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SOME CONSIDERATIONS OF THE FEASIBILITY COMPONENTS OF THE JARPN II RESEARCH PLAN

GOVERNMENT OF JAPAN

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ABSTRACT

The full-scale JARPN II research plan was presented and discussed at the Scientific Committee in 2002. The plan incorporated two survey components 'offshore' and 'coastal'. Some research elements in the plan were defined as feasibility studies: the logistic of the sampling in coastal area in 2002 and 2003 using small type whaling catcher boats; sample size of minke whale in the coastal component; sample size of sei whale and sampling of sperm whales in the offshore component. Making use of samples and data collected in the 2002 and 2003 surveys, analyses related to the feasibility studies were conducted. Based on the results of those analyses it is concluded that a) no substantial problem occurred during the coastal surveys using small type whaling catcher boats, therefore the coastal component of the JARPN II will continue using same kind of vessels and methodology; b) sample size of minke whale in the coastal component will be increased from 50 to 120, with 60 animals to be sampled in each of the early and the late season; c) the sample size of sei whale in the offshore component will be increased from 50 to 100 animals; d) sampling of ten sperm whales will be continued. The main text of this paper presents the background and rationale for the changes proposed. The appendices of this paper provide details of the analyses conducted, which support the changes proposed in the JARPN II.

INTRODUCTION

The full-scale JARPN II started from the 2002 season, after two years of feasibility study in 2000 and 2001 (Government of Japan, 2002a; 2002b). The main objectives of JARPN II are the following:

1. Feeding ecology and ecosystem studies, involving studies of prey consumption by cetaceans, prey preferences of cetaceans and ecosystem modelling.
2. Monitoring environmental pollutants in cetaceans and the marine ecosystem.
3. Stock structures of whales.

The full JARPN II plan involves two survey components, 'offshore', which is covered by the *Nisshin Maru* research fleet and 'coastal', which is covered by small type whaling catcher boats. The coastal component is necessary to cover the temporal and spatial gaps, which can not be covered by the *Nisshin Maru* (Government of Japan, 2002b).

Under these objectives the research area was set in sub-areas 7, 8 and 9 and the target species and sample sizes were set as follows: 150 common minke whales (100 to be sampled by the offshore survey and 50 by the coastal survey); 50 Bryde's whales (offshore survey); 50 sei whales (offshore survey) and 10 sperm whales (offshore survey) (Government of Japan, 2002b).

In the original JARPN II plan (Government of Japan, 2002b), some research components were defined as feasibility studies:

> 'The survey plan for the first two-year period is as follows. The surveys in 2002 will be conducted in late season from June to October. The small type whaling catcher boats will cover mainly Stratum 7N in September and October. The survey in 2003 will be conducted in early season from April to August. The small type whaling catcher boats will cover Strata 7MI and 7SI in April and May. **The logistic feasibility of sampling using small type whaling catcher boats will be evaluated after the first two-year period.** Basically the same pattern will be repeated three times until the 6-year comprehensive review.' (Extract from Government of Japan, 2002b, page 25).

Individual appendices in this report should be cited in the form:

> 'Author name'. 2004. 'Appendix title'. Appendix XX, pp XX-XX. *In*: Government of Japan (Fujise, Y., Tamura, T. Kato, H. and Kawahara, S. eds.), Some considerations of the feasibility components of the JARPN II research plan. Paper SC/56/Oxx submitted to the 56th IWC Scientific Committee Meeting (Available from the IWC Secretariat).

Note that some appendices can not be cited without a written permission from the authors.

'For minke whales (case of inshore areas of sub-area 7), a minimum of 26 to 102 animals are required in each year. Fifty animals should be adopted. **The sample size may be modified using new data obtained after two-year (small type whaling eateher) feasibility survey.'** (Extract from Government of Japan, 2002b, page 28).

'A report of each cruise will be submitted to annual meetings of IWC/SC and to other organizations. **A report on the two-year feasibility surveys by small type whaling catcher boats will be submitted to the IWC/SC following completion of the survey to check the logistic feasibility. At the same time the results of sample size recalculation for sei whales will be reported using the new data.** A comprehensive report following six-years of research will be submitted to IWC/SC'. (Extract from Government of Japan, 2002b, page 36).

'In the two-year feasibility study, it was planned to examine whether sperm whales had direct and/or indirect relationship with the surface ecosystem or not. Sperm whales taken in the feasibility study mainly fed on a variety of non vertical migratory deep-sea squids and some deep-sea squids which conduct daily vertical migration between the deep sea (say, deeper than 400m in depth) in the daytime and the surface layer (shallower than 200m) at night. Preliminary examination of ecosystem models suggested that sperm whales might have some impact on the surface ecosystem. However, as the total number of samples is only 13, **final conclusions require that sampling be continued as a feasibility study.'** (Extract from Government of Japan, 2002b, page 14).

This paper presents the results of the feasibility studies in JARPNII.

RESULTS

Logistic feasibility of sampling in the coastal area using small type whaling catcher boats

Detailed examination of the logistic aspects of the coastal surveys in 2002 and 2003 are given in Appendix 1 (see also Kishiro *et al.*, 2004). From that examination it was concluded that no substantial logistic problem occurred during the coastal surveys. Therefore, coastal survey can be continued as a component of the JARPN II using the same kind of vessels (small type whaling catcher boats) and methodology.

Sample size of common minke whale in the coastal regions

Geographical and/or temporal variations of prey species of the common minke whales were revealed in the coastal regions from the surveys in 2002 and 2003.

In 2002, major prey species found in the forestomach contents were Japanese anchovy *Engraulis japonicus* (46.9%), walleye pollock *Theragra chalcogramma* (20.4%), Pacific saury *Cololabis saira* (12.2%), Japanese common squid *Todarodes pacificus* (12.2%) and Krill *Euphousia pacifica* (8.2%) (Kishiro *et al.*, 2003).

In 2003, major prey species found in the forestomach contents were Japanese sand lance *Ammodytes personatus* (49.9%), Krill (35.1%), and Japanese anchovy (2.0%). Unidentified fishes (13.0%) were thought to be probably sand lances (Yoshida *et al.*, 2004). The sand lance, which was dominant prey species in minke whale stomachs taken in the present survey, was not collected by the other JARPN II surveys (Fujise *et al.*, 2003; Tamura *et al.*, 2004).

The results from the coastal surveys not only differed between two areas but they were very different from those in the offshore area. In the offshore area, dominant prey species of common minke whale was Japanese anchovy (79.5%) and Pacific saury (64.0%) in the early and late seasons, respectively (Fujise *et al.*, 2003; Tamura *et al.*, 2004).

Considering that the prey consumption is important input data for the ecosystem model, it is necessary to estimate the prey consumption of minke whales in the coastal area separately for early and late season, with sufficient accuracy. This information can not be extrapolated from the offshore area.

The coastal survey strongly suggested interaction between minke whale and fisheries because sand lance, walleye pollock, and common squid are commercially very important species for the coastal fisheries in the areas and seasons surveyed. Therefore, it is imperative to strengthen investigations in coastal areas.

Re-calculation of the required sample sizes was done by using these data and results suggest a sample size of 80 and 60 individuals in the early and late seasons, respectively (Appendix 2). This suggests that sample size should be modified to be at least 60 individuals in each area/season.

As a result, the coastal survey component needs to be conducted twice a year and 60 individuals need to be sampled early and late in the season, respectively.

Recalculation of sample size of sei whales

In the full-scale JARPNII plan, the sample size of sei whales was calculated using prey composition data from past commercial whaling. However, data on stomach content weight and their standard deviation were from Bryde's whales in the JARPNII feasibility study, because such data were not available for sei whales (Appendix 5 of SC/54/O2).

In the 2002 and 2003 surveys, it was revealed that the sei whale fed on a wider range of prey species such as krill, copepods, Pacific saury and Japanese anchovy. Also a different composition of prey species from past commercial whaling was found (Fujise *et al.*, 2003; Tamura *et al.*, 2004).

Using data of sei whales obtained in the 2002 and 2003 surveys, the required sample size of sei whales was re-calculated (Appendix 3). The new calculation show that at least 100 sci whale per year are required for estimating prey consumption with sufficient precision (C.V. =0.2).

Therefore, the sample size of the sei whale needs to be changed from 50 to 100 individuals from the 2004 survey.

Sperm whale

The full JARPN II research plan noted that it was desirable to keep the sperm whale as a target species (feasibility category) in order to study further their relationships with the surface ecosystem and also because of their large biomass (Government of Japan, 2002b). Target sample size of sperm whale was set tentatively at tcn animals a year. During JARPNII surveys, a total of 28 sperm whales were sampled mainly in the sub-area 7. The results show that neon flying squid, which is an important commercial species and plays some role in the pelagic ecosystem, occupied 5% of contents in the stomach of sperm whales sampled (Appendix 4).

Furthermore, because the sperm whale is one of top predator species as a toothed whale, this species can be used for monitoring the environmental pollutants (Appendix 5). Therefore, it is concluded that sampling of sperm whales is useful for at least qualitative studies. Ten individuals should be maintained as a target species in the full-scale JARPNII survey.

CONCLUSIONS

After reviewing of feasibility components of the full-scale JARPNII research plan, it is recommended to modify the original plan as follow;

1. No substantial logistic problem occurred during the coastal surveys using small type whaling catcher boats. Therefore the coastal survey can be continued as a component of the JARPN II using the same kind of vessels (small type whaling catcher boats) and methodology. However, prey species of common minke whales was remarkably different between two areas in the coastal surveys. In order to estimate prcy consumption with sufficient preeision, the eoastal survey component needs to be conducted twice a year and 60 individuals need to be sampled in each of the early and late season.
2. The sample size of the sei whale calculated using new data from the 2002 and 2003 surveys suggests that the current sample size should be changed. It was eoncluded that sample size of sei whales needs to be changed from 50 to 100 individuals.
3. Sampling of sperm whales is useful for at least qualitative studies. Ten individuals should be maintained as a target speeies in the full-seale JARPNII survey.

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APPENDIX 1

FEASIBILITY OF COSTAL SURVEYS IN THE JARPN II, FROM THE VIEWPOINT OF LOGISTICS

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ABSTRACT

The present paper examines the feasibility of the 2002 and 2003 coastal surveys under the JARPN II; the surveys were principally introduced as a supplemental program to facilitate the data and sample collection from places where, and at times when, the survey by the offshore *Nisshin-maru* unit was not able to operate or was unavailable. The first survey was conducted in coastal waters off Kushiro port (sub-area 7N) and the second one off Ayukawa port (sub-area 7M). From examination of the cruise reports and comparison with reports from pelagic cruises it was determined that the research system adopted is mostly acceptable and applicable for the full-scale coastal survey with slight modification and the addition of appropriate sighting surveys. It was revealed that there are considerable geographical and/or temporal variations in the prey composition of minke whales. Taking account of existing knowledge such as the year to year changes in minke whale feeding habits, the coastal surveys should be conducted on a yearly basis in each local area. It is also clear that these coastal surveys will provide data highlighting local conflicts occurring between minke whales and fisheries.

KEYWORDS: COMMON MINKE WHALE; PACIFIC OCEAN; SCIENTIFIC PERMITS, FEASIBLITY STUDIES

INTRODUCTION AND NARRATIVE OF THE SURVEY

Japan submitted the research plan for the full-scale JARPN II to the 54th IWC/SC annual meeting (Government of Japan, 2002). Although the new plan was organized as a full-scale research program it had some feasibility studies such as incorporating a coastal component and the taking of sei whales (*Balaenoptera borealis*). The research plan noted that the feasibility components would be reviewed after the first two year of operations; " ....the logistic feasibility of sampling using small type whaling catcher boats will be evaluated after the first two-year period."

As in separate reports by Kishiro *et al.* (2003) and Yoshida *et al.* (2004), in the first season, the coastal survey took place in the waters off Kushiro port in a part of the sub-area 7 N during 10 September to 12 October 2002.Through the first operation, a total of 50 common minke whales (*B. acutorostrata*; hereafter refered to as minke whale) were taken from coastal waters within a 30 miles radius (Kishiro *et al.*, 2003; Fig. 1). In the subsequent year, the survey moved to the middle part of Sub-area 7, waters off Ayukawa port Sanriku coast (Sub-area 7M). This second operation was conducted within a 30 miles radius during the period 10 April to 2 May 2003, and a total of 50 minke whales were taken from Sendai Bay (Yoshida *et al.*, 2004, Fig. 2).

This paper reviews the feasibility of the past two coastal surveys from the viewpoint of logistics and assesses its applicability for the future surveys.

1. Scope and logistic arrangement of the coastal surveys

The coastal surveys were principally planned to conduct sampling in coastal areas in which the offshore survey (Nisshin-maru unit) could not operate and/or in the season when the fleet would not be available. Thus, we chose the two local areas described above for the reason that these two areas are most probably places where we would be able to investigate the nature of the conflict between local fisheries and minke whales. Coastal fisheries are prosperous and migration of minke whales occurs in both localities.

For the coastal survey in sub-area 7, we incorporated a land-based operation system; one land station was established in the respective season, whose functions were to serve as a platform for biological sampling and flensing and also as the head-quarters for the operation. As summarized in Table 1, the land station was established in the Kushiro port area, Kushiro City, Hokkaido (4258N-14422E) in the 2002 season during 10 Sept. - 12 Oct. 2002. A total of three small type whale catchers were used as sampling vessels. For the 2003 season we moved to the southern part of sub-area 7, Ayukawa Town, Miyagi Prefecture (3817E-14130N). The land station here was located in the port area of Ayukawa and a total of four catcher boats were incorporated taking account of possible sampling difficulties depending on weather and sea state. The operation lasted from 10 April to 2 May 2003. Numbers of the research staff, whale catchers' crew, flensing workers and others combined were 89 and 105 in the 2002 and 2003 season respectively.

Preparations and logistic arrangements proceeded smoothly because both local areas were traditional whaling towns which have enough facilities and technical staff for the sampling operation.

2. Timing and space of the operation

In order to maintain freshness of stomach contents, we firstly examined elapsed time between capturing and flensing. With receipt of advice from experts, we established that the samples should be flensed (or to say stomach contents should be collected) within four hours after capturing. This gives three hours for transportation of carcasses at 10knot/hr and one hour for handling. The research area was therefore limited to a 30miles radius. In order to minimize time for transportation, the carcasses were pulled onto the rear deck of the catcher boat with a pick-up net. The elapsed times from capture and start of flensing were 3 hours 4 minutes on average (1:00 – 6:45 hours) and 2 hours 57 minutes on average (1:43 – 5:54 hours) in the 2002 and 2003 seasons respectively, These elapse times are mostly within the suggested permissible time to maintain the original external appearances of prey items in the stomach .

Spatial distribution of samples seems to be evenly scattered in the 2002 season, off Kushiro port, and it is apparently concentrated in the Sendai Bay in the 2003 season (Figs 1- 2). However, the latter concentration correlated with the area in which minke whales were actually seen in the research area (30 n. mile radius from Ayukawa port). There were very few minke whales outside of the area of concentration. Resultant sampling locations ranged 1.90 to 27.40 n. miles (11.50 in average), and 5.40 to 18.2 n. miles (11.6 n. miles in average) from the coast in the 2002 and 2003 seasons respectively.

The *Nisshin-maru* was unavailable from 24 September to 8 November in 2002, and from 1 January to 13 May in 2003. Thus, it is evident that the 2003 coastal survey was carried out in the season when the pelagic fleet was not available (she was engaged in the 2002/2003 JARPA and then put in to the dock). Even if the fleet had been available it would have been difficult to take samples from such a shallow and busy (due to usual operation of other small fishing boats) area inside of the bay (Fig.2). Clearly, the offshore unit could not have operated within the resultant sampling area of 1.9 nm. – 27.4 nm. from the coast due to insufficient water depth and the abundance of local fishing gear.

On the other hand, in the 2002 season, there was certainly some overlap between the timing of operations of the coastal vessels and that of the pelagic fleet namely, the period 10 - 23 September 2002. However, there was distinctive segregation of the two surveys with the pelagic fleet operating in waters far more distant than 30 miles from the coast and the small type catcher vessels operating closer to shore in eloser proximity to other fishing operation. This separation allowed the collection of samples for stomach content analysis from both the coastal and pelagie zones in the same time period.

From the above, it is elear that the eonduct of the two coastal surveys met the objectives of the plan to provide sampling from plaees and times which the offshore unit was not available or not able to operate.

3. Sampling scheme

The following sampling scheme was implemented:

(1) The catcher boats depart the port two miles apart from each other in the direction of expeetcd whale concentrations.
(2) Catcher boats try to take the first encountered whale eaeh day.
(3) If the target is a sehool of more than one animal, the target is ehosen using a random digit table.
(4) After capturing the target, the respective boats return to the land station as soon as possible.
(5) If the boats miss the target, they resume sighting mostly along the course set up at the departure until the 30mile limitation boundary. After reaehing the boundary, the boat changes course as appropriate and at the suggestion of the leading cateher boat or headquarters.

The above system was especially designed for the eoastal surveys taking account of operational capaeity, ability, and boat arrangcments of the small type whale eatchers. Although the present system is different from the sophistieated random sampling system adopted by the JARPA and the JARPN II offshore unit, it is acceptable in terms of stomach contents colleetion if the samples evenly cover thc area where whales were seen within research area.

However, it seems necessary to modify the sampling procedure somewhat such that the searching direetion is chosen by random manner each day and it is worth investigating the applicability of such modification.

4. Biological sampling

The platform of the land stations were especially designed for conducting biologieal sampling and relevant data eollections. All research items planned in advance were conducted without any problems. As summarized in Table 2, we collected a total of 37 and 36 research items from the whale samplcs in the 2002 and the 2003 season rcspectively. Thcse corresponded to 62.7 or 61.0 % of those carried out on the deck of the pelagic unit, *Nisshin-maru*...

Collection of stomach contents, which was the most important item, was very successfully conducted. Only one stomach was damaged by a harpoon and the other 49 stomachs were successfully sampled in each season. For stomach contents collection, sampling procedure followed the same protocol as for the pelagic fleet with the participation of an experienced researcher who had collected stomach contents on the offshore unit, *Nisshin-maru*. In addition to sampling of stomach contents, weighing of stomach contents, field sorting of food species and measuring of food size were smoothly conducted.

Thus, biological sampling and data collection on the platform of the land station in the costal surveys were successfully conducted to the same standard as those collected by the offshore unit.

5. Data collection on the catcher boat

Due to limited vessel capacity, only one dedicated researcher was able to be onboard each catcher boat. However, it was planned that catching/sighting effort data would be systematically obtained on the catcher boats in addition to recording weather/sea state every hour. From a logistic viewpoint, these data collections were smoothly conducted by good cooperation among the crew and researchers. However, these data were actually not used for the purpose of abundance estimation beeause the catcher boats did not operate in a systematic manner.

Thus, as proposed in the research plan (GJPN, 2002) in order to obtain data for abundance estimation we used independent dedicated sighting vessels incorporating the *Kyoshin-maru* #2 and the *Shonan-maru* in the 2002 and the 2003 season. They conducted sighting surveys by line-transect method covering a significantly wider area than the sampling areas.

In the 2002 season, the independent sighting survey was carried out based on the line transect method off Kushiro port from 10 to 24 September 2002. The sampling area was covered by 7 transects and a total of 40 minke whales of 38 schools were seen as primary sightings during 681.5 miles of effective searching distanee (Kishiro *et al.*, 2003). Data are currently being analyzed (Miyashita, personal communication). However, in the 2003 season, the dedicated sighting survey was designed to cover a wider area along the Pacific coast off northern Honshu from 35N to 41N (Yoshida *et al.*, 2004) and the sampling area consisted of only a small portion of the sighting area. The sampling area was searched by two line transects and only one school of minke whales was sighted (Yoshida *et al.*, 2004). Such low number of sightings is very unlikely to represent the actual status of minke whale migration and is most probably due to the too large zigzag track design. The track line for sighting surveys should be carefully designed taking account of the local pattern of minkc whale distribution and the geographical features of the coast line.

6. Cooperation with prey surveys

One of the main objectivcs of JARPN II is to estimate the prey preference of cetaceans. The prey prcference will be estimated basically by comparing the prcy eomposition in the stomach of whales and thc prey composition in the environment. The latter is obtained by conducting concurrent prey surveys in the same area. The prey surveys wcre conducted concurrently with the whalc surveys off Kushiro in September/October 2002 (Kishiro *et al.*, 2003) and off Sanriku in April 2003 (Yoshida *et al.*, 2004). While the whale surveys were conductcd in the rather limited areas by small-type whaling catchcr boats, the prey surveys covered a wider areas in order to elucidate the distribution pattern of cach prey. Also the sighting survcys were conducted by the dedicated sighting vessels. As the prey preference is to be used in the ecosystem models, the distributional overlap between whales and each prey species should be considered as a factor in the analysis of prey preferenees.

The sighting surveys were conducted on the same track lines as the prey surveys and within a time frame of one week. There were no serious logistic problems in the cooperation between whale, prey and sighting surveys as carried out in the offshore surveys. On the other hand there are some problems in estimating absolute biomass of prey species in order to obtain an accurate picture of the prey composition in the environment. In the acoustic survey combined with targeting trawl operations, accurate values of target strength (TS) are not available for some prey species such as krill and sand lance. In addition, the predetermined stations for the trawl survey plannd for Pacific saury and squids were unsuitable for the acoustic survey and the information on gear efficiency of the mid-water trawl net is insufficient.

Most prey species are the important fisheries resources and the above-mentioned difficulties will be addressed by progress of stock assessment work. As minke whales were concentrated in limited parts of the survey area and the distribution patterns of prey species are generally more complicated near the edge of the continental shelf, increased effort should be given to the prey surveys in those areas. At present all data from the whale, prey and sighting surveys as well as oceanographic data are being analyzed in detail with the Geographical Information System (GIS).

DISCUSSION

Geographical and/or temporal variations of prey species of the common minke whales were rcvealed in the coastal regions from the surveys in 2002 and 2003. In 2002, major prey speeies found in the forestomach contents were Japanese anchovy *Engraulis japonicus* (46.9%), walleye pollock *Theragra chalcogramma* (20.4%), Pacific saury *Cololabis saira* (12.2%), Japanese common squid *Todarodes pacificus* (12.2%) and Krill *Euphausia pacifica* (8.2%) (Kishiro *et al.*, 2003). In 2003, major prey species found in the forestomach contents were Japanese sand lance *Ammodytes personatus* (49.9%), Krill (35.1%), and Japanesc anchovy (2.0%). Unidentified fishes (13.0%) were thought to be probably sand lances (Yoshida *et.al.*, 2004). The sand lance, which was the dominant prey species in minke whale stomachs taken in the present survey, was not an identified prey species in the other JARPN II surveys (Fujise *et al.*, 2003; Tamura *et al.*, 2004).

The results from the coastal surveys not only differed between the two areas but they were very different from those in the offshore area. In the offshore area, dominant prey species of common minke whale was Japanese anchovy (79.5%) and Pacific saury (64.0%) in the early and late seasons, respectively (Fujise *et al.*, 2003; Tamura *et al.*, 2004).

Considering that prey consumption is important input data for the ecosystem model, it is necessary to estimate the prey consumption of minke whales in the coastal area separately for early and late seasons, with sufficient aeeuracy. This information ean not be extrapolated from the offshore area. In addition, year to year ehanges in minke whale feeding are well known (Kasamatsu and Tanaka 1992), and this fact suggests local sampling also should be conducted on a yearly basis.

The coastal surveys also strongly suggested interaction between minke whales and fisheries because sand lance, walleye pollock, and common squid are commercially very important species for the coastal fisheries in the areas and seasons surveycd. Therefore, it is imperative to strengthen investigations in coastal areas.

RECOMMENDATIONS

As conclusions, we recommend following for future planning of the costal surveys:

(1) The research system adopted in the 2002 and 2003 seasons can be principally applicable for the full-scale coast survey.
(2) Independent dedicated sighting surveys appropriately designed taking account of the local pattern of whale distribution and geographical features should be conducted simultaneously with sampling operations.
(3) It was revealed that there are considerable geographical and/or temporal variations of prey composition of minke whales. In addition, taking account of such existing knowledge as the year to year changes in minke whale feeding habits, the coastal surveys should be conducted on a yearly basis in each local area.
(4) The costal surveys strongly indicated local conflicts between minke whales and fisheries, and therefore investigations in coastal areas should be strengthencd.

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Table I. Comparison of logistic aspects in research activities between the coastal (Kushiro, Ayukawa) and offshore research unit in JARPN II 2002/03. Assessment by classes* of HH: complete high; HL: high but slightly low; MH: medium but slightly high; M: medium; L: low.

Items	Sub item	Kushiro (Subarea 7N coast)	Ayukawa (Subarea 7M coast)	Nisshin-maru, offdhore (Subarea7/8/9)
Outline	Research period	10 Sept. - 12 Oct. 2002 (planned 10 Sept - 16 Oct. 2002)	10 April - 2 May 2003 (planned 8 April - 20 May 2003	17 May - 8 August 2003
	Survey area	Within a 30 nm. Radius from the Kushiro Port	Within a 30 nm. Radius from the Ayukawa Port	Sub-area 7, 8 and 9, excluding the EEZ zones of foreign countries
	Sample size	50 common minke whales	50 common minke whales	100 common minke whales (50 Bryde's whale, 50 sei whale and 10 sperm whale)
	Sampling vessels	3 small type whale catchers	4 small type whale catchers	3 sighting/sampling vessels, 1 research base
Research system	Inter exchange with local	L	HL; lécture to pupils	L
	Land base access	HL	M	L
	Communication with outside	M	HL	HH
	Cooperation among catchers	M	M	HH
	Cooperation with other RV	MH	MH	HH
Facility	HQ office	HH	MH	HH
	Research Platform	M	HH	HH
	Flensing platform	M	HL	HH

Table 2. General assessment on scientific aspects between the coastal surveys (Kushiro, Ayukawa) and the offshore unit (Nisshin-maru) in JARPN II 2002/03. Abbreviations indicate the logistic validity classified as follow. HH: complete high; HL: high but slightly lower; MH: medium but slightly higher; M: medium; L: low

Items	Sub item	Kushiro (Subarea 7N coast)	Sanriku-Ayukawa (Sub area 7M coast)	Nisshin-maru, offshore (Subarea7/8/9)
Survey period		HL: mostly meet migration peak there	HL: mostly meet migration peak there	HL: mostly meet migration peak there
Survey area	Coverage	HL: mostly represent universal area as coastal migration	M: still difficult to represent universal area for coastal migration	HL: mostly represent universal area as feeding migration
	Sample distribution	HL: samples were evenly collected with in the 30 nm. radius	M: samples were collected from concentrated spot	HL: samples were collected from broad pelagic area
Research activity				
1) Sampling and samples	sampling efficiency	MH: weak against to rough weather	MH: weak against to rough weather	HL: comparatively robust against rough weather
	towing	HL: pulling up carcass on the rear deck with hammock net	HH: pulling up carcass on the rear deck with hammock net	HL: tie carcass besides sampling vessel
	Lifting	HL: lifting up carcass to a truck with hammock net	HH: lifting up carcass to a truck with hammock net	no lifting required
	sampling bias	HH: unbiased, cover every sexual and reproductive status	HL: unbiased, mostly cover every sexual and reproductive status	HH: unbiased, representing natural composition of sexual and reproductive status

(Continue)

2) Biological collection	Collection work	HL: Smoothly conducted without serious problems and required samples were collected.	HL: Smoothly conducted without serious problems and required samples were collected.	HH: Smoothly conducted without serious problem
	Stomach contents	HL: well sampled from the carcass without vomiting and represent unbiased fauna of food organisms	HL: well sampled from the carcass without vomiting and represent unbiased fauna of food organisms	HL: well sampled without vomiting and represent unbiased food habits
2) Sighting	Sampling vessel	MH: systematically recorded but unable to use for abundance estimation	MH: systematically recorded but unable to use for abundance estimation	HH: systematically recorded
	Dedicated SV	HL: systematical covers the sampling area with appropriate track design by the line transect manner and saw adequate number of animals	M: systematical covers wider area including out side of sampling area but no sighting was made may be due to inadequate track designing.	HL: mostly meet migration peak there
3) Combination with prey survey vessels	Communication	MH	M	HH

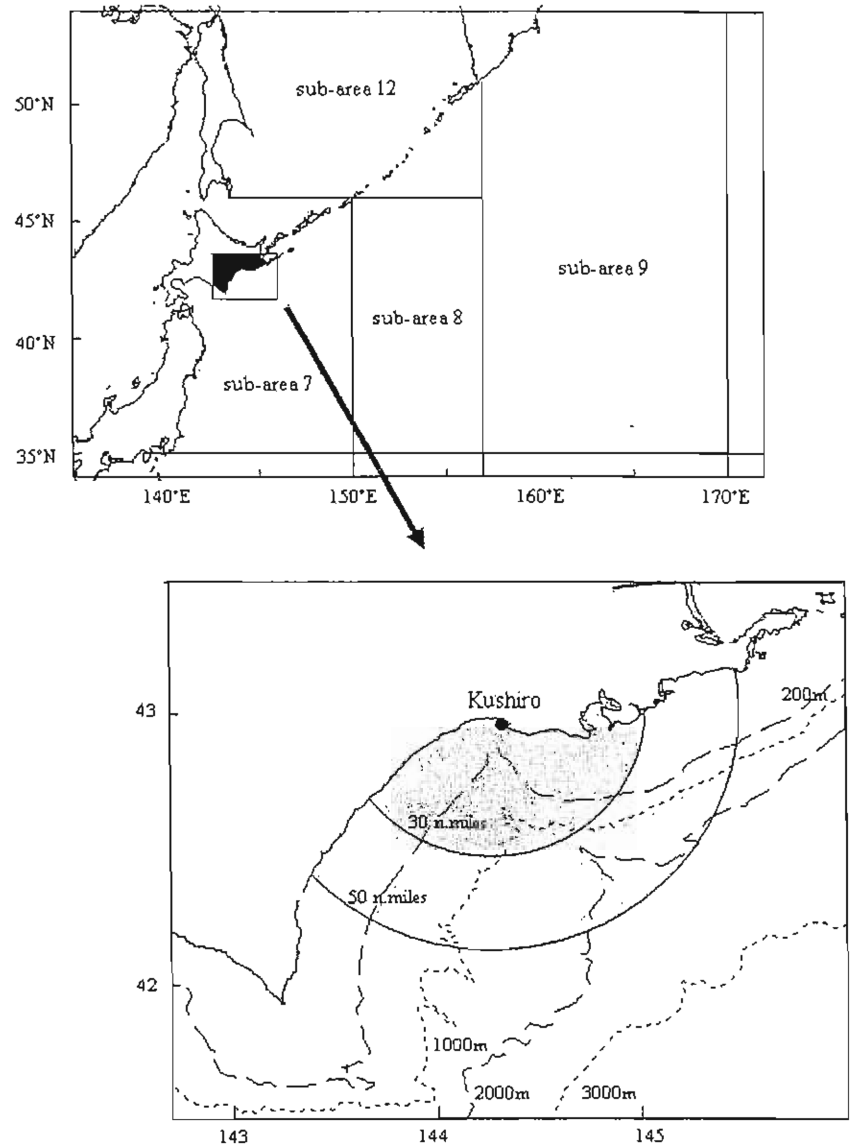

Fig. 1. The IWC sub-areas for western North Pacific minke whales (upper) and research area of the 2002 coastal whale survey in the JARPN II (lower).

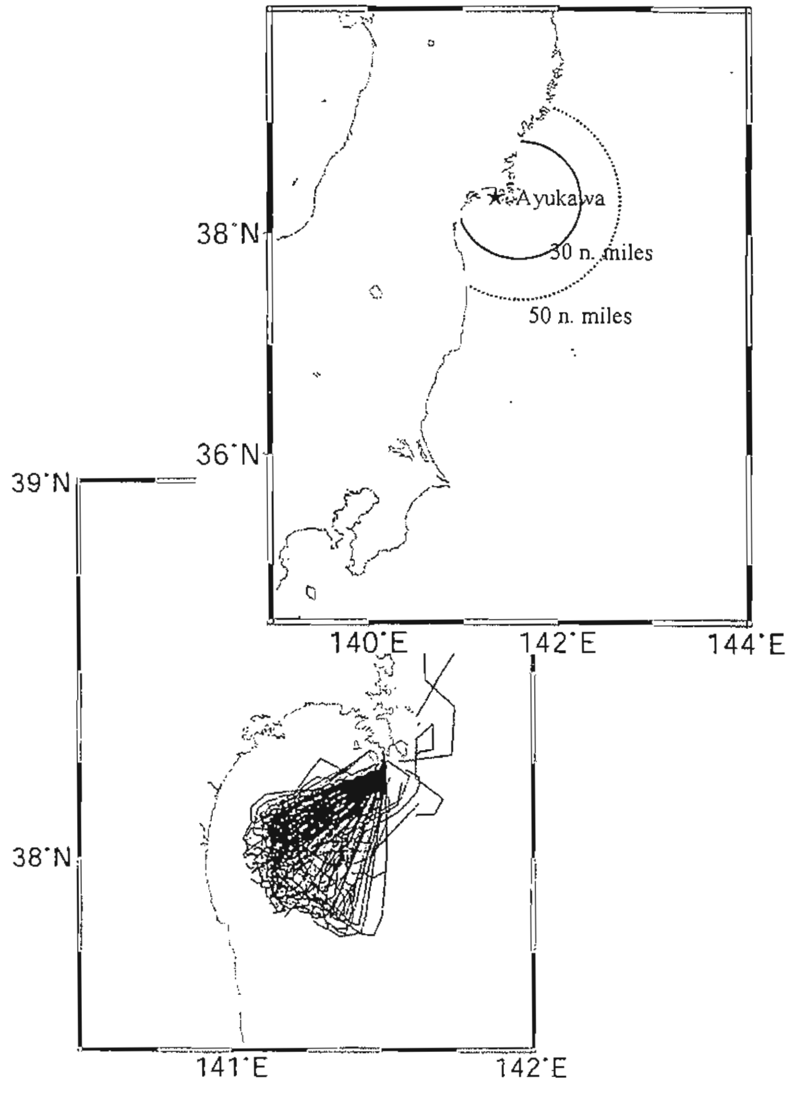

Fig. 2. Research area of the 2003 coastal whale survey in the JARPN II (upper) and cruise tracks made by sampling vessels during the survey (lower).

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APPENDIX 2

RECALCULATION OF SAMPLE SIZE OF COMMON MINKE WHALES IN COASTAL AREAS REQUIRED FOR ESTIMATING CONSUMPTION OF VARIOUS PREY ITEMS BASED ON RESULTS OF JARPN II

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ABSTRACT

The required sample size of common minke whale *Balaenoptera acutorostrata* in coastal areas (Kushiro and Sanriku regions) was recalculated using the stomach contents data from the JARPN II in 2002 and 2003. 60-80 samples per year are required in each region in order to estimate the prey consumption of common minke whales with appropriate statistical accuracy

KEYWORDS: COMMON MINKE WHALE; NORTH PACIFIC; FOOD/PREY; MODELLING; SCIENTIFIC PERMITS

INTRODUCTON

One of the major objectives of JARPN II is to construct an ecosystem model, using stomach contents, prey preference, and other data. The ecosystem model would give fisheries managers a better understanding of the ecosystem dynamics and some guiding principles for multi-species management of marine living resources.

In this paper, the required sample size of common minke whale *Balaenoptera acutorostrata* in coastal areas (Kushiro and Sanriku regions) is recalculated using the data from JARPN II in 2002 and 2003 in order to provide accurate data for the ecosystem model in JARPN II. The method used was the same as that applied for the North Atlantic minke whales (The Norwegian marine mammal research program, 1992). The purpose of these calculations is to estimate the prey consumption by common minke whales in each coastal region with appropriate statistical accuracy (CV=0.2).

MATERIAL AND METHOD

Sample size of common minke whales required for statistical examinations

To calculate required sample size of common minke whales in coastal areas (Kushiro and Sanriku regions), we used the data of the stomach contents from the JARPN II in 2002 and 2003. The following formulas were applied (The Norwegian marine mammal research program, 1992).

Year and area (Kushiro and Sanriku regions) were fixed.

Consider i prey type indexed i = 1,..., I.

In each research area, whale is sampled randomly:

X = amount of prey in stomach

T = a type of prey

For simplicity, we assume that whales feed on a single prey species at each feeding, so that T is a single species:

$$P(T=i)=\rho_i\ ;\ i=1,\cdots,I \qquad (1)$$

Then, from the amount of stomach contents, we calculated the mean and the variance:

$$E(X \mid T=i)=\mu_i \qquad (2)$$

$$Var(X \mid T = i) = \sigma_i^2 \tag{3}$$

If n numbers of whales are sampled in the year, N_i of these will have prey type i in their stomachs. Let the quantities be $X_{i1}, \ldots, X_{iN_i}$, then μ, and ρ_i are estimated:

$$\hat{\rho}_i = N_i / n \tag{4}$$

$$\hat{\mu}_i = 1/N_i \sum_{K=1}^{N_i} X_{ik} \tag{5}$$

Then, the estimated mean amount of prey type i in stomach of a random whale is

$$\hat{\rho}_i \hat{\mu}_i = 1/n \sum_{K=1}^{N_i} X_{ik} \tag{6}$$

If W numbers of whales are in the area over the year, the estimated consumption of prey type i is

$$\overline{C}_i = W \hat{\rho}_i \hat{\mu}_i \tag{7}$$

For simplicity, we disregard uncertainly in W. Then, the mean and variance of C_i is

$$E(\overline{C}_i) = W \rho_i \mu_i \tag{8}$$

$$Var(\overline{C}_i) = W^2 \frac{1}{n} \rho_i \left(\sigma_i^2 + (1-\rho_i)\mu_i^2\right) \tag{9}$$

Therefore, the coefficient of variance of $\overline{C}_i$ is

$$c.v.^2(\overline{C}_i) = \frac{1}{n}\left[W^2 \rho_i \left(\sigma_i^2 + (1-\rho_i)\mu_i^2\right)\right](W \rho_i \mu_i)^{-2} \tag{10}$$

To determine n, the criterion is to choose n as small as possible.

$$n \geqq \left[W^2 \rho_i (\sigma_i^2 + (1-\rho_i)\mu_i^2)\right] / (W \rho_i \mu_i)^2 \alpha^2 \tag{11}$$

A value of $\alpha = 0.2$

seems to be a reasonable choice.

Sample size n is determined by solving inequality (11).

Research areas

We conducted the survey in two areas; the Sanriku and Kusiro research areas (Fig. 1), and recalculation of required sample size of eommon minke whales were made in each area.

Data set used

The data employed in this estimation were the composition of prey species consumed by whales, average stomach contents weight (kg) and its *S.D* on a regional basis using JARPN II data (Table 1). N is the number of whales eating in each dominant prey species (krill, Japanese anchovy, Pacific saury, Sand lance, walleye pollock, Japanese common squid and others).

RESULTS

Food habit of common minke whales in coastal area

The sighting position and prey species of common minke whales sampled by small type whaling vessels in each area are shown in Fig. 2 and 3. They fed mainly on sand lance in the Sanriku region in April and May. However, in September and October in the Kushiro region, they fed on various prey species such as Pacific saury, Japanese anchovy, walleye pollock and Japanese common squid. Because prey species are different depending on the research area, it is necessary to separately calculate the sample sizes for each area.

Sample size of common minke whales

The results of our estimation are shown in Table 2.

To achieve the *CV* under 0.2 for consumption of most important prey species, the minimum of 77 and 58 common minke whales are required in the Sanriku region and the Kushiro region, respeetively.

CONCLUSION

60-80 samples are required in each region in order to estimate the prey consumption of common minke whales in a year with appropriate statistical accuracy.

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The Government of Japan. 2002. Research plan for cetacean studies in the western North Pacific under special permit (JARPNII). Paper SC/54/O2 presented to the IWC Scientific meeting (unpublished). 115pp.

The Norwegian marine mammal research program 1992. A research proposal to evaluate the ecological importance of minke whales in the Northeast Atlantic. Paper SC/44/NAB18 presented to the IWC Scientific meeting (unpublished). 85pp.

Table 1. Data of the dominant prey species of common minke whales in JARPN II for each region (N is the number of dominant prey species consumed by whales).

A. 2002NP (Kusiro region-Autumn)

Dominant prey	N	%	Mean (kg)	*S. D.*
Japanese anchovy	21	44.7	13.1	9.0
Walleye pollock	11	23.4	27.8	22.3
Japanese common squid	6	12.8	40.7	29.3
Pacific saury	5	10.6	47.6	35.6
Krill	4	8.5	42.4	38.6
Empty	0	-	-	-
Broken	3	-	-	-

B. 2003NP (Sanriku region-Spring)

Dominant prey	N	%	Mean (kg)	*S. D.*
Sand lance	26	68.4	35.2	46.9
Krill	12	31.6	48.8	40.5
Empty	0	-	-	-
Broken	12	-	-	-

Table 2. Calculated sample size of common minke whales in each region.

A. 2002NP (Kusiro region-Autumn)

Year	Dominant prey	Sample size (C.V. = 0.2)	Research Period
2002	Japanese anchovy	58	Autumn
	Walleye pollock	151	
	Japanese common squid	273	
	Pacific saury	342	

B. 2003NP (Sanriku region-Spring)

Year	Dominant prey	Sample size (C.V. = 0.2)	Research Period
2003	Sand lance	77	Spring
	Krill	109	

2002NP (Kushiro region) 2003NP (Sanriku region)

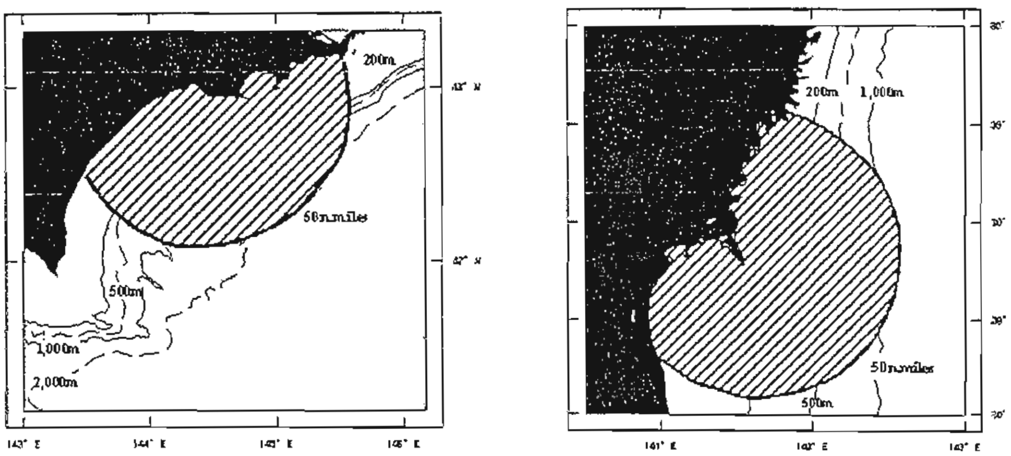

Fig. 1. Research area of coastal regions in JARPN II.

April and May

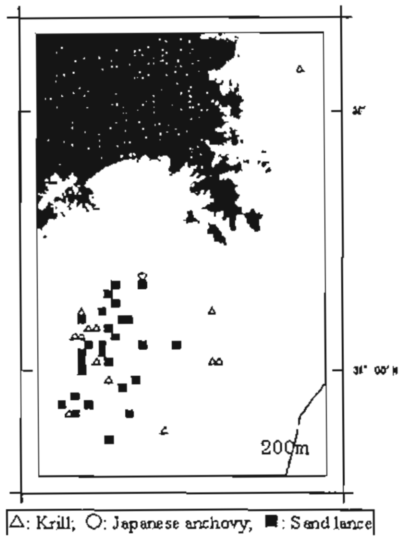

Fig. 2. Sighting position and prey species of common minke whales sampled in Sanriku region.

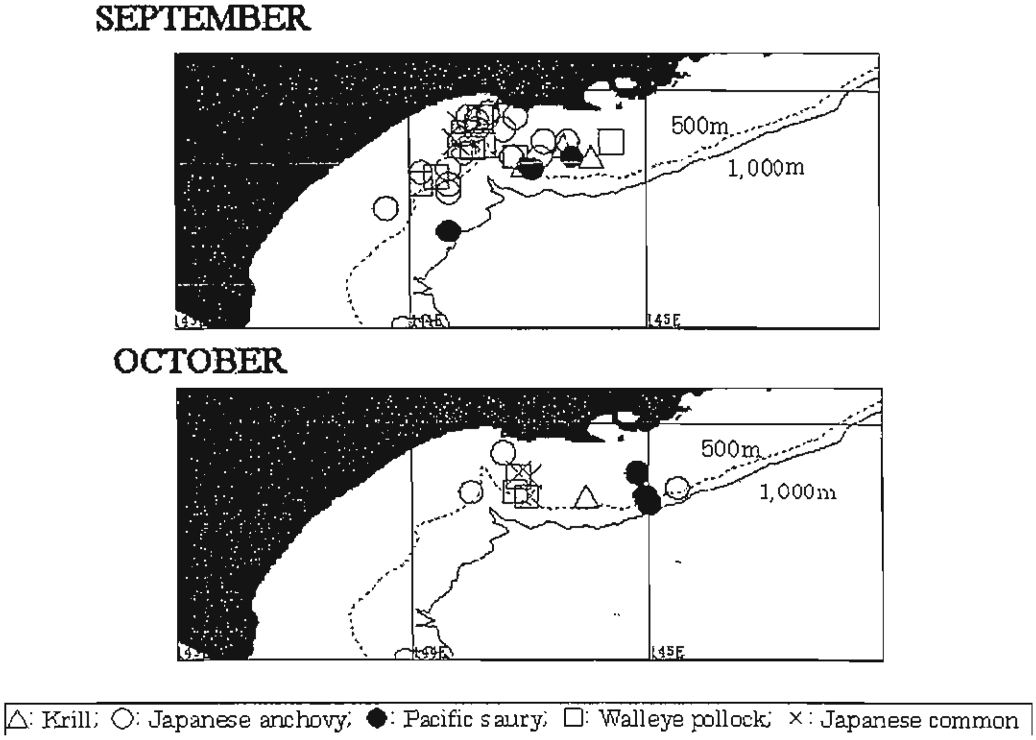

Fig. 3. Sighting position and prey species of common minke whales sampled in Kushiro region.

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APPENDIX 3

RECALCULATION OF SAMPLE SIZE OF SEI WHALES REQUIRED FOR ESTIMATING CONSUMPTION OF VARIOUS PREY ITEMS BASED ON RESULTS OF JARPN II

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ABSTRACT

The required sample size of sei whale *Balaenoptera borealis* in sub areas 7, 8 and 9 was recalculated using the stomach contents data from the JARPN II in 2002 and 2003. The value of 145 obtained using combined data from the two years is more plausible at present. On the other hand, if we adopt the lowest value of 85 which was calculated from the 2003 data, the precision of the estimate would be worse than *CV* = 0.2 in most years and, if we take the value of 223 calculated using the 2002 data, the precision will be better than *CV* = 0.2 in most years.

KEYWORDS: SEI WHALE; NORTH PACIFIC; FOOD/PREY; MODELLING; SCIENTIFIC PERMITS

INTRODUCTION

One of the major objectives of JARPN II is to construct an ecosystem model, using stomach contents, prey preference, and other data. The ecosystem model would give fisheries managers a better understanding of the ecosystem dynamics and some guiding principles for multi-species management of marine living resources.

In this paper, the required sample size of sei whale *Balaenoptera borealis* in sub areas 7, 8 and 9 was recalculated using the data from JARPN II in 2002 and 2003 in order to provide accurate data for the ecosystem model in JARPN II. The method used was the same as that applied for the North Atlantic minke whales (The Norwegian marine mammal research program, 1992). The purpose of these calculations is to estimate the prey consumption by sei whales with appropriate statistical accuracy (*CV*=0.2) in the survey period.

MATERIAL AND METHOD

Sample size of sei whales required for statistical examinations

To calculate required sample size of sei whales, we used the data of the stomach contents from the JARPN II. The following formulas were applied (The Norwegian marine mammal research program, 1992).

Year and area (total research area) were fixed.

Consider i prey type indexed i = 1,…, I.

In the research area, whale is sampled randomly:

X = amount of prey in stomach

T = a type of prey

For simplicity, we assume that whales feed on a single prey species at each feeding, so that T is a single species:

$$P(T=i)=\rho_i\ ;\ i=1,\cdots,I \qquad (1)$$

Then, from the amount of stomach contents, we calculated the mean and the variance:

$$E(X\mid T=i)=\mu_i \qquad (2)$$

$$Var(X\mid T=i)=\sigma_i^2 \qquad (3)$$

If n numbers of whales are sampled in the year, N_i of these will have prey type i in their stomachs. Let the quantities be $X_{i1}, \ldots, X_{iNi}$, then μ_i and ρ_i are estimated:

$$\hat{\rho}_i = N_i / n \tag{4}$$

$$\hat{\mu}_i = 1 / N_i \sum_{K=1}^{N_i} X_{ik} \tag{5}$$

Then, the estimated mean amount of prey type i in stomaeh of a random whale is

$$\hat{\rho}_i \hat{\mu}_i = 1 / n \sum_{K=1}^{N_i} X_{ik} \tag{6}$$

If W numbers of whales are in the area ovcr the year, the estimated consumption of prey type i is

$$\overline{C}_i = W \hat{\rho}_i \hat{\mu}_i \tag{7}$$

For simplicity, we disregard uncertainly in W. Then, the mean and variance of C_i is

$$E(\overline{C}_i) = W \rho_i \mu_i \tag{8}$$

$$Var(\overline{C}_i) = W^2 \frac{1}{n} \rho_i \left(\sigma_i^2 + (1 - \rho_i) \mu_i^2 \right) \tag{9}$$

Therefore, the coefficient of variance of $\overline{C}_i$ is

$$c.v.^2(\overline{C}_i) = \frac{1}{n} \left[W^2 \rho_i \left(\sigma_i^2 + (1 - \rho_i) \mu_i^2 \right) \right] (W \rho_i \mu_i)^{-2} \tag{10}$$

To determine n, the eriterion is to choose n as small as possible.

$$n \geq \left[W^2 \rho_i (\sigma_i^2 + (1 - \rho_i) \mu_i^2) \right] / (W \rho_i \mu_i)^2 \alpha^2 \tag{11}$$

A value of $\alpha = 0.2$

seems to be a reasonable choice.

Sample size n is determined by solving inequality (11).

Research area

To caleulate required sample size of sei whale, we examined the total research area (sub-areas 7, 8 and 9) (Fig. 1).

Data set used

We caleulated required sample sizc of sei whales for estimating their prcy consumption in the research area in each year. The data employed in this estimation were the composition of prey species consumed by whales, average stomach contents weight (kg) and its *S.D.* on a yearly basis of JARPN II data (Table 1). N is the number of whales eating each dominant prey species (Copepods, krill, Japanese anchovy, Pacific saury and others).

The required sample size of sei whales is calculated on a yearly basis rather than a monthly basis from JARPN II results, because the data on food habits of sei whales in May, August and September were insufficient by themselves.

RESULTS

Sample size of sei whales

The results of our estimation are shown in Table 2.

To achieve the *CV* undcr 0.2 for consumption of most important prey species (quantity of 30% or more), the minimum of 223 and 85 sei whales are required in each year. When the data of the two years is eombined, a minimum of 145 sei whales is required

When the research plan was eompiled in 2002 (The government of Japan, 2002), the required sample size of sei whales was ealculated based on past commercial whaling data for prey composition and data of Bryde's whale in JARPN II feasibility study results for stomach contents weight and its *S.D.* The minimum of 64 sei whales was required in each year.

However, the results of the survey of prey species and their stomach contents weight in JARPN II in 2002 and 2003 were substantially different from the past data.

DISCUSSION

Samplings of two research seasons in 2002 and 2003 were concentrated in June and July, while sampling was not sufficient in May, August and September (Fig. 2). Therefore, recalculations on a seasonal basis might not be appropriate, and the value of 145 obtained from combined data of two years is more plausible at present. On the other hand, if wc adopt the lowest value of 85 which was calculated from the 2003 data, the precision of the estimate would be worse than $CV = 0.2$ in most years. On the other hand, if we take 223 animals, the precision will be better than $CV = 0.2$ in most years. Therefore, we recommend a sample size of 100 animals per year for sei whales.

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The Government of Japan. 2002. Research plan for cetacean studies in the western North Pacific under special permit (JARPNII). Paper SC/54/O2 presented to the IWC Scientific meeting (unpublished). 115pp.

The Norwegian marine mammal research program 1992. A research proposal to evaluate the ecological importance of minke whales in the Northeast Atlantic. Paper SC/44/NAB18 presented to the IWC Scientific meeting (unpublished). 85pp.

Table 1. Data of the dominant prey species of sei whales in JARPN II (N is the number of dominant prey species consumed by whales).

Year	Dominant prey	N	%	Mean (kg)	*S. D.*
2002	Copepoda	11	31.4	34.3	49.8
	Krill	16	45.7	57.8	121.4
	Japanese anchovy	6	17.1	163.9	311.9
	Pacific saury	1	2.9	39.8	-
	Other	1	2.9	0.7	-
	Empty	3	-	-	-
	Broken	1	-	-	-
2003	Copepoda	21	52.5	20.4	23.2
	Krill	6	15.0	6.0	10.2
	Japanese anchovy	13	32.5	87.0	136.5
	Other	0	0.0	-	-
	Empty	8	-	-	-
	Broken	2	-	-	-
2002+ 2003	Copepoda	32	42.7	25.2	34.5
	Krill	22	29.3	43.7	105.4
	Japanese anchovy	19	25.3	111.3	202.0
	Pacific saury	1	1.3	39.8	-
	Other	1	1.3	0.7	-
	Empty	11	-	-	-
	Broken	3	-	-	-

Table 2. Calculated sample size of sei whales in each year.

A. 2002NP

Year	Dominant prey	Sample size (C.V. = 0.2)	Research Period
2002	Copepoda	223	Summer
	Krill	271	
	Japanese anchovy	650	

B. 2003NP

Year	Dominant prey	Sample size (C.V. = 0.2)	Research Period
2003	Copepoda	85	Spring-Summer
	Krill	614	
	Japanese anchovy	242	

2002NP+2003NP

Year	Dominant prey	Sample size (C.V. = 0.2)	Research Period
2002-03	Copepoda	145	All
	Japanese anchovy	400	

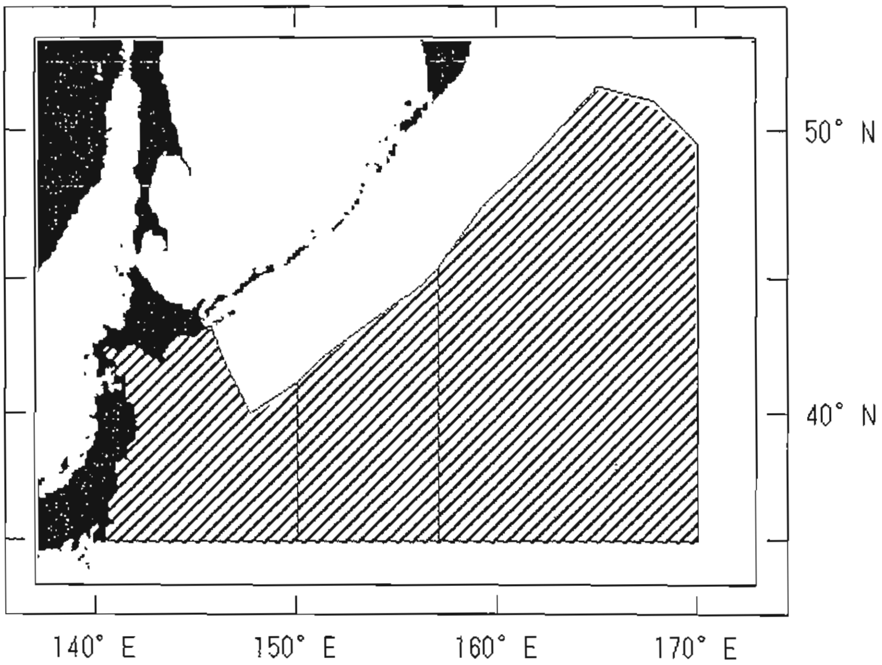

Fig. 1. Research area in JARPN II.

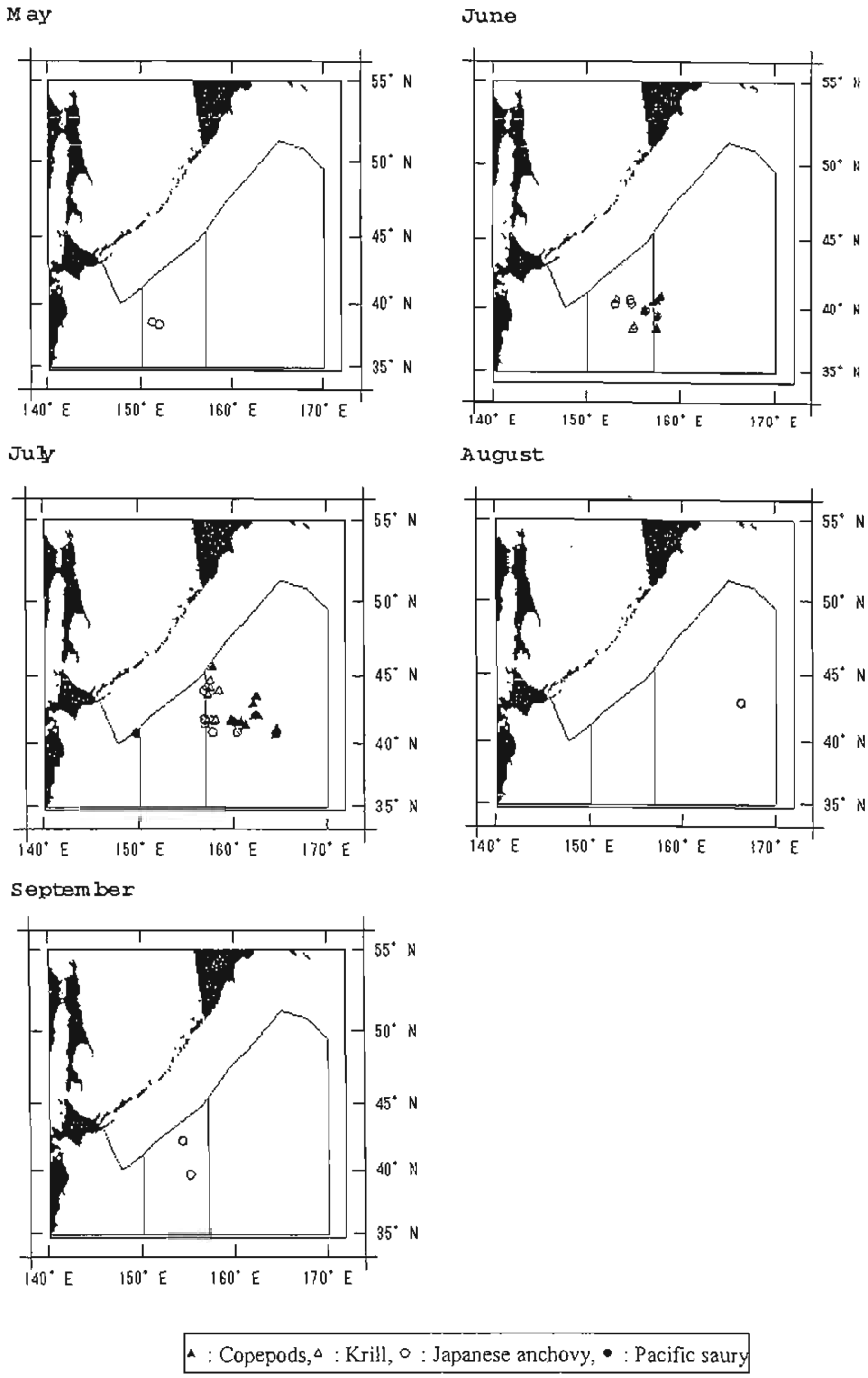

Fig. 2. Sighting position and prey species of sei whales sampled in each month in 2002 and 2003.

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APPENDIX 4

FOOD HABITS OF SPERM WHALES BASED ON JARPN II (2000-03)

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ABSTRACT

The stomach contents of twenty-eight sperm whale (*Physeter macrocephalus*) sampled in the western North Pacific from May to September as part of the 2000 - 2003 JARPN II surveys, were analyzed. Thirty-two prey species consisting of 28 squid, 1 octopus and 3 fish, were identified. Sperm whales fed mainly on various mesopelagic squids. The most important prey species in the JARPNII surveys were 5 squids (*Taningia danae, Histioteuthis dofleini, Belonella pacifica borealis, Ancistrocheirus lesueu* and Neon flying squid *Ommastrephes bartrami*). Four species of these five squids are mesopelagic squids, while one species, neon flying squid is pelagic one and is an important resource for commercial fisheries. Preliminary estimates indicate that eight hundred thousand tons of neon flying squid are consumed by sperm whales equivalent to roughly eight times the total estimated fisheries catch of this species in the western North Pacific. In stomach contents of sperm whales, estimated proportion of squids living in surface layer and those migrating to surface during night time in each sub-area ranged from 0.0 to 11.4%. It is considered that the influence on the surface ecosystem by sperm whale feeding should not be disregarded, because the biomass of sperm whales is huge. To elucidate the food habits of sperm whales (especially, qualitative information in sub-areas 8 and 9) and to understand the influence of sperm whale feeding on the surface ecosystem, more data is needed.

KEYWORDS: SPERM WHALE; NORTH PACIFIC; FOOD/PREY; SQUIDS; MODELING; SCIENTIFIC PERMITS

INTRODUCTION

The sperm whale (*Physeter macrocephalus*) is distributed in waters from the equator to the edge of the polar pack ice area. The abundance of sperm whales in the western North Pacific was estimated to be 102,112 animals (CV=0.155)(Kato and Miyashita, 1998).

Some papers have reported on the stomach eontents of sperm whales from the Sanriku-Hokkaido coastal whaling ground and the North Pacific pelagic whaling ground in the past. Berzin (1971). Kawakami (1980) summarizes these reports lists the species of fish in found in the stomachs of sperm whales. He notes that the proportion of fishes in the stomach contents of sperm whales varies substantially depending on areas with a range of 1-68 %. In the northern part of the west of 180 longitude fishes comprised 7-29 % of the stomach contents. Squids were the most dominant prey. The most important prey species in the Sanriku-Hokkaido area during winter season were neon flying squid *Ommastrephes bartrami*, Kurage ika *Histioteuthis dolfleini*, Yatude ika *Octopoteuthis* sp. and giant squid *Moroteuthis robusta*. Stomach content data were classified according to prey groups in most cases, such as krill, fish and squid. There were also records of empty stomaehs and blanks. The fullness of stomach contents was categorized into five classes (R = 3/4 - 4/4, rrr = 2/4 – 3/4, rr = 1/4 – 2/4, r = < 1/4, 0 = empty) and the freshness of stomach contents was categorized into four classes (F = fresh, fff = lightly digested, ff = moderately digested, f = heavily digested).

However, since 1980, there have been few published reports of the feeding habits of sperm whales in the North Pacific. Furthermore, there are few quantitative data on stomaeh contents.

Sperm whales seem to play an important role in the food web, especially, in the mesopelagic and deep sea, because their high abundance and huge biomass.

In this study, prey species and prey size based on the stomach contents of 28 sperm whales sampled as part of the JARPN II in the western North Pacific are examined. The results improve our knowledge of the feeding habits of sperm whales in this region. Furthermore, these data will contribute to the design of a long-term research program and the consideration of a more realistic strategy for building an ecosystem model in future.

MATERIALS AND METHODS

Research area and period

The sperm whales were sampled in sub-areas 7, 8 and 9 excluding the EEZ of foreign countries. Fig. 1 shows the sighting positions of sperm whales sampled in each month from May through September (combined data for the years 2000, 2001, 2002, and 2003). Table 1 shows sex, body length, stomach contents weight and its ratio to body weight in each area. Sampled whales were immediately transported to a research base vessel, where biological measurements and sampling was carried out.

Sampling of stomach contents

As soon as the sperm whale was on the research base vessel upper deck, the stomachs were removed within a few hours after capture. Then, contents from each stomach (both cases of including and exeluding liquid) was weighed to the nearest 0.1 kg and kept frozen for later analyses.

Data analyses

In the laboratory, prey speeies in thc samples were identified to the lowest taxonomic level as possible. Undigested prey items were identified using morphological characteristic (Kubodera and Furuhashi, 1987, Okutani, 1995). The otoliths and jaw plate were used to identify the fish, squid and octopus with advanced stage of digestion (Kubodera and Furuhashi, 1987).

When undigested squid were found, mantle length and the weights were measured to the nearest 1 mm and 1 g, respectively.

The total number of eaeh prey species in the sample was calculated. Digested prey and buccal masses of squid and oetopus and half of the total number of free otoliths were added to the numbers of undigested prey items in forestomach and fundus eontents. The total weight of each prey species was added, apparently.

Feeding Indices

The relative frequeney of occurrence of each prey species (*RF*) in each whale was caleulated as follows:

$$RF = (Ni / N_{all}) \times 100 \qquad (1)$$

Ni = the number of prey speeies i in eaeh whale

N_{all} = the total number of prey species in each whale

Then, the relative prey importance by weight of eaeh prey species (*RW*) was calculated as follows:

$$RW = (W_i / W_{all}) \times 100 \qquad (2)$$

W_i = the apparent wet weight of contents eontaining prey species i

W_{all} = the total wet weight of contents analyzed.

The estimated proportion of squids living in surface layer to those migrating to surface during night time occurring in the stomachs of sperm whales.

The estimated proportion of squids living in surface layer to those migrating to surface during night time occurring in the stomachs of sperm whales (*PS*) was caleulated as follows:

$$PS = (PSW_i / WW_{all}) \times 100 \qquad (3)$$

PSW_i = the proportion of stomach contents weight of surface organisms as prey in each whale I

WW_{all} = the total wet weight of contents analyzed.

RESULTS

Diversity of prey species

Thirty-two prey species consisting of 28 squid, 1 oetopus and 3 fish were identified in sperm whales caught between 2000 and 2003 as part of JARPNII (Table 2).

Composition of prey species

The occurrence (%) and apparent wet weight composition (%) of prey species consumed by sperm whales caught between 2000 and 2003 is shown on Table 3. They fed mainly on 5 squid species (*Taningia danae*, *Histioteuthis dofleini*, *Belonella pacifica borealis*, *Ancistrocheirus lesueu* and Neon flying squid). The apparent wet weight composition (%) of fish was 4.2 % in sub-area 7. The estimated proportion of squids living in surface layer to those migrating to surface during night time occurring in the stomachs of sperm whales ranged from 0.0 to 11.4 %.

Size frequency of prey species

The size frequency of *B. pacifica borealis*, *H. dofleini* and *G. borealis* is shown in Fig.2.

Belonella pacifica borealis

The dorsal mantle length of *B. pacifica borealis* ingested by sperm whales ranged from 360 to 612 mm with a single mode at 495 mm (Fig. 2A).

Histioteuthis dofleini

The dorsal mantle length of *H. dofleini* ingested by sperm whales ranged from 107 to 210 mm with a single mode at 154 mm (Fig. 2B).

Gonatopsis borealis

The dorsal mantle length of *G. borealis* ingested by sperm whales ranged from 261 to 298 mm with a single mode at 284 mm (Fig. 2C).

Weight and freshness of stomach contents (Table 1)

The stomach contents weight of sperm whales caught between 2000 and 2003 as part of JARPN II ranged from 9.0 kg to 265.5 kg. The maximum stomach contents weight was equivalent to 1.2% of body weight. The freshness of stomach contents were eategorized as follows: F (6 inds., 27.3%),), fff (6 inds., 27.3%), ff (5 ind., 22.7%) and f (5 inds., 22.7%).

DISCUSSION

Diversity of prey spccies

Sperm whales caught between 2000 and 2003 as part of JARPN II fed mainly on various mesopelagie squids. Thirty-two prey species consisting of 28 squid, 1 octopus and 3 fish were identified. The most important prey speeies were 5 squid species (*Taningia danae*, *Histiateuthis dofleini*, *Belonella pacifica borealis*, *Ancistrocheirus lesueu* and Neon flying squid). This is very different from past records (*i.e.* Kawakami, 1980).

It seems that there are geographical, seasonal and yearly changes of prey species in the research area. The past samples were coneentrated around inshore area (Joban-Sanriku area) during winter (*i.e.* Kawakami, 1976; Okutani *et al.*, 1976; Okutani and Satake, 1978). Our sample coneentrated on the inshore area (sub-area 7), which is not different from past record, but seasons were during spring and summer. Additional samples are therefore needed to clarify these food habits, especially offshore area (sueh as sub-areas 8 and 9).

Daily prey consumption and feeding activity

The weight of stomaeh contents of sperm whales may be different according to the size of whales, although it is considered to be less than 300 kg. In Kurile Island, it was found that they did not consume more than 200 kg (Betesheva and Akimushkin, 1955). The stomach contents weight of the sperm whale in the Cook Strait region of New Zealand was reported to have varied from 12.7 to 105 kg (Gaskin and Cawthorn, 1967). Clarke (1977) considered the amount of daily prey consumed by sperm whales would be from 2 to 4 % of their body weight and calculated as 300 kg and 200 kg for males and females, respectively. Tamura (2003) ealculated their dairy consumption using three different equations. The calculated daily prey consumption of sperm whale (average body weight 18.5 tons) in North Pacific was ranged from 304 to 648 kg (from 1.6 to 3.5%). Based on JARPNII data, the stomach eontents weight ranged from 9.0 kg to 265.5 kg. The maximum stomach contents weight was equivalent to 1.2% of their body weight. According to Tamura (2003)'s calculation, the sperm whale must feed several times in a day.

In the Antaretic, they generally feed on prey near the surface during nighttime (Matsushita, 1955). However, in the western North Pacific, as some prey species in stomach contents of whales caught in the daytime were very fresh (no digestion), sperm whales apparently also feed during daytime.

The impact on resources of neon flying squid

In sub-area 7, two sperm whales fed on neon flying squids. Their average weight of stomach contents was 95.8% and 18.5% of body weight. The average proportion of neon flying squids consumed by sperm whales sampled was estimated as 5.0% of their total prey consumption in the western North Pacific during the research season.

The neon flying squid is a very important target species for fisheries in the western North Pacific. Recent fisheries catch was reported as one hundred thousand tons per year in western North Pacific (Fisheries Agency, 2002). They are widely distributed in both the coastal and offshore areas (Naito *et al.*, 1977).

An earlier report shows that sperm whales fed mainly on neon flying squids (20%:occurrence of squids) around Joban area (sub-area 7) in winter (Okutani *et al.*, 1976). In the case that the sperm whales feed on neon flying squid as 5 % of their prey consumption, the total consumption was estimated to be eight hundreds thousand tons, equivalent to roughly eight times the total estimated recent fisheries eateh of this species in the western North Pacifie.

It is neeessary to eollect more data regarding their feeding habits to consider the impact of sperm whale predation for the resourees of neon flying squids.

Application to ecosystem models

The sperm whales were eonsidered to be mesopelagic squid feeders in our research area. However, it was reported that they fed mainly on mesopelagic and/or bottom fishes in other region (Iceland, Bering Sea, West of Canada and New Zealand) (Pike, 1950; Okutani and Nemoto, 1964; Gaskin and Cawthorn, 1967; Roe, 1969).

Furthermore, sperm whales also fed on some squids related to surfaee layer such as *Onychoteuthis borealijaponica, O. banksi, Moroteuthis loennbergi*, eight armed squid (*Gonatopsis borealis*) and neon flying squid. The estimated proportion of squids living in surfaee layer to those migrating to surface during night time occurring in the stomachs of sperm whales ranged from 0.0 to 11.4 %. It is therefore considered that the influenee on surfaee ecosystem by sperm whale predation can not be disregarded, because the biomass of sperm whales is huge.

In the future, these data will be imputed to Ecopath & Ecosym type models to better understand the role of sperm whales in the marine ecosystem.

The neon-flying squid, which were found in the sperm whale stomach contents is one of the important commereially utilized squids, and therefore there is a possibility of direct competition with this fishery. The data colleeted by JARPN II will be useful for at least single-species management of neon flying squid in the western North Pacific in the future.

This report provides results from the very small-scale sampling of sperm whales from 2000 to 2003. The stomach contents of 28 sperm whales sampled in the western North Pacific from May to September of these years were analyzed. However, these samples are concentrated in inshore area (Sub-arca 7). To elucidate the food habits of sperm whales (especially, offshore area such as sub-areas 8 and 9) and to understand the relation of sperm whale predation to the surface ecosystem, more data is needed. These data will contribute to the design of a long-term research program and the consideration of a more realistic strategy for building ecosystem models in future.

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Table 1. Biological and stomach contents data of sperm whales sampled in JARPN II surveys from 2000 to 2003.

Sub area	N		Body length (m)			Stomach contents (kg)			Ratio of body weight (%)			Frequency of freshness of stomach contents					
	Male	Female	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	F	fff	ff	f	Empty	Broken
7	7	15	10.1	8.2	12.8	103.5	9.0	242.2	0.5	0.1	1.2	6	5	3	5	1	2
8	1	2	8.7	7.9	9.9	60.7	18.9	137.4	0.2	0.0	0.5	0	1	0	0	2	0
9	0	3	11.0	10.4	11.5	168.0	106.4	265.5	0.4	0.1	0.7	0	0	2	0	0	1

Table 2. Prey species of sperm whales taken in the western North Pacific from 2000 to 2003.

	Scientific name	English name	Occurences in previous report	Ref.	Remarks
Cephalopoda					
	Enoploteuthis chuni			3	Day time: 300-900 m; Nigh ttime: Upper 200m
	Ancistrocheirus lesueuri		0 >	1	Night time: Upper 100m (DML is u<0.01er 35mm)
	Toningia danae		0 >	1	Night time: Upper 180m (Sub-adult); Upper 1,200m (Adult)
	Octopoteuthis sicula		0 >	1	Day time: Lower 200m, especially 300-400m, Night time: Lower 500m (DML is u<0.01er 15mm)
	O deletron			1	Day time: Lower 200m, especially 300-400m, Night time: Lower 500m (DML is u<0.01er 15mm)
	O. megaptera			2	Day time: Mid-bottom water; Night time: Surface layer
	O. sp. (Type M)				
	O. sp. (Type L)				
**	*Onychoteuthis borealijaponica*			2	Surface layer
**	*O. banksi*			1	Upper 150 m
*	*Moroteuthis loennbergi*		0 >	2	From surface layer to bottom layer
	M. robusta	Giant squid	0 >	1	U<0.01er 100m of bottom layer
	Gonatus berryi			1	Day time: 500-800 m; Nigh ttime: 400-800m (Sub-adult)
	G. pyros			1	Day time. 400-700m, Night time: 100-500m especially 300-400m (DML is u<0.01er 20mm)
	G. middendorffi			1	Day time: 400-800m, Night time: Upper 500m (DML is u<0.01er 21mm)
	Eogonatus tinro			2	From surface layer to bottom layer
	G. ,ﾂﾛ0				
*	*Gonatopsis borealis*	Eight-armed squid	0 >	1	Day time. 400-800m (DML is 16-47mm), Night time: 0-400m
	Histioteuthis dofleini		0 >	1	Day time: 500m, Night time: 50m (DML is 12-14mm)
	H. corona inermis			1	Day time: 600m (DML is 25-27mm)
	H. sp.				
	H. meleagroteuthis			1	Day time: 700m, Night time: 400m (DML is 16-32mm)
	Architeuthis martensi			1	From 200-1200 m
*	*Ommastrephes bartromi*	Neon flying squid	0 >	4	Day time: 300-400m, Night time: Surface layer
	Pholidoteuthis sp.			1,2	Day time: Bottom layer (400-2,000m), Night time. Mid layer
	Discoteuthis discus			1	Day time: upper 750m, Night time: upper 400m (DML is u<0.01er 53mm)
	Cycloteuthis okimushkini			1	Day time: Upper 650m, Night time: Upper 200m
	Chiroteuthis imperator			2	From mid layer to bottom layer
	C. calyx		0 >	1	Day time: 500-800m, Night time: 0-500m (Sub-adult)
	Asperoteuthis acanthoderma			2	From mid layer to bottom layer
	Galiteuthis pacifica			1	Day time: lower 900m, Night time: 0-1200m (Sub-adult)
	Galiteuthis sp.				
	Belonella pacifica borealis		0 >	1	Day time: 600-800m (DML is u<0.01er 60mm)
	Megalocranchia maxima			2	Mid layer
	Megalocranchia sp.				
	Cranchidae sp.				
	Allaposus mollis			1	0-3,200 m, especially 0-200m, 450-1,000m
Pisces					
	Trachipterus ishikawae	King of salmon			
	Laemonema longipes	Threadfin hakeling	0 >		
	Theragra chalcogramma	Walleye pollock	0 >		

*: Surface migration during night; **: Surface distribution in a day

1: Roper, C. F. E. and R. E. Young (1975), 2: Ness, K. N. (1987), 3: Okutani, T. (1980), 4. Tanaka (in Japanese: 2000)

(○ is shown in previous report as prey species of sperm whales around of Japan)

Table 3. Occurrence, number and wet weight composition (%) of each prey species consumed by sperm whales in each sub-area. *: Surface migration during night; **: Surface distribution in a day

Prey species	7			8			9		
	N=19 (N=3: Empty)			N=3			N=3		
	Occurrence %	Number of squids %	Weight of squids %	Occurrence %	Number of squids %	Weight of squids %	Occurrence %	Number of squids %	Weight of squids %
Cephalopoda									
Enoploteuthis chuni	5.3	<0.01	<0.01						
Ancistrocheirus lesueuri	57.9	6.4	6.6						
Taningia danae	47.4	15.3	24.1	100.0	23.8	83.4	100.0	74.1	97.5
Octopoteuthis sicula	15.8	0.2	0.03						
Octopoteuthis deletron	21.1	1.6	0.5						
O. megaptera	10.5	0.4	0.1						
O. sp. (Type M)	21.1	2.2	1.6						
O. sp. (Type L)	10.5	0.6	3.8						
** *Onychoteuthis borealijaponica*	15.8	0.2	0.6						
** *O. banksi*	5.3	<0.01	<0.01						
* *Moroteuthis laennbergi*	15.8	1.5	0.5						
M. robusta	15.8	0.5	5.2						
Gonatus berryi	26.3	1.2	0.2				33.3	0.9	<0.01
G. pyros	15.8	1.6	<0.01	100.0	4.8	0.1			
G. middendorffi	15.8	0.2	0.03						
Eogonatus tinro	5.3	0.1	<0.01						
G. [illegible]	63.2	4.2	0.4				33.3	0.9	<0.01
* *Ganatopsis borealis*	42.1	3.7	4.6						
Histioteuthis dofleini	84.2	26.2	26.1	100.0	61.9	16.6	66.7	24.1	2.5
H. corona inermis	10.5	0.2	0.04						
H. sp.	26.3	3.1	1.0	100.0	9.5	<0.01			
H. meleogroteuthis	5.3	<0.01	<0.01						
Architeuthis martensi	5.3	0.03	0.5						
* *Ommastrephes bartrami*	10.5	1.8	6.4						
Pholidoteuthis sp.	5.3	0.3	0.8						
Discoteuthis discus	10.5	0.3	0.1						
Cycloteuthis okimushkini	10.5	0.2	0.3						
Chiroteuthis imperator	15.8	0.2	0.01						
C. calyx	21.1	0.5	0.7						
Asperoteuthis acanthoderma	5.3	0.1	0.2						
Galiteuthis pacifica	63.2	8.6	1.2						
Goliteuthis sp.	10.5	0.1	0.01						
Belonella pacifica borealis	57.9	15.3	9.3						
Megalocronchia maxima	5.3	0.8	0.3						
Megalocranchia sp.	5.3	0.1	0 03						
Cranchidae sp.	5.3	0.3	0.04						
Unidentified squids	26.3	1.5	0.02						
Alloposus mollis	5.3	0.1	0.2						
Pisces									
Trachipterus ishikawae	15.8	0.2	4.3						
Laemanemo longipes	5.3	0.03	<0.01						
Therogra cholcogromma	5.3	0.03	<0.01						
Unidentified fish	5.3	0.1	0.2						
Estimated contribution rate of surface *		7.1	10.8		0.0	0.0		0.0	0.0
Estimated contribution rate of surface *+**		7.3	11.4		0.0	0.0		0.0	0.0

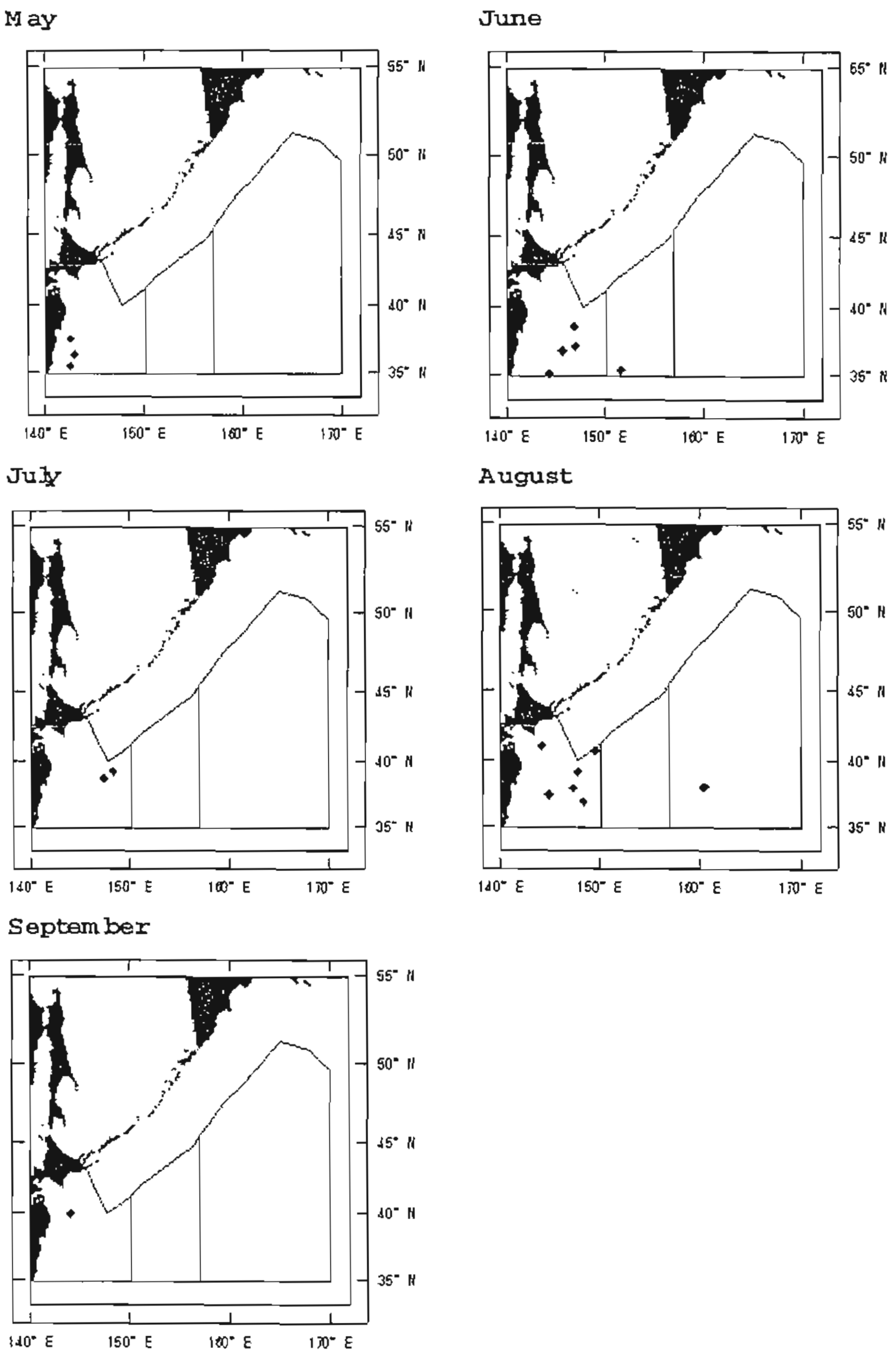
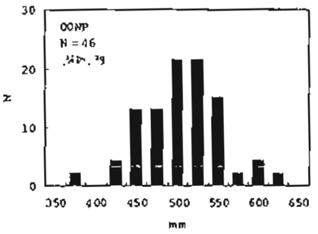
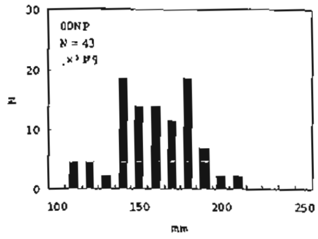


Fig. 1. Sighting positions of sperm whales sampled in each month from May through September (combined data for the years 2000, 2001, 2002 and 2003).

(A) *Belonella pacifica borealis,*



(B) *Histioteuthis dofleini*



(C) *Gonatopsis borealis*

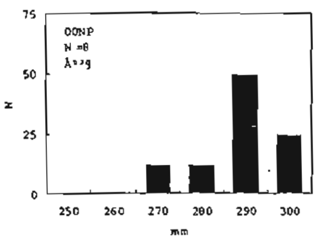


Fig. 2. The body length of dominant prey species consumed by sperm whale in 2000 JARPNII.

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APPENDIX 5

ON THE USEFULNESS OF SPERM WHALES TAKEN IN THE JARPN II FOR THE MONITORING OF ENVIRONMENTAL POLLUTANTS IN THE MARINE ECOSYSTEM

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ABSTRACT

The sperm whale was included as a targeted species in the JARPN II in addition to the common minke, Bryde's and sei whales to address the first objective of the JARPN II 'feeding ecology and ecosystem studies'. The second objective of the JARPN II is the monitoring of environmental pollutants in cetaceans and the marine ecosystem. Preliminary analyses of data from pollution studies in JARPN II detected higher concentrations of PCBs and mercury in the blubber and liver of sperm whales. Results also suggested that the sperm whale may have a higher ability to detoxify Me-Hg. For these reasons, the sperm whale is one of the most useful species for monitoring the pollutants in the marine ecosystem. These studies should be continued under the JARPN II.

KEYWORDS: POLLUTANTS; HEAVY METALS; ORGANOCHLORINES; PACIFIC OCEAN; COMMON MINKE WHALE, BRYDE'S WHALE; SEI WHALE; SPERM WHALE; SPECIAL PERMIT

INTRODUCTION

The sperm whale is the largest toothed whale and one of the most abundant whale species. In the western North Pacific, population abundance of sperm whales was estimated to be 102,112 animals (Kato and Miyashita, 1998). Biomass is also large (approx. 1.8 million tons). As sperm whales consume large quantities of food in this area, they can not be ignored in the construction of an ecosystem model which is the first objective of the JARPN II 'feeding ecology and ecosystem studies'. For this reason, the sperm whale was included as a targeted species in addition to the common minke, Bryde's and sei whales for the JARPN II. The sampling of sperm whales has been conducted as a feasibility study in the JARPN II (GOJ, 2002). During the 2002 and 2003 JARPN II a total of 15 sperm whales were sampled.

The second objective of the JARPN II is the monitoring of environmental pollutants in cetaceans and the marine ecosystem. Under this objective, samples are collected not only from whales, but also from prey species of whales and air and seawater in the research area. This sampling design makes it possible to examine the dynamics of pollutants such as PCBs, DDTs, Hg, Cd and Pb in the marine ecosystem of the western North Pacific.

This paper discusses the importance of sperm whales in terms of the monitoring of pollutants.

PRELIMINARY RESULTS FROM THE ANALYSES OF POLLUTANTS

Table 1 and 2 show the preliminary results of analyses on PCBs, total mercury (T-Hg) and methyl-mercury (Me-Hg) in blubber, liver and muscle of four whale species (sperm, common minke, Bryde's and sei whales) taken in the JARPN and JARPN II research area of the Western North Pacific. PCBs and Hg levels occurred in the following order: sperm whales > common minke whales > Bryde's and sei whales. These results are consistent with a previous pollution study (AMAP, 1998). Persistent pollutant levels in the whale bodies are determined by the levels in food items, pollutant biological half-life and hiological factors, such as age and sex. These preliminary results might suggest that the trophic levels of the major food items are one of the most important factors determining pollutant levels in whales.

Table 2 also shows the percentage of Me-Hg to T-Hg in liver and muscle samples of the four whale species. Most of mercury intake via feeding by all four species is expected to be in the methyl-form (Law, 1996). Therefore, this percentage (Me-Hg/T-Hg) in the liver indicates the ability and rate of demethylation (i.e. detoxification) of the whale body. In the case of sperm whales, the percentage of Me-Hg is significantly lower than for the baleen whales. This could suggest that the sperm whale has a higher demethylation ability and tolerance in toxicity of Me-Hg. In future, the mechanism of detoxification of Me-Hg in the sperm whale should be examined.

Future studies will also require incorporation of biological parameters such as age, sex, reproductive status and food habitat into analyses, since it is likely that pollutant accumulation will vary with biological processes.

CONCLUSION

Preliminary analyses show that higher concentrations of PCBs and mercury were dctected in blubber and liver of sperm whales. Results also suggested that the sperm whale may have a high ability to detoxify Me-Hg. These results mean that the sperm whale is an important species for pollution studies.

In conclusion, the sperm whale is one of the most useful species for monitoring the pollutants in the marine ecosystem and the study should be eontinued under the JARPN II. To date, we have also analysed organoehlorines and trace elements in the whale prey items, seawater and atmosphere. In the future, studies of the sperm whale will contribute to understanding the fate of pollutants in the marine environment.

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Table 1. PCB levels (µg/g wet wt.) in the blubber and the muscle of sperm, common minke, Bryde's and sei whales from Western North Paeifie in the JARPN and JARPN II surveys.

Species		PCBs Blubber (µg/g wet wt.)	PCBs Muscle (µg/g wet wt.)
Sperm whale (2000-2003)	Ave.	2.3	0.06
	(min.-max.)	(0.70-8.1)	(0.02-0.26)
	n	15	13
Common minke whale (1994-2003)	Ave.	1.4	0.03
	(min.-max.)	(0.16-11)	(0.01-0.06)
	n	466	9
Bryde's whale (2000-2003)	Ave.	0.14	0.01
	(min.-max.)	(0.03-0.47)	(<0.01-0.04)
	n	42	8
Sei whale (2002-2003)	Ave.	0.075	<0.01
	(min.-max.)	(0.01-0.28)	
	n	55	5

PCBs: PCBs are fat-soluble, and show higher concentration in blubber and other fatty tissues of whales, according to research. As is indicated in the table, PCB concentration in the muscles of the four whale species is quite low and clears the provisional restriction standard by a large margin. PCB contamination ean be said to be not very serious. However, the concentration in the blubber of some minke and sperm whales in the western North Pacific exceeded the provisional restriction, although Bryde's and sei whale blubbers cleared the standard. Thorough measures are being taken to remove these pollutants, including processing through bleaching of by-products.

Table 2. Total and methyl Hg levels (µg/g wet wt.) and methyl/total Hg ratio (%) in the liver and muscle of sperm, common minke, Bryde's and sei whales from Western North Pacific in the JARPN and JARPN II surveys.

Species		Total Hg		Methyl Hg		Methyl/Toal Hg	
		Liver (µg/g wet wt.)	Muscle (µg/g wet wt.)	Liver (µg/g wet wt.)	Muscle (µg/g wet wt.)	Liver (%)	Muscle (%)
Sperm whale (2000-2002)	Ave.	62	2.1	1.1	0.7	8.1	48
	(min.-max.)	(3.2-250)	(0.86-4.6)	(0.53-1.6)	(0.45-1.1)	(0.80-16)	(37-55)
	n	18	18	5	5	5	5
Common minke whale (1994-2002)	Ave.	0.64	0.20	0 14	0.12	31	63
	(min.-max.)	(0.001-4.3)	(0.004-0.83)	(0.012-0.40)	(0.017-0.19)	(9.7-50)	(34-96)
	n	788	788	40	40	40	40
Bryde's whale (2000-2002)	Ave.	0.18	0.047	0.041	0.025	28	47
	(min.-max.)	(0.011-1.1)	(0.004-0 12)	(9.2-72)	(0.001-0.037)	(9.2-72)	(15-61)
	n	143	143	43	43	43	43
Sei whale (2002-2002)	Ave.	0.43	0.053				
	(min.-max.)	(0.065-1 6)	(0.021-0 081)	NA	NA	NA	NA
	n	39	39				

NA: Not Analysed

Mercury: Research indicates that mercury shows relatively high concentration in the internal organs (especially liver) and muscles (red meat) and is lower in the blubber (fat layer) of whales. The muscles of the Bryde's and sei whales showed the lowest mercury concentration, followed by that of the minke whale but still being less than the provisional restriction levels set by the Ministry of Health, Labour and Welfare. On the other hand, concentration in the sperm whale muscle greatly exceeded the provisional restriction levels, showing as high as 4.6 ppm in the muscles. Also, for coomon minke whales taken between 1994 and 1997 in the western North Pacific a small portion (1.0%) of the muscle samples (eight out of 788) exceeded slightly the provisional restriction levels of the Ministry of Health, Labour and Welfare, but none of the 490 samples taken in the last five years exceeded the standard, although we now inspect all muscle tissues of common minke whales taken. Bryde's and sei whales in the western North Pacific showed low contamination, and the muscles of common minke whales in the same waters can also be considered safe.

As regards sperm whale, measures have been adopted to prevent its distribution in the market until an effective method to remove mercury from the muscle has been developed.

Note: The Ministry of Health, Labour and Welfare has set down 0 4 ppm as the standard in total mercury concentration for fishery products, and for those that exceed the provisional restriction to undergo a further test for methyl mercury, designating those that exceed 0.3 ppm as mercury contaminated fishery products. The provisional restriction standard for PCBs in fishery products is 3 ppm for those of inshore waters and 0.5 ppm for offshore fishery products. Cetaceans are categorized in the latter (0 5 ppm).