Estimation of mixing proportion of O/J common minke whales in sub-area 12 using cookiecutter shark scar as ecological marker

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ABSTRACT
Using cookiecutter shark scars as ecological marker observed from the research vessel, the mixing proportion of O and J stocks in the Sea of Okhotsk was estimated using maximum likelyhood method. During the sighting and biopsy sampling survey conducted in 2009, cookiecutter shark scar was confirmed using a high resolution digital camera from all targeted animals (22 animals). Information on the proportion of animals with scars with stock identification in the population was obtained from the past research takes in the sub-area 11 in 1996 and 1999. Using these data, the proportion of J stock was estimated as 0 % in the sub-area 12.

Introduction

Cookiecutter shark is a species of small dogfish shark occurring in warm, oceanic waters. They inhabits all of the world's major tropical and warm-temperate oceanic basins, the cookiecutter shark is most common between the latitudes of 20ºN and 20ºS, where the surface water temperature is 18-26ºC (Ebert, 2003). The name "cookiecutter shark" refers to its feeding habit of gouging round plugs, like a cookie cutter, out of larger animals. It spends the day at a depth 1-3.7 km and at night they rises up the shallow waters at night to feed. Marks made by cookiecutter sharks have been found on a wide variety of marine mammals. Bite scars made by cookiecutter shark shows that the animals migrates in the common habitat of cookiecutter sharks in major tropical warm-temperate waters where is the wintering and breeding grounds for migratory marine mammals including common minke whales.

Fujise *et al.* (2001) reviewed the relationship between genetically identified O or J stock animals and occurrence of scars, based on samples of common minke whales taken by JARPN. They showed high correlations between occurrence of scar and each stock determined by genetic data. Goto *et al.* (2009) furthermore examined the observation of scars between JARPN II (2002-2007) and they showed assignments using the number of scars were not a full diagnostic for the minke whales of J and O stocks, but at least there was a strong likelihood that animals which have no scars on the body were immature J stock animals. An they also pointed out that significant differences were found between mature and immature animals within both stocks in the number of scar. In this study, using cookiecutter shark scars observed during the sighting survey as ecological markers, the proportion of O and J stocks of common minke whales in the Sea of Okhotsk was estimated.

Materials and method

Observation method of cookiecutter shark scars on the research vessel is shown in Yoshida and Kanaji (2010). They used the high resolution digital camera and confirmed the presence of scars on the dorsal side of common minke whales during the sighting and biopsy sampling survey in the Sea of Okhotsk in 2009 summer.

During the JARPN project in the sub-area 11 in 1996 and 1999, the cookiecutter shark scars were recorded for each animal (Fujise et al., 2001). Those animals were allocated to each stock based on the mtDNA data by Goto.

Therefore the proportion of animals with scars in the population were estimated from the observation during these JARPN projects.

The proportion of the O/J stocks in the field was estimates as follows:

$P(S) = P(S|J)P(J) + P(S|O)P(O)$

where P( ) is the probability,

S is event that the animal has cokkiecutter shark scar on the dorsal side,

J is event that the animal is in J stock,

O is event that the animal is in O stock.

Because $P(J) + P(O) =1$ then

$P(J) = (P(S) – P(S|O)) / (P(S|J) – P(S|O))$

$P(O) = 1 – P(J)$.

Those can be estimated by maximizing the likelihood

$L = n_s \, ln\{P(S|J) P(J) + P(S|O) (1- P(J)) + n_w \, ln\{1- (P(S|J)P(J) + P(S|O)(1-P(J)))$

where n_s is number of animals with scars, n_w is number of animals without scars in the field.

Results and discussion

During the 2009 sighting and biopsy survey, a total of 46 schools of 48 animals were found and 22 animals were tried to be closed and the scar observation were tried. Scars were identified clearly using a digital camera during the 2009 Okhotsk sighting and biopsy survey (Fig. 1). The positions of animals with scars were widely distributed in the research area (Fig. 2). In the 22 animals observed, all of the animals were identified to have scars (Yoshida and Kanaji, 2010). Therefore P(S) is assumed to be one.

The proportion of the animals with scars by stock in the sub-area 11 are shown in Table 1. The positions of scar occurrence has three categories, such as, only dorsal side, only ventral side and both sides. The number of scars was counted for each animals. Because the scars were observed for the dorsal side only from the research vessel in the field, the proportion of animals which has scars on the dorsal side is comparable for this study. In the 23 J-stock animals, the 13 animals have scars on the dorsal side and 10 animals with no scars on the dorsal side, then the P(S|J) was assumed as 57%. In the 49 animals identified as O-stock, all had scars on the dorsal side, then the P(S|O) is assumed as 100%. (Table 2).

Using all informatin, the maximum likelihood estimation of P(J) and P(O) are 0 and 1, respectively. This means that the animals observed in the research area in 2009 are assumed to affiliated with the O-stock.

The estimated body length of 22 animals with scars in the 2009 survey ranged from 5.2 m to 8.4 m and the composition are 5m range four animals, 6 m range four, 7 m range nine and 8 m range five animals. In these animals, 5.2 m animals (two animals) had only one scar, but those are clearly identified (Fig. 2). Goto et al. (2009) pointed out that immature J-stock animals has no scar on the body at all, then the minimum size animal observed in the 2009 survey (5.2 m) with scar was not J-stock animal and they belonged to O-stock with highly likelihood.

In the last RMP/IST, the proportion of J-stock animals in the Sea of Okhotsk (sub- area 12SW) was estimated using the flipper color pattern and the conception date (IWC, 1997). The proportion of J-stock were 0.278 in June, 0.041in July and 0.046 in August. Considering the research season in 2009 to be in July and August, the present estimation value (0% J-stock) was not so different from those in the last RMP/IST. The last values are based on

the dead animals and can not be obtained during the sighting survey. To estimate the proportion, it is reasonable by DNA analysis from the skin sample obtained by biopsy. However, in 2009, it is prohibited to import the biopsy samples from the Russian EEZ because of the difference of recognition on export/import permission between Japan and Russia (Yoshida and Kanaji, 2010). Therefore the cukkiecutter shark scar as ecological markers is only useful tool for estimation of the proportion from the observation on the sighting survey in the Sea of Okhotsk including the Russian EEZ at this stage.

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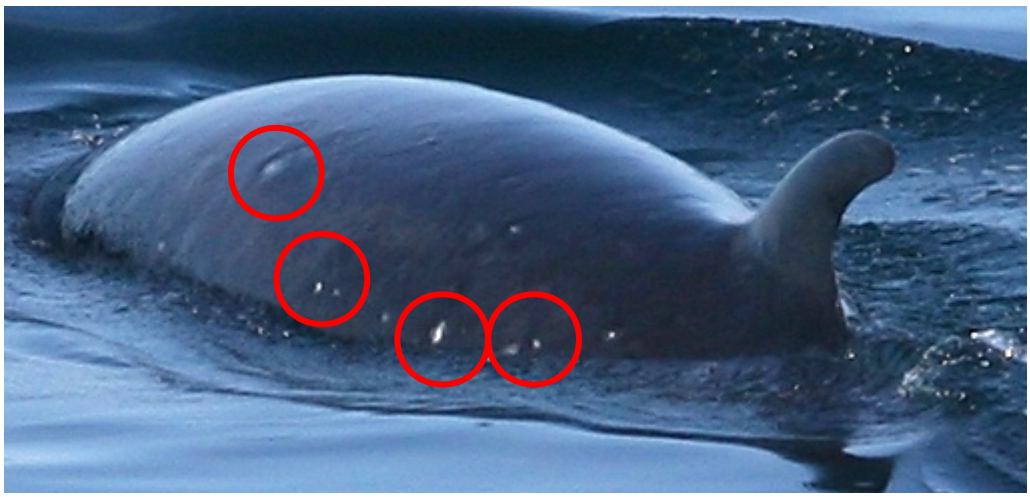

Fig. 1. Example of cokkiecutter shark scar observed on the dorsal side during the sighting and biopsy sampling survey in the Sea of Okhotsk in 2009.

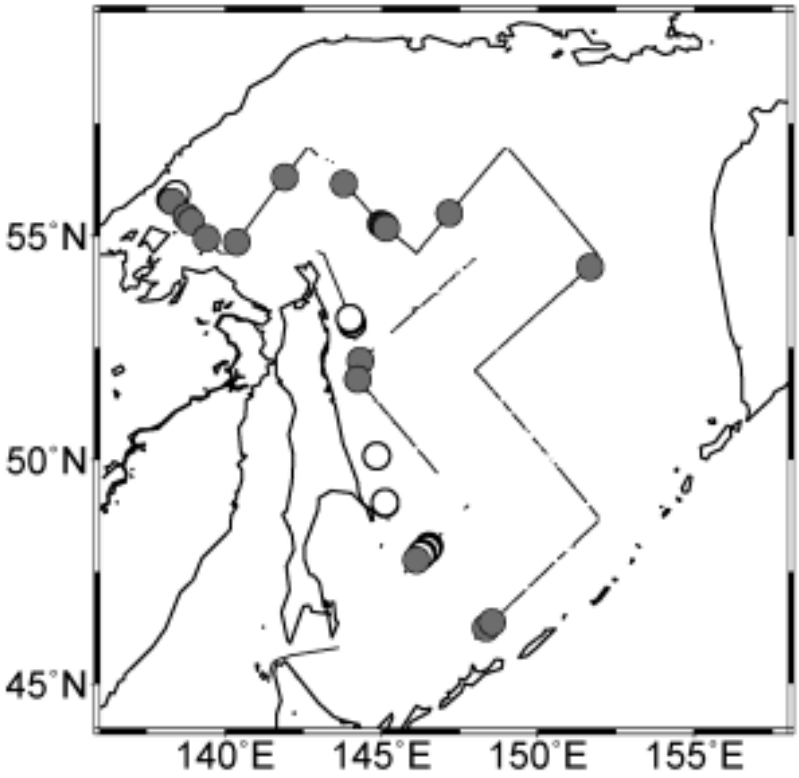

Fig. 2. Sighting positions of the common minke whales with scars.
All animals observed (black circle) have scars. White circle shows animals without trying of observation. Line shows the track line on effort.

Fig. 3. The animals with one scar. The estimated length was 5.2 m for each animal.

Table 1. Number of animals with cokkiecutter shark scars observed during the JARPN project in the sub-area 11 in 1996 and 1999. Stock identification was based on the mtDNA analysis.

Stock	Animals with scars (%)				No scars	Total
	Dorsal side only	Ventral side only	Both sides	Sub-total		
J	2 (8.7)	2 (8.7)	11 (47.8)	15 (65.2)	8 (34.8)	23 (100)
O	0 (0)	0 (0)	49 (100)	49 (100)	0 (0)	49 (100)

Table 2. Percentage of scars observed on the dorsal side during the JARPN project in the sub-area 11 in 1996 and 1999.

Stock	Results of dorsal side observation number (%)		Total
	With scars	Without scars	
J	13 (56.5)	10 (43.5)	23 (100)
O	49 (100.0)	0 (0)	49 (100)