

SEGREGATION OF TWO FORMS OF SHORT-FINNED PILOT WHALES OFF THE PACIFIC COAST OF JAPAN*

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ABSTRACT

Two forms of the short-finned pilot whale are known off the Pacific coast of Japan. The northern form, having larger body size, distinct saddle mark and round contour of the head seen from the top, inhabits the coastal waters between fronts of the cold Oyashio Current and warm Kuroshio Current, or 12°–24°C in surface water temperature and 35°–43°N in latitude. The southern form, having smaller body size, indistinct saddle mark and square shaped contour of adult male head, is known from wide range of the coastal and offshore waters south of the Kuroshio Front (over 18°C and south of 39°N) with some degree of possible density gap within the range. Their geographical ranges may occasionally overlap in the boundary area, but mixed schools of two forms are believed to be very rare. The geographical and social segregation, individually identifiable morphological differentiation, and similarity in their life history characteristics suggest that they can be dealt as separate subspecies or local stocks of the short-finned pilot whale. Although north/south segregation of the corresponding forms might exist in the eastern North Pacific, current information is insufficient for further consideration.

INTRODUCTION

Yamase (1760) described two kinds of pilot whales off Taiji on the Pacific coast of central Japan, the one *Shiho goto* was larger and had white dorsal patch, and the other *Naisa goto* was smaller and had no dorsal mark. Gray referred similar distinction for Japanese pilot whales, and named his *Naisa gota* (appeared in his 1846 and 1866 papers) or *Naisa goto* (in his 1846 paper) as *G. sieboldii* Gray, 1846 and *Shibo golo* (in 1846, 1866 and 1871 papers) as *G. sibo* Gray, 1871. The minor difference in the spelling is not important. The *Ohnan goto* of Yamase (1760) and Gray (1866) is now considered to represent the false killer whale *Pseudorca crassidens* (Owen, 1846). Recent Japanese whalers who hunted pilot whales also distinguished two pilot whales *Tappa-*

* Early version of the manuscript was submitted to the 38th annual meeting of the Scientific Committee of the International Whaling Commission in Bournemouth in May 1986 with document no. IWC/SC/38/SM12.

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naga (=having long flipper) off northern Japan and *Ma-gondo* (=common pilot whale) off central and southern Japan. Since the last century this caused confusion for Japanese whale taxonomists, and caused the use of various scientific names as reviewed by Hawley (1960) and Kasuya (1975).

Nishiwaki, Kasuya, Brownell and Caldwell (1967) examined pilot whale skulls taken off Izu coast (34°30'N) and Taiji (33°35'N) to find that the pilot whales off the Pacific coast of central Japan which was called by the vernacular name of *Ma-gondo* and had been considered to represent *Globicephala melaena* (Traill, 1809) was actually *G. macrorhynchus* Gray, 1846. Kasuya (1975) examined statistics of pilot whale catch by Japanese small-type whaling and the skulls taken by the fishery off the Pacific coast of northern Japan, found that all the specimens examined by him possessed characteristics of rostral region of *G. macrorhynchus* described by Bree (1971), and concluded, acknowledging the possibility of presence of some local stocks, that *G. macrorhynchus* is the only confirmed member of recent pilot whale fauna in the western North Pacific. Although *G. melaena* survived in the northern Sea of Japan till the 12th century and the current existence was not fully denied (Kasuya, 1975), no supporting evidence was collected after the study and there was accumulated indications suggesting the absence of *G. melaena* in the Bering Sea and northern North Pacific (see below).

In 1982, some of the Japanese small-type whalers resumed harvesting pilot whales off the southern part (38°N to 40°N) of the Sanriku region (Pacific coast of northern Japan between 38°N to 41°30'N) as reviewed by Kasuya and Tai (1986), and some of the catch were examined by Miyazaki (1983). He reported that two kinds of pilot whales were taken in the season. The one (southern form of this study) was a type that was common off the Pacific coast of central and southern Japan (Izu and Taiji) and studied by Nishiwaki *et al.* (1967), Yonekura, Matsui and Kasuya (1980), Kasuya and Matsui (1984), Kasuya and Marsh (1984) and Marsh and Kasuya (1984). The other (northern form of this study) was new to him. Although, both forms shared skull characteristics of *G. macrorhynchus* described by Bree (1971), the latter was easily distinguished from the former by distinct saddle mark and larger body size (Miyazaki, 1983; Kasuya, 1986b).

In the present study, we analyze distribution and segregation of the two forms of short-finned pilot whales using sighting records in the western North Pacific collected since the finding of Miyazaki (1983), and some additional records of previous sightings, some of which are identifiable to two forms based on photographic or other records.

MATERIALS AND METHODS

Identification of two forms

The short-finned pilot whale identified in this study as "northern form" represents those being recognized by Japanese whalers as *Tappa-naga*, and its

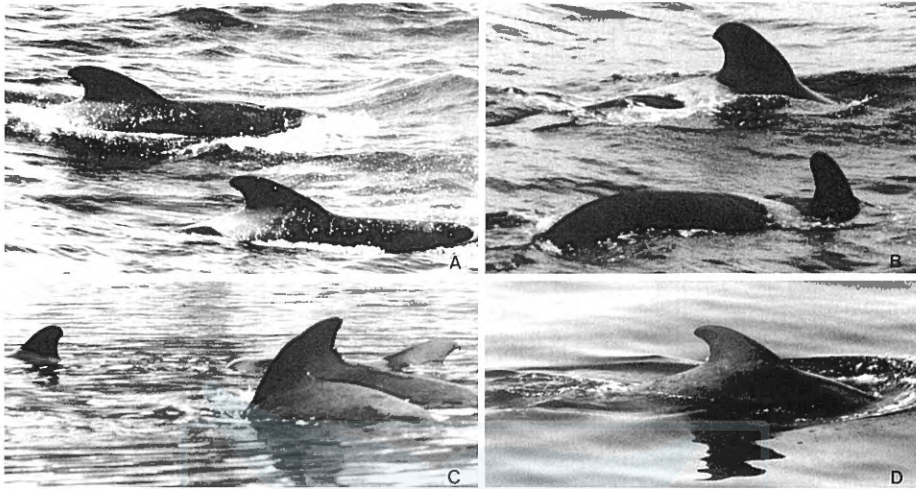


Fig. 1. Difference of saddle mark between the two forms of short-finned pilot whales off the Pacific coast of Japan. A and B: northern form, C and D: southern form.

counterpart “southern form” represents *Ma-gondo* of the whalers. Compared with the southern form, the northern form has larger body by about 1 m (female) to 2 m (male) (Kasuya, 1986) and round contour of head viewed from the above. Adult males of the southern form has square shaped head (Yonekura, Matsui and Kasuya, 1980). The dorsal fin of adult males of the northern form tends to be narrower than that of the southern form, but the difference is indistinct. Miyazaki (1983) reported slight difference in the flipper length (longer in the northern form).

The saddle mark of the northern form is usually more light varying in color from pure white to very light grey, and that of the southern form is grey or dark grey and almost unrecognizable on the carcass (Yonekura, *et al.*, 1980). However, the absolute brightness is an inferior cue especially for the ship board observers because its visual character changes by weather condition, direction of sun, and depth of whales in the water. The eye patches are slightly more bright in the northern form, but they are indistinct and are not suitable for the identification purpose. The size of saddle mark is variable among northern form individuals.

The best external characteristics that separate the two forms are not the size or brightness of the saddle mark, but the direction and distinctness of the posterior boundary of the saddle mark (Fig. 1). On the northern form the posterior boundary of the saddle mark is clearly bounded by the posterior black area of the body and directed antero-ventrally, and additionally the saddle mark does not extend posteriorly beyond the level of anus but extend anteriorly usually beyond the level of posterior margin of the dorsal fin. On the southern form, however, it extends posteriorly to the mid-length of tail

TABLE 1. LIST OF CRUISES CONDUCTED BY THE JAPAN FISHERY AGENCY AND USED TO COLLECT DATA IN FIG. 2 OF THIS STUDY

Name of vessel	Year	Month	Pilot whale sightings*	Reference for cruise track line
Konanmaru No. 25	1982	1-3	present	Miyashita (1986b)
Toshimaru No. 15	1983	1-3	absent	Miyashita (1986b)
Toshimaru No. 15	1984	1-3	present	Miyashita (1986b)
Toshimaru No. 15	1985	1-3	absent	Miyashita (1986b)
Toshimaru No. 25	1986	5-6	present	Miyashita and Kasuya (1987)
Shonanmaru	1983	6-7	present	Miyashita (1985)
Toshimaru No. 25	1983	6-8	present	Miyashita (1985)
Shonanmaru	1984	6-8	absent	Miyashita (1986a,b) Kasuya (1986a)
Toshimaru No. 25	1984	6-9	present	Miyashita (1986a,b) Kasuya (1986a)
Toshimaru No. 25	1985	6-9	present	Miyashita (1986b)
Toshimaru No. 18	1986	6-9	present	Miyashita and Kasuya (1987)
Shonanmaru	1985	7-9	present	Miyashita (1986b)
Toshimaru No. 15	1985	9-10	absent	Miyashita (1986b)
Toshimaru No. 15	1986	9-10	present	Miyashita and Kasuya (1987)
Kankimaru No. 58	1986	9-10	present	Miyashita and Kasuya (1987)

* Pilot whale sightings in the area indicated in Fig. 2.

peduncle. The posterior and ventral boundaries of the saddle mark of the southern form gradually fades into the black body color making it difficult to define the boundary. The saddle marks of live pilot whales in Figs 1 and 2 of Plate I in Yonekura *et al.* (1980) are now clear to represent those of northern forms, but other photographs of the carcasses and a drawing in text-Fig. 2 of their study represent the southern form.

Using above criteria, Kasuya (1986b) could identify all the postnatal northern forms used in his study (about 300 individuals over 1.5 years old), and found no individuals that could be considered as intermediate of the two forms of the short-finned pilot whale. However, none of the four full term fetuses of northern form (165 to 185 cm in body length) had recognizable saddle mark (Kasuya, unpublished) and the distinction of the two forms appeared to be difficult except for the larger body size of the northern form (Kasuya, 1986b). This suggests that the distinction of two forms by the saddle mark becomes possible at an age between 0 and 1.5 years or well before the mean age at weaning 2.4–3.1 years (Kasuya, 1986b), which causes no difficulty in the identification of northern form schools.

Source of sighting data

Main body of the data used in this study was the results of whale sighting cruises conducted by Japan Fishery Agency in 1982 through 1986 (Table 1).

TABLE 2. DALL'S PORPOISE SIGHTINGS AND HARPOONING CRUISES IN THE WESTERN NORTH PACIFIC AND BERING SEA, WHICH PROVIDED INFORMATION ON PILOT WHALE DISTRIBUTION FOR THE PRESENT STUDY

Name of vessel	Year	Month	Pilot whale sightings	Reference for cruise track line
Hoyomaru No. 67	1979	6-8	none*	Miyazaki, Jones and Beach (1984)
Hoyomaru No. 12	1982	8-9	2 schools off Japan	Kasuya and Ogi (1987)
Hoyomaru No. 12	1983	8-9	none	Kasuya and Ogi (1987)
Hoyomaru No. 53	1984	5-6	none	Miyazaki and Fujise (1985)
Hoyomaru No. 12	1985	8-9	none	Kasuya and Ogi (1987)
Hoyomaru No. 12	1986	8-10	present	Yoshioka <i>et al.</i> (1987)

* Personal communication of Dr N. Miyazaki.

In these cruises the sighting of whales was conducted along pre-fixed track line using the method that had been used in the Antarctic minke whale assessment cruise (Best and Butterworth, 1980), and all the marine mammal sightings were recorded. The trackline was designed systematically to cover evenly the survey area. Instruction was given since 1984 to biologist on board or to captain of the vessel to distinguish the two forms of short-finned pilot whales and to take photographs of those individuals for later confirmation. Some additional photographs or sketches were left by observers of earlier cruises at voluntary base.

Additional information was available from published reports of five cruises conducted by Japan Fishery Agency for Dall's porpoise sightings and harpooning in the western North Pacific (Table 2). Among these cruises pilot whales were sighted only during the 1982 and 1986 cruises, but information obtained from other cruises was also valuable as the indication of absence of pilot whales in the surveyed area. Biologists were on board of these five cruises.

In addition to above cruises, sightings data collected during 4 cruises of the *Hakuhomaru* and 4 cruises of the *Tanseimaru* (both were conducted by the Ocean Research Institute, University of Tokyo), and each cruise of the *Hayachinamaru* and *Koeimaru* were used. These cruises (conducted in 1967 to 1985) were selected from many other similar kind of cruises by the presence of at least one pilot whale sighting. Kasuya or some trained observers were on board of these cruises to collect records of whale sightings. Two schools of the northern form and one school of unidentified form were cited from Ogi (pers. comm in 1985) and Kuroda (1956), respectively. Some of these sightings were identified to the whale types using photographs.

Catch of drive fisheries or of small-type whaling in Kasuya and Marsh (1984) or in Kasuya and Tai (1986) were used as well as a stranding in Kasuya and Marsh (1984) as the indication of occurrence of the species.

The surface water temperature was recorded at the position of sighting for many of the above records.

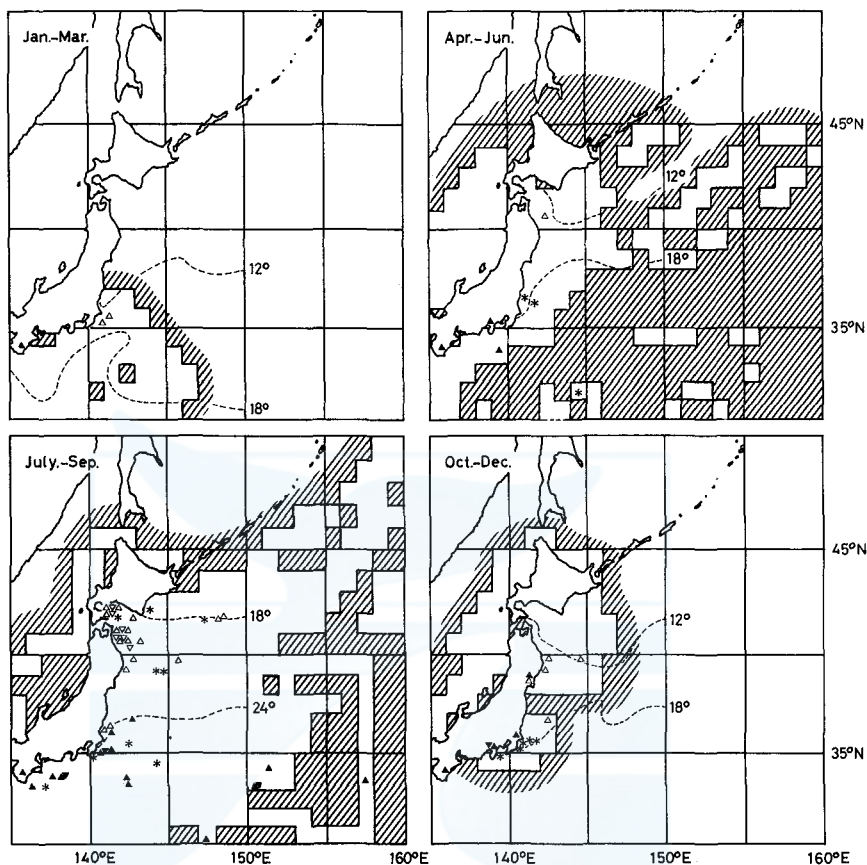


Fig. 2. Sightings of short-finned pilot whales and surveyed area (inside of the shaded area indicated by one degree squares). Open triangle: school of northern form, Closed triangle: school of southern form, Star: school of unidentified form. Marks inside the coast line represent catch or stranding. The isotherms indicate ten years mean of surface water temperature in March, July, September, and December (Japan Oceanographic Data Center, 1978).

RESULTS

Geographical segregation

The surveyed area and sightings of pilot whales are indicated by seasons in Fig. 2. In winter (January to March), the sighting effort was limited to the south of 37°N. Northern forms were sighted twice off the Boso Peninsula at between 35°N and 36°N. In spite of extended sighting effort no southern forms were sighted to the north of 30°N, but several sightings were recorded to the south of the latitude (Table 4, for further details of these sightings see Miyashita (1986b)). In this season the drive fishery off Taiji (33°35'N) captured schools of the southern form, indicating their presence in the coastal waters

of the latitude.

In spring (April to June), the sighting effort expanded to wider geographical area, although the total surveyed areas was still limited. Northern forms were sighted off northern Japan at latitudes between 40°N and 41°N. A school of southern form was sighted at about 34°N. Several additional sightings of the form were recorded to the south of 30°N (Miyashita, 1986b). Drive fishery at Taiji (33°35'N) and at Arari (34°50'N) on the Izu coast captured schools of the southern form in this season. These suggest a northward expansion of the concentration of southern form whales in the spring season. A school of unidentified form in Fig. 2 (5th May 1986) in the coastal waters in 36°–37°N and 141°–142°E was recorded by the captain of the *Toshimaru No.25* as the southern form. Although the surface water temperature at the position (8.6°C) appeared to be too low for the southern form, this position was just to the inshore colder side of a very distinct water front (surface water temperature decline of 12.3°C in 24 n.m.), and both forms could have been present at the spot. Since the correctness of the identification could not be supported by photographs or subsequent sightings (the cruise had only one sighting of pilot whales), we tentatively dealt the school as unidentified.

In summer months (July to September), the sighting effort expanded widest. Northern forms were sighted in the Japanese coastal waters between 36°N and 43°N, and west of 149°E longitude. Most of these sightings were concentrated within about 100 nautical miles from the coast. In spite of considerable amount of sighting effort (three 40 to 45 days cruises in August through September, and two similar cruises in May through August), there were no sightings of pilot whales in the Bering Sea and western North Pacific west of 175°E in the Subarctic Convergence Zone and north of it (Table 2). Pilot whales of unidentified form were sighted south of the Subarctic Convergence in the central North Pacific in August (Table 3). These data suggest that short-finned pilot whales do not usually enter into the Subarctic Convergence Zone in the North Pacific and the long-finned pilot whale does not exist in the Bering Sea and northern North Pacific.

In the same season, southern forms were sighted to the south of 37°N. Segregation between the two forms is clear (Fig. 2). At Taiji (33°35'N), the drive fishery captured southern form schools. Although density seemed to be low south of 25°N or east of 152°E suggesting the maximum range of the population in the western North Pacific (IWC, 1987), firm conclusion was hard to be drawn due to the limited sighting effort in the offshore waters. In addition to this, there is an apparent density hiatus in the Kuroshio Current area and the distribution seems to be discontinuous between coastal area and offshore Kuroshio Counter Current area. The sighting trackline was arranged systematically for even coverage of the area, so the density hiatus does not seem to be an artifact of uneven sighting effort (for details see Miyashita, 1986b). Further study is needed to confirm more than one stocks of the southern form short-finned pilot whales in the western North Pacific.

TABLE 3. SIGHTINGS OF PILOT WHALES DURING THE CRUISES DEALT IN THE PRESENT STUDY, OUTSIDE OF THE RANGE IN FIG. 2 AND NORTH OF 35°N. NONE OF THE WHALE TYPES WERE IDENTIFIED

Date of sighting	Position of sighting	Area	Water temp.	Name of vessel
2 Aug. 1967	42°04'N, 175°00'E	w. N. Pac.	19.6°C	Hakuhomaru
2 Aug. 1967	41°57'N, 171°54'E	w. N. Pac.	22.9°C	Hakuhomaru
3 Aug. 1967	41°56'N, 165°17'E	w. N. Pac.	19.9°C	Hakuhomaru
28 Aug. 1971	39°04'N, 134°36'E	S. of Japan	24.5°C	Hakuhomaru

In autumn months (October to December), sighting effort was limited to the Pacific coast between 34°N and 39°N, and there were sighted three schools of northern forms (to the north of 36°N). Northern forms were caught by Japanese small-type whaling off the Pacific coast in October and November in latitudes between 37°N and 40°N (Miyazaki, 1983; Kasuya and Tai, 1986). Southern forms were not sighted in the coastal waters south of 36°N in this season, but the presence was indicated by the stranding of a school at Choshi (35°43'N), and frequent catch by the drive fishery on Izu coasts (34°40'N) and at Taiji (33°35'N) (Kasuya and Marsh, 1984). Miyazaki (1983) reported catch of the southern form by small-type whaling off Sanriku (38°N to 40°N) in October 1982. However, this was possibly a rare incident for the region in this season, because such case did not occur during the following four pilot whaling seasons (Kasuya, 1986; unpublished; Kasuya and Tai, 1986) and because it was the first case for the gunner to hunt such short whales of adult shape (Mr Y. Toba, pers. comm in 1983).

There are reasons to believe that northern forms may occasionally occur off Taiji (33°35'N) on the Pacific coast of central Japan (see Discussion).

In the Sea of Japan, we have only one record of sighting of pilot whales of unknown form (Table 3). The species seems to be uncommon in the area as already mentioned by Kasuya (1975). We do not have data to indicate which form of pilot whales are distributed in the Sea of Japan.

Thermal segregation

Table 4 shows number of short-finned pilot whale sightings by surface water temperature, type of whales and season. Southern forms were sighted at the water temperature between 24° and 31°C in summer, and between 20° and 24°C in winter. The observed seasonal difference of the low temperature limit was 4°C (lower in winter), while the geographical northern range shifted to the south by about 9° in latitude. The actual thermal difference in the habitat between winter and summer must have been larger, because there were frequent winter drives of this form at Taiji (33° 35'N) where surface water temperature could be below 20°C (Fig. 2). This indicates that the seasonal change of the geographical range of southern form short-finned

TABLE 4. MONTHLY SURFACE WATER TEMPERATURE AT THE POSITION OF SHORT-FINNED PILOT WHALE SIGHTING IN FIG. 2 (WITHOUT PARENTHESIS) AND THOSE IN THE WATERS SOUTH OF 30°N LATITUDE MADE BY CRUISES LISTED IN TABLE 1 (IN PARENTHESES)

W.T.* (°C)	Northern form				Southern form			Unidentified		
	1-3	4-6	7-9	10-12	1-3	7-9	10-12	4-6	7-9	10-12
8								1**		
14									1	
15		1								
16	1							1		
17	1			1						1
18										
19			6							
20			1		(2)					1
21			1		(3)			1		
22			4		(2)				1	2
23			4		(1)					
24						4				
25						1			1	
26						2(2)	(1)		1	
27						5(7)				
28						4(1)		(2)	1	
29						(2)				
30						(1)				

* Water temperatures between n° and $n+1^{\circ}$ C indicated by n (n being integer).

** Captain of the research vessel (*Toshimaru No. 25* cruise in 1986) recorded this as a southern form school (see text).

pilot whales is not large enough to retain a constant surface water temperature environment for the stock. In other words, some additional factors such as basithermo structure or food availability is also controlling the distribution and their distribution does not always cover the whole geographical range permitted by their thermal tolerance.

Northern forms, on the other hand, were sighted at the surface water temperature between 19°C and 24°C in summer, and at between 15°C and 18°C in other seasons (Table 4). Accumulation of more data may give wider thermal range, especially for the lower limit. Kasuya and Tai (1986) reported that the water temperature at the position of northern form catch (38°N to 40°N) in October and November ranged from 12°C to 21°C with a peak frequency of catch at 16°–17°C. The surface water temperature of 10°–15°C corresponds to the front of the cold Oyashio Current in the area. The summer sightings of three pilot whale schools of unidentified form at 41°–43°N will represent the northern form. We consider that northern forms move in the fall to the southern wintering ground (north of 35°N and south of the Oyashio

Front) from their summering range expanded probably up to 43°N accompanying the seasonal shift of the Oyashio Front. Their southern range does not change seasonally so much as the northern range, and they endure the seasonal change of the surface water temperature between 12° and 24°C (Fig. 2).

The segregation between the northern and southern forms of short-finned pilot whales is usually distinct geographically and thermally. Although there exist some examples of geographical or possible social intermingling, such cases seem to be rare and unusual as discussed below.

DISCUSSION

The characteristics that we have used in the present study to separate two forms of short-finned pilot whales off the Pacific coast of Japan are similar to those used by Yamase (1760) to describe two kinds of pilot whales off Taiji (33°35'N) on the Pacific coast of Japan. Gray's (1846; 1866) description of the pilot whales off Japan is almost identical to that of Yamase (1760). This lead us to consider that our "southern form" is equivalent to their *Naisa goto* or *Naisa gota* which was named as *G. sieboldii* Gray, 1846, and our "northern form" is equivalent to their *Shiho goto* or *Shibo golo* named as *G. sibo* Gray, 1871. Both of these scientific names have been correctly considered by Bree (1971) to be junior synonyms of *G. macrorhynchus* Gray, 1846.

The next question will be if the northern form individuals still occur off Taiji which situates further south of the ordinal range of the northern form confirmed in the present study. There are evidences supporting this. In winter, a belt of cold coastal water below 18°C extends from 35°N (the ordinary southern range of the northern form in both summer and winter) to 33°N (south of Taiji at 33°35'N) along the Pacific coast of Japan. Thus it is expected for some northern form individuals to stray to the waters off Taiji. An ex-whaler and a present dolphin meat dealer Mr M. Mizutani of Taiji Town and Mr Y. Seko of the Taiji Fish Market gave us the description of the northern form correctly and told their belief that one of the small-type whaling vessels at Taiji caught the northern form pilot whale (their *tappa-naga*) once (Mizutani) or several times (Seko) after World War II. Since the meat of southern forms is esteemed over that of northern forms, their identification can be trusted. As the small-type whaling ceased operation off Taiji since 1978, the catch could have been before the date.

In their sample of more than 500 southern form short-finned pilot whales, Kasuya and Marsh (1984) found only one male of putative northern form and excluded it from their analysis. This male was found in an aggregation of about 230 southern form individuals caught at Taiji in June 1975, and examined by their colleague. It was 5.8 m in body length, or 0.6 m larger than the largest southern form in their sample. The testis (1.7 kg) was at the lower limit of the testis weight (1.7–3.0 kg) of southern forms measuring over 5 m

in body length, but it was of reasonable weight for the northern form of that body size (Kasuya, 1986b). The lack of observation of saddle mark or age estimate inhibited reliable classification of the whale type. Yonekura *et al.* (1980) did not recognize among their sample of 211 individuals (most of them were not included in Kasuya and Marsh (1984)) any individuals which could be classified to the northern form.

Only confirmed records of southern forms off the Sanriku coast (33°–37°N) were seven individuals taken by a small-type whaling vessel at Ayukawa (38°15'N) on 5th November 1982, examined by Dr N. Miyazaki (1983) and aged by Kasuya (1986b). These individuals were apparently taken from a school of the same form (Y. Toba, pers. comm in 1984). These were no additional records of such incidence during the five years operation of the whaling in October and November, 1982 to 1986. Kasuya (1986b) identified about 300 individuals taken by the small-type whaling off Sanriku during the period as the northern form based on the pigmentation, and confirmed it using body length on age relationship. These suggest that the two forms of short-finned pilot whales rarely form a common school even though their range of distribution may occasionally situate close or overlap in the boundary area.

Although there exist opinions to consider that the saddle mark of the short-finned pilot whale may change brightness or shape by growth or physiological conditions (see below), currently available data indicate that the feature of saddle mark we have described above is a stable characteristics to identify individually two forms of short-finned pilot whales off Japan with possible exception of newborn individuals. The whale type of newborns is identifiable only by body size assisted by the age information (Kasuya, 1986b). The life history of northern form short-finned pilot whales off Japan differs from that of the southern form (Kasuya and Marsh, 1984) only in the larger body size and later mating peak (May vs. September), and all the life history characteristics that were found by them to be peculiar to the short-finned pilot whale are shared by both northern and southern forms (Kasuya, 1986b). Kasuya (1986b) speculated from these some ecological mechanisms which might inhibit free interbreeding between the two forms, and considered that the degree of differentiation between the two forms will be at the level of subspecies or local stocks. Wada (1988) arrived at the similar conclusion through the analysis of isoenzymes.

Two types of short-finned pilot whales have been distinguished in the eastern North Pacific using various independent characteristics, e.g. body size and head shape (Mitchell, 1975) and skull morphology (Polisini, 1980). Published studies on the pigmentation of short-finned pilot whales in these waters are confusing. Yablokov and Evans (1981) described individual variation of the saddle mark of short-finned pilot whales in the southern California Bight, and Leatherwood, Reeves, Perrin and Evans (1982) and Evans, Thomas and Kent (1984) questioned its stability and the usefulness for stock identifi-

cation. The latter authors, however, suggested in the same study a possibility of geographical variation of the pigmentation pattern, indicating that the short-finned pilot whales in the eastern tropical Pacific usually have no or only faint markings on the dorsal surface. The apparent disagreement of opinions probably came from the mixing of some minor individual variation of pigmentation in a single population and more stable difference between stocks.

A short-finned pilot whale photographed off Baja California and the Gulf of California by T. Arnborn (pers. comm. in 1986) and Leatherwood *et al.* (1982) had saddle mark similar to that of the present northern form, and a school of 35 pilot whales sighted off Seattle (48°28'N, 133°51'W) in August had apparently similar saddle mark with the northern form sighted off Japan (39°50'N, 145°42'E) in August during the same cruise (Yoshioka, Ogura and Shikano, 1987). We confirmed the photographic records of these sightings. While describing the external morphology of *G. scammonii*, which was identified by Bree (1971) as a junior synonym of *G. macrorhynchus*, Scammon (1874) made no comment on the saddle mark of the type specimen taken by him off Baja California (31°N). His detailed description of the variation of killer whale saddle mark in the same book suggests that he would have mentioned the saddle mark of the type specimen if it had such clear one as found on short-finned pilot whales off northern Japan or off the coast of North America. These suggest, as well as a comment in Evans *et al.* (1984), the presence of geographical segregation of two forms of the short-finned pilot whale in the eastern North Pacific. Although information on other biological feature of these individuals is needed for further consideration, there is a possibility that each of them corresponds to the southern and northern forms off Japan. The short-finned pilot whale in the North Pacific could have evolved two geographical forms (or subspecies), one in the tropical waters and the other in the temperate waters north of it.

We do not have information on the morphology of pilot whales sighted in the central northern North Pacific (Table 3). The latitudes of sightings (39°–42°N), which were just to the south of the Subarctic Convergence Zone, leave possibility for them being either of the two forms of the present study. However, in view of the concentration of northern forms in the Japanese coastal waters and the apparent discontinuity of distribution in the offshore waters, we consider that the Japanese coastal individuals of the northern form will constitute a local stock of relatively small population size. Miyashita (1986b) estimated the population as about 5,000 individuals.

ACKNOWLEDGEMENTS

Thanks are due to many anonymous scientists and crew on board of the research vessels who cooperated in collecting sighting records of pilot whales. Drs T. Arnborn, H. Ogi, C. Shikano, M. Yoshioka provided photographs and

records of sightings of short-finned pilot whales for the present study. Dr N. Miyazaki critically read the manuscript. Mr S. Matsui helped us in collecting information on the historical records of the northern form catch in Taiji. Dr A.A. Hohn advised us in references. Mrs Y. Yamamoto and Mrs M. Ikeya helped us in data analysis and drawings.

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