A hypothesis on the migration pattern of J-stock common minke whales.

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ABSTRACT

A hypothesis on the migration pattern of J-stock common minke whale was proposed at the 61 IWC Scientific Committee meeting (Hatanaka *et al.*, 2010). Here this hypothesis was evaluated in the context of the available information on pattern of mixing between O and J-stocks, sighting distribution,, sea ice condition and by-catch by coastal fishing gear. The proposed hypothesis fix well with the above mentioned information, which was obtained in the Sea of Japan and Okhotsk Sea.

INTRODUCTION

It is well known that there were two stocks of common minke whales, the Okhotsk Sea – West Pacific stock (O-stock) and the Sea of Japan – Yellow Sea – East China Sea stock (J-stock) (Omura and Sakiura, 1956). Kato (1992) reported that the conception date of J-stock was autumn (October-November), while that of O-stock was winter (January-March). Previous studies reported on the peak whaling seasons and possible migration route of the J-stock (Ohsumi, 1983). Gong (2005) hypothesized a migration pattern for J-stock whales. In recent years genetic techniques have been developed and used to allocate individual whales to O and J stocks and also information on by-catch has been accumulated in a more systematic manner in recent years.

A new hypothesis on the migration of J-stock was presented to the 61 IWC Scientific Committee meeting in 2009 (Hatanaka *et al*., 2010). It was based on the information that the breeding season of the J-stock is approximately three month earlier than that of the O-stock. This suggested that the typical winter/breeding-summer/feeding migration pattern of baleen whales could not be applied to J-stock.

In this study the hypothesis proposed by Hatanaka et al. (2010) is examined in the context of the available information on pattern of mixing proportion of O and J-stocks, sighting distribution, sea ice condition and by-catch by coastal fishing gear.

MATERIALS AND METHODS

The Hatanaka *et al*. (2010) hypothesis is characterized as follow:

a. Northward (feeding) migration begins in January – February.

b. Pregnant females migrate into the southern part of Okhotsk Sea in April following the retreat of sea ice.
c. The main feeding season is April – June.
d. Southward (breeding) migration starts in July.
e. Segregation by sex and maturity occurs.
   e-1. Pregnant females migrate to northernmost distribution area.
   e-2. In general, adult animals migrate and distribute in offshore waters in the Sea of Japan.
   e-3.The migration of juveniles is different from adult animals. They stay close to the coasts of Japan and Korea almost all year around.

Various kinds of data have been considered to examine this hypothesis:

1) Mixing proportion of J-stock in sub-area 11 based on mtDNA (Table 1). The mixing proportion was estimated using a Bayesian approach (Punt, 2003), which was previously employed during the *Implementation Simulation Trials* (IST) for North Pacific common minke whales and included estimation of the standard deviations. In these estimations, the haplotype composition of samples from Japanese by-catches in sub-area 6 (Sea of Japan) (n=362) during 2001 to 2007 and that of samples from sub-areas 8 and 9 taken in JARPN and JARPNII surveys (n=690) between 1994 and 2007 were used as representative samples of J and O stocks, respectively.

2) Mixing proportion of J-stock in sub-area 12 based on cookie-cutter shark scars (Miyashita *et al.*, 2010).

3) Sighting survey data
   - Sighting positions in April – June (Figure 1) (Miyashita *et al.*, 2009).
   - Sighting positions in July - September (Figure 2).
   - Estimated length composition of sighted animals (estimated by eye from the vessel) (Figure 3).

4) Sea ice coverage in the Okhotsk Sea (Figure 4).

5) By-catch information
   - Geographical location of by-caught J-stock animals in the coast of Japan, by month (Figure 5).
   - Monthly change in the number of by-caught J-stock animals in the coast of Japan (Figure 6).
   - Length composition of by-caught animals (Figure 3).

The consistency between the hypothesis characteristics (items a. to e. above) and the available data (items 1) to 5) above) was examined.

RESULTS

1. Mixing proportion of J-stock animals in sub-area 11

The mixing proportion of J stock in April is high for both sexes and the proportion of females is extremely higher than males (commercial samples in Table 1). This is consistent with items b and e-1.

The mixing proportion decreases in May (Table 1). This might suggest that J-stock animals disperse widely to the southwest part of the Okhotsk Sea as sea ice melts in May. The alternative explanation is that the lower proportion of J stock reflects an increase of O stock animals in this sub-area.

The mixing proportion of J stock becomes slightly high again in July and August (JARPN samples in Table 1). This might suggest that J stock animals return to sub-area 11 from the southwest part of Okhotsk Sea on the course of breeding migration to lower latitude areas. This is consistent with item d.

2. Scars of cookie-cutter shark

The analysis of shark scars (Miyashita *et al*., 2010) showed that the proportion of J stock animals is zero in July – August in Sub-area 12. This coincides with item d.

3. Sighting distribution

Common minke whales are distributed widely in the whole Sea of Japan in April to June (Figure 1). This supports item c.

Common minke whales in the Sea of Japan are less frequent in July-September than in April – June (Figure 2). Density (number of sighting per 100 nautical miles) is one third of that in April – June (0.49 versus 1.49). This supports items c and d.

Although estimate of body length by eye from the vessel is not precise, Figure 3A suggests that most of the sighted animals are adult (larger than 6.5 m). Sightings are distributed in offshore waters (Figures 1 and 2). This supports item e-2.

4. Sea ice coverage in the Okhotsk Sea

Sea ice covers the southwest part of the Okhotsk Sea and the La Perous Strait was closed in March (Figure 4). Therefore J stock animals can not get into the Okhotsk Sea in March. Then the Strait opens in April and sea ice apart slightly from the north coast of Hokkaido and southeast coast of Sakhalin. Therefore the distribution of J stock animals should be restricted to these coastal areas in April. Then they disperse into the southwestern part of Okhotsk Sea following the retreat of the sea ice, but probably they can not reach the north part of the Sea. It is said that large whales can not pass the Tatarskij (Mamiya) Strait between the continent and Sakhalin Island. This supports item b.

5. By-catch information

J stock animals are caught in coastal areas of Japan (Figure 5) though catch are fewer in some months especially in September. This supports item e-3.

Monthly number of by-catch shows that animals occur through all year (Figure 6). There is a peak in January, which coincides with item a. The reason of a decrease in the number of by-caught animals in September and October is unknown. However these months correspond to the breeding season of this stock.

Most of by-caught animals are juvenile of 3-5.5 m (Figure 3). This supports item e-3.

DISCUSSION

The hypothesis proposed by Hatanaka et al. (2010) is supported by the various kind of available data from the Sea of Japan and Okhotsk Sea. There is a possibility that more than one sub-stock exist within the J-stock (Kanda *et al*., 2010). The hypothesis treated here is regarding large-scale migration and may not applicable to resident group in the Yellow Sea. The feeding migration route is schematically shown in Figure 7 for adults and Figure 8 for juveniles. Breeding migration is assumed to be the reverse in the case of adults. There are two possibilities of juveniles, one is that they migrate from coastal area to adults' feeding area when they grow and the other is that they return to breeding area once and then migrate to adults' feeding area.

Although there is no direct information on the breeding area, it is supposed to be in the East China Sea as juveniles are distributed along the Pacific coast of southwest Japan, because the movement through the Kanmon Strait and Seto

Inland Sea from the Sea of Japan is not plausible as by-catch is seldom reported within the Seto Inland Sea.

In general the typical migration pattern of baleen whales is that the feeding migration starts in spring and return to breeding area in autumn (breeding in winter). However in the case of J stock a different migration pattern is assumed as they appear to be autumn breeders. This unusual pattern might be caused from the closing and openings of Sea of Japan in the past ice age. It was suggested that the divergence time of the J and O stocks was 0.14 Ma (Pastene *et al*., 2007) which was much older than the opening of Sea of Japan after the last glaciation some 10 thousands years ago. Therefore, the two stocks might have used different refugia around the area while closing, that prevented them from interbreeding, and only the J stock subsequently entered Sea of Japan. Although its peak is different from each other, the conception dates are actually variable within the stocks (Kato, 1992). That variation could have also existed at the past. The breeding season of the J stock could have shifted forward since then, due to the whales' adaptation to the environments in Sea of Japan.

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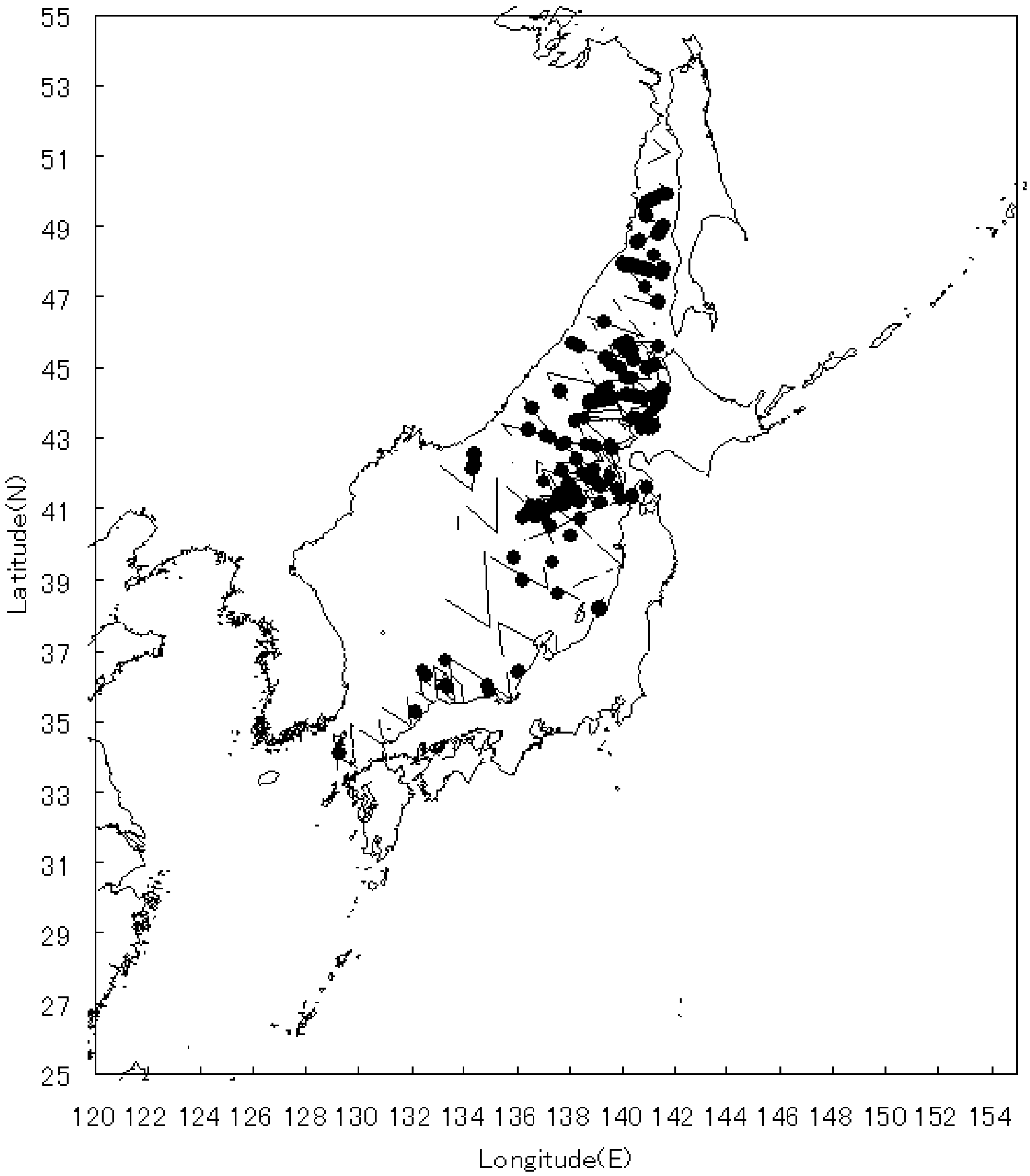


Figure 1. Sighting positions (black circle) of common minke whales in the Sea of Japan with track line on effort indicated. Data from six Japanese cruises in April to June between 2003 and 2007

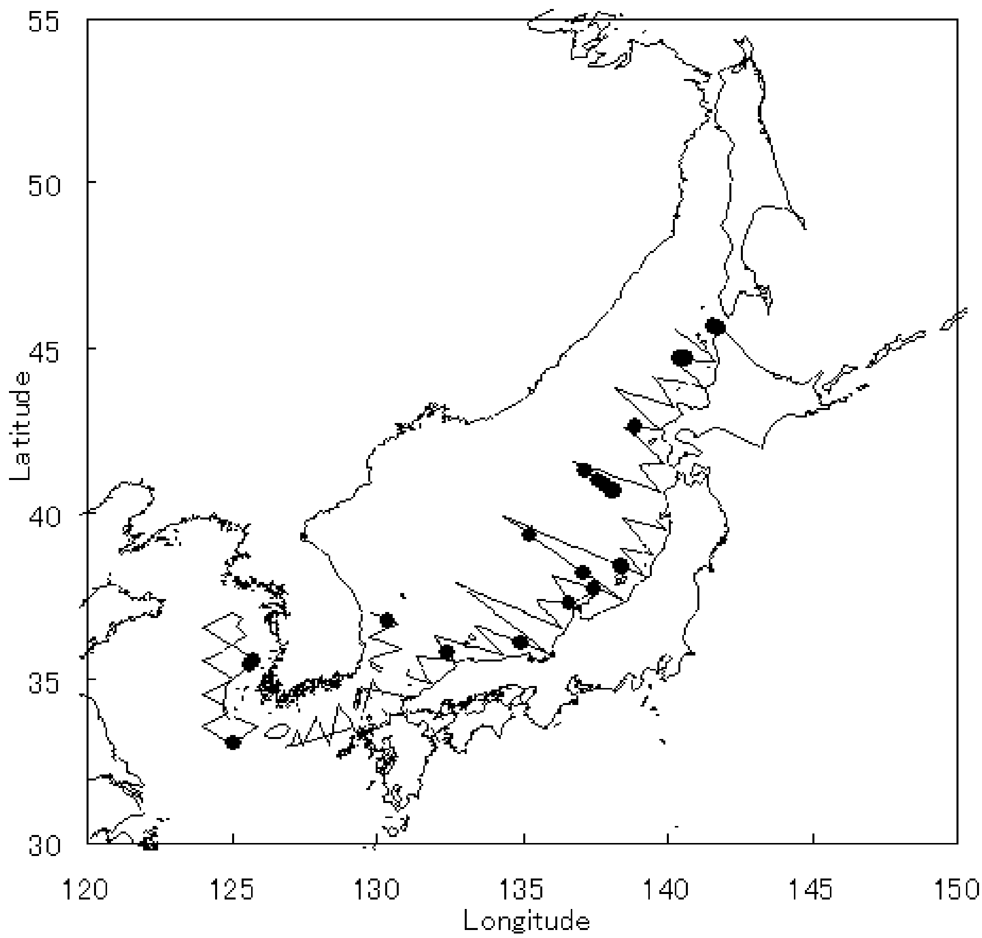
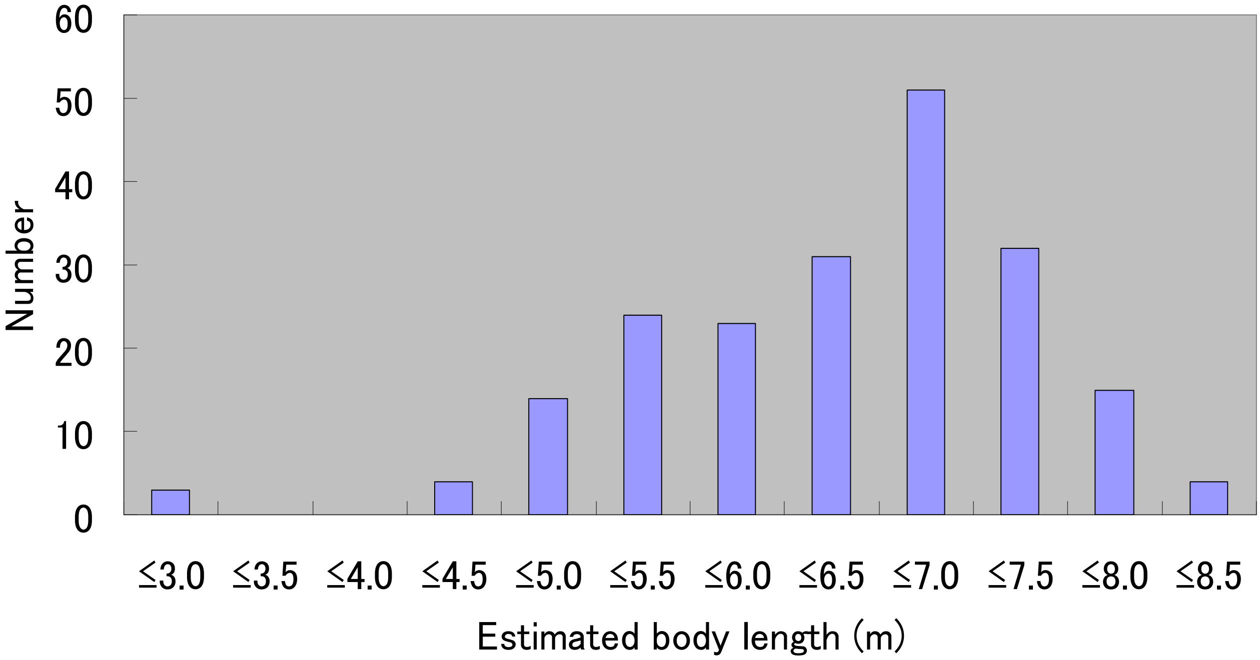
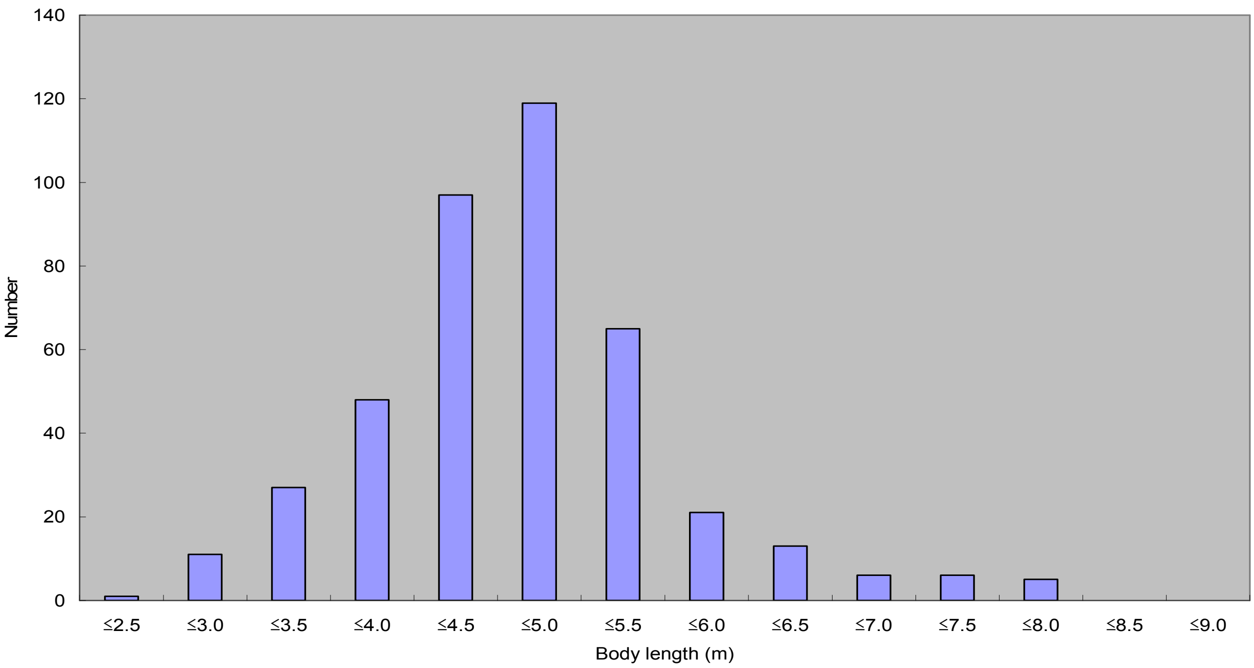


Figure 2. Track line on effort in July – September and sighting positions of common minke whales. Data from *Toshimaru No.25* in 1988 and *Shunyo-maru* in 1994

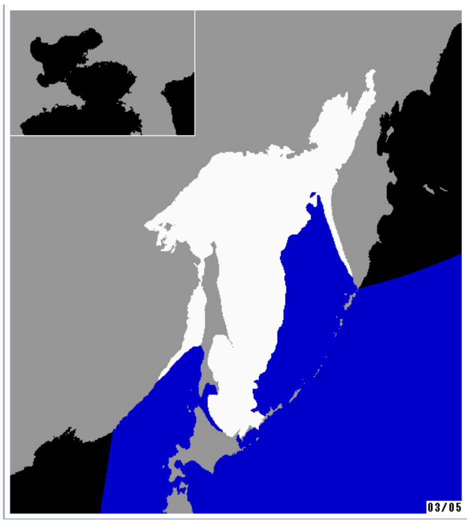


A ： Animals sighted during the sighting surveys (n=201).



B: By caught animals (n=419)

Figure 3. Body length composition of animals sighted during sighting surveys (A) and by-caught animals (B) in the Sea of Japan



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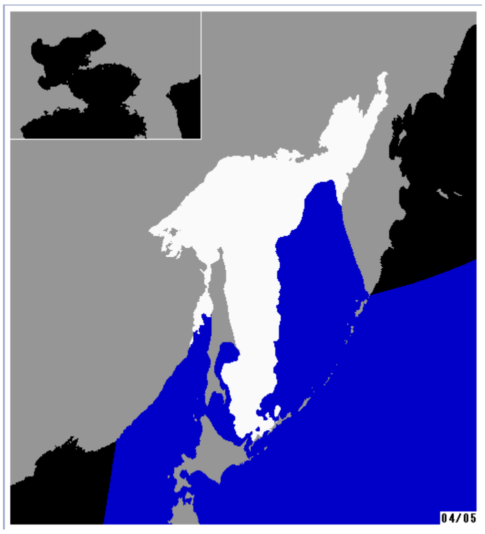

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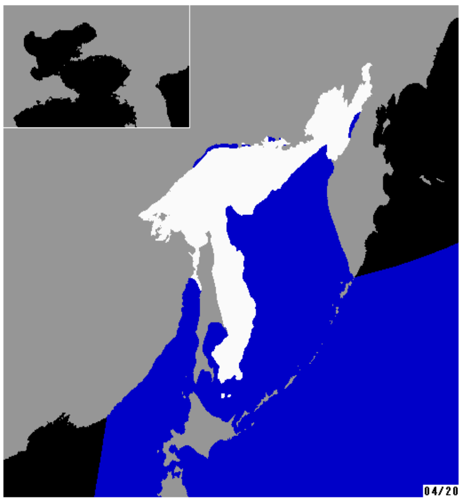

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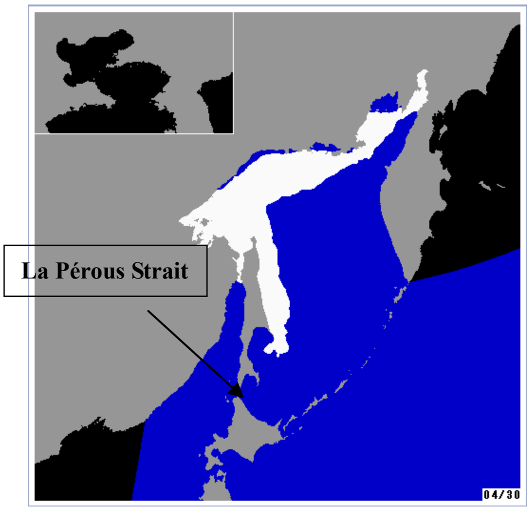
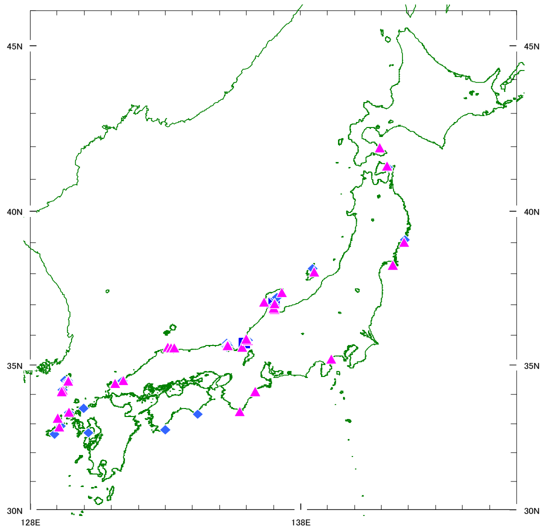


30 April

Fig. 4. Average sea ice coverage in the Sea of Okhotsk during 1971 to 2000.
From the website of the Japan Meteorological Agency
(http://www.data.kishou.go.jp/kaiyou/db/seaice/okhotsk/okhotsk_normal.html).



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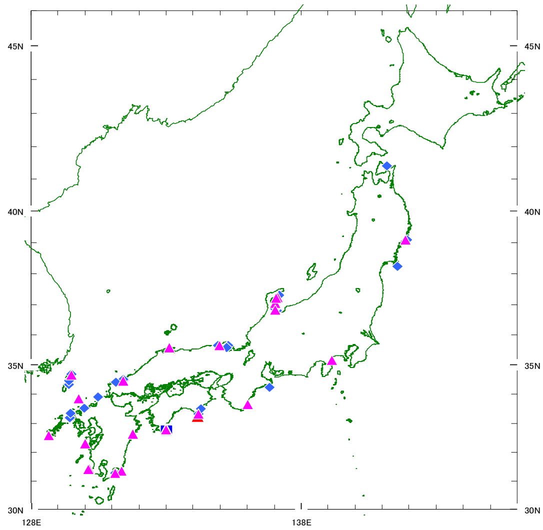

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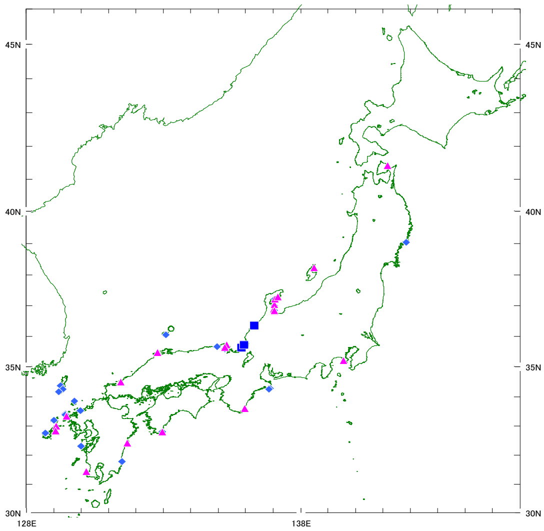

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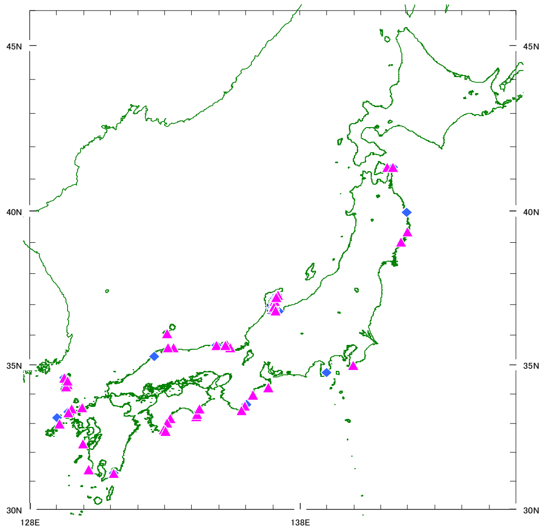

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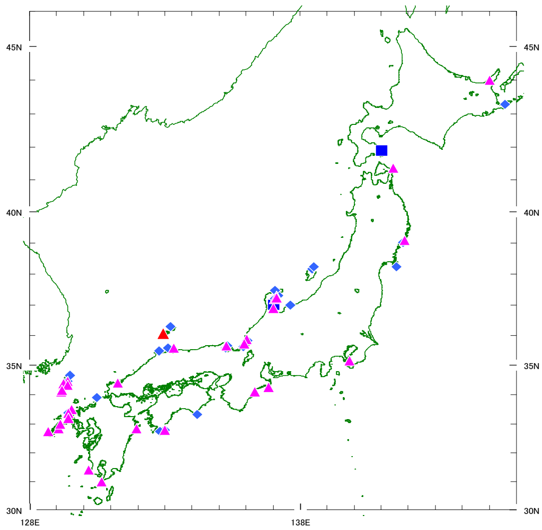

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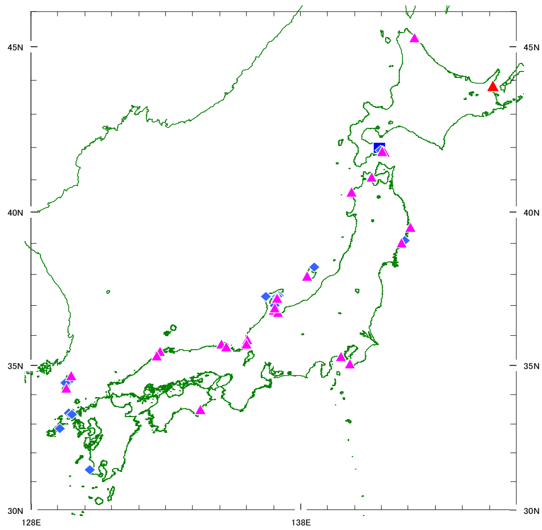

June

(Fig. 6. continued)

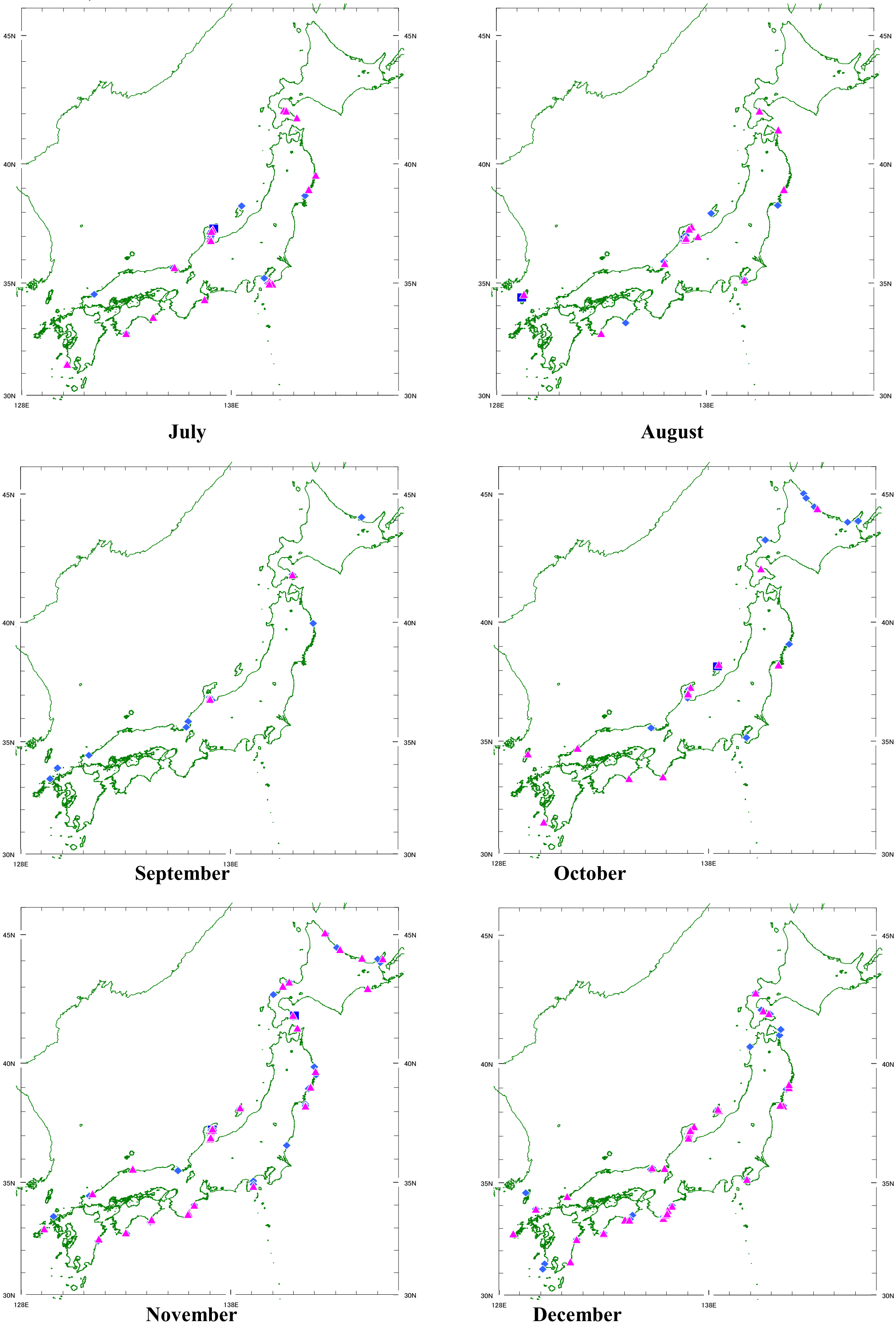

Figure 5. Geographical distribution of by-caught animals, by month. Stocks were indentified using microsatellite DNA. Pink triangle: Female less than 6m, red triangle: Female more than 6m, light blue rhomb: male less than 6m and blue square: male more than 6m.

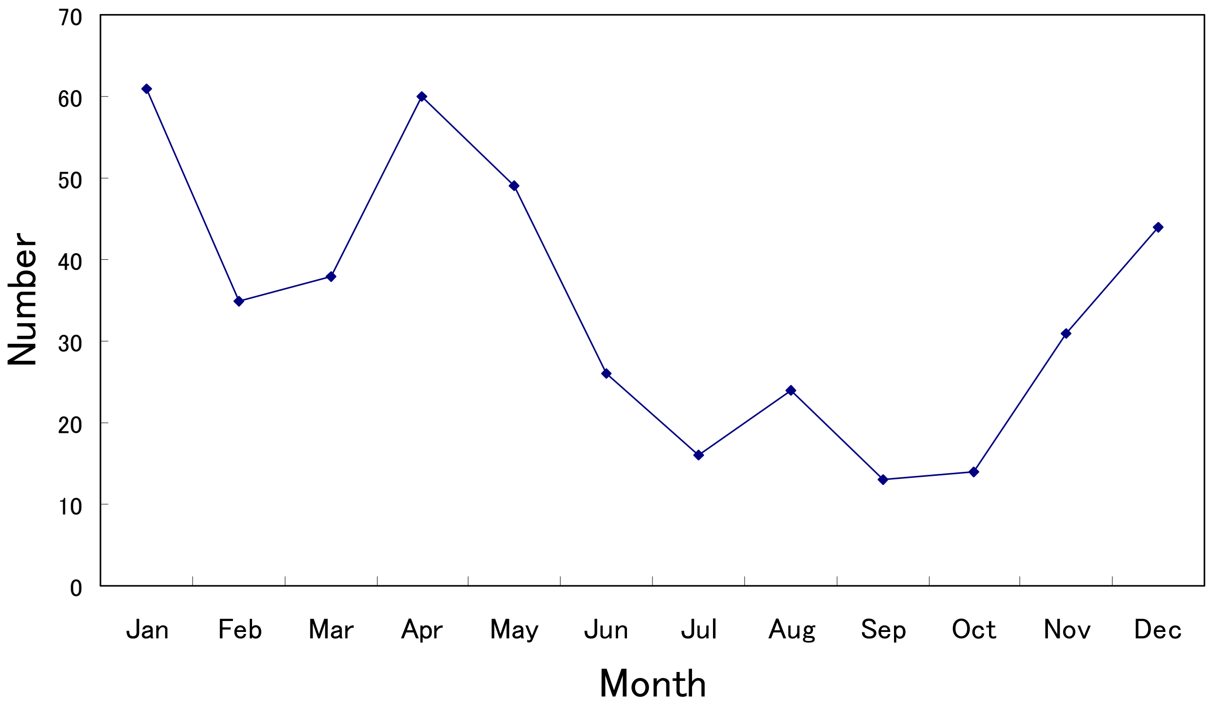

Figure 6. Number of by-caught of J-stock animals by month in sub-area 6

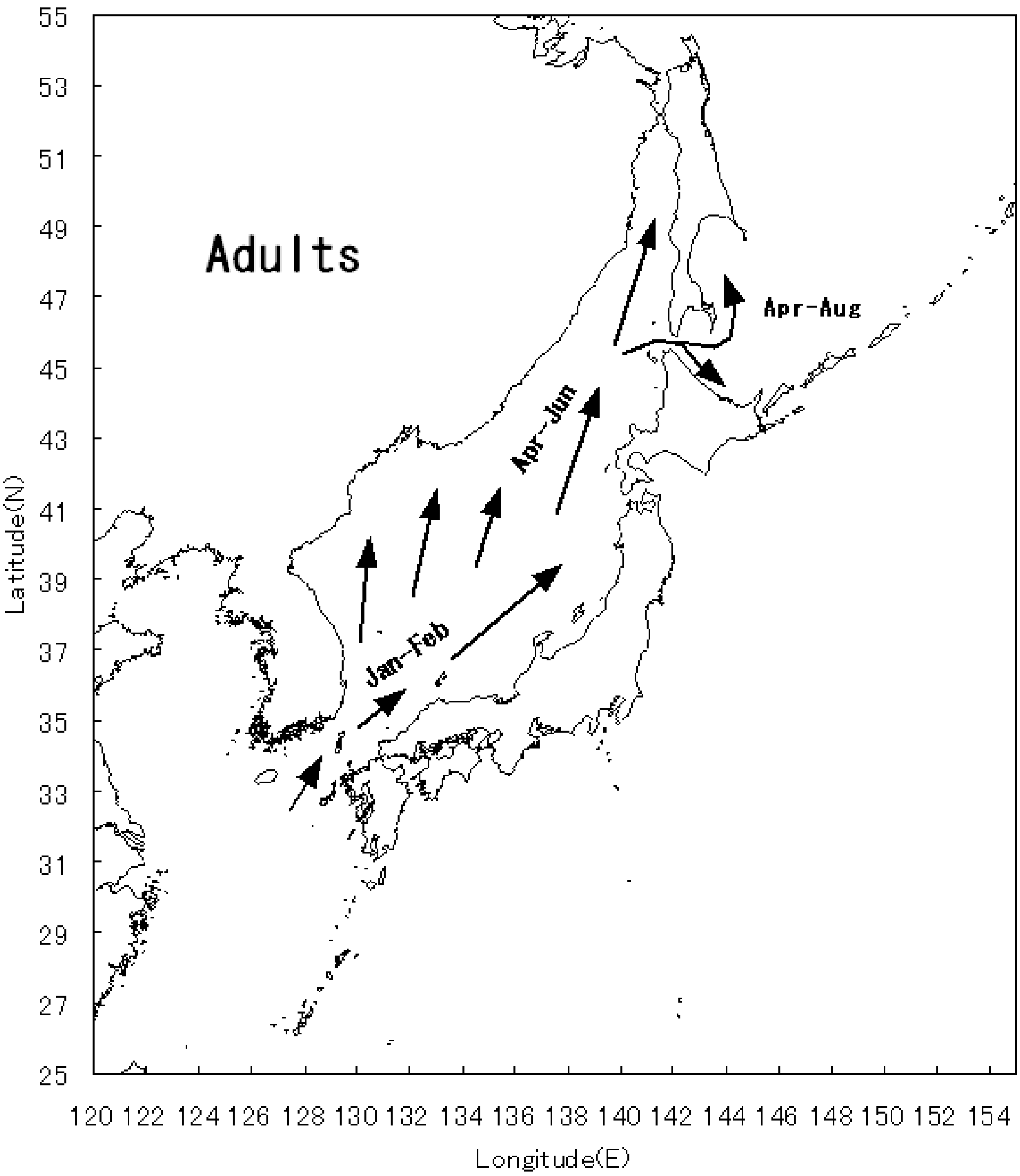

Figure 7. Assumed feeding migration route of adult J-stock animals

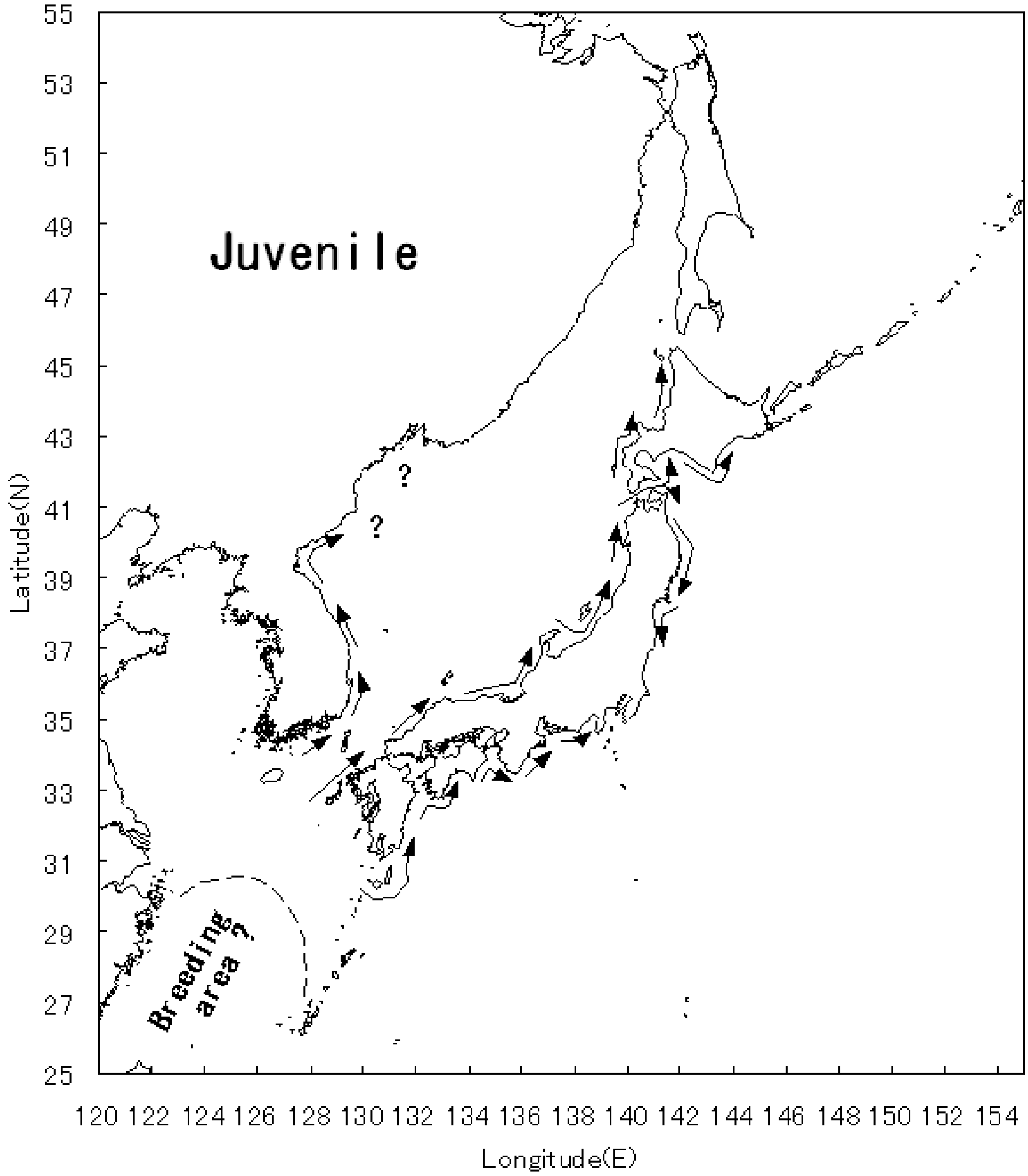

Figure 8. Assumed feeding migration route of juvenile J-stock animals

Table 1. The mixing proportion of the J stock in SA11 based on mtDNA data obtained from samples of past commercial whaling, JARPN, and bycatches.

Sample source	Period	N	Mix. Prop.	S.D.
Commercial whaling	**1983-1987**			
Female				
April		**53**	**0.645**	**0.066**
May		**51**	**0.055**	**0.036**
June		**24**	**0.263**	**0.086**
July		**2**	**0.253**	**0.196**
August		**5**	**0.143**	**0.124**
September		**2**	**0.257**	**0.199**
Male				
April		**2**	**0.747**	**0.196**
May		**14**	**0.125**	**0.080**
June		**9**	**0.092**	**0.084**
July		**2**	**0.250**	**0.194**
August		**3**	**0.204**	**0.167**
September		**4**	**0.167**	**0.141**
JARPN				
Female				
July	**1999**	**22**	**0.453**	**0.103**
August	**1996**	**11**	**0.137**	**0.097**
Male				
July	**1999**	**27**	**0.219**	**0.079**
August	**1996**	**18**	**0.441**	**0.112**
By-caches				
Female and male	**2001-2007**	**11**	**0.921**	**0.073**

N = sample size, S.D. = standard deviation