studied in JARPN II. Minke, Bryde's and sei whales feed on wide variety of preys. To collect these prey species data, wide variety of sampling gears were used in JARPN II. However, data of copepods and Pacific saury were spatially sparse in comparison with other species because nets were used. Species other than copepods and Pacific saury were studied using echosounders. If their biomass can be estimated using echosouders, one will be able to study

more detailed prey preference of cetaceans in both spatial and temporal scales. Biomass of copepods can be estimated using echosounders. However, because of small body size of copepods, estimation of target strength as well as development of acoustical species identification methods are critically important. These points will be studies in future JARPN II. Because Pacific saury is distributed mainly near ocean surface layer (e.g. <10m), surface trawling technique developed by Ueno *et al.* (2004) is only way for estimation of biomass. Up looking echousounder mounted on Autonomous Underwater Vehicle (AUV) can be used for alternation of trawling. However, development and deployment of such new equipment will take time and they will not take place in immediate future. To sample prey species, use of MOHT (Matsuda-Oozeki-Hu-Trawl) net in addition to nets used in JARPN II will enhance sampling efficiency as suggested by Oozeki *et al.* (2004). Small blocks of prey surveys were treated as representatives of the entire survey area because availability of fisheries research vessel for prey survey was not allowed to survey in entire area. Ideally, cooperative survey should be conducted in entire the survey area. Entire survey area will be surveyed in future JARPN II from time to time if conditions allow.

To estimate prey preference of cetaceans, examination of stomach contents data is only way to identify species consumed by them specifically (e.g. Haug *et al.*, 1995; 1996; Lindstrøm *et al.*, 2001; Murase *et al.*, 2007., Tamura *et al.*, 1998; Tamura and Fujise, 2002). In addition, prey biomass should also be estimated concurrently with cetacean samplings. There are several papers to study prey preference of cetaceans using distribution pattern data of cetaceans and preys without using stomach contents of cetaceans (Friedlaender *et al.* 2006; Piatt and Methven 1992; Witteveen *et al.*, 2008). These studies only indicated effect of distribution patterns of prey on distribution patterns of cetaceans but they could not tell any prey preference of cetaceans because they could not identify actual prey species consumed by cetaceans. Feeding ecology of baleen whales can be studied using several methods other than stomach contents. Barros and Clarke (2002) categorized those methods as follows; direct observation of feeding (e.g Dunham and Duffus 2001; Hoelzel *et al.* 1989; Tershy 1992), traditional methods (analysis of vomit, scat, stomach and intestine contents), fatty acids (e.g. Møller *et al.* 2003), stable isotopes (e.g Gendron *et al.* 2001; Mitani *et al*., 2006; Todd *et al.* 1997), genetic identification of scat (e.g. Jarman *et al.*, 2002) and video taping of feeding behaviour. In addition, telemetries such as satelltite tag and time and depth recorder (TDR) (e.g. Croll *et al.* 2001; Fiedler *et al.* 1998) were also used for feeding ecology study in recent years. Direct observation of feeding is limited to above the sea surface or short duration of underwater observation by scuba survey. Given diversities and vertical distribution patters of prey species of minke, Bryde's and sei whales direct observation method is not applicable to those species. Haug and Lindstrøm (2003) compared the traditional methods with the rest of new methods and concluded that those new methods have not proven to provide detailed quantitative information on the diet of individual animals and must be supplemented with traditional methods especially with identifying and measuring items in gastrointestinal contents though the combinations of those methods can support their results each other.

It is recognized that both climatic and biological regime shifts occurred in the North Pacific Ocean and their effect on fisheries and ecosystem were actively investigated by North Pacific Marine Science Organization (PICES). Although there are many definition of regime shift, the study group of fisheries and ecosystem responses to recent regime shift under PICES defined regime shift as "a relative rapid change from one decadal-scale period of a persistent state to another decadal-scale period of persistent state" (King, 2005). Climate indices such as the Pacific Decadal Oscillation (PDO) indicated that significant climatic regime shifts were occurred around 1976, 1989 and 1998 in recent decades (Overland *et al.*, 2008). Responses of pelagic biological organisms to climatic regime shifts were reported including copepods

(Tadokoro *et al.*, 2005), Japanese anchovy, Japanese sradine, Pacific saury and mackerel (Takasuka *et al.*, 2008; Tian *et al.*, 2004; Yatsu *et al.*, 2008). Some analysis provided simple interpretation of interaction between climatic and biological regime shifts based on spawning temperature optima theory (e.g. Takasuka *et al.*, 2008) but the interpretation is difficult in other cases because of complexity of interactions (Yastu *et al.*, 2008). Stomach contents collected by commercial fisheries indicated that common minke whales switched their preys according to biological regime shift of prey abundances (Kasamatsu and Tanaka, 1992). However, effects of both biological and climatic regime shifts on baleen whales in the western North Pacific are still largely open to question because of lack of data collected through systematic surveys. So far, regime shift have not been reported during JARPN II from 2002 to 2007. To detect effect of regime shifts on cetaceans as well as effect of predation by cetaceans on biological regime shifts, long term cetacean prey survey program is critically important.

ACKNOWLEDGMENT

Authors expressed thanks to all the crews and researchers who engaged in the offshore component of JARPNII. This survey was supported by Fisheries Agency of Japan, Fisheries Research Agency of Japan and the Institute of Cetacean Research. We thank to these institutions for their support.

REFERENCES

Barros, N. B. and Clarke M. R. 2002. Diet. In: *Encyclopedia of marine mammals.* W. F. Perrin, B. Wűrsig and J. G. M. Thewissen (eds) San Diego: Academic Press, pp323-327.

Croll, D. A., Acevedo-Gutiérrez, A., Tershy, B. R. and Urbán-Ramirez, J. 2001. The diving behaviour of blue and fin whales: is dive duration shorter than expected based on oxygen stores? *Comp. Biochem. Physiol.* A 129:797-809.

Dunham, J. S. and Duffus, D. A. 2001. Foraging patterns of gray whales in central Clayoquot Sound , British Columbia, Canada. *Mar. Ecol. Prog. Ser.* 223:299-310.

Fiedler, P C., Reilly, S B., Hewitt, R P., Demer, D., Philbrick, V A., Smith, S., Armstrong, W., Croll, D A., Tershy, B R. and Mate, B R. 1998. Blue whale habitat and prey in the California Channel Islands. *Deep-Sea Res II* 45:1781-1801.

Friedlaender, A. S., Lawson, G. L. and Halpin, P. N. 2006. Evidence of resource partitioning and niche separation between humpback and minke whales in Antarctica: implications for interspecific competition. Paper SC/58/E32 submitted to the 58th IWC Scientific Committee Meeting, 37 pp. (unpublished) [Available from the International Whaling Commission]

Gendron, D., Aguíñiga, S. and Carriquiry, J. D. 2001. δ^{15}N and δ^{13}C in skin biopsy samples: a note on their applicability for examining the relative trophic level in three rorqual species. *J. Cetacean Res. Manage.* 3:41-44.

Government of Japan. 2000. Research plan for cetacean studies in the western North Pacific under Special Permit (JARPN II) (Feasibility Study Plan for 2000 and 2001). Paper SC/52/O1 submitted to the 52th IWC Scientific Committee Meeting,, 68 pp. (unpublished) [Available from the International Whaling Commission]

Government of Japan. 2002. Research plan for cetacean studies in the western North Pacific under Special Permit (JARPN II). Paper SC/54/O2 submitted to the 52th IWC Scientific Committee Meeting. (unpublished) [Available from the International Whaling Commission]

Haug, T., Gjosaeter, H., Lindstrøm, U. and Nilssen, K. T. 1995. Diet and food availability for north-east Atlantic minke whales (*Balaenoptera acutorostrata*), during the summer of 1992. *ICES J. Mar. Sci.* 52: 77-86.

Haug, T., Lindstrøm, U., Nilssen, K. T., Rottingen, I. and Skaug, H. J. 1996. Diet and food availability for northeast Atlantic minke whales, Balaenoptera acutorostrata. *Rep. Int. Whal. Commn.* 46: 371-382.

Haug. T. and Lindstrøm, U. 2003. Diet studies and cetaceans –methodological aspects. Paper SC/J02/FW1 presented to IWC modeling workshop on cetacean-fishery competition, June 2002 9pp. (unpublished) [Available from the International Whaling Commission]

Hoelzel, A. R., Dorsey, E. M. and Stern, J. 1989. The foraging specialization of individual minke whales. *Anim. Behav.* 38:786-794.

International Whaling Commission. 1994. Report of the Working group on North Pacific minke whale management trials. *Rep. Int. Whal. Commn.* 44: 120-125.

International Whaling Commission. 2001. Report of the workshop to review the Japanese whale research programme under special permit for North Pacific minke whales. *J. Cetacean Res. Manage.* (Suppl.) 3:377-413.

International Whaling Commission. 2003. Report of the Scientific Committee. *J. Cetacean Res. Manage.* (Suppl.) 5:1-92.

Jarman, S. N., Gales, N. J., Tierney, M., Gill, P. C. and Elliott, N. G. 2002. A DNA-based method for identification of krill species and its application to analysing the diet of marine vertebrate predators. *Mol. Ecol.* 11: 2679-2690.

Kasamatsu, F. and Tanaka, S. 1992. Annual changes in prey species of minke whales taken off Japan 1948-87. *Nippon Suisan Gakkaishi*, 58:637-51.

King, J.R (Ed.). 2005. Report of the study group on fisheries and ecosystem responses to recent regime shifts. *PICES Scientific Report* 28, 162 pp.

Lindstrøm, U. and Haug, T. 2001. Feeding strategy and prey selectivity in common minke whales (Balaenoptera acutorostrata) foraging in the southern Barents Sea during early summer. *J. Cetacean Res. Manage.* 3: 239-249.

Mitani, Y., Bando, T., Takai, N. and Sakamoto, W. 2006. Patterns of stable carbon and nitrogen isotopes in the baleen of common minke whale *Balaenoptera acutorostrata* from the western North Pacific. *Fish. Sci.* 72: 69-76.

Møller, P., Rorn, E. W., Dietz, R. Haug, T., Ruzzante, D. E. and Øien, N. 2003. Regional differences in fatty acid copositon in common minke whales (*Balaenoptera acutorostrata*) from the North Atlantic. *J. Cetacean Res. Manage.* 5:115-124.

Murase, H., Tamura, T., Kiwada, H., Fujise, Y., Watanabe, H., Ohizumi, H., Yonezaki, S., Okamura, H. and Kawahara, S. 2007. Prey selection of common minke and Bryde's whales in the western North Pacific in 2000 and 2001. *Fish. Oceanogr.* 16:186-201.

Murase, H., Tamura, T., Isoda, T., Okamoto, R., Yonezaki, S., Watanabe, H., Tojo, N., Matsukura, R., Miyashita, K., Kiwada, H., Matsuoka, K., Nishiwaki, S., Inagake, D., Okazaki, M., Okamura, H., Fujise, Y. and Kawahara, S. 2009. Prey preferences of common minke (*Balaenoptera acutorostrata*), Bryde's (*B. edeni*) and sei (*B. borealis*) whales in offshore component of JARPNII from 2002 to 2007. Paper SC/J09/JR18 presented to the JARPN II review workshop, Tokyo, January 2009 (unpublished). 31pp.

Okazaki, M., Inagake, D., Murase, H., Watanabe, H., Yonezaki, S., Nagashima H., Matsuoka, K., Kiwada, H. and Kawahara, S. 2009. Okazaki, M., Inagake, D., Murase, H., Watanabe, H., Yonezaki, S., Nagashima H., Matsuoka, K., Kiwada, H. and Kawahara, S. Oceanographic conditions of the western North Pacific based on oceanographic data collected during the JARPN II. Paper SC/J09/JR34 presented to the JARPN II review workshop, Tokyo, January 2009 (unpublished). XXpp.

Oozeki Y, Hu F, Kubota H, Sugisaki H, Kimura R. 2004. Newly designed quantitative frame trawl for sampling larvae and juvenile pelagic fishes. *Fish. Sci.* 70:223-232.

Overland, J., Rodionov, S., Minobe, S. and Bond, N. 2008. North Pacific regime shifts: Definitions, issues and recent transitions. *Prog. Oceanogr.* 77: 92-102.

Piatt, J. F. and Methven, D. A. 1992. Threshold Foraging Behavior of Baleen Whales. *Mar. Ecol. Prog. Ser.* 84: 205-210.

Tadokoro, K., Chiba, S., Ono, T., Midorikawa, T. and Saino, T. 2005. Interannual variation in *Neocalanus* biomass in the Oyashio waters of the western North Pacific. *Fish Oceanogr.* 14: 210-222.

Takasuka, A., Oozeki, Y. and Kubota, H. 2008. Multi-species regime shifts reflected in spawning temperature optima of small pelagic fish in the western North Pacific. *Mar. Ecol. Prog. Ser.* 360: 211-217.

Tamura, T., Fujise, Y. and Shimazaki, K. 1998. Diet of minke whales Balaenoptera acutorostrata in the northwestern part of the north Pacific in summer, 1994 and 1995. *Fish. Sci.* 64: 71-76.

Tamura, T. and Fujise, Y. 2002. Geographical and seasonal changes of the prey species of minke whale in the Northwestern Pacific. *ICES J. Mar. Sci.* 59:516-528.

Tamura, T., Matsuoka, K. and Fujise, Y. 2009. Methodology and survey procedure under the JARPN II – offshore component - with special emphasis on whale sampling procedures. Paper SC/J09/JR4 presented to the JARPN II review workshop, Tokyo, January 2009 (unpublished). 16pp.

Tershy, B. R. 1992. Body size, diet, habitat use, and social behavior of Balaenoptera whales in the Gulf of California. *J. Mamm.* 73:477-486.

Tian, Y., Ueno, Y., Suda, M. and Akamine, T. 2004. Decadal variability in the abundance of Pacific saury and its response to climatic/oceanic regime shifts in the northwestern subtropical Pacific during the last half century. *J. Mar. Syst.* 52: 235-257.

Todd, S., Ostrom, P., Lien, J. and Abrajano, J. 1997. Use of biopsy samples of humpback whale (*Megaptera novaengliae*) skin for stable isotope δ13C determination. *J. Northwest Atl. Fish. Sci.* 22:71-76.

Ueno, Y., Suyama, S., Kurita, Y. and Kumazawa, T. 2004. Design and operation methods of a mid-water trawl for quantitative sampling of a surface pelagic fish, Pacific saury (*Cololabis saira*). *Fish Res.* 66: 3-17.

Witteveen, B. H., Foy, R. J., Wynne, K. M. and Tremblay, Y. 2008. Investigation of foraging habits and prey selection by humpback whales (*Megaptera novaeangliae*) using acoustic tags and concurrent fish surveys. *Mar. Mamm. Sci.* 24: 516-534.

Yatsu, A., Aydin, K. Y., King, J. R., McFarlane, G. A., Chiba, S., Tadokoro, K., Kaeriyama, M. and Watanabe, Y. 2008. Elucidating dynamic responses of North Pacific fish populations to climatic forcing: Influence of life-history strategy. *Prog. Oceanogr.* 77: 252-268.