SC/68A/IA/04

Summary of the time trends of some biological parameters of the North Pacific sei whales in 1960's to 2010's from concurrent analyses on data from the commercial whaling and JARPN II program

H. Maeda, Y. Ishikawa and H. Kato

INTERNATIONAL
WHALING COMMISSION

Summary of the time trends of some biological parameters of the North Pacific sei whales in 1960's to 2010's from concurrent analyses on data from the commercial whaling and JARPN II program

HIKARI MAEDA [1], YUICHIRO ISHIKAWA[2*] and HIDEHIRO KATO,[2,3]

[1] *National Research Institute of Far Seas Fisheries, Japan Fisheries Research and Education Agency, Fukuura 2-12-4, Kanazawa-ku, Yokohama, Kanagawa, 236-8648, Japan*
[2] *Tokyo University of Marine Science and Technology, 4-5-7 Konan, Minato-ku, Tokyo 108-8477, Japan*
[3]*Institute of Cetacean Research, Toyomi-cho 4-5, Chuo-ku, Tokyo 104-0055, Japan*

Contact e-mail: hikarim@affrc.go.jp

ABSTRACT

Based on the master thesis submitted to TUMSAT Graduate school in 2013 the present paper extracted some key results with some additional analyses for the SC IA discussion in 2019. The paper examined time trends of some biological parameters, length at sexual maturity, sexual maturity curve vs age and age at sexual maturity through 1966 to 2010 (no catching 1977 to 2001) under using same standard methodology between commercial whaling and JARPN II.Through the analyses time trend of biological parameters for the North Pacific sei whales are thought to be well reflect the population trends, and to be independent information to support the multi-stock model prediction for the sei whale population under single stock scenario (SC/68a/IA01).

KEYWORDS: SEI WHALE, BIOLOGICAL PARAMETER, COMMERCIAL WHALING, JARPN II

INTRODUCTION

Sei whale have been caught since the early 20th century. Figure 1 shows catch history of North Pacific sei whale during 1910 to 2018 with cessation years 1977 - 2001. Remarkable increase of the catch was happened in later 1960's with peak of that in 1969 and ended in 1976. After cessation of catching through 1977 to 2001, JARPAN II taking sei whales with annual quota of 100 samples started from 2002 to present.

Masaki (1976) examined biological parameters such as age at sexual maturity are directly related to the reproduction of population using data through 1952 to 1972. However, after his study there was no such study, then Ishikawa tried to examine time trend of some biological parameters for the North Pacific sei whale data from both commercial whaling 1966 -75 and JARPN II in 2002-2010 using same standard methodology between commercial whaling and JARPN II, subsequently submitted it the master's thesis on graduate school of Marine Science at Tokyo University of Marine Science and Technology.

For the present study we extracted some key results (length at sexual maturity, sexual maturity curve vs age and age at sexual maturity) from the thesis to contribute in-depth assessment (IA) on the North Pacific sei whale with some additional analyses, especially compare with the multi-stock model prediction for the sei whale population under single stock scenario (SC/68a/IA01).

**Current address: Shochifukaya high school, 369 Uenodai, Fukaya, Saitama 336-0801, Japan*

MATERIALS AND METHOD

Samples and data used

The commercial whaling data used about 13,512 individuals captured in the eastern part of the sea, out of the data of 24,138 individuals caught by Japanese mother vessels during the 1966-1975. The JARPN II data used 784 individuals caught in the offshore area survey of JARPN II in 2002-2010. Figure 2 shows catch distribution under commercial whaling during 1966 to 1973 in the North Pacific. The survey area of JARPN II located west end of the commercial distribution. Commercial catch distribution had widespread throughout the North Pacific and it had varied by year. During commercial whaling era, the concerned areas were moved southward generally by year.

Proportion of sexual maturity

A male with a testicle weighing more than 0.9 kg following Masaki (1976) and a female with at least one corpus luteum or albicans in her ovaries (Lockyer, 1984b) were classified to be sexually mature status. Based on sexual maturity criteria, we calculated the sexual maturity curve by age and fitted the logistic curve by the least squares method to the sexual maturity rate weighted by the number of samples.

Mean age at sexual maturity from transition phase of earplug (*tmp*)

We used readable earplugs obtained from North Pacific sei whales collected during JARPN II surveys (2002–2010) in the western North Pacific. For age determination, earplugs were preserved in 10% neutral buffered formalin solution. In the laboratory, the earplugs were bisected and one surface along the central axis of the core using a blade according to Lockyer (1972). Then, the earplugs were ground on a wet stone to expose the neonatal line and the growth layers and to smooth the surface. The cut surfaces of the earplugs were then examined underwater using a stereomicroscope. Age was determined by reading the growth layers appearing on the bisected surface of the earplug, assuming annual deposition of growth layers (one pair of dark and light laminae accumulate per year). We recorded transition phase when we clearly identified the part that exhibited a sudden decrease in its spacing.

Analysis of age at sexual maturity using transition phase was an estimation method that is not affected by sexual segregation or capture selectivity. However, some biases are pointed out in estimation of *tmp*, in this study, *tmp* was analyzed under consideration of bias such as truncation bias or time lag in recognition of the transition phase and examined according to Kato (1983) taking the truncation and the fringe effects, incorporating similar principle the later study by Thomson *et. al.* (1999) which is widely known as un-biased estimator.

In original paper of Masaki (1976), the truncation bias was not examined in the *tmp* analyses, therefore the *tmp* was re-analyzed incorporating correcting methods above for both the commercial operation and JARPN II.

RESULTS AND DISCUSSION

Mean length at first ovulation

Figure 3 shows yearly change of mean length at sexual maturation based on only animals having first ovulation by ovary examination (*Lmov*). The value of *Lmov* remained almost constant over the time in the range of 13.5 m to 14.0 m. There is no significant difference statistically between commercial and JARPN II (Bartlett test, p=0.151).

Sexual maturity curve versus age

On sexual maturity curve versus age was examined as in figure 4, the upper illustrates the change in pattern of sexual maturity curve vs. age with indicating conceptional pattern of the stock level by Ohsumi (1986) which is expressed pattern of sexual maturity curve to stock level in the North Pacific fin whales. The bottom represents sexual maturity curve with divided into three periods (1966-1970, 1971-1975, 2002-2010) for the North Pacific sei whale. Pattern from the analyses, the first (1966-70) is almost identical with the third (2002-2010; JARPN II), while the second shows transit pattern suggesting low stock level. The result suggests recovery of the population in the JARPN II era form the previous commercial whaling era in 1971-1975.

Mean age at sexual maturity based on transition phase (*tmp*)

Figure 5 shows annual change of *tmp* by year class and sex. The value of *tmp* have varied for both sex by year class. From the series of *tmp*, it increased around 8 to 10 years old 1980's to 2000's, while it had declined from 9 to 7 years old from 1960's to late 1970's for both sexes base on JARPN II. By commercial whaling data, it was detected that *tmp* increased 11 years old in 1920' to 8.5 years old in 1970' s year classes. Taking the density

dependent principal among studies on cetaceans to environment, above *tmp* trend indicate population recoveries under JARPN II period.

Apparent pregnancy rate

Apparent pregnancy rate for North Pacific sei whale mostly remained constant around 0.7 (Figure 6).

Environmental changes

Although it is quick assessment, we tried to examine environment background to such change of biological parameters. Figure 7 shows long-term variability of zooplankton biomass in the summer *Oyashio* region of the North western Pacific Ocean, that is feeding area for the North Pacific sei whales (Odachi, 1994). Possible food availability varied by decade with higher peak in early 1970s and 2000 onward and lower in late 1970's to middle of 1990's.

Overview

Through the analyses time trend of biological parameters for the North Pacific sei whales are thought to be well reflect the population trends, lower in 1960's but higher in 1990's. That is consistent with reaction under the earlier whaling with high catch level in 1960's, followed by population recovery after the commercial whaling ended. It is useful to support the multi-stock model prediction for the sei whale population under single stock scenario (SC/68a/IA01) from biological point of view.

REFERENCES

Punt, E. A. 2019. Further updated progress report: A multi-stock model for North Pacific sei whales. SC/68A/IA/01. Nairobi.19pp

Ishikawa, Y. 2013. Long term trend of some biological parameters of the North Pacific sei whales. Master's thesis on Maine Science, Graduate School at Tokyo University of Marine Science and Technology. Tokyo. 104pp.

Kato, H. 1983. Some consideration on the decline in age at sexual maturity of the Antarctic Minke whale. *Rep.Int.Whal. Commn.* 33:393-399.

Lockyer, C. 1972. Maturity of the Southern fin Whale (*Balaenoptera physalus*) using Annual Layer Counts in the Ear Plug. Journal du Conseil, 34: 276-294.

Lockyer, C. 1984. Review of Baleen Whale (Mysticeti) Reproduction and Implications for Management. Report of the International Whaling Commission, 6: 27-50.

Masaki, Y. 1976. Biological studies on the North Pacific sei whale. *Bull. Far. Seas. Fish. Res. Lab.* 14:1-104.

Odachi, K. 1994. Study on zooplankton dynamics and long-term fluctuation in the Tohoku region. Examination on age determination of the fin whales. *Bull. Tohoku Regi. Fish. Res. Lab*. 56:115-173 (In Japanese).

Ohsumi, S. 1986. Yearly change in age and body length at sexual maturity of a Fin whale stock in the eastern north pacific. *Sci. Rep. Whales Res. Inst.* 37:1-16.

Thomson, R.B., Butterworth, D.S. and Kato, H. 1999. Has the age at transition of southern hemisphere minke whales declined over recent decades? *Mar. Mamma. Sci.* 15:661-682.

FIGURES

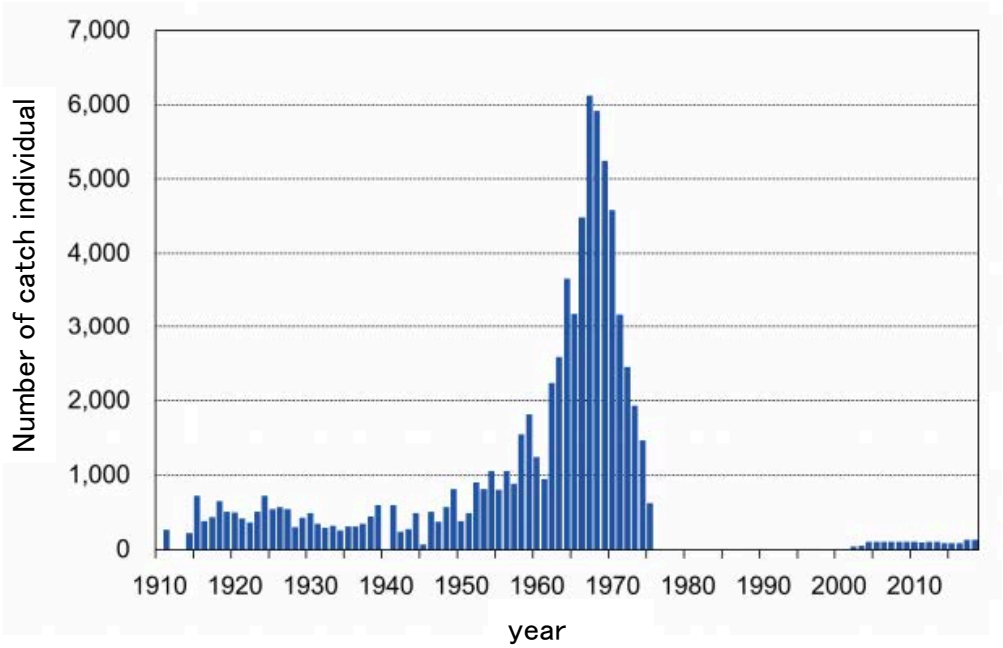

Figure 1. Number of catch individuals of North Pacific sei whale during 1910 to 2018.
Data source: http://kokushi.fra.go.jp/H30/H30_54.pdf

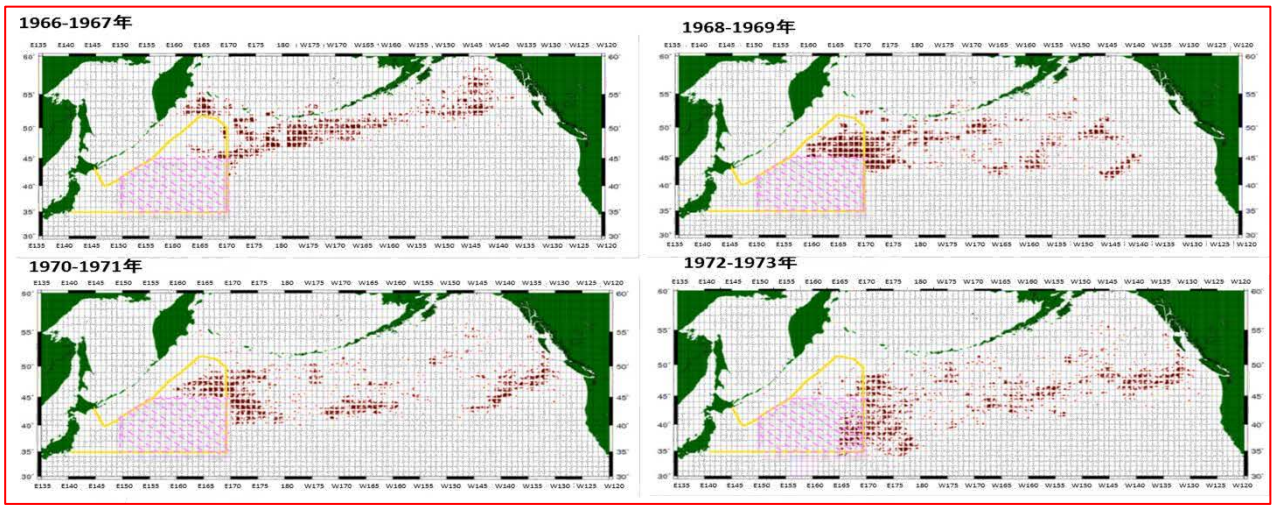

Figure 2. Changes in the catch position of sei whales under the commercial whaling period (1966-1973) in the North Pacific. The catch year are pooled every two years. The red dot indicates the capture position of commercial whaling, the area surrounded by the yellow line is the survey area of JARPN II, and the area shaded by red is the major capture position of the sei whale in JARPN II

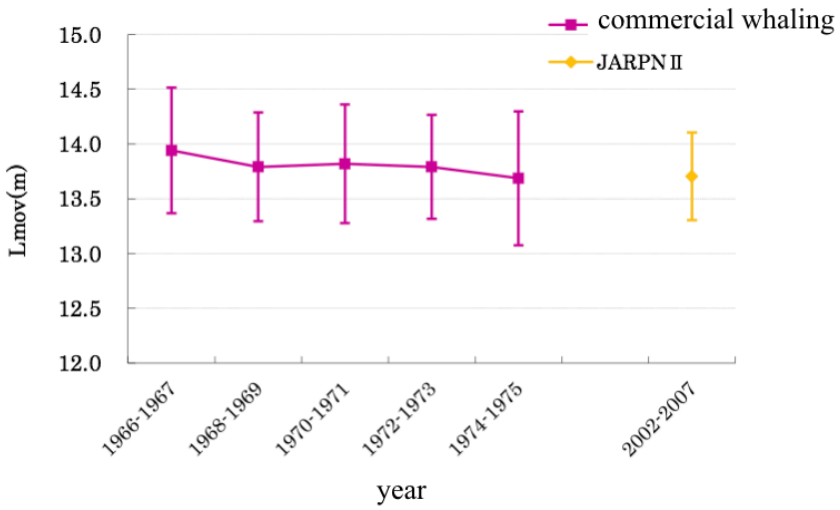

Figure 3. Yearly change of mean length at first ovulation (*Lmov*).

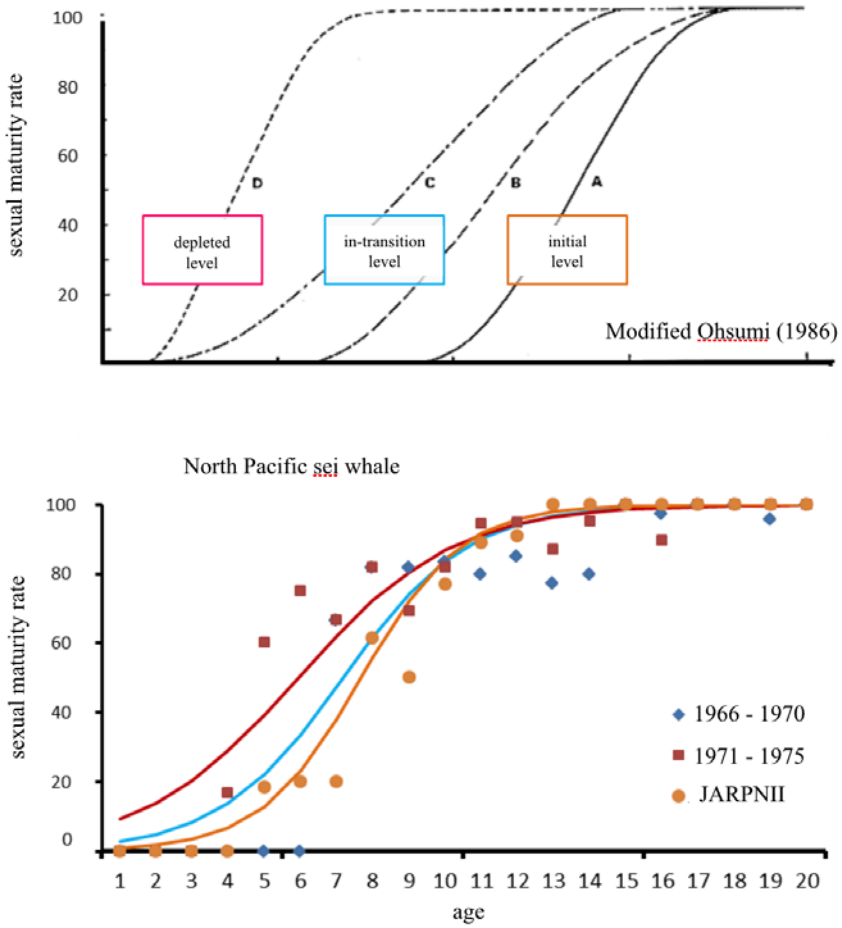

Figure 4. The change in pattern of sexual maturity curve vs. age with indicating conceptional pattern of the stock level by Ohsumi (1986) which is written about variability of sexual maturity curve to stock level in the North Pacific fin whales (upper). The sexual maturity curve with divided into three periods (1966-1970, 1971-1975, 2002-2010) for the North Pacific sei whale.

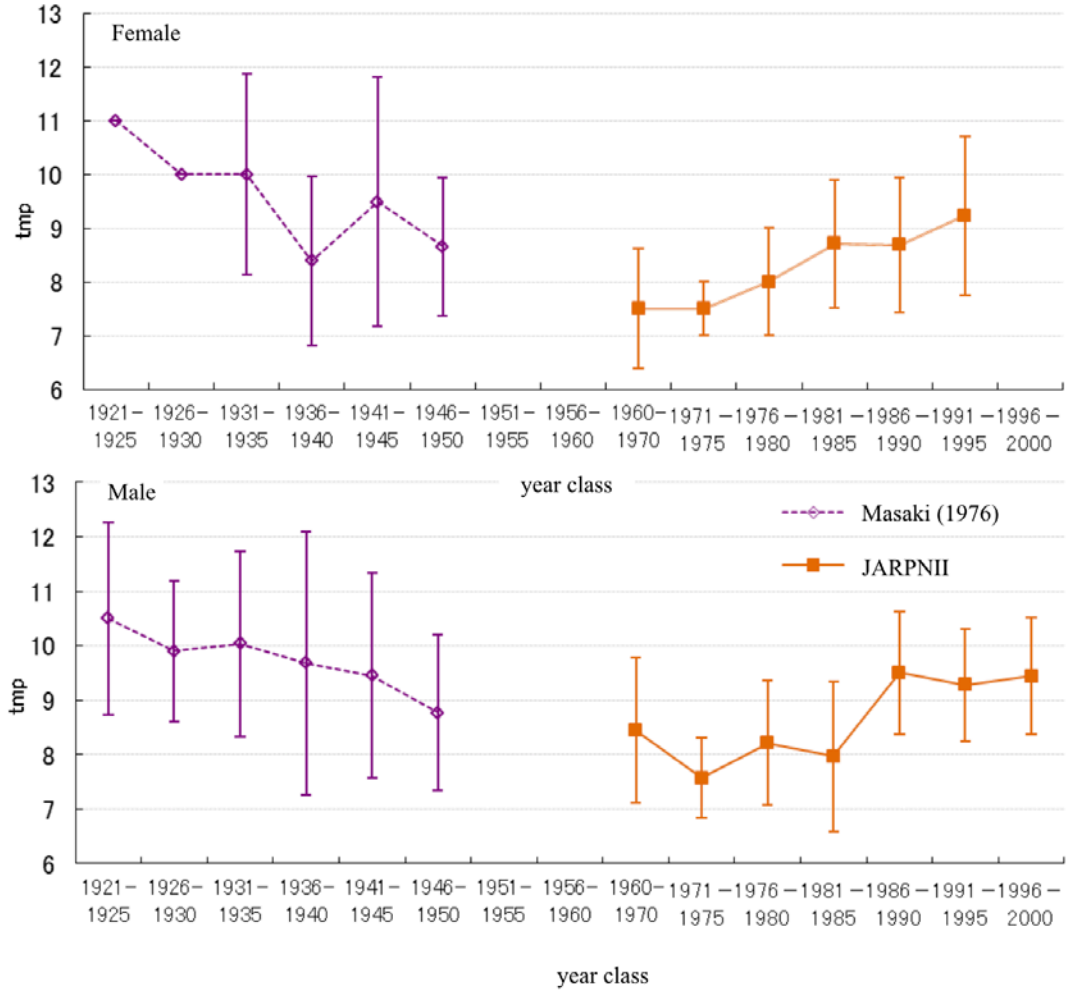

Figure 5. Annual change of mean age at sexual maturity from transition phase of earplugs by year class and sex (top: female, bottom: male).

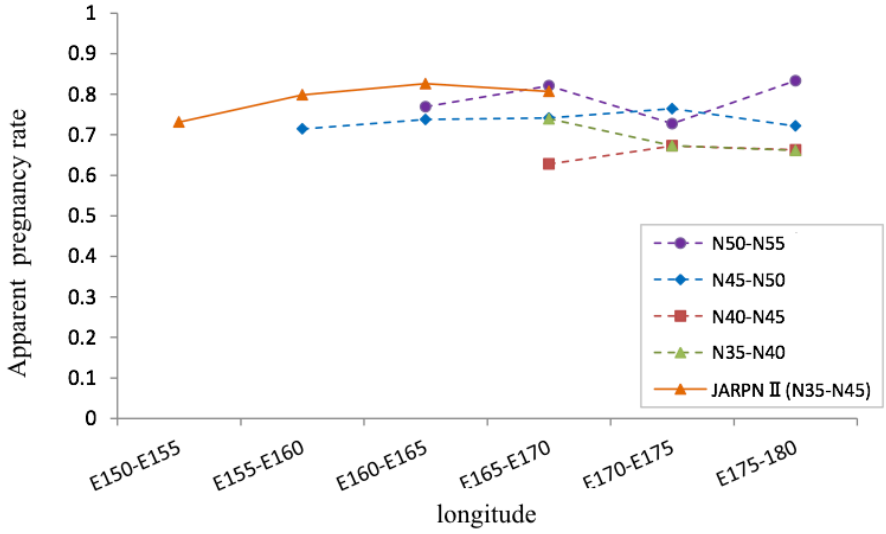

Figure 6. Changes in the apparent pregnancy rate of North Pacific sei whales by latitude and longitude. The solid orange line is the apparent pregnancy rate of JARPN II, and the dotted line is the apparent pregnancy rate of commercial whaling.

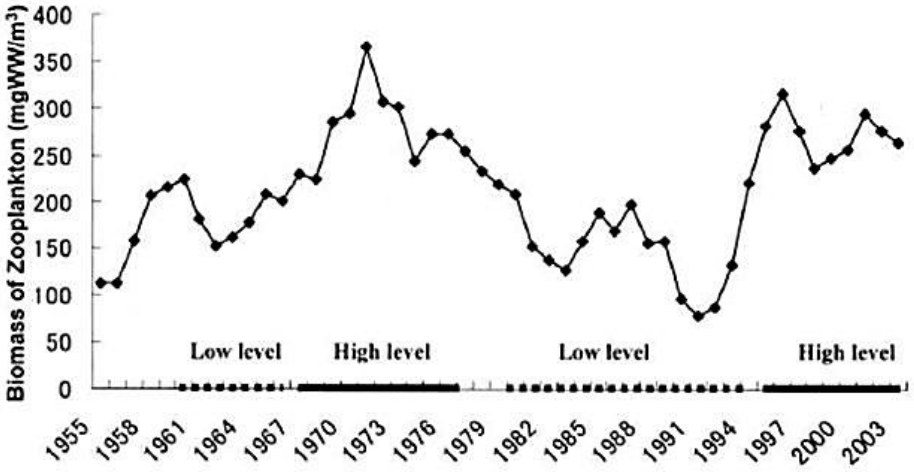

Figure 7. Long-term variability of zooplankton biomass in the summer Oyashio region of the northwestern Pacific Ocean (Modified Odachi 1994), feeding area for the North Pacific sei whales.