Length composition and sex ratio of western North Pacific minke whales and their consistencies with stock structure hypotheses

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ABSTRACT

Length composition and sex ratio data from bycaught minke whales around Japan from 2001 to 2007 and JARPN/JARPNII minke whale samples from 1994 to 2007 were used to evaluate the hypothesis that proposed two J stocks (JW and JE) and two O stocks (OW and OE). J-type and O-type animals were identified based on microsatellite DNA analysis. J-type animals from Sea of Japan and Pacific coast showed quite similar characteristics in the data, indicating they belonged to the same single stock. The data showed that, at the Pacific side of Japan, O-type immature animals distribute mainly coastal area whereas O-type mature animals distribute mainly offshore area. This distribution pattern can be explained only when a single stock, but not two stocks, exist in the area. These data support strongly the present hypothesis of single J and single O stocks.

INTRODUCTION

The stock structure of minke whales in the western North Pacific has been studied since 1950s (Omura and Sakiura, 1956; Ohsumi, 1983; Wada, 1991; Kato, 1992; Gong, 2005; Kanda *et al*., 2009a; Pastene *et al*., 2010). These authors consistently hypothesized two stocks, J (the Sea of Japan-Yellow Sea-East China Sea stock) and O (the Okhotsk Sea-West Pacific stock). In the *Implementation Simulation Trials* for RMP, a hypothesis that divided O stock into two (OW and OE) was proposed by US scientists (Baseline C; Taylor and Martien, 2004). However, this hypothesis was abandoned in 2010 (IWC (2010). Instead, a complicated hypothesis that included five stocks was proposed (IWC, 2010). Among the five stocks, two J stocks, JW in the Sea of Japan and JE along the Pacific coast of Japan, and two O stocks, OW in the Pacific coastal area and OE in the off-shore area, were included in this hypothesis. In our paper, we examined whether or not the length composition and sex ratio data were consistent with these four stocks.

MATERIALS AND METHODS

Length and sex data of animals incidentally caught by set net gears in coastal area of Japan from 2001 to 2007 were used (bycatch). In addition, those data from JARPN and JARPNII from 1994 to 2007 were used. Bycatch data provides seasonal appearances of animals to some extent, as set net gears are stationary. Contrary, JARPNII surveys were conducted in spring (April and May) in sub-area 7CS, autumn (September and October) in sub-area 7CN and spring and summer in offshore waters, and consequently seasonal appearances throughout the year were not able to be traced.

The stock of each individual was distinguished based on genetic variation at the 16 microsatellite loci as described in Kanda *et al*. (2009b). Only individuals identified as J and O stocks were used (approximately 90% of total samples; see more details in Kanda *et al*. 2009b). Samples were grouped geographically according to sub-areas adopted in the Preparatory Meeting for NP minke whale *Implementation* review, and four seasons were defined: spring = April and May, summer = June to August, autumn = September and October, and winter = November to March. In some sub-areas, the seasonality analysis was restricted from the availability of the samples. Based on Kato (1992), body lengths of 6.5 for males and 7.0 for females were used as boarder line of mature and immature animals. Length frequency figures were made in regard to stocks, sub-areas, bycatch or JARPN/JARPNII catch, sex and seasons. Characteristics in body size, seasonal appearance, maturity and sex ratio were examined.

RESULTS

J stock

Characteristics are itemized as follows.

Sub-area 2C - Bycatch (Fig. 1)

i) Appeared throughout the year; the most abundant in winter and the least in autumn.
ii) Mostly immature animals in both sexes.
iii) The peak of length frequency was approximately at 5 m.
iv) 1:1 sex ratio.

Sub-area 6E - Bycatch (Fig.2)

i) Appeared throughout the year; the most abundant in winter and the least in autumn.
ii) Mostly immature animals in both sexes.
iii) The peak length was about 5 m.
iv) 1:1 sex ratio.

Sub-area 7CS - Bycatch (Fig.3)

i) Appeared throughout the year but low; somewhat abundant in winter, rare in autumn.
ii) All immature animals.
iii) Their lengths were similar with animals in Sub-areas 2C and 6E.
iv) Approximately 1:1 sex ratio.

Sub-area 7CS - JARPNII (Fig.4)

i) Seasonality not observed because the surveys were conducted mainly in April and May.
ii) Their lengths were larger than those of bycatches; possibly because JARPNII samples were caught in further off-shore water than bycatches were.
iii) Mostly immature animals.
iv) More males than females; but the sex ratio of 1:1 can not be neglected as sample size was small.

Sub-area 7CN - Bycatch (Fig. 5)

i) Might appear throughout the year; the seasonality was not observed due to small sample size.
ii) Mostly immature animals.
iii) Probably 1:1 sex ratio

Sub-area 7CN - JARPNII (Fig. 6)

i) Survey was conducted in summer and autumn, and they appeared in both seasons.
ii) Both immature and mature animals appeared; but mature females were rare.
iii) Male dominant in both maturity stages; overwhelming in matures.

Overall observation on J stock

The above mentioned characteristics were summarized as follows,

i) In the case of bycatch, J stock animals appear throughout the year, but the number is larger in winter and smaller in autumn in the Sea of Japan (see also Kanda *et al*., 2010). J-type animals in the Pacific coastal areas tend to appear in the same manner especially in Sub-areas 2C and 7CS. J-type animals in sub-area 7CN likely show consistency with this trend although the sample size was small.
ii) Most of bycathches are immature in all sub-areas, and the peak of length is about 5 m.
iii) Samlpes caught by JARPNII contains substantial number of mature males in sub-area 7CN; but mature females are few even in the catch by JARPNII in any of these sub-areas
iv) Sex ratio is about 1:1.

The hypothesis of the two J stocks should be evaluated as follows.

i) No real difference is seen in seasonal appearance, length frequency and sex ratio of J animals between the Sea of Japan and Pacific coastal areas.
ii) This supports that animals from Pacific coastal area belong to the same stock with that from the Sea of Japan. The hypothesis of the two separate J stocks is not supported.
iii) JE stock distributes in Pacific coastal sub-areas 2C, 7CS and 7CN in this hypothesis.

However, most of J-animals caught in these sub-areas are immature and mature males in sub-area 7CN. Mature females are hardly seen in these sub-areas. This indicates that animals in these three sub-areas are not a complete stock but a part of a stock. The hypothesis of JE stock in Pacific coastal areas is not consistent with the data examine in this study.

O stock

Characteristics are itemized as follows.

Sub-area 2C - Bycatch (Fig. 7)

i) Appeared in spring and winter.
ii) Both males and females were immature.
iii) 1:1 sex ratio

Sub-area 7CS - Bycatch (Fig. 8)

i) Appeared mainly in spring, while rare in other seasons.
ii) Mostly immature animals.
iii) 1:1 sex ratio.

Sub-area 7CS - JARPNII (Fig. 9)

i) Surveys were conducted in spring and summer.
ii) Larger immature and adult whales appeared in spring. Adult males appeared in summer, while immature and adult females were rare.
iii) Females were high in sex ratio in spring, while males were high in summer.

Sub-area 7CN - Bycatch (Fig. 10)

i) Appeared mainly in spring and summer.
ii) Both immature and mature were included.
iii) Sex ratio was somewhat favor in females.

Sub-area 7CN - JARPNII (Fig. 11)

i) Surveys were conducted in summer and autumn.
ii) Immature and mature whlaes appeared in both sexes, but mature females were a few.
iii) Male dominant in mature animals; lesser extent but similar trend in immature animals.

Sub-area 7W - JARPNII (Fig. 12)

i) Surveys were conducted in spring and summer.
ii) Immature and mature animals appeared in both sexes, but matures dominated in males.
iii) Males were high in sex ratio; mature males dominated in this sub-area.

Sub-areas 7E+8+9 - JARPNII (Fig. 13)

i) Surveys were conducted mainly in spring and summer.
ii) Most of animals were mature males.
iii) Sex ratio was overwhelmingly high in males.

Overall observation on O stock

The above mentioned characteristics were summarized as follows.

1) In the case of bycatch, O animals appear mainly in spring and summer in Pacific coastal areas. Most of them are immature and sex ratio is about 1:1.
2) Whales caught by JARPNII contains matures that are mainly males.
3) Most of animals in off-shore sub-areas including 7W are mature males.

The hypothesis of two O stocks should be evaluated as follows.

i) In this hypothesis, OW stock distribute in 2C, 7CS, 7CN and 7W and OE stock in 7W, 7E, 8 and 9.
ii) Immature animals appeared in coastal sub-areas (2C, 7CS and 7CN) and under this hypothesis, they all belong to OW stock. Contrary, immature animals seldom appear in off-shore sub-areas (7W, 7E, 8 and 9); this means that immature animals of OE stock do not exist, which is unlikely as an independent stock. This negates the hypothesis of two O

stocks.

iii) Baker *et al*. (2010) suggested that an independent OW stock characterized by intermediate haplotype frequencies between JE and OE in sub-areas 7CS, 7CN and 7W. However, this is not supported because microsatellite analysis indicated that J-type animals hardly existed in sub-area 7W.

DISCUSSION

The patterns of length composition, sex ratio and immature/mature ratio reflect a pattern of temporal and geographical segregation in the western North Pacific minke whales but not additional structure as suggested by Wade *et al*. (2010).

In this study we examined those biological information to evaluate the plausibility of additional structure in the J and O stocks as proposed in Hypothesis III.

Seasonal occurrences and length frequency of J-type animals were very similar between the Sea of Japan and Pacific coastal areas. These observations are not consistent with the hypothesis of two separate J stocks, but rather suggest that those animals belong to the same single stock.

Adult J-type animals were hardly found in the hypothesized habitat of the JE stock. This is not consistent with the view of a single JE stock occurring through the year in the Pacific coastal area of Japan.

The hypothesis of two O stocks, OW in coastal area and OE in offshore water, provided a large contradiction because, based on our observations, OE stock becomes the one with no immature animals. This is not consistent biologically.

Baker *et al*. (2010) suggested an independent OW stock characterized by intermediate genetic frequencies between J and O stocks. In other words, OW stock shall include both J and O type animals. In the two O stocks hypothesis, both O stocks mix in sub-area 7W, but J-type animals are not found in sub-area 7W. This is another contradiction.

In summary, length, sex and maturity data are consistent with recent genetic analyses and they do not support the hypotheses of two J stocks and two O stocks. These data support strongly the present hypothesis of single J and single O stocks.

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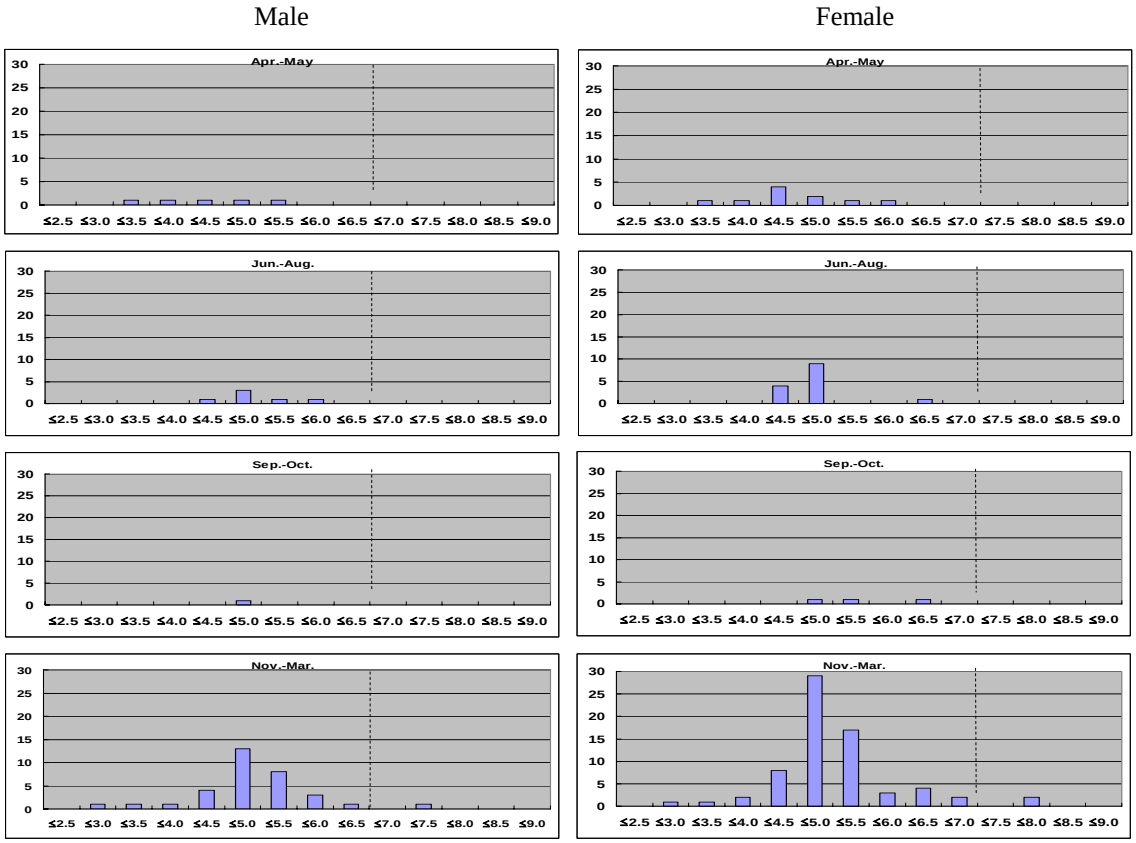

Fig. 1. Length frequency in J stock sub-area 2C-Bycatch.

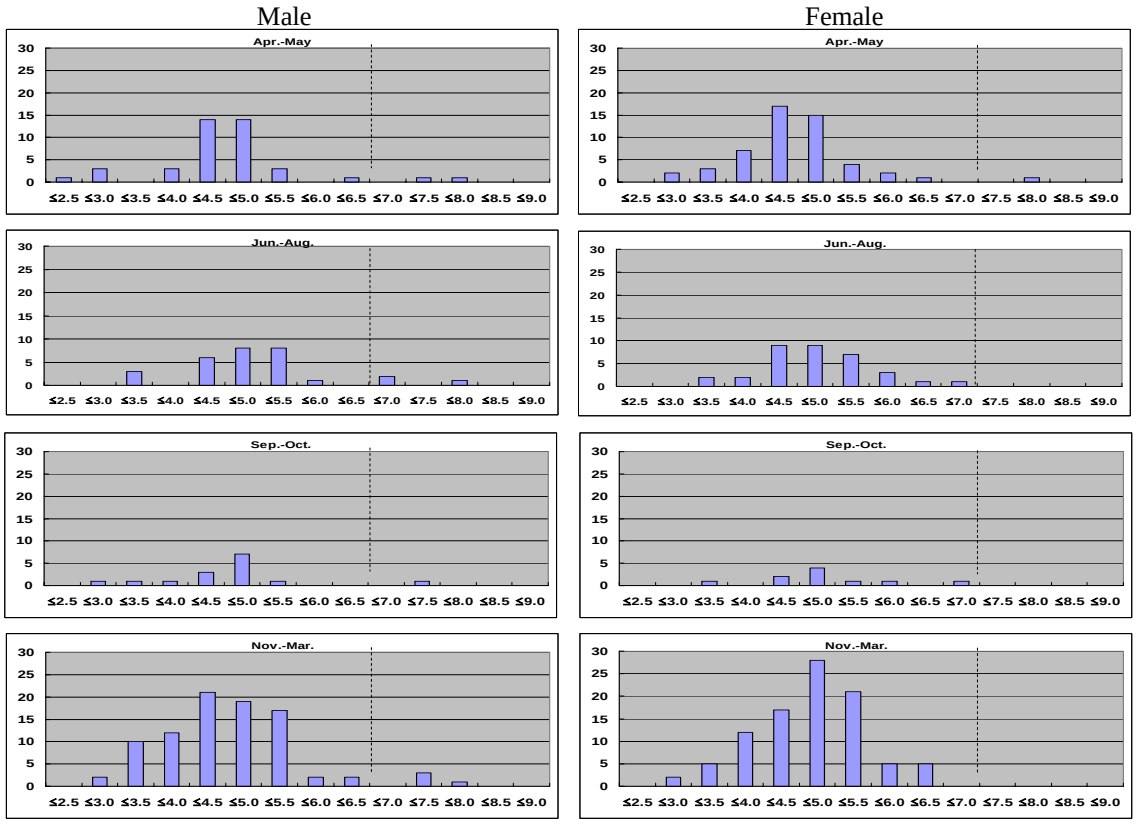

Fig. 2. Length frequency in J stock sub-area 6E-Bycatch.

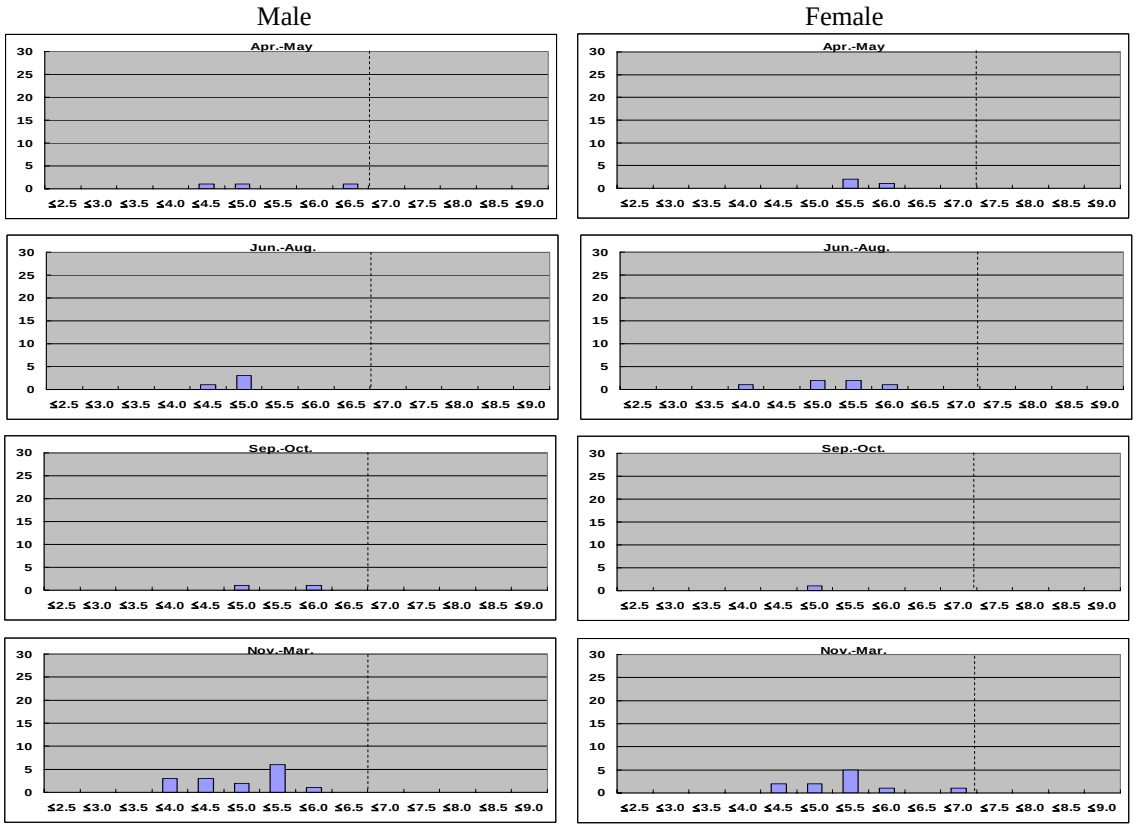

Fig.3. Length frequency in J stock sub-area 7CS-Bycatch.

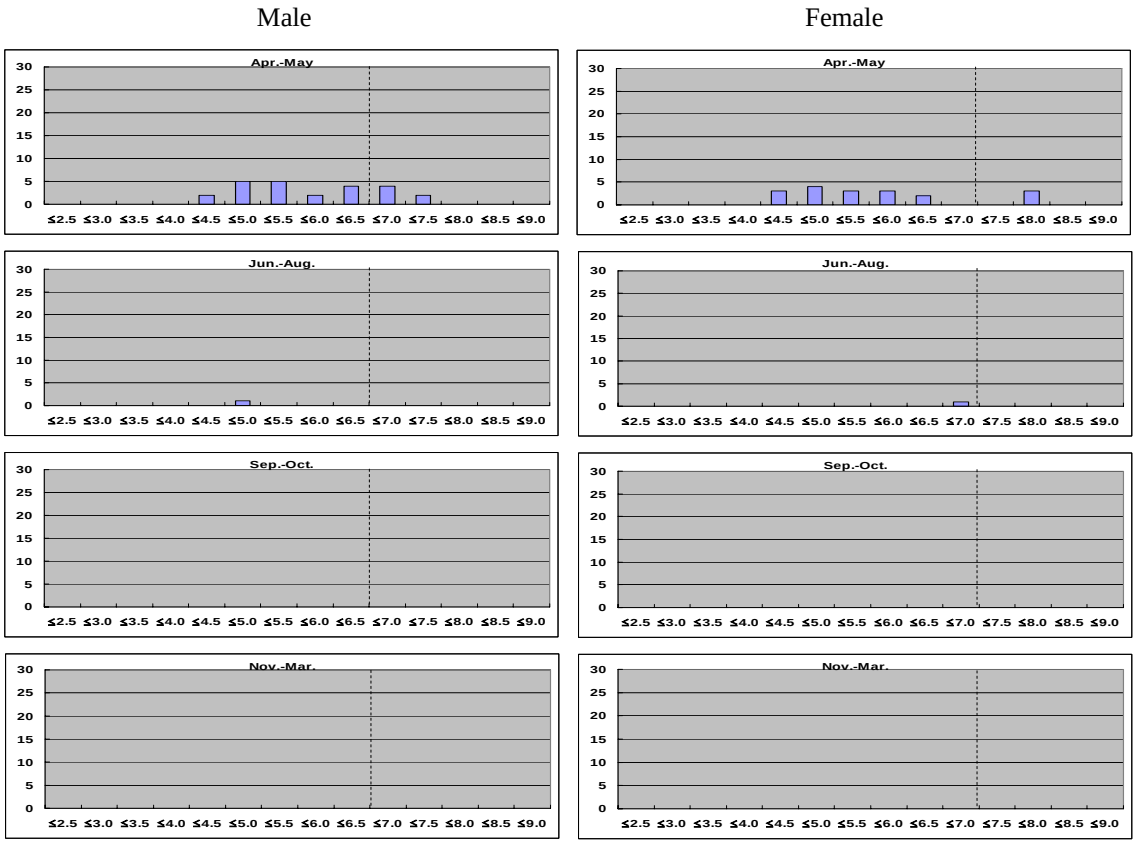

Fig. 4. Length frequency in J stock sub-area 7CS-JARPNII.

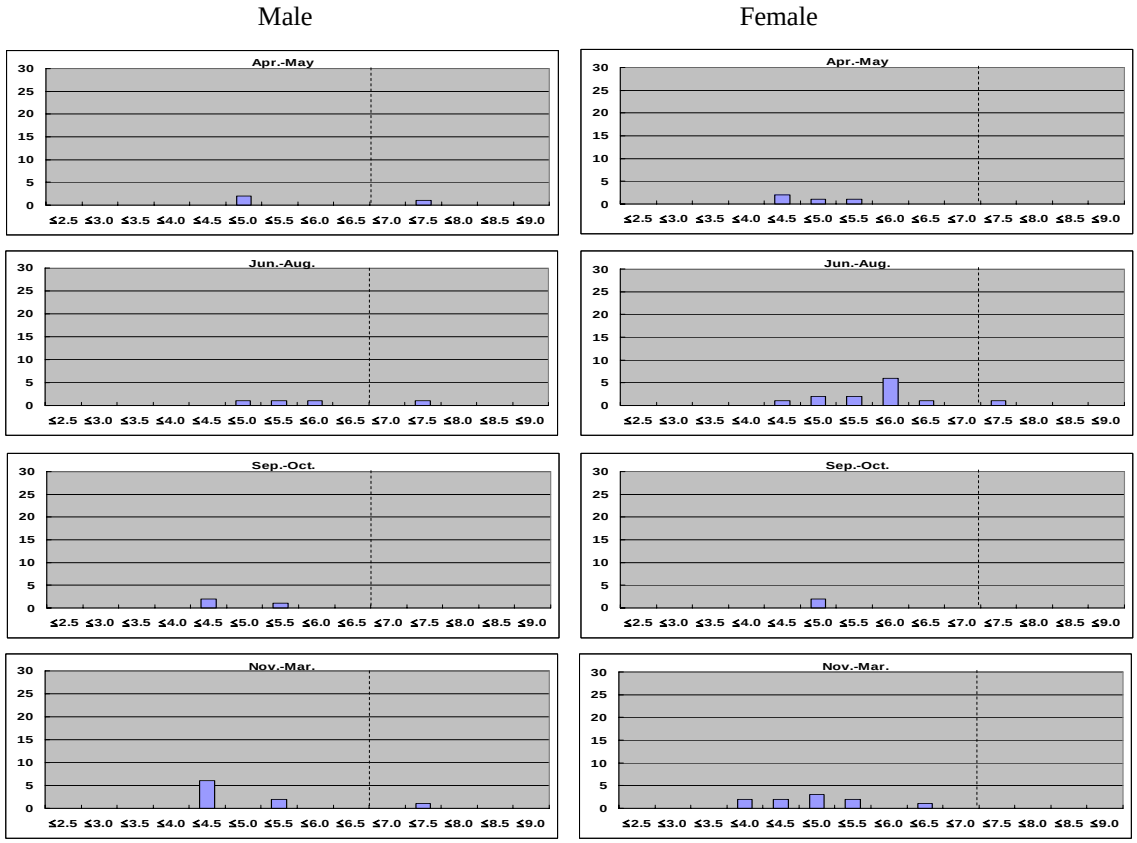

Fig. 5. Length frequency in J stock sub-area 7CN-Bycatch.

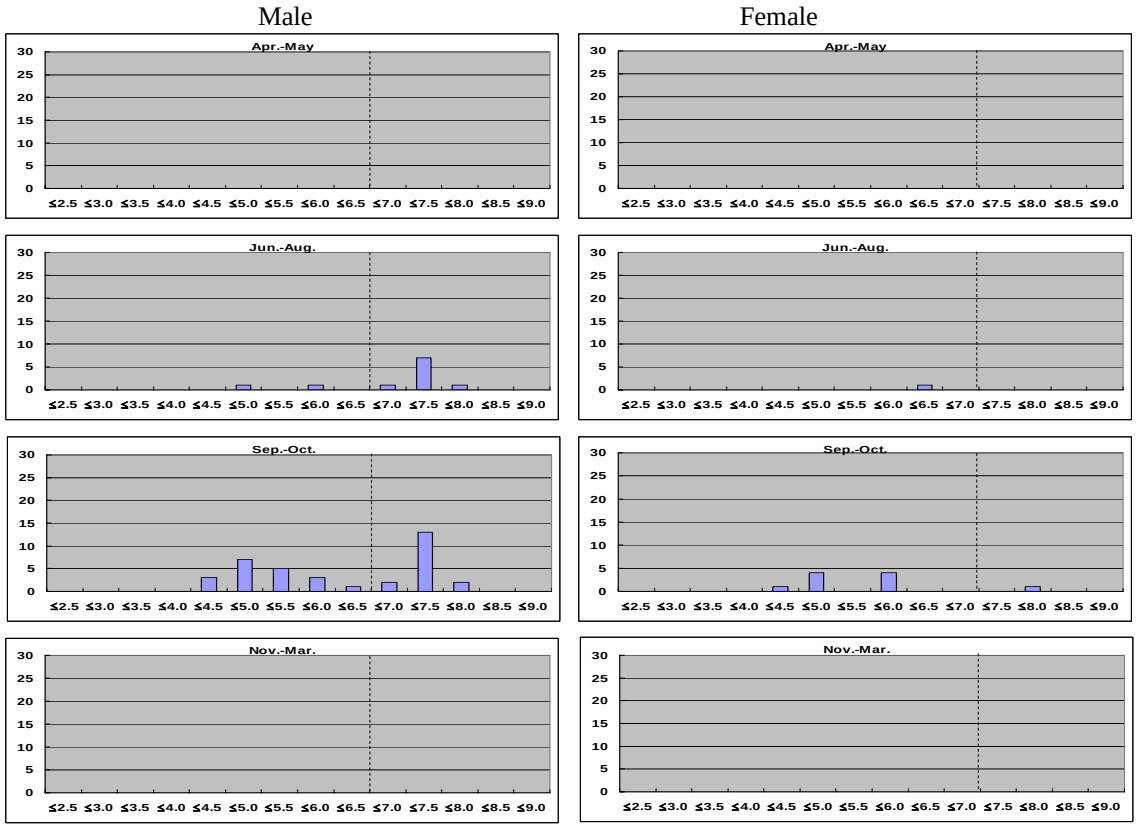

Fig. 6. Length frequency in J stock sub-area 7CN-JARPANII.

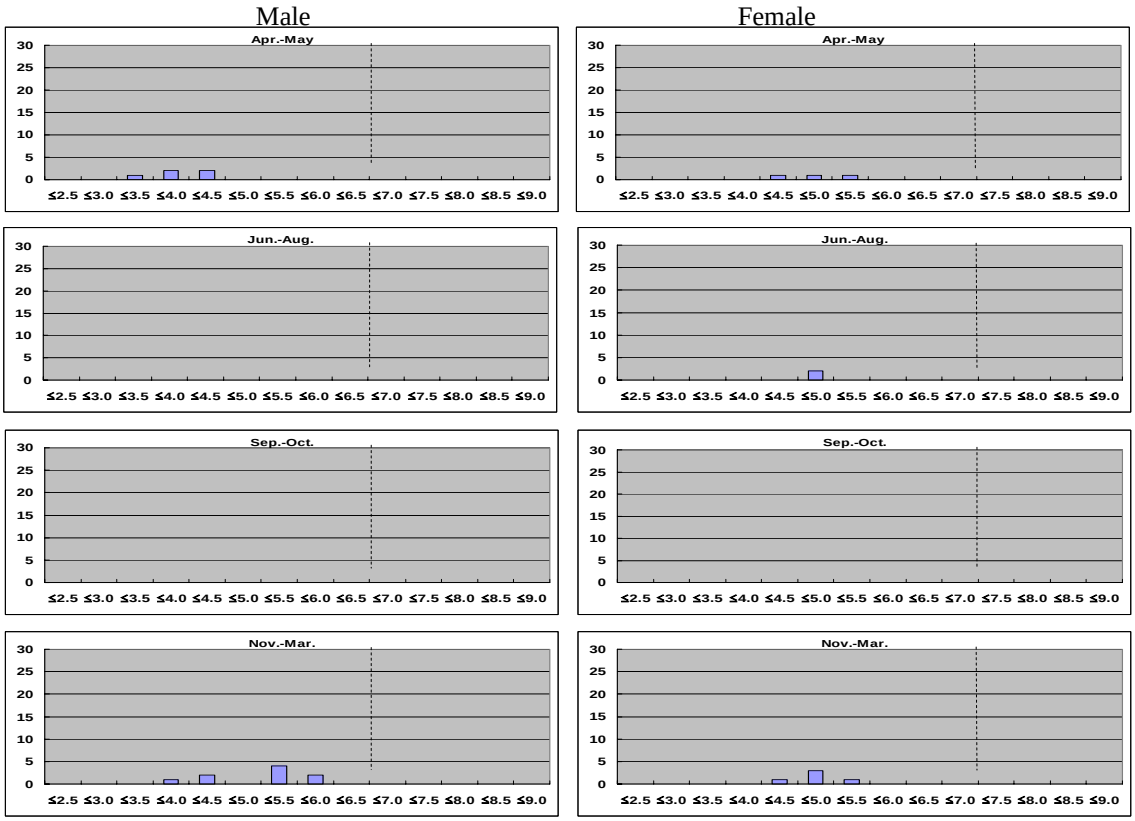

Fig.7. Length frequency in O stock sub-area 2C-By-catch.

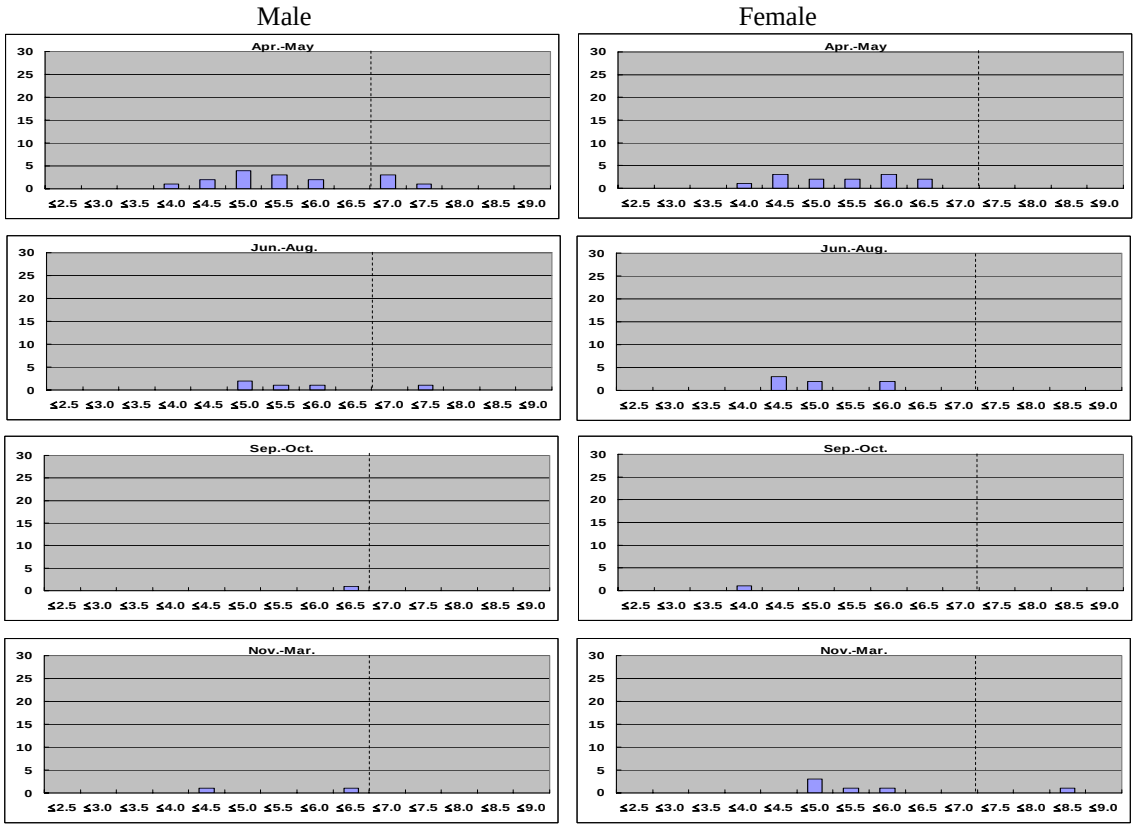

Fig. 8. Length frequency in O stock 7CS-Bycatch.

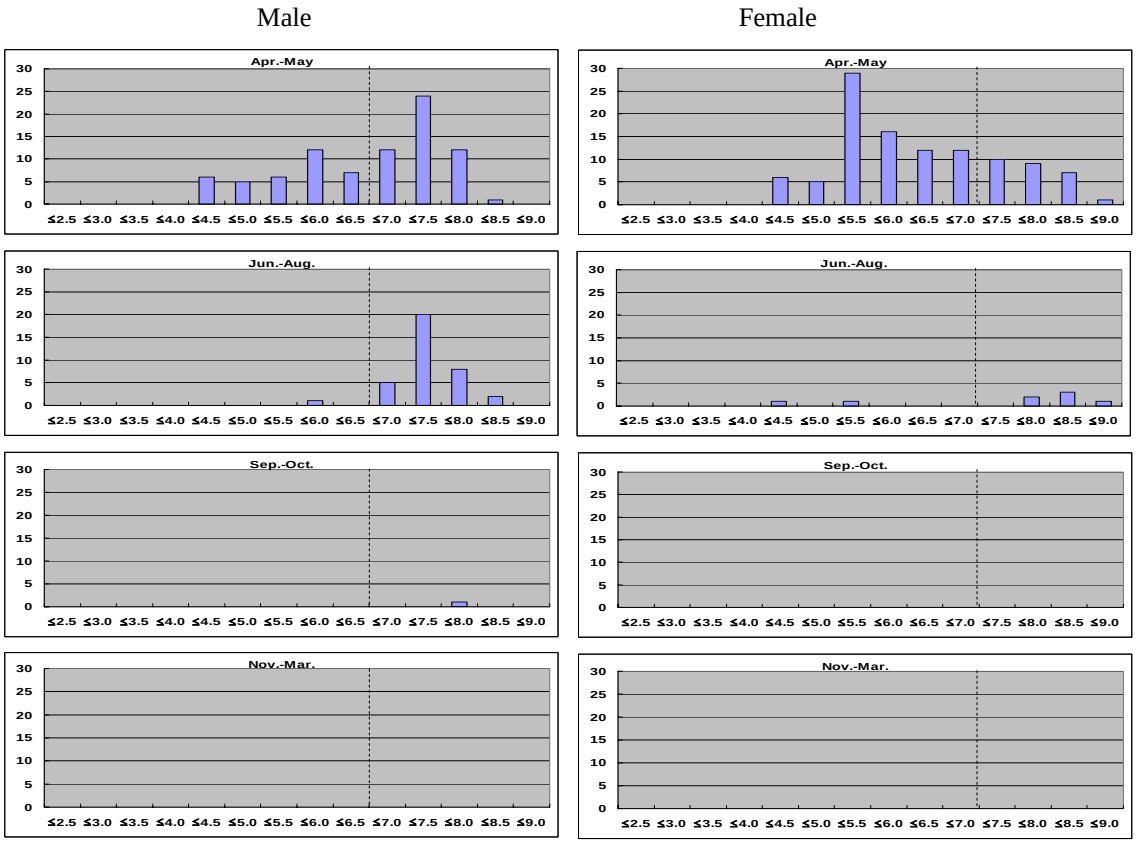

Fig. 9. Length frequency in O stock 7CS-JARPNII.

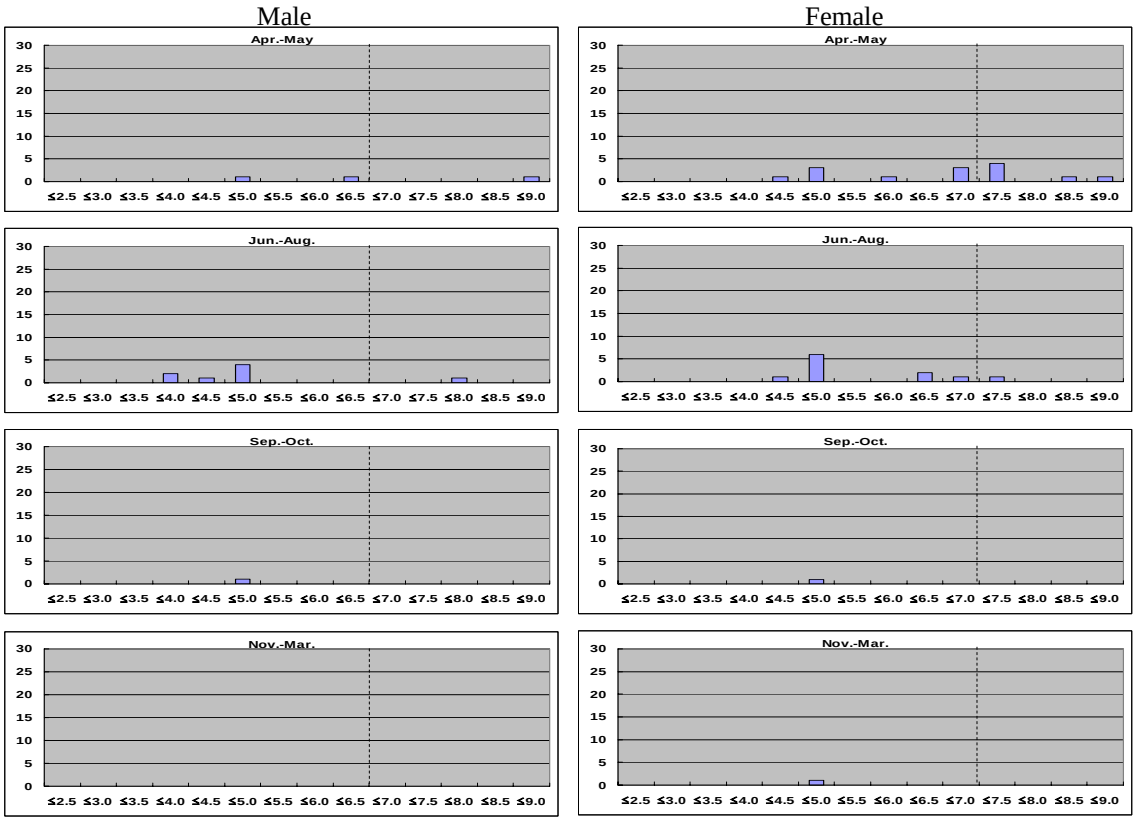

Fig. 10. Length frequency in O stock 7CN-Bycatch.

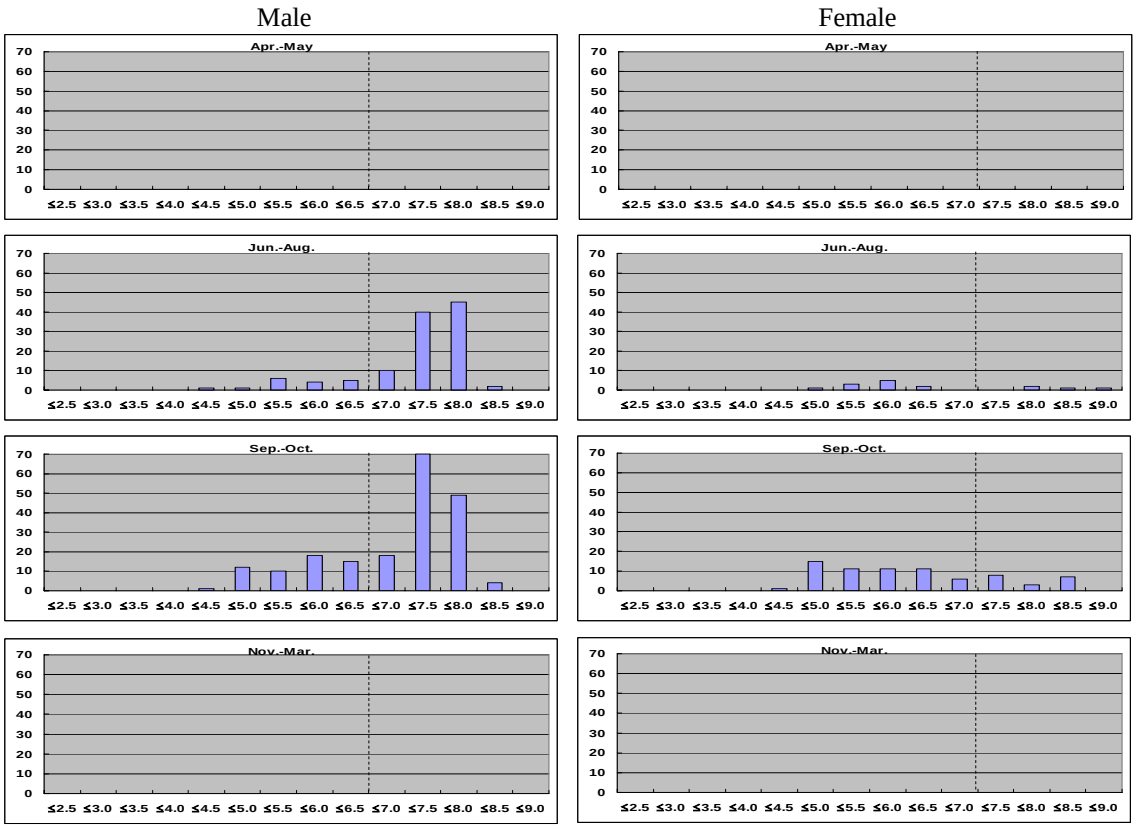

Fig. 11. Length frequency in O stock 7CN-JARPNII.

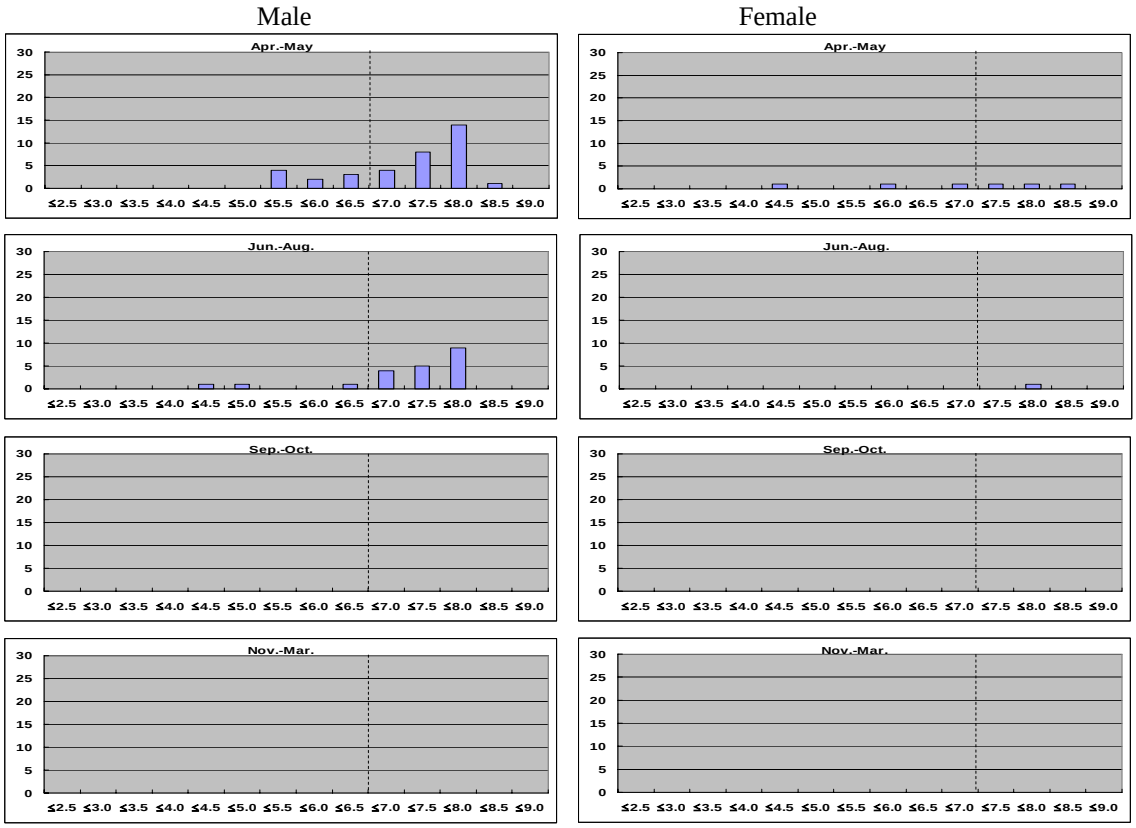

Fig. 12. Length frequency in O stock 7W-JARPNII.

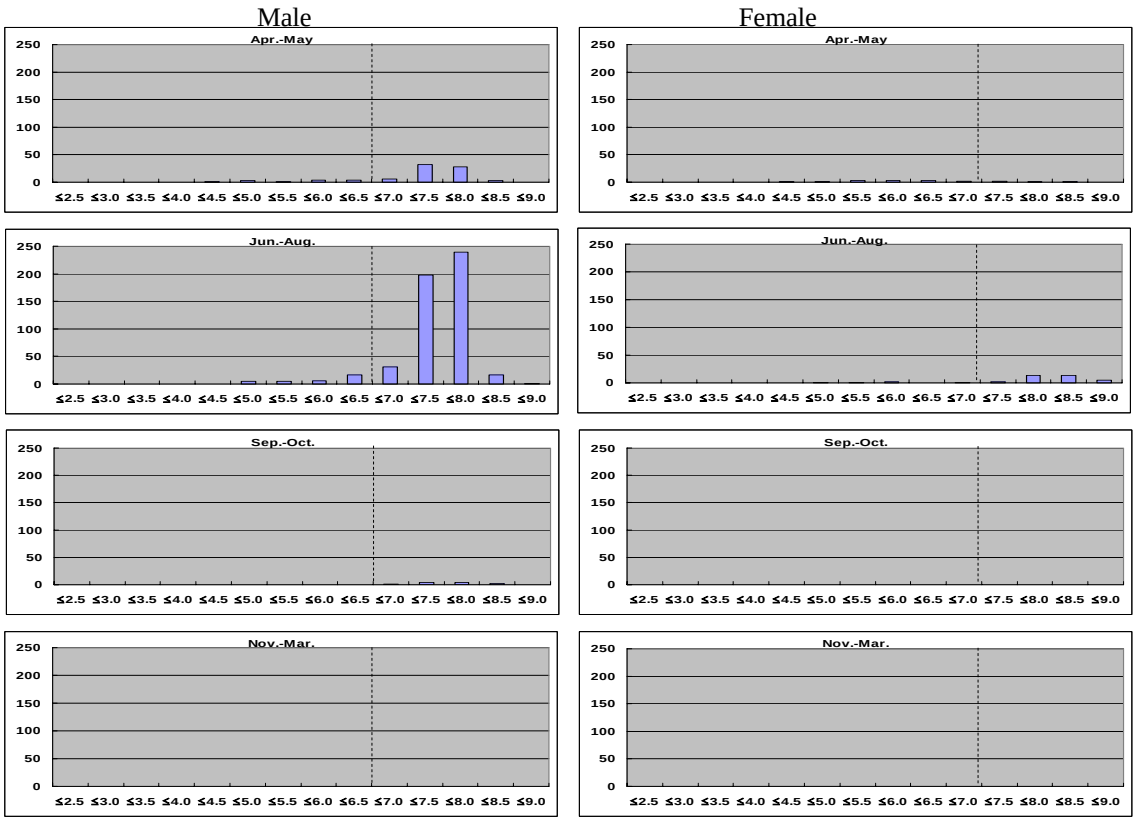

Fig. 13. Length frequency in O stock 7E+8+9-JARPNII.