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BIOLOGICAL RESULTS OF BEAKED WHALES SURVEYED BY JAPANESE WHALE RESEARCH PROGRAMME UNDER SPECIAL PERMIT IN THE ANTARCTIC AND THE NEED OF THEIR RESEARCH TAKE

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ABSTRACT

After reviewing several biological items such as distribution, migration, morphology, biological parameters, diving behavior, food and feeding, biochemical components, catch history, and current population sizes of beaked (Family Ziphiidae) whales from the Antarctic by use of previous references, including the results of IWC/IDCR whale sightings survey, the research data which were collected by Japanese whale research programme under the special permit in the Antarctic (JARPA) from 1987/88 were examined on almost the same items for understanding of present biological knowledge on beaked whales in the Antarctic. Thus, it was recognized that our biological knowledge on this whale group remains still very poor, because amounts of biological measurements and collection of biological materials by use of whales caught are still scarce for there is no history of exploitation of them. However, we found that beaked whales, most of which are Southern bottlenose whales, are distributed widely and abundantly in the Antarctic as one of remarkable contributions of the IWC/IDCR and the JARPA, and we understand that beaked whales play important roles in the Antarctic ecosystem and they will become good indicators of change in the Antarctic environment. It is considered that we should commence the research take of the beaked whales in the Antarctic as soon as possible for development of biological knowledge of them and for the monitoring of environmental change in the Antarctic.

INTRODUCTION

Japan has been conducting research take of minke whales in the Antarctic every year from 1987/88 under the Article 8 of the International Convention for the Regulation of Whaling. This Japanese whale research programme under special permit in the Antarctic (JARPA) has two research objects (Government of Japan, 1987). One of them is the estimation of biological parameters of the Antarctic minke whale, and another is the elucidation of the roles of whales in the Antarctic ecosystem.

In the past seven times of researches including two times of

feasibility studies, Japan layed emphasis on the first object, and related to the second object, It collected minke whale samples and investigated their stomach contents, body weights, weights and chemical compositions of various body parts to obtain the knowledge on physiology of fattyness, their trophic level and energy flow. Related to the second object on other whales than the minke whale, whale sightings data including whale species, numbers of schools and whales, distribution, and other research items have been accumulated.

Accompanying with the developments of the IWC/IDCR whale sighting cruises and the JARPA, it has been understood gradually that beaked (Family Ziphiidae) whales, especially the Southern bottlenose whale, occupy large part of components in the ecosystem of the Antarctic (cf. Kasamatsu and Joyce, 1991; Fujise *et al.*, 1993). Thus, we recognize that it will be impossible to understand on the roles of whales in the Antarctic ecosystem with ignorance of existence of beaked whales.

Now, the Resolution on Research on the Environment and Whale Stocks which was passed at the 45th Annual Meeting of the IWC (IWC, 1993, Appendix 12) emphasizes the importance of the research on the effect of environmental change to the whale stocks, and we have recognized deeply that the need of development of the research related to the second object of the JARPA increases largely to obey the IWC Resolution. As the toothed whales have high trophic levels and long life spans, the environmental change in their life range is reflected and accumulated in the body tissues of toothed whales more than baleen whales. Therefore, for the replyment to and practice of the Resolution, we consider that the time to start the research take of the beaked whales on which our biological knowledges remains still very poor as examined later, although they occupy large ecological positions in the Antarctic ecosystem and they are suitable as indicators of environmental change in the system.

The reason why biological knowledges have been accumulated so small on beaked whales from the Antarctic is considered to be largely caused by the history that there has been practically no exploitation of these whale resources. According to the International Whaling Statistics, only USSR whaling fleets took a total of 50 Southern bottlenose whales and one Arnox's beaked whale for 15 years from 1962/63 to 1977/78 as shown in Table 1, and most of biological knowledges about these whale species have been fragmentally obtained mainly from stranded whales in the Southern Hemisphere.

This paper has three aims: one is to review previous knowledge on beaked whales from the Antarctic including the IWC/IDCR sightings surveys and analyses of whale sightings data which have been accumulated on beaked whales, the second is to analyse the sightings data accumulated by the JARPA from 1987/88, and the third is a consideration on the need of research take of beaked whales mainly for the development of environmental surveys in the Antarctic.

REVIEW OF PREVIOUS BIOLOGICAL KNOWLEDGES ON THE ANTARCTIC BEAKED WHALES

Taxonomy

Concerning with the taxonomy of Southern Hemisphere Ziphiidae whales, recently Balcomb (1989) reviewed on the Arnoux's beaked whale, Heyning (1989) on the Cuvier's beaked whale, Mead (1989a) on Shepherd's beaked whale, Mead (1989b) on the Southern bottlenose whale, and Mead (1989c) on the *Mesoplodon* species, respectively.

Distribution

Among 19 Zipiidae whales, 12 species are distributed in the Southern Hemisphere, and there is possibility that the following 8 species of the beaked whale may be distributed in the Antarctic assuming from maps shown by Martin (1990):

Arnoux's beaked whale, *Berardius arnuxii*
Southern bottlenose whale, *Hyperoodon planifrons*
Cuvier's beaked whale, *Ziphius cavirostris*
Shepherd's beaked whale, *Tasmacetus shepherdi*
Hector's beaked whale, *Mesoplodon hectori*
Gray's beaked whale, *M. grayi*
Andrew's beaked whale, *M. bowdoini*
Straptoothed whale, *M. layardi*

Brownell (1974) shows reported positions of Arnoux's beaked whales and Southern bottlenose whales on a map of the Antarctic. According to Robinneau (1973), an Andrew's beaked whale was stranded on Kergelen Is. A Gray's beaked whale was collected from unknown position of the Antarctic (Mead, 1989c).

Sightings records of beaked whales have been reported by every cruise report of the IDCR whale sightings cruises which have been conducted from 1978/79 by the IWC (cf. Kasamatsu *et al.*, 1988). It is practically difficult to identify species of a swimming beaked whale by a whale sighting vessel. Beaked whales dive usually for long time and they are nervous to the vessel. Furthermore, the IDCR research vessels do not approach in principle to the school of beaked whales when they are found, because the main object of the IDCR research is for the minke whale. Kasamatsu *et al.* (1988) and Kasamatsu (1993) report on the identification of three species of beaked whales by the IDCR surveys from the Antarctic, and they are the Arnox's beaked whale, Southern bottlenose whale and Cuvier's beaked whale, in addition to un-identified Genus *Mesoplodon* and Ziphiidae whales. Joyce *et al.* (1990) recorded on a finding of Gray's beaked whale from the Antarctic Area I.

According to Kasamatsu *et al.* (1988), the ratios of beaked whales of which species were identified were 12.7 % among all beaked whales found, and 90.0 % were Southern bottlenose whales, 7.1 % were Arnoux's beaked whales, and 2.9 % were Cuvier's beaked whales among beaked whales of which species were identified, based on the data obtained by the IDCR sightings surveys during

years from 1978/79 to 1983/84. According to Kasamatsu and Joyce (1992), the number of beaked whales of which species were identified were 173 Southern bottlenose whales and 17 Arnoux's beaked whales, so that Southern bottlenose whales occupy 91.1 % of the beaked whales from the Antarctic, although 1,087 beaked whales (85.1 %) were not identified their species.

The IDCR whale sightings surveys reveal that beaked whales, most of which are Southern bottlenose whales, are distributed widely and circumpolarly in the Antarctic (Kasamatsu *et al.*, 1988). They also suggest that there is an adverse relationship on the distribution pattern between minke and beaked whales. Kasamatsu (1993) mapped the positions of beaked whales which were found by the IDCR research vessels, and he showed that the distribution densities of beaked whales in the Antarctic were high in the South Atlantic and Indian Ocean Sectors and they were low in the South Pacific Sector.

Migration

Sekiguchi *et al.* (1992) suggest that the Southern bottlenose whales pass through South African coast in February on the way of northward migration from the Antarctic and in October on the way of southward migration to the Antarctic, based on the stomach contents of stranded whales and whale sightings results in the area. Kasamatsu (1993) found the distribution density of beaked whales changed in the Antarctic by season, and he considered this phenomenon indicates the seasonal migration of these whales. He also reported that distribution density of beaked whales in the Antarctic becomes the highest in the later part of January, but the seasonal change was not so large in seasons from late December to late February. Ensor (1989) estimates that at least a part of the Southern bottlenose whales arrives in the Antarctic austral spring, assuming from the fact that some of this whale species were found in the Antarctic in September and October. Furthermore, as shown in Table 1, USSR whaling fleets took Southern bottlenose whales in the Antarctic from November to March with the peak in December.

Water temperature

Kasamatsu (1993) shows the frequency distribution of surface water temperature at the positions where beaked whales were found in the Antarctic by use of the IWC/IDCR whale sightings data. These whale groups are distributed in wide water temperature belt of -1° to +11°C, and they are abundant in the range of -1° to +7°C.

Morphology

The osteology of the Southern bottlenose whale was studied by Flower (1882) and Fraser (1945). Tomilin and Latyshev (1967) report on the result of body proportion measurements of a female Southern bottlenose whale. Zemskii and Budylenko (1970) report on results of measurements of a skull and body proportions of the same wale species from the Antarctic with many photographs. Mead (1989a) reviews on the morphology of the Southern bottlenose whale.

Balcomb (1989) reviews on the morphology of the Arnoux's beaked whale, Heyning (1989) on the Cuvier's beaked whale, and Mead (1989c) on the Genus *Mesoplodon* species.

However, all the above reports or reviews do not describe on the morphology in detail, because they are based on small amount of samples. Therefore, enough knowledges have not been accumulated yet on the beaked whales from the Antarctic.

Body length records
Mead (1984) summarizes previous records on the maximum and minimum body lengths by sexes of several species of beaked whales. The maximum body length was less than 10 m for all whale species. All the species of this Family have a characteristics that females are larger than males in both Hemispheres. There is a record of 2.42 m as a new born calf of a Gray's beaked whale (Hale, 1931).

Body weight records
Zemskii and Budylenko (1970) report that body weights of a 700 cm long male and a 570 cm long female Southern bottlenose whales were 5,200 and 3,800 kg, respectively. Among them weights of each body part of the male were also measured and reported by them.

There are records of body weight measurements on two Gray's beaked whales, and they were 1,075 and 1,100 kg for a 474 cm long male and a 494 cm long female, respectively (Mead, 1989c).

School size
Kasamatsu and Joyce (1991) report on the school sizes of beaked whales sighted by the IDCR whale sightings. According to them, single schools are the most frequent, schools of 7 and more whales becomes scarce, and the maximum school size was 15 whales.

Diving behaviour
It is believed that the diving time and depth of beaked whales are long and deep, and they usually surface near the position of diving. Kasamatsu and Joyce (1991) use 25.1 min. as the average diving time and 33, 87, and 100 sec. as the respiration frequency at a surfacing for the estimation of $g(0)$ of beaked whales in the Antarctic. Kasamatsu (1993) calculates that the maximum, minimum, and average diving times are 46, 11, and 25.3 min., respectively, and he also reports that the maximum, minimum, and average respiration frequencies at a surfacing time are 18, 6, and 8.8 times, respectively.

The diving times of the Northern bottlenose whale are reported to be 14 - 70 min. (Benjaninsen and Christensen, 1979).

Catch history of beaked whales in the Antarctic
As reviewed by Mitchell (1975) and Kock and Shimadzu (1994), the toothed whale taken regularly was only the sperm whale, and killer whales and Southern bottlenose whales were pursued irregularly and in small numbers only. Table 1 shows the yearly change

in the catch of the Southern bottlenose whales in the Antarctic by USSR whaling fleets from 1963/64 to 1977/78 based on the International Whaling Statistics. A total of 50 whales were caught during the years. In addition to them, one Arnoux's beaked whale was caught during the years. As will be described in later section, total amount of 50 whales for 15 years are negregible considering from the large population size of the Southern bottlenose whale, and it will be safely recognized that the stock keeps the initial population level as same as other species of beaked whales in the Antarctic, for there is no catch history for them practically in the Antarctic.

Estimation of present population size

The IWC/IDCR whale sighting cruises have been continuing from 1978/79 season, and all the IWC management Areas have been surveyed more than two times. Kasamatsu and Joyce (1991) estimate uncorrected total population sizes of beaked whales by use of sighting data from 1978/79 to 1987/88 to be 79,552 whales. They emphasis that this figure should be corrected by *g(0)*, because these whale species have long diving time and they are difficult to be found, and they estimated the corrected population size to be 170,000-320,000 whales by use of *g(0)* of 0.25-0.50 which were estimated by simulation by them.

Kasamatsu (1993) further estimates total population size of beaked whales in the Antarctic is 599,300 (CV=0.15). He also estimates total biomass of beaked whales to be 2,696,900 tons assuming the average body weight of them is 5.2 tons which was measured by Zemskii and Budylenko (1970) for a Southern bottlenose whale. And, he emphasises that beaked whales are the second most important whales next to the minke whale in the Antarctic ecosystem.

Biological parameters

Mead (1984) reviews some kinds of biological parameters of beaked whales from the Southern Hemisphere from previously accumulated reports, although the amount of data are small on the direct estimation of the parameters. In the review he makes notice that it should be careful to apply the same figures of the Northern bottlenose whale to the Southern bottlenose whale, because the osteologies of both whale species are different each other, although the figures of the Baird's beaked whale may be applied to the Arnoux's beaked whale, because they are morphologically close each other.

Taylor (1957) reports a case that an Arnox's beaked whale was iced up in the Antarctic. It may be a cause of the natural mortality of the whale.

Food and feeding

As there are rare cases of catch of beaked whales from the Antarctic, it has not been known much about their food and feeding. Hale (1931) reports that large amount of beaks of squids (perhaps *Polupus variolatus*) was found from the stomach of an Arnoux's beaked whale which was stranded in Australia. Fraser (1945)

notes that the stomach of a Southern bottlenose whale cntained a few crystalline lenses of cephalopods.

Sekiguchi *et al.* (1992) examined stomach contents of two Southern bottlenose whales which were stranded on the beach of South Africa, and they report that the contents are all open sea squids, and 14 squid species, including the Antarctic origin, were identified from beaks. They also estimate ratios of biomass of these species of squids.

Biochemical components

Zemskii and Budylenko (1970) analysed chemical components of the Southern bottlenose whale. According to them, 69-71 % of blubber tissue is fat, and 84.5 % of water, 1.2 % of fat, 10.0 % of protein and 4.3 % of remainders are composed in the muscle tissue. They measure also Vitamin A content, cristallization temperature, gravity, and unsaponifiable components of the oil.

However, reports on the accumulation of artificial substances such as organochlorides in body tissues are scarce in number for beaked whales from the Southern Hemisphere. Marcovecchio *et al.* (1993) report on the accumulation of heavy metals of the body of Cuvier's beaked whales which were collected from the coast of south-west Atlantic of Argentina. Kemper *et al.* (1993) report on results of analysis of heavy metals in body of *Mesoplodon* species from Australia, and cadomium density was high in the case of the sraptoothed whale.

However, no data has been available on the study of contamination of heavy metals or artificial substances in beaked whales from the Antartic.

ANALYSIS OF DATA OBTAINED FROM THE JARPA

Data used

The following data are collected and used from the JARPA in the Antarctic Areas IV and V from 1987/88 to 1992/93:

a. Date engaged in the whale sightings
b. Sightings distance in each day
c. Cetacean species found
d. Difference of primary and secondery sightings
e. Position of school found
f. Estimated school size
g. Range of estimated body length in a school
h. Surface water temperature

In addition to them, some data on the observation of behaviour of beaked whales which was carried out in 1993/94 season (Nishiwaki *et al.*, this meeting) are used in this paper.

Composition of cetacean found in research areas

Table 2 shows total numbers of shools and individuals of all the cetaceans found and identified by the JARPA in the Areas IV and V

during years, 1987/88-1992/93. The main objective whale species is the minke whale, and when a school of blue, humpback or right whales is found, a research vessel use the closing mode and approaches to the school to confirm the species and school size as same manner as minke whale school. However, in the cases of other cetacean species the research vessel uses passing mode as same manner as the IDCR manner, so that it is difficult to identify species and to estimate school size. Especially, beaked whales have many kinds of similar shaped species and dive long time, so that it is practically difficult to identify species and school size, without close observation of the school for long time.

As shown in Table 2, the reported ratios of individual numbers of toothed whales is 42.4 % of all cetaceans sighted, and among the toothed whales, beaked whales occupy 17.2 %. The number of beaked whales found are 1.9 times more than those of the sperm whales. We must consider here that the sighting abilities are different by whale species, and those of beaked whales are lower than other whale species.

Four species were identified in the beaked whales found in the research areas. They are the Arnoux's beaked whale, Southern bottlenose whale, Cuvier's beaked whale, and Gray's beaked whale. In addition, other Genus *Mesoplodon* species are also identified, although species name was not clear. Among these species identified beaked whale species including *Mesoplodon* species, Southern bottlenose whales are the most dominant (87.1 % in the case of school and 71.2 % in the case of individuals), Arnoux's beaked whales are the second (6.5 % and 23.4 %), *Mesoplodon* whales are the third (4.3 % and 4.1 %), Cuvier's beaked whales are the fourth (1.4 % and 0.6 %), and Gray's beaked whales are the most rare (0.7 % and 0.6 %).

According to Kasamatsu *et al.* (1988), three species (Southern bottlenose, Arnox's beaked, and Cuvier's beaked whales) of beaked whales were identified by the IDCR whale sightings survey. *Mesoplodon* whales are also recorded without identified species names. Southern bottlenose whales are the most abundant in number of individuals (90%), Arnoux's beaked whales are the second (7%), and Cuvier's beaked whales are the third (3%). These figures are somewhat different from those of results of the JARPA, but it can be concluded that the Southern bottlenose whale occupies about 90% of beaked whales which are distributed in the Antarctic. Then, it can be recognized that most of unidentified beaked whales found in the JARPA are Southern bottlenose whales.

Distribution of beaked whales in research areas

Figs. 1 and 2 show positions of several kinds of beaked whale schools sighted by the JARPA in the research areas of south and north of 55°S, respectively, from 1987/88 to 1992/93. In the waters north of 55°S, sightings survey has been carried out only on the ways to and from the main research areas of the Antarctic, but it is found that beaked whales are distributed widely in lower latitudinal waters of the Southern Hemisphere, as shown in

Fig. 2. Further studies will be needed on the relation between beaked whales and oceanographic structure of the Southern Hemisphere.

As shown in Fig. 1a, Southern bottlenose whales are distributed widely in the open sea of the Antarctic. They are also distributed near the pack-ice edge, but they seem to be relatively rare in the Ross Sea and Prydz Bay. Unidentified beaked whales shows similar distribution pattern in the Ross Sea and Prydz Bay, as shown in Fig. 1e. Considering the fact that most of unidentified beaked whales are Southern bottlenose whales, it can be estimated that the Southern bottlenose whales are not distributed widely and densely in the Ross Sea and Prydz Bay. The distribution pattern of the distribution pattern of the Southern bottlenose whale is somewhat different from that of the ordinary form of the minke whale which is distributed densely near the pack-ice edge and in the Ross Sea and Prydz Bay.

Kasamatsu (1993) indicates that distribution density of beaked whales in the Antarctic is low in the areas of 120°E-110°W in the IDCR whale sightings survey. Then, there should be a longitudinal cline of distribution density in the JARPA research area. However, so clear cline is not seen in the JARPA result longitudinally as shown in Fig. 1.

Although finding data are few in the cases of Arnoux's beaked whales, they are found at the pack-ice edge in Areas IV and V and in the southern bottom of the Ross Sea, as shown in Fig. 1b. The frequency distribution of surface water temperature at the position of finding of beaked whales is shown in Table 6. The range is -1° - +4°C in the case of unidentified beaked whales, and -1° - +1°C in the case of Southern bottlenose whales, but it is -2° - -1°C in the case of Arnoux's beaked whales. This shows that the Arnox's beaked whale is distributed in more south and colder waters than the Southern bottlenose whale.

Then, it will be concluded that the distribution pattern of the Arnox's beaked whale is clearly different from that of the Southern bottlenose whale, and it may be estimated that both whale species are segregated each other in the Antarctic.

Distributions of other beaked whales in the Antarctic are not still clear because of their very rare finding. It will be needed to continue research to confirm their distribution patterns in the Antarctic.

Seasonal change in density distribution

Table 3 shows distribution density (schools/research distance) of beaked whales in each decade of dates by Areas. There is large fluctuation in the density. The seasonal change in density is not clearly shown, and the density in the middle December is the highest. Although CPUE figures are not available, USSR whaling fleets took the most Southern beaked whales in December, as shown in Table 1. This is coincided to the result of the JARPA, but not to that of the IDCR as examined by Kasamatsu (1993). These

phenomena are the same in both the Areas IV and V.

School size

School sizes were estimated on the beaked whale schools found. Table 4 shows the frequency distribution of school sizes of beaked whales found in the Antarctic. Among 118 schools of which species were identified as Southern bottlenose whales, the maximum size was 8, and most cases were single schools. The frequency of finding decreases with increase of school size, and the average school size was 1.9 whales. On the other hand, in the case of Arnox's beaked whales the maximum school size was 20 whales, and the average school size was 8.2 whales. Only three schools of *Mesoplodon* whales were estimated their school size. Two were single, and one was composed of two whales. The average is 1.3 whales.

The maximum school size of unidentified species beaked whales was 10 among 1,288 schools, single schools were the most frequent, and the average was 1.83 whales. The frequency pattern of this group is similar to that of the Southern bottlenose whales. Kasamatsu and Joyce (1991) show the school compositions of beaked whales in the case of the IDCR research. The maximum was 15 whales, and the frequency decreases with the increase of school size. This pattern is similar to the present result.

Range of estimated body length

The maximum and minimum body lengths in a school were recorded on 111 schools of beaked whales which were found during whale sightings, and the results are shown in Table 5. Although the results include all the beaked whale species, most of them may be regarded to be Southern bottlenose whales, for about 90 % of beaked whale schools are estimated to be the Southern bottlenose whales.

The maximum body length record is 12 m, but there is only one school which is composed of whales of 10 m long and over. There are mode at 6 m class for both the maximum and minimum records.

The longest body length record which was measured directly is 7.45 m for the Southern bottlenose whale and 9.75 m for the Arnoux's beaked whale, respectively. Therefore, the estimated body length of 12 m is excessive, and estimated body length records of less than 10 m are not unrealistic, for Arnoux's beaked whales occupy about 5 % of the beaked whale schools.

As the minimum estimated body length, 3 m is recorded. This figure may be realistic, for there is a record of 2.4 m of directly measured body length of the Gray's beaked whale.

Fig. 2 shows a distribution map of beaked whales by body length class. It may be estimated that the class of less than 5 m is distributed in the off-shore waters from pack-ice edge, the class of 5-7 m is distributed widely, and the class of longer than 7 m is mainly distributed near the pack-ice edge. This phenomenon coincides to the distribution pattern that Southern bottlenose whales of which body lengths are relatively small are

distributed widely in the Antarctic and Arnoux's beaked whales of which body lengths are relatively long are distributed near the pack-ice edge.

From above consideration, it may be concluded that body length of beaked whale can be estimated fairly correct.

Chance of finding of schools

As shown Table 2, the chance of primary finding of beaked whale schools is 90.1 % , and the chance of the secondery finding is not so frequently. On the cases of species were identified, the ratios of the primary findings are 85.6, 89, and 33 % for the Southern bottlenose whale, Arnoux's beaked whale, and *Mesoplodon* whales, respectively.

Observation on behaviour

Behaviour of beaked whales was observed on 12 schools and 18 individuals by approaching of research vessels to the schools. There were 5 schools to which research vessels tried to approach, but their species could not be identified, because the vessel lost the school in the early stage of approaching, However, school sizes of these schools were estimated.

The maximum duration of observation of a school was limitted within one hour, for this kind of observation was not the main work of the JARPA research. There were two schools on which the second finding were not successful, six schools were succeeded to find only two times, and four schools were able to be found 3 and 4 times.

In Southern bottlenose whales, the most nearest approaching distance was 0.02 n. miles, and in other five cases the nearest approaching distances were 0.2-0.4 n. miles. In the Arnoux's beaked whale it was 0.3 n. miles, and it was 0.3-0.9 n. miles for the cases of unidentified beaked whale schools.

The diving behaviour of these schools was also observed. The average diving time was 13.7 min. and the average surfacing time was 6.1 min. in the case of Southern bottlenose whale schools. They were 16.1 and 6.5 min., respectively, for all the beaked whale schools. These figures are somewhat different from those reported by Kasamatsu (1993). According to him, average diving time of beaked whale schools is 25.3 min. and the average surfacing time is 32.6 sec. (3.7 sec. x 8.8 times). According to Leatherwood *et al.* (1982), there are tree reports on the diving times of the Northern bottlenose whales. They are 3-15 min. with the average of 7.8 min. in 10 cases of observations (Winn *et al.*, 1970), diving time of 14-70 min. with average of 33.1 min. on 10 cases (Christensen, 1980), and usually they were 5-10 min. (Yablokov *et al.*, 1974). There is large deviation among reports. The record of surfacing time for the Northern bottlenose whale is not available.

It is said that beaked whales surface near the position from which they dive, but the distances between diving point and

surfacing point were 0.2-1.3 n. miles and the average was 0.7 n. miles in the present observation.

Above observations indicate that it will be practically rather difficult to collect a sample whale from the Antarctic.

CONSIDERATION ON THE NEED OF RESEARCH TAKE OF BEAKED WHALES IN THE ANTARCTIC

By the endeavers of the IWC/IDCR whale sightings surveys since 1978/79 and th eJARPA since 1987/88 in the Antarctic, it has become evident that the beaked (Family Ziphiidae) whales are very abundant with population size of about 600,000 whales and biomass of about 2,700,000 tons and the Southern bottlenose whale is the key species of the toothed whales in the Antarctic ecosystem as well as another key species of the minke whale of the baleen whales. This will be one of the large contribution of the IWC/IDCR whale sighting survey and the JARPA in the Antarctic.

Despite this important fact, it is strongly recognized that our biological knowledge has been keeping poor levels by reviewing of previous papers and analysing the data accumulated by the JARPA. Biological knowledges can be obtained by collecting whale body samples systematically, obtaining the needed measurement data and biological materials from the whale samples, and analysing these data and samples thouroughly. However, previous biological knowledges come mainly from stranded animals, and biological studies have been made by use of these rare, few and unsystematically collected data and materials from these animals.

In both the IDCR surveys and the JARPA, the main research object has been forcused to the minke whale, and there has not been enough time to engage in research for beaked whales which have not been the main object and have not been sampled to collect biological data and materials from them to study. These conditions are other reasons of the currenly poor biological knowledge on the beaked whales from the Antarctic.

As we found that beaked whales are the main component of the Antarctic ecosystem and the IWC passed a resolution on the need of research on the effect of change in the marine environment to whale resources in its 45th Annual Meeting, member countries of the IWC must not leave current condition of the Antarctic beaked whales as they are. Much more, the Southern bottlenose whale occupies about 90 % of beaked whales in the Antarctic, and it is a species which is listed up in the Nomenclature of the Final Act of the International Convention for the Regulation of Whaling in 1946. Therefore, the IWC should have high responsibility to the development of knowledge of this whale species.

We consider that it will be needed to conduct surveys on the following items as soon as possible:

Abundance estimation

It is needed to grasp the amount of biomass of whales for elucidation of the role of whales in an ecosystem, and the estimation of population size is the base of this work. As reviewed above, there are two papers by Kasamatsu and Joyce (1991) and Kasamatsu (1993) by use of the IDCR data, but there are several problems on the abundance estimations. The main target of the IDCR survey is the minke whale and enough sightings effort has not put into the survey of beaked whales, and so closing mode of whale sightings has not been applied to the beaked whale schools. Then, identification of whale species, counting of school size, and estimation of body length are not enough. As beaked whales are long time divers, the use of correction factors such as $g(0)$ are especially needed.

The precise estimation of abundance will be practical, when beaked whales become the second target whale species for research take in addition to the minke whale, and the results will be used as the base of estimation of biomass for better understanding of the Antarctic ecosystem.

Estimation of biomass

The biomass estimation on each species which compose a ecosystem is needed for the elucidation of each species on the roles of the ecosystem. As described above, the abundance estimation is the fundamental, and, in addition to it, it is need to estimate age structure, growth curve, and body length-weight relationships. For this series of study, biological investigation must be conducted by random collection of sample whales from population, by measurements of body length and weight and collection of materials, and by age determination using age characters collected. These studies are accompanied with catch of whales.

Food and feeding

The study of food and feeding is the base of understanding on the ecological position of the whale species in a ecosystem and calculation of energy flow. However, previous food studies for the Southern Hemisphere beaked whales has been done only by use of stranded animals outside of the Antarctic. The materials from stranded animals do not show the normal condition of the animals. Catch of animals is needed to study food and feeding in the normal condition in the ecosystem by sampling fresh whale individuals.

The study of stomach contents of food animals will contribute largely to the understanding of food webs in the ecosystem, as Nemoto *et al.* (1988) examined on stomach contents of sperm whales.

Monitoring of environmental change

The IWC passed a resolution in its 45th Annual Meeting that the Scientific Committee should give the priority to studies of research on the effect of change in marine environment to whale resources. Now, the change in environment affects to the food composition and biological parameters such as the age at sexual

maturity, pregnancy rate, and natural mortality. Swartz (1993) noted that the assessment of any potential effects would requir, at minimum, the identification of biological parameters most likely to effect direct and indirect responses to environmental change. And, for this purpose, we need to catch whales systematically, to measure and collect needed materials such as age characters, reproductive organs, and stomach contents, and to analyse these data and materials.

Such a large population size which was estimated by Kasamatsu (1993) may be understood as the result of increase of populations of beaked whales accompanied with the decrease of population size of the male sperm whales caused by the over exploitation, if there is an interaction of food in the Antarctic between male sperm whales and beaked whales, as similar to the relationships between ordinary blue and minke whale in the Antarctic. There is a possibility to prove this assumption by examine the yearly change in some biological parameters such as age at sexual maturity or pregnancy rate.

Concerning to the marine pollution, as beaked whales have long life span and high food chain level, they accumulate pollutants easily into their body tissues through their food animals, if their feeding ground has become polluted. This characteristics means that beaked whales are suitable for indicators of history of marine pollution in the feeding ground. And, it is needed to catch whale samples and collect useful body tissues for this kind of study.

In addition to it, most of the squids are in higher trophic level and usually shortly lived animals, and they may become useful indicator of marine pollution in short term. Now, main foods of beaked whales are estimated to be squids. Although it is still difficult for man to collect the Antarctic squids technically, toothed whales are skillful collecters of squids. If beaked whales are sampled systematically and continuously, we can not only investigate the accumulation and change of pollutants in the body tissues, but also monitor yearly or short-term change and fluctuation of the pollution by the chemical analysis of body tissues of squids which will be collected easily and fresh from stomach of beaked whales sampled.

Conclusion

There is an ecological difference between baleen and toothed whales in their roles to an ecosystem, because their trophic levels are different each other. The monitoring of the Antarctic environment has been carried out by the JARPA by use of the minke whale as a key species of baleen whales, However, we have not accumulated enough information of change in environment by use of beaked whales which are the key species of toothed whales and play important role in the Antarctic ecosystem, because systematic catch has not been conducted yet. This should be unjustified for the development of environmental study of the Antarcitic. We consider that the IWC should give agreement and support to a research proposal for any member country to commence research

take of beaked whales as soon as possible for obey and fulfill the resolution at the 45th Annual Meeting in 1993. The possibility of research take of beaked whales, especially the Southern bottlenose whale, should be explored under the JARPA as the most practical style of survey.

This kind of research will also contribute largely for the development of the biology of beaked whales from the Antarctic.

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Table 1. Catch of Southern bottlenose whales by USSR in the Antarctic, 1962/63-1977/78 (after the Inter. Whal. Statistics).

Season	November	December	January	February	March	Total
1962/63	-	-	-	-	2	2
1963/64	-	-	-	-	-	-
1964/65	-	-	1	-	-	1
1965/66						1
1966/67						2
1967/68						1
1968/69	-	-	1	-	-	1
1969/70	-	-	-	-	-	-
1970/71	-	-	-	-	-	-
1971/72	-	-	-	2	-	2
1972/73	9	16	-	-	2	27
1973/74	-	4	-	-	-	4
1974/75	-	1	2	-	-	3
1975/76	-	-	1	-	-	1
1976/77	-	2	-	-	-	2
1977/78	-	1	2	-	-	3
Total	9	24	6	2	4	50

Table 5. Range of body lengths in schools of all kinds of beaked whales found, 1987/88-1992/93.

Body length	Schools		Body length	Schools	
(m)	Max.	Min.	(m)	Max.	Min.
3	-	2	8	8	8
4	7	7	9	3	-
5	22	29	10	-	-
6	42	38	11	-	1
7	28	26	12	1	-
			Total	111	111

Table 6. Surface water temperatures at the positions of beaked whales found in 1992/93.

Temp.	Schools				Temp.	Schools			
(°C)	U.B.	S.B.	A.B.	Total	(°C)	N.B.	S.B.	A.B.	Total
+5	-	-	-	-	+0	30	3	-	33
+4	5	-	-	5	-0	66	3	-	69
+3	7	-	-	7	-1	47	2	6	55
+2	18	-	-	18	-2	-	-	1	1
+1	14	3	-	17	Total	187	11	7	205

Remarks: U.B. : Unidentified beaked whale, S.B.: Southern bottlenose whale, A.B.: Arnoux's beaked whale.

Table 2. Whales and dolphins sighted by research vessels in Japanese whale research in the Antarctic, 1987/88-1992/93.

Number of Sightings

Species	Primary Ice-55° Sch	Ice-55° Wha	55°-16° Sch	55°-16° Wha	Comb Sch	Comb Wha	Secondary Ice-55° Sch	Ice-55° Wha	55°-16° Sch	55°-16° Wha	Comb Sch	Comb Wha	Not recorded shool size Primary Ice-55°	Primary 55°-16°	Primary Comb	Secondary Ice-55°	Secondary 55°-16°	Secondary Comb	Comb	Combined Sch	Combined Wha
Blue whale	21	30	-	-	21	30	10	16	-	-	10	16	-	-	-	-	-	-	-	31	46
Fin whale	82	208	4	5	86	213	18	47	-	-	18	47	-	-	-	-	-	-	-	104	260
Sei whale	6	6	21	34	27	40	-	-	2	3	2	3	-	-	-	-	-	-	-	29	43
Minke whale	3711	10437	20	38	3731	10475	2264	6740	-	-	2264	6740	-	-	-	-	-	-	-	5995	17215
Minke whale(dwarf form)	15	15	1	1	16	16	3	3	-	-	3	3	-	-	-	-	-	-	-	19	19
Like minke whale	246	270	4	4	250	274	71	166	-	-	71	166	3	-	3	-	-	-	3	324	440
Bryde's whale	-	-	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Humpback whale	473	845	12	15	485	860	119	218	2	2	121	220	-	-	-	-	-	-	-	606	1080
Right whale	33	38	5	7	38	45	5	6	-	-	5	6	-	-	-	-	-	-	-	43	51
Pygmy right whale	-	-	1	80	1	80	-	-	-	-	-	-	-	-	-	-	-	-	-	1	80
Baleen whale	52	70	20	23	72	93	18	32	-	-	18	32	-	-	-	-	-	-	-	90	125
Sperm whale	911	960	65	225	976	1185	242	260	4	9	246	269	-	-	-	-	-	-	-	1222	1454
Killer whale	324	4721	2	23	326	4744	106	1276	-	-	106	1276	-	-	-	-	-	-	-	432	6020
Long-finned pilot whale	7	353	4	81	11	434	2	40	-	-	2	40	-	-	-	-	-	-	-	13	474
False killer whale	-	-	-	-	-	-	1	30	-	-	1	30	-	-	-	-	-	-	-	1	30
Pilot whale	34	1460	5	184	39	1644	16	484	-	-	16	484	-	-	-	-	-	-	-	55	2128
Hourglass dolphin	80	493	14	76	94	569	55	431	1	10	56	441	-	-	-	-	-	-	-	150	1010
S.right whale dolphin	3	38	1	10	4	48	-	-	-	-	-	-	1	-	1	-	-	-	1	5	48
Striped dolphin	-	-	3	730	3	730	-	-	-	-	-	-	-	-	-	-	-	-	-	3	730
Like striped dolphin	-	-	1	50	1	50	-	-	-	-	-	-	-	-	-	-	-	-	-	1	50
Common dolphin	-	-	3	1052	3	1052	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1052
Lagenorhyncus species	-	-	2	300	2	300	-	-	-	-	-	-	-	-	-	-	-	-	-	2	300
S.bottlenosed whale	101	185	2	3	103	188	17	34	1	3	18	37	-	-	-	-	-	-	-	121	225
Arnoux's beaked whale	8	54	-	-	8	54	1	20	-	-	1	20	-	-	-	-	-	-	-	9	74
Cuvier's beaked whale	1	2	-	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2
Gray's beaked whale	-	-	1	1	1	1	1	1	-	-	1	1	-	-	-	-	-	-	-	2	2
Mesoplodon species	1	2	4	10	5	12	1	1	-	-	1	1	-	-	-	-	-	-	-	6	13
Beaked whales	1172	2151	39	80	1211	2231	120	214	2	6	122	220	-	1	1	-	-	-	1	1334	2451
Unidentified dolphin	55	394	56	839	111	1233	9	90	3	14	12	104	-	-	-	-	-	-	-	123	1337
Unidentified whale	661	834	37	109	698	943	78	162	1	1	79	163	17	1	18	1	-	1	19	796	1106
Baleen whale	4639	11919	89	208	4728	12127	2508	7228	4	5	2512	7233	3	-	3	-	-	-	3	7243	19360
Toothed whale	2642	10419	146	2825	2788	13244	562	2791	8	28	570	2819	1	1	2	-	-	-	2	3360	16063
(*Ziphiidae)	1283	2394	46	94	1329	2488	140	270	3	9	143	279	-	1	1	-	-	-	1	1473	2767
Unidentified whale	716	1228	93	948	809	2176	87	252	4	15	91	267	17	1	18	1	-	1	19	919	2443
Combined	7997	23566	328	3981	8325	27547	3157	10271	16	48	3173	10319	21	2	23	1	-	1	24	11522	37866

Table 3. Seasonal change in distribution density of beaked whales, 1987/88 - 1992/93.

Research Period		Beaked Whales (all records) AreaIV				AreaV				Com.
Month	Day	87/88	89/90	91/92	Com.	88/89	90/91	92/93	Com.	
12	1-10		0.023	0.015	0.019			0.009	0.009	0.017
	11-20		0.025	0.039	0.030		0.021	0.039	0.035	0.032
	21-31		0.017	0.018	0.018		0.045	0.010	0.035	0.024
1	1-10		0.017	0.008	0.011		0.013	0.015	0.014	0.013
	11-20	0.008	0.008	0.033	0.014	0.009	0.033	0.013	0.019	0.017
	21-31	0.019	0.018	0.032	0.024	0.017	0.017	0.016	0.017	0.020
2	1-10	0.003	0.008	0.005	0.006	0.009	-	0.009	0.006	0.006
	11-20	0.018	0.027	0.016	0.021	0.002	0.010	0.009	0.008	0.015
	21-29	0.013	0.021	0.012	0.014	-	0.018	0.010	0.010	0.012
3	1-10	0.019	0.027	0.019	0.022	-	0.004	0.009	0.006	0.017
	11-20	0.008		0.007	0.008	-	0.011	0.016	0.011	0.009
	21-31	0.006		0.003	0.005	0.006	-	0.011	0.007	0.006
	Com.	0.011	0.019	0.018	0.017	0.007	0.018	0.016	0.015	0.016

Research Period		Beaked Whales (unknown species) AreaIV				AreaV				Com.
Month	Day	87/88	89/90	91/92	Com.	88/89	90/91	92/93	Com.	
12	1-10		0.021	0.015	0.018			0.009	0.009	0.016
	11-20		0.025	0.033	0.028		0.021	0.038	0.034	0.030
	21-31		0.016	0.015	0.016		0.044	0.010	0.034	0.022
1	1-10		0.013	0.008	0.010		0.012	0.014	0.013	0.011
	11-20	0.005	0.007	0.020	0.010	0.008	0.031	0.013	0.018	0.014
	21-31	0.019	0.016	0.026	0.021	0.017	0.015	0.014	0.015	0.018
2	1-10	0.003	0.007	0.003	0.005	0.009	-	0.007	0.006	0.005
	11-20	0.018	0.025	0.015	0.020	0.002	0.010	0.009	0.008	0.014
	21-29	0.012	0.020	0.010	0.013	-	0.017	0.008	0.009	0.011
3	1-10	0.019	0.026	0.016	0.021	-	0.004	0.002	0.003	0.015
	11-20	0.008		0.006	0.007	-	0.011	0.016	0.011	0.009
	21-31	0.006		0.001	0.004	0.006	-	0.011	0.007	0.006
	Com.	0.011	0.017	0.015	0.015	0.007	0.017	0.015	0.014	0.014

Research Period		S. Bottlenose Whale AreaIV				AreaV				Com.
Month	Day	87/88	89/90	91/92	Com.	88/89	90/91	92/93	Com.	
12	1-10		0.002	-	0.001			-	-	0.001
	11-20		-	0.005	0.002		-	0.001	0.001	0.002
	21-31		0.001	0.002	0.002		0.001	-	0.000	0.001
1	1-10		0.005	-	0.002		0.001	0.001	0.001	0.001
	11-20	0.003	0.001	0.012	0.004	0.001	0.002	-	0.001	0.003
	21-31	-	0.002	0.006	0.003	-	0.002	0.002	0.002	0.002
2	1-10	-	0.002	0.002	0.001	-	-	0.001	0.000	0.001
	11-20	-	0.001	0.001	0.001	-	-	-	-	0.001
	21-29	0.001	0.001	0.001	0.001	-	0.001	-	0.001	0.001
3	1-10	-	0.001	0.002	0.001	-	-	0.001	0.000	0.001
	11-20	-		0.001	0.001	-	-	0.001	0.000	0.001
	21-31	-		0.001	0.001	-	-	-	-	0.000
	Com.	0.000	0.001	0.003	0.002	0.000	0.001	0.001	0.001	0.001

Table 4. School size composition of several species of beaked whales in the waters south of 55°S, 1987/88-1992/93.

School size	S. Bottlenose Whale			Arnoux's Beaked Whale			Cuvier's Beaked Whale			Gray's Beaked Whale			Mesoplodon			Beaked Whales (all records)		
	Pri.	Sec.	Com.	Pri.	Sec.	Com.	Pri.	Sec.	Com.	Pri.	Sec.	Com.	Pri.	Sec.	Com.	Pri.	Sec.	Com.
1	50	6	56	1	-	1	-	-	-	-	1	1	-	1	1	613	67	680
2	33	6	39	1	-	1	1	-	1	-	-	-	1	-	1	425	42	467
3	11	4	15	-	-	-	-	-	-	-	-	-	-	-	-	164	24	188
4	3	1	4	-	-	-	-	-	-	-	-	-	-	-	-	36	4	40
5	2	-	2	1	-	1	-	-	-	-	-	-	-	-	-	23	1	24
6	1	-	1	1	-	1	-	-	-	-	-	-	-	-	-	9	1	10
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
8	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	3	-	3
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	4	-	4	-	-	-	-	-	-	-	-	-	10	-	10
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	1	1
Total	101	17	118	8	1	9	1	-	1	-	1	1	1	1	2	1284	140	1424

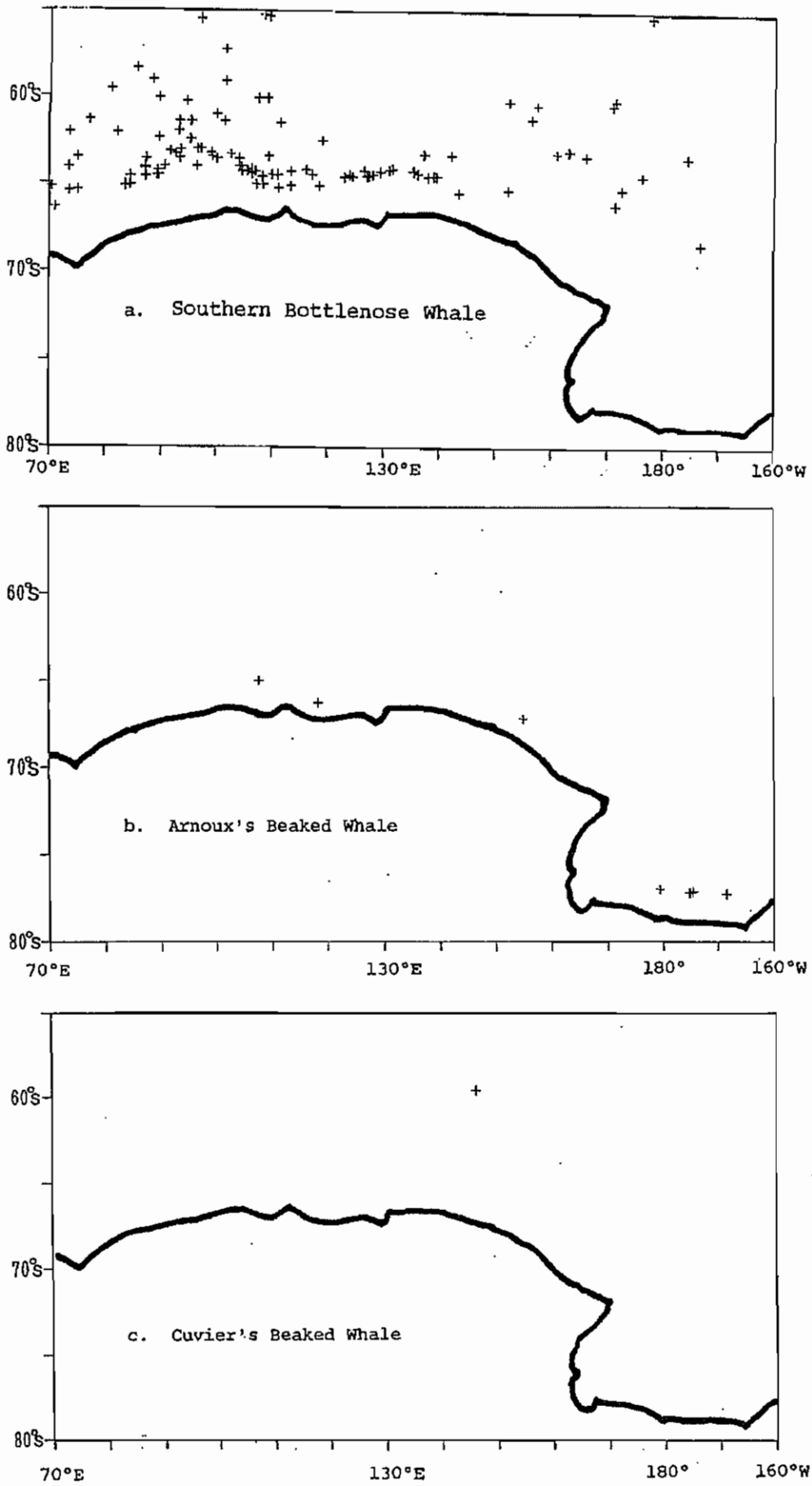
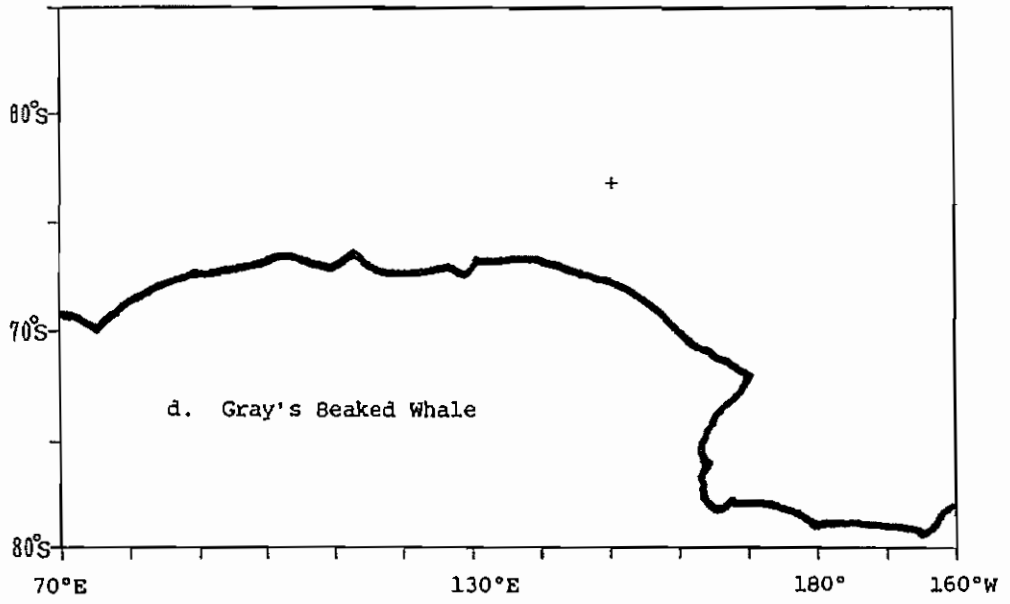
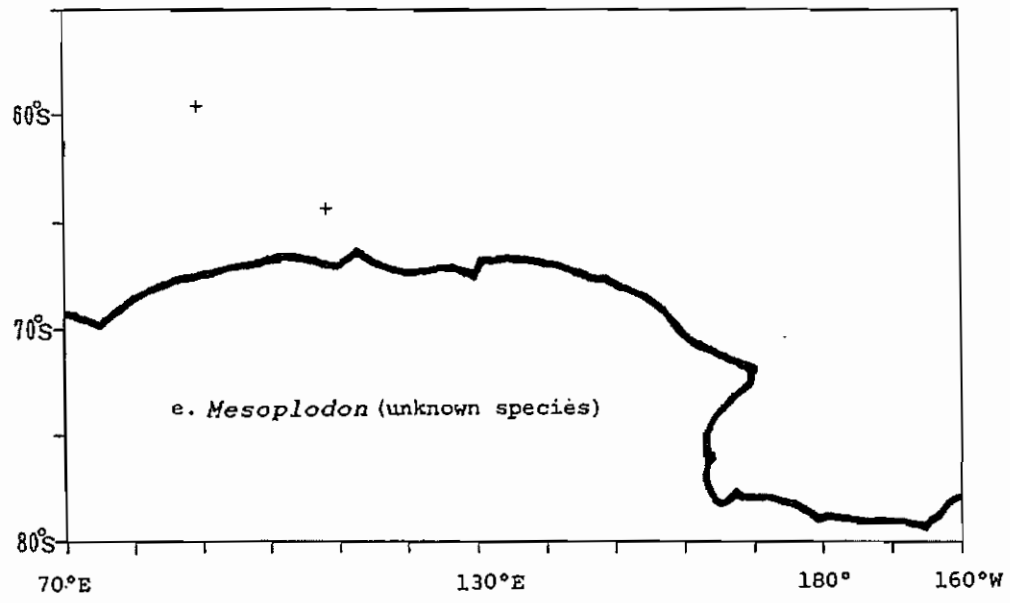


Fig. 1. Beaked whale schools sighted by Japanese research vessels, 1987/88-1992/93 (South of 55°S).





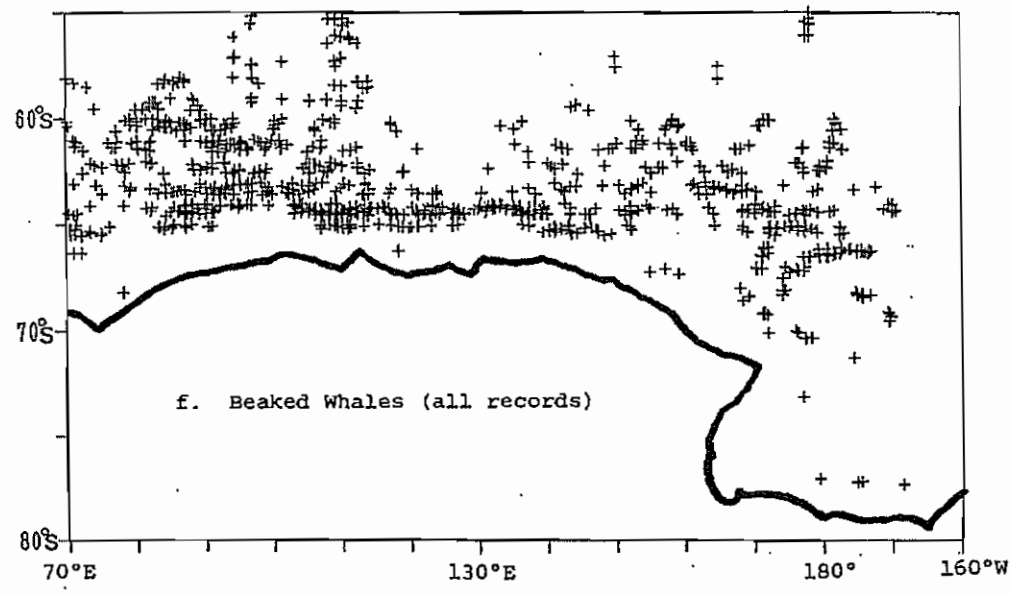


Fig. 1. Continued.

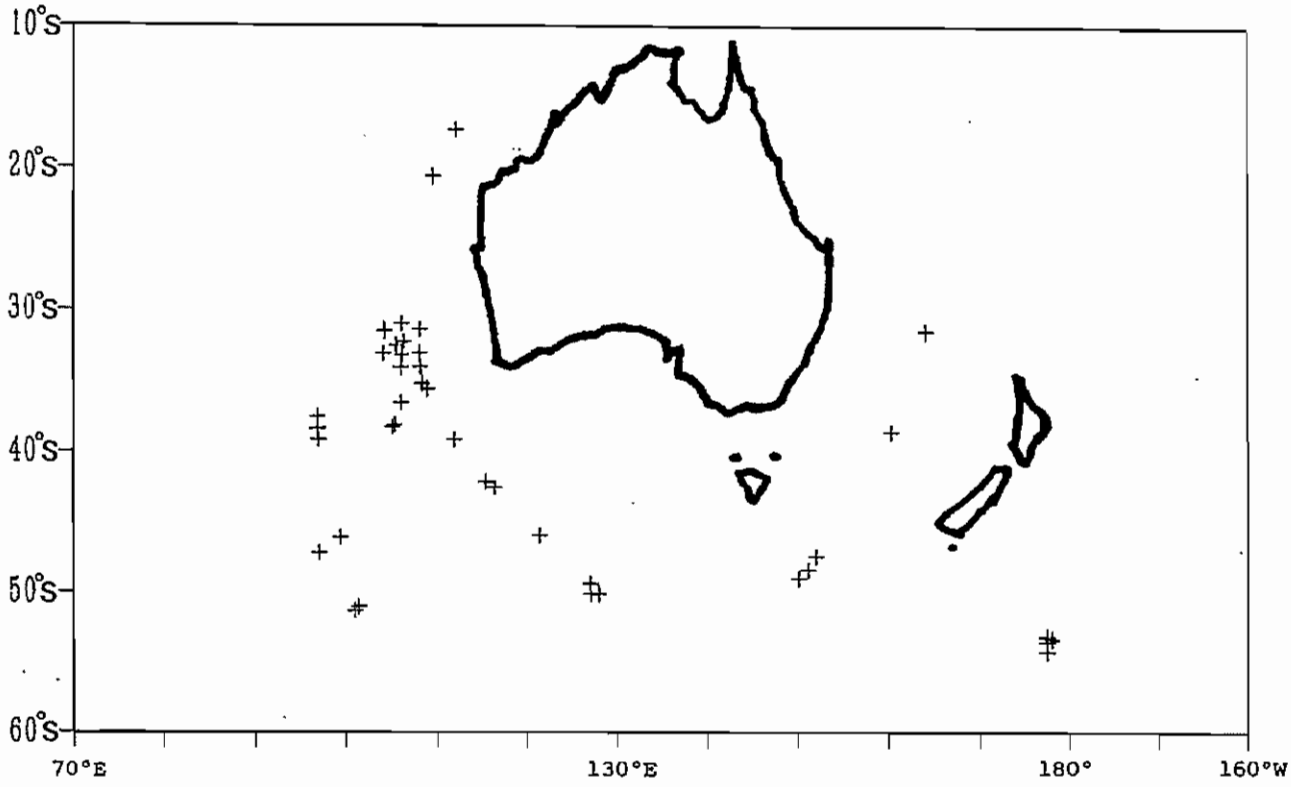


Fig. 2. Beaked whale schools sighted by Japanese research vessels, 1987/88-1992/93 (North of 55°S).

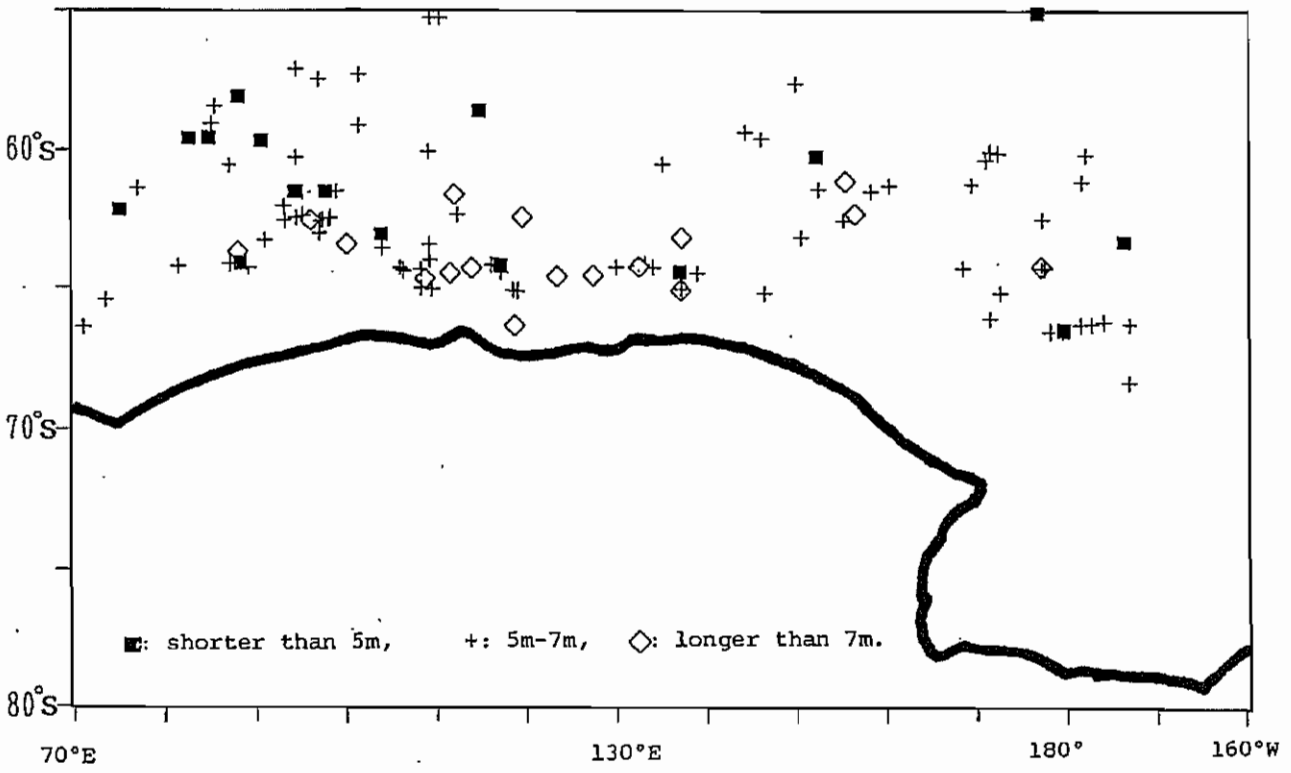


Fig. 3. Difference of positions of beaked whale schools sighted by body length classes, 1987/88-1992/93.