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Comprehensive Summary on W Stock Hypothesis of Minke Whale through JARPN Program

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ABSTRACT

The Japanese Government conducted JARPN Program to elucidate the stock structure and feeding ecology of minke whales in the western North Pacific during six years from 1994 to 1999. A considerable amount of samples and data were obtained through the program. Analyses on mtDNA, nuclear DNA, allozyme, biological markers, morphological/morphometric, pollutants burden, parasites and stable isotopes were carried out. This paper reviewed these results, focussing on W Stock hypothesis. No supportive results for this hypothesis was obtained, while a wide variety of differences was found between O and J Stocks.

INTRODUCTION

The hypothesis of two stocks of minke whale, the Sea of Japan-Yellow Sea-East China Sea stock (J Stock) and Okhotsk Sea-West Pacific stock (O Stock), was commonly used for minke whales in the western North Pacific. IWC Scientific Committee conducted a comprehensive assessment of North Pacific minke whales in 1991, and agreed that there were at least two stocks (IWC, 1992). The eastern boundary of O Stock for the run of HITTER/FITTER models was set at 157° or 150° E, because there was no available data east of 157° E (IWC, 1992). New stock structure hypotheses were introduced by the Working Group on North Pacific Minke Whale Management Trials in 1993, i.e. three sub-stocks in the J Stock and four sub-stock in the O Stock and an additional stock (W Stock) in the central region (157-170° E or 150-170° E)(IWC, 1994a).

These new hypotheses were developed because there was no direct evidence to role them out, though there was no evidence to support them (Hatanaka et al., 1994).

Recognizing this, the Scientific Committee has pointed out the desirability of improving information on the stock structure in the area (IWC, 1994b). Accordingly, the Japanese Government started a research program under the special permit (JARPN) in 1994. Then, these hypotheses were reexamined in the Working Group on North Pacific Minke Whale Trials in 1996, based on the information obtained from JARPN and re-analyses of old data (IWC, 1997a). The group agreed that the available data and information were generally inconsistent with there being sub-stocks and that the sub-stock structure was dropped in the trials (IWC, 1997b). However, while the group agreed that no evidence was presented to support the hypothesis of W Stock, the group could not conclude on the plausibility of W Stock. The Scientific Committee agreed that a comprehensive review of JARPN should be held in 2000 to evaluate whether the objectives have been achieved. This paper summarizes the results on W Stock hypothesis obtained through the JARPN program until 1999.

DIRECT INFORMATION TO SUPPORT W STOCK OBTAINED THROUGH JARPN

1. DNA analyses

Goto and Pastene (2000) conducted RFLP analysis of whole mtDNA control region and sequencing of a 487 bp segment of the control region using 418 samples obtained through JARPN and 29 samples taken in Korea and the Sea of Japan. Results showed that whales from sub-area 6 were discriminated from whales from the Pacific side of Japan. However, no significant statistical differences were found among sub-area 7, 8 and 9, and W Stock hypothesis was not supported.

Abe et al. (2000) conducted microsatellite analysis for the samples obtained by JARPN. They investigated 8 microsatellite loci, and showed that samples from sub-areas 7, 8 and 9 followed the Hardy-Weinberg equilibrium. Authors concluded that results could not support the existence of the W Stock in the off-shore waters of North Pacific and support the mixing of J and O Stocks in sub-area 11.

2. Allozyme analysis

Wada (2000) conducted an allozyme analysis, using 497 specimens obtained through JARPN from 1994 to 1999. Results showed that the stock other than O Stock was not supported in sub-areas 7, 8 and 9 and that the mixing of J and O Stocks was occurred in sub-area 11.

3. Biological parameters

Zenitani et al. (2000) conducted analyses on biological parameters. After identification of J or O Stock in individual basis based upon mtDNA analysis by Goto et al. (2000), authors found differences in mean body length of physical mature animals, conception date, and growth and maximum body length between J and O Stocks. However, no difference was found in such biological markers between sub-areas 7, 8 and 9. On the other hand, sex ratio and size composition were different more or less between these sub-areas, suggesting segregation by sex and maturation within one stock.
Okamura et al. (2000) eamined the possibility of the existence of W Stock minke whale in sub-area 9 by means of hypothesized models on conception date of samples obtained by JARPN. A model which only O Stock existed in sub-area 9 gained support on the basis of the AIC, and the statistical power of the result was discussed.

4. Morphological and morphometric analyses
Hakamada and Fujise (2000) examined the data of external measurements collected during JARPN in order to detect the existence of a hypothesized W Stock. From the analysis of co-variance using 12 items of the body proportion, no meaningful difference was observed among sub-areas 7, 8 and 9. Results could not support the W Stock hypothesis. However, significant differences were showed between J and O Stocks by means of analysis of variance (AMOVA) and discriminant analysis.

5. Pollutants burden
Nakata et al. (2000) investigated persistent organic pollutants such as PCBs and organochlorine pesticides for the blubber of 76 animals collected by JARPN. Two groups were identified, and one of them (including 4 individuals) collected from the Sea of Okhotsk was estimated to be derived from the Sea of Japan. Little evidence for W Stock in the Pacific side was found.
Fujise et al. (2000) conducted a study on heavy metals and organochlorines accumulated in minke whale tissues. The discriminant analysis revealed that no significant difference was observed among the Pacific sub-areas (sub-areas 7, 8 and 9) and then they found no evidence to support W Stock hypothesis.

6. Parasites
Kuramochi et al. (2000) analyzed nine species of parasites and two species of epizoits. W Stock could not be differentiated from O Stock because no area-specific parasite was found and regional differences in prevalence and intensity of parasite were not so large to identify W Stock.. However, J Stock whales are characterized by a low prevelance of

Pennella balaenoptera compared with O Stock animals.

7. Stable isotopes

Mitani et al. (2000) investigated the stable isotope ratio of carbon and nitrogen on 44 samples taken from sub-areas 7, 8 and 11. The values of stable isotopes showed different distribution pattern between Pacific (sub-areas 7 and 8) and Okhotsk Sea (sub-area 11), but not within Pacific (between sub-areas 7 and 8). This result coincided with population structure showed by genetic analyses, and did not support W Stock hypothesis.

8. Others

Matsuoka et al. (2000) studied the seasonal variations of distributions of minke whales based on sightings made in JARPN surveys. Although there were uncovered areas and seasons, authors estimated that minke whales are distributed continuously from coastal waters to offshore waters in the western North Pacific.

Tamura et al. (2000) investigated the fatness of minke whales sampled by JARPN program. No difference was observed in fatness between O Stock (sub-area 7) and W Stock (sub-area 9), while it was observed between J and O Stocks.

CONSISTENCY BETWEEN RESULTS OBTAINED BY JARPN AND PAST KNOWLEDGE

Results obtained from JARPN Program clearly indicated that there were remarkable differences between J and O Stocks but there was no difference between O and W Stocks. Differences between J and O Stocks were found in mtDNA (Goto et al. 2000), nuclear DNA (Abe et al., 2000), allozyme (Wada, 2000), maximum body length (Zenitani et al., 2000), growth curve (ibid.), conception date (ibid.), pollutants (Fujise, et al., 2000, and Nakata et al., 2000), parasites (Kuramochi et al., 2000) and stable isotopes (Mitani et al., 2000). These results were well consistent with a established theory that there are two stocks of minke whale in the western North Pacific (Omura and Sakiura, 1956; Ohsumi, 1983; IWC, 1983; Hatanaka, 1997; Pastene et al. 2000).

The JARPN Program provided data on sex ratio and maturity rate by sub-areas. These data should be tested whether these are consistent with hypotheses on segregation and migration or not. The length compositions by sex and by sub-areas were examined by Zenitani et al. (2000). It was showed that females were relatively abundant in the Okhotsk Sea (sub-area 11); the maturity rate (rate of mature animals)

was relatively lower in coastal area (sub-area 7) and mature males were dominant in offshore area (sub-area 9). Mitani et al. (2000) estimated that some animals caught in the Okhotsk Sea (sub-area 11) migrated from the West Pacific (sub-areas 7 and 8), based on stable isotope analysis. These are consistent with the hypothesis on migration and segregation of O Stock (Hatanaka and Miyashita, 1997). At the same time, segregation by sex and maturity especially in sub-area 9 indicates that animals in this sub-area can not be a stock, but that they are a part of the stock.

DISCUSSION

At the Working Group on North Pacific Minke Whale Trials in 1996 which was held after two years survey of JARPN, while the group agreed that no evidence was presented to support the hypothesis of W Stock, some members considered that the information did not exclude this possibility. The reasons were, 1) insufficient data to detect genetic differences, 2) insufficient seasonal coverage of sub-area 9 (not included April to May, and size and sex compositions of animals in April-June are important), 3) insufficient spatial coverage of sub-area 9 (especially not the northern coastal area), and 4) large portions of sub-areas 8 and 12 had not been sampled.

Through JARPN program during six years, most of these points were improved substantially. The number of samples used in mtDNA analyses, for example, increased from 121 to 502 including 4 biopsy samples. Eighty-one samples (including size and sex data) were obtained in May-June in sub-area 9, and 91 samples were from sub-area 8. Goto and Pastene (2000) pointed out that genetic analyses based on JARPN samples used large sample sizes, at least larger than those used in most of the genetic studies on the marine mammals.

However, samples were not obtained from northern coastal area of sub-area 9 and from sub-area 12, because the permission of Russian Government was not taken. Data from sub-area 12, such as sex ratio and size composition, would be useful to know the segregation and migration of O Stock, and samples from this sub-area were essential for detecting the mixing rate of J and O Stocks. However, information from sub-area 12 could not provide us any direct evidence to support W Stock hypothesis, because animals in sub-area 9 (pure W Stock) have no difference from O Stock. As for the northern coastal area of sub-area 9, length and sex data from Russian catches are available (Ivashin, 1992). If abnormally large animals are ignored, the sex ratio and male length distribution are similar to those in sub-area 12, and length composition of females is similar to those in sub-area 11 (Hatanaka and Miyashita, 1997). This

means that small animals (smaller than 6 m or so) are relatively few in this area, and small animals of W Stock are still unknown in this case.

The necessity of showing statistical power on results of analyses has been pointed out. However, it is difficult to set the appropriate alternative hypothesis in case of O/W Stocks situation, because no significant difference was observed between them. However, Okamura and Goto (2000) tried to estimate the statistical power of their analysis on conception date, assuming that mean difference of conception date was one month between O and W Stocks. In this case, available 13 samples from sub-area 9 had a power of about 70 %. Okamura et al. (2000) conducted a simulation for estimating statistical power using allele frequency data from Adh-1 loci. It was estimated that the present sample size in sub-area 9 (178 individuals) had a good statistical power in the case of two stocks, one was O Stock in sub-area 9 and other was an assumed stock which 80 % of O Stock and 20 % of J Stock were mixed. Authors also estimated the dispersal rate of 0.33 between sub-areas 7 and 9 and pointed out that there was no meaning of distinguishing such slight difference for management objectives. In addition, Goto and Pastene (2000) estimated that the dispersal among sub-areas 7, 8 and 9 was 131.2 females per generation. These high dispersions suggested that those animals were substantially same population.

Some people might think that JARPN Program could not provide any definitive evidence to prove that O and W were the same stock, while it provide results that there was no substantial difference between them. However, W stock hypothesis was not founded based on supportive information, but it was set because of no available data in off shore waters in 1993. Now a large amount of data and samples were available through JARPN Program, and they did not support W Stock hypothesis at all. We have no more reason to maintain it. In other word, if the present information was available at the meeting of Working Group on North Pacific Minke Whale Management Trials in 1993, no one set up the W Stock hypothesis.

In Summary, a fairly large amount of data was collected through JARPN Program and a wide variety of analyses were conducted. However, supportive information on the existence of a W Stock has not emerged. JARPN Program has revealed various differences between J and O Stocks. This fact indicates that the various methods applied to detect the existence of different stocks could give positive results when more than one stock is present.

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