DISTRIBUTION OF MOTHER-CALF DALL'S PORPOISE PAIRS AS AN INDICATION OF CALVING GROUNDS AND STOCK IDENTITY

TOSHIO KASUYA* AND HARUO OGI**

ABSTRACT

Eighty nine mother-calf Dall's porpoise pairs were sighted in August and September 1982, 1983 and 1985 in the Bering Sea and the western North Pacific (outside the principal range of the *truei*-type population). These sightings were analyzed with an attempt to determine the range of the calving ground and the identity of the stocks. Three discrete concentrations of such pairs were found in the study area, two in the Pacific area north of 45°N and another in the central Bering Sea. The *dalli*-type Dall's porpoises in the surveyed area represent at least two local stocks each breeding to the north and south of the western Aleutian Islands. In addition to these, there is probably another stock which calves off the east coasts of the northern Kuril Islands, although its relationship with the Sea of Japan-Okhotsk Sea stock needs additional examination.

INTRODUCTION

Using sightings data of Dall's porpoise, *Phocoenoides dalli* (True, 1885), from the western North Pacific south of the Aleutian Islands obtained between August and September 1982 (which corresponds to the mating season after the parturition peak of the species (Newby, 1982)), Kasuya and Jones (1984) indicated that mother-calf pairs occurred north of the Subarctic Convergence. They also noted the dominance of weaned juveniles and presumably of males in the Subarctic Convergence zone, and their behavior of approaching vessels. Ogi and Fujise (1984) conducted a cruise during the same season in 1983 and recorded similar geographical behavior differences (Kasuya and Shiraga, 1985).

Miyazaki and Fujise (1985) reported the results of a similar cruise in May and June 1984, south of the western Aleutian Islands. Although their sightings of mother-calf Dall's porpoise pairs were limited due to the period before the parturition peak, their data indicated the presence of latitudinal difference of catchability of the species which probably reflected the difference in the bow riding behavior. This suggests that the Dall's porpoise segregates by growth stages, sex and reproductive status even prior to the parturition peak.

* *Far Seas Fisheries Research Laboratory, 5-7-1, Orido, Shimizu-shi, Shizuoka-ken, 424 Japan*
** *Faculty of Fisheries, Hokkaido University, 6-1-1, Minatomachi, Hakodate-shi, Hokkaido, 041 Japan*

The above studies brought to question if such segregation within the species, especially that of the calving individuals extends further north into the Bering Sea. In order to resolve this question, Japan Fisheries Agency conducted in 1985 a 47 days cruise of the *Hoyomaru No. 12* in the Bering Sea for sighting and collecting biological sample from the species by harpooning (Ogi, Tanaka, Kuramochi and Yamamoto, 1986).

Using data obtained during these three cruises conducted after the parturition peak for Dall's porpoises, the present study analyzes segregation of their breeding population, and attempts to identify the local stocks of the species in the western North Pacific and Bering Sea.

MATERIALS AND METHODS

Materials used are sighting records of Dall's porpoises obtained during three cruises (17 August to 17 September 1982, 10 August to 16 September 1983, and 6 August to 17 September 1985) of the *Hoyomaru No. 12*. This vessel was chartered by the Japan Fisheries Agency for the purpose of studying the biology of the Dall's porpoise incidentally taken in the Japanese salmon gillnet fishery. During these cruises sightings were conducted in the same way as those described by Kasuya and Jones (1984). Most of the Dall's porpoise schools were chased for possible harpooning, although the length and method of the chase were not the same between the cruises and the proportion of passed schools (schools neither chased or closed for harpooning or for further observation) were significantly higher in the 1985 cruise as mentioned below. In the following section the former survey mode (i.e., research vessel stops ordinary sightings activity and to approach the porpoise schools for observation or harpooning) is expressed as closing mode, and the latter (i.e., the vessel continues sighting on the prefixed track line even after finding a school) as passing mode.

Biologists on board the 1982 cruise were Y. Fujise, T. Kasuya and C. Thomson. Outline of the cruise track line and proportion of individuals constituting mother-calf pairs in the daily sightings of the Dall's porpoise are given in Fig. 1 and Appendix Table 1. Further details of the cruise and sightings are in Kasuya and Jones (1984).

Y. Fujise, H. Ogi and S. Shiraga were on board of the 1983 cruise, except for the two days period (14 August and 8 September) when it cruised within fishery conservation zone (FCZ) of the Union of Soviet Socialist Republics (USSR), the survey was conducted in the Pacific area south of the FCZ of the United States of America (USA) and all Dall's porpoise schools encountered were chased. Sightings were discontinued on 2 days of rough weather, but continued on days of poor visibility. Results of the sightings and the cruise track line are given in Fig. 2 and Appendix Table 2.

The 1985 cruise was conducted with four biologists on board, H. Ogi, H. Tanaka, T. Kuramochi and Y. Yamamoto. Most of the period of the north bound cruise and days spent in the northern Bering Sea the vessel cruised the FCZ of the USA or the USSR, and the chasing or harpooning was not conducted (8–12 August, 16–21 August, 5–6 September, 11–12 September). Sightings were discontinued in rough weather (27 August), but continued on some days of poor visibility (7 to 11, and 25 August). The sighting track line and sightings of Dall's porpoises are shown in Fig. 3 and Appendix Table 3.

RESULTS

Density distribution

Kasuya and Ogi (1986) analyzed segregation between the two color types of Dall's porpoise (*dalli*-type and *truei*-type, terminology after Kasuya (1978)), using data which became available after Kasuya (1978), i.e. Kasuya and Jones (1984), Miyazaki, Jones and Beach (1984), Miyazaki, Fujise, Komuro and Taketomi (1984), Ogi and Fujise (1984) and Ogi *et al.* (1986). Recently Miyashita and Kasuya (1987) made similar analysis using additional data obtained during several whale sighting cruises, and indicated that although the ranges of the two color types overlap the *truei*-type predominates in the summer season in the Pacific area between 40°N and 45°N latitude and between 145°E and 155°E longitude and that the northern boundary does not change significantly during May to September when the Japanese coastal Pacific is predominated by *dalli*-types from the Sea of Japan-Okhotsk Sea Stock.

Our survey data do not show clear density change in the northern boundary area of *truei*-types (Appendix Tables 1 to 3). Additionally, distribution of the Dall's porpoise in the surveyed area did not show clear density gap which may correspond to the stock boundary deduced in the present study, although there were detected some apparently high density areas, i.e. around the western Aleutian Islands (Appendix Table 3) and in the Pacific area at around 45°N latitude and 160° to 165°E longitude (Appendix Tables 1 and 2; Kasuya and Jones, 1984). The density was low in the northern Bering Sea north of 59°N latitude (Appendix Table 3).

Dall's porpoises are reported to be uncommon to the north of the cape Navarin (Anon., 1986) and on the continental shelf in the eastern and northeastern Bering Sea (Anon., 1985). Our survey in 1985 confirmed this (Appendix Table 3).

Mother-calf pairs in the western North Pacific

In the 1982 cruise there were 39 sightings of mother-calf pairs in the waters predominated by the *dalli*-type and three of unidentified type in the *truei*-type area (Kasuya and Jones, 1984). None of the former sightings was identified as the *truei*-type. The majority of them (36 pairs) were concentrated in a small area between 165°E and 174°E (eastern end of the research area) longitude and north of 45°N latitude (Fig. 1). The remaining three pairs were

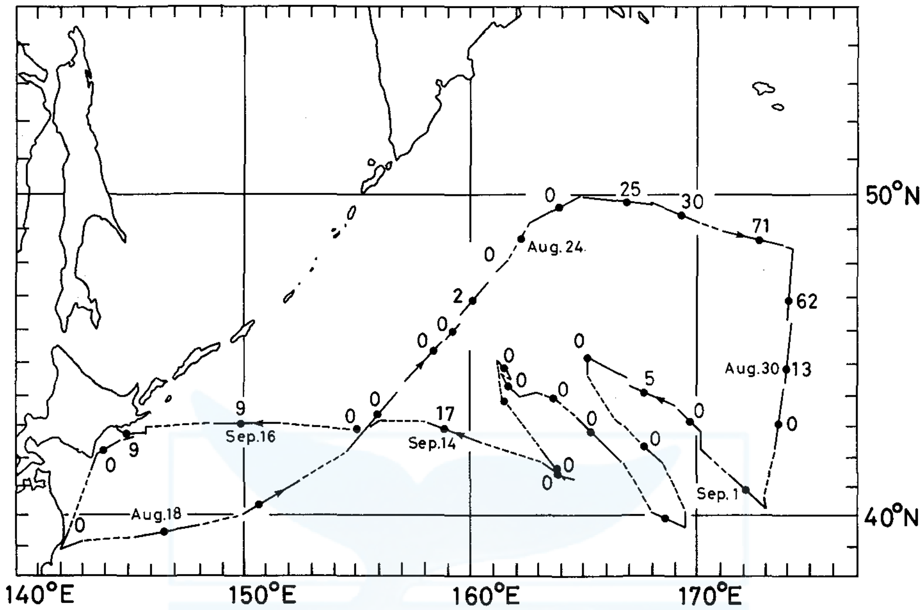

Fig. 1. Distribution of mother-calf pairs of the Dall's porpoise indicated by the percentage of individuals constituting such pairs in the daily number of individuals sighted. *Hoyomaru No. 12* Cruise, 17 August to 17 September, 1982. Solid line indicates track line surveyed, dotted line track line not surveyed, and closed circle noon position. No mother-calf pairs of the *truei*-type were identified during the cruise.

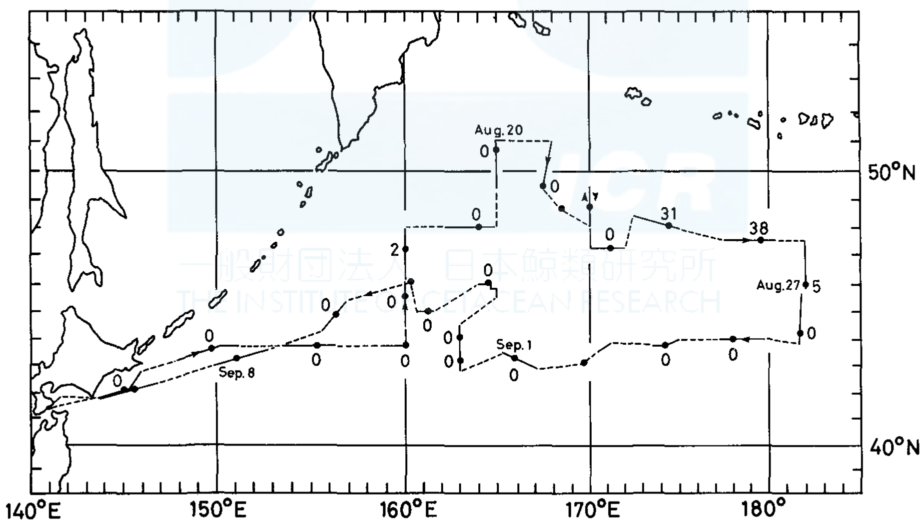

Fig. 2. Distribution of mother-calf pairs of the Dall's porpoise indicated by the percentage of individuals constituting such pairs in the daily number of individuals sighted. *Hoyomaru No. 12* cruise, 10 August to 16 September, 1983. Solid line indicates track line surveyed, dotted line track line not surveyed, and closed circle noon position. No mother-calf pairs of the *truei*-type were identified during the cruise.

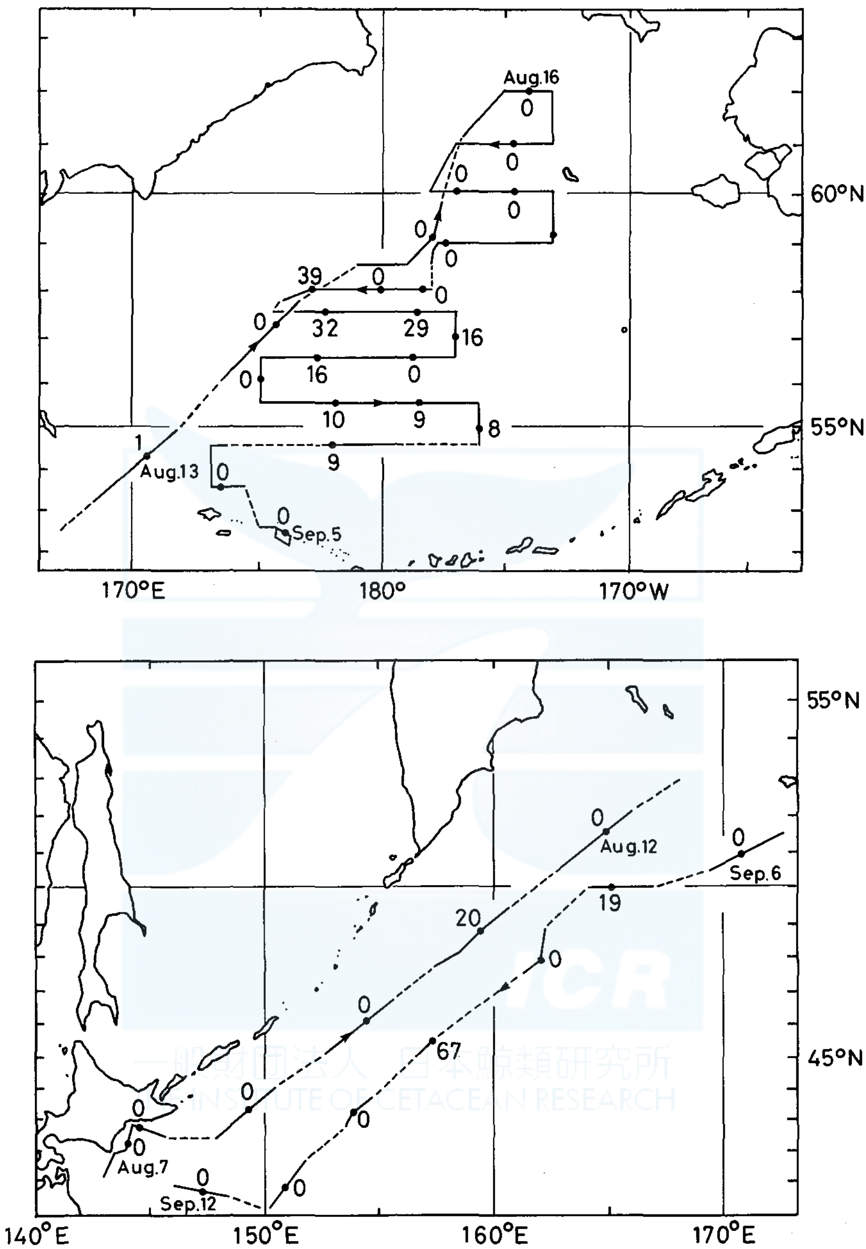

Fig. 3. Distribution of mother-calf pairs of the Dall's porpoise indicated by the percentage of individuals constituting such pairs in the daily number of individuals sighted. *Hoyomaru No. 12* cruise, 7 August to 17 September, 1985. Solid line indicates track line surveyed, dotted line track line not surveyed, and closed circle noon position. No mother-calf pairs of the *truei*-type were identified during the cruise.

sighted in the *dalli*-type area but occurred in the three isolated positions, i.e. approximately in 47°N, 160°E; 44°N, 168°E; 43°N, 159°E.

The 16 mother-calf pairs recorded during the 1983 cruise in the Pacific area occurred in the *dalli*-type area and none were identified as the *truei*-type. One of them was sighted on 18 August in 47°N and 160°E, which was about 500 nautical miles (nm) west of the western limit of the rest of the pairs (Fig. 2), but it was close to the position of one of the three isolated records of mother-calf pair in the 1982 cruise (see above). The remaining 15 pairs were sighted in the Pacific area east of 172°30′E and north of 45°N. The western boundary of this range is located about 300 nm east of the possibly corresponding calving area identified in the previous year (east of 165°E and north of 45°N, see Fig. 1) and these two identified ranges overlapped only in the area east of 172°E.

Of the 34 mother-calf pairs identified in the 1985 cruise, 12 pairs were sighted in the Pacific area (6 pairs on 11 August, 5 pairs on 7 September, and one pair on 9 September, see Appendix Table 3). They were found north of the major range of the *truei*-type distribution (Fig. 3), and none of them were identified as the *truei*-type. The positions of the 5 pairs encountered on 7 September (50°N, 165°E) were situated on the western limit of the aggregation of 36 mother and calf pairs encountered during the 1982 cruise (see above), but the remaining 7 pairs (11 August and 9 September) situated west of 160°E longitude and were close to the position of two isolated western records in 1982 and 1983 cruises.

We conclude from the above data that the distribution of mother-calf pairs suggests the presence of two discrete calving areas for *dalli*-type Dall's porpoise in the western North Pacific. One is found approximately between 45° and 49°N latitude and west of 160°E longitude. This was deduced from only 9 sightings and additional data are still needed to confirm the range and magnitude of this area. However, we consider the presence of this calving area to be reliable because it was confirmed during the three survey cruises. The other is the area east of 165°E longitude and north of 45°N latitude. This calving area extended at least to 178°W longitude, but the eastern limit is not known because of the limitation of survey area. The identified western range of this calving area was variable. In 1982 it was situated at 165°E longitude, possibly as in the case of 1985 season when only western portion of the range was surveyed. The apparent eastern shift of this area in 1983 was possibly due to the northward shift of the area into the USA FCZ (see Discussion). We do not consider that two mother-calf pairs sighted in isolated locations south of 44°N and east of 159°E on 3 and 14 September (Fig. 1 and Appendix Table 1) represent another breeding area, because it has not been confirmed by subsequent cruises in the area (Appendix Tables 2 and 3, Figs 2 and 3).

The two calving areas in the western North Pacific described above are separated by about 5 degree in longitude or about 250 nm in the minimum linear distance (distance between the sightings on 11 August 1985 (48°16′N, 158°32′E) and that on 7 September (49°59′N, 164°10′E)). They were further separated in 1982 and 1983. This indicates the discontinuity of these two calving grounds.*

Mother-calf pairs in the Bering Sea

The Bering Sea was surveyed in 1985, and there were sightings of 22 mother-calf pairs. None of these pairs were identified as *truei*-type. The southern most sighting of a mother-calf pair in the Bering Sea occurred on 13 August in 54°27′N and 170°04′E, or just on the southern boundary of the Bering Sea. The other 21 pairs were sighted in the central portion of the Bering Sea. No mother-calf pairs were sighted in the northern Bering Sea (north of the 59°N) in spite of the sightings of 82 Dall's porpoises in this area (Fig. 3).

The proportion of mother-calf pairs in the Bering Sea declined toward the Aleutian Islands (Fig. 3), from the highest figure of over 39% in the middle part of the Bering Sea at 58°N latitude (24 August) to 8% at 55°N latitude (2 September). During this time the survey method was the closing mode. During the five day period in the FCZs of USA and USSR around the Aleutian Islands (12–13 August and 4–6 September), the passing mode was used and only one mother-calf pair (mentioned above) was identified among 396 Dall's porpoises. This apparently low proportion of mother-calf pairs in the Aleutian Islands area can not be fully explained by the difference of detectability between the two survey methods.

On the other hand, mother-calf pairs of Dall's porpoise were identified even on the days of passing mode survey when no porpoise schools were closed or chased (nine mother-calf pairs in the total of 322 individuals sighted on 11 and 13 August, and 3 and 9 September 1985, see Fig. 3), but no mother-calf pairs were sighted on some of the subsequent days of closing mode (six days of 14, 15, and 23 August, and 10 and 12 September 1985, when total of the 134 Dall's porpoises were sighted). Therefore, not denying the possibility that more mother-calf pairs might have been identified if we had used the closing mode in the Aleutian Islands area, we believe that the apparently low abundance of mother-calf pairs in the area reflects the geographically biased distribution of calving individuals, and that the calving ground in the Bering Sea is discrete from those in the Pacific Ocean.

*: *After this manuscript was sent to printer, Yoshioka, Ogura and Shikano (1987) completed a transpacific research cruise on board of the* Hoyomaru No. 12 *in August through October 1986 for sightings of Dall's porpoises. They confirmed calving grounds off the east coast of northern Kuril Islands (represented by four mother-calf pairs in 43° to 46°N latitude and 155° to 165°E longitude) and south of the Aleutian Islands (seven mother-calf pairs in 47° to 49°N latitude and 180° to 165°W longitude), and found the third calving ground in the Gulf of Alaska east of 153°W (eight mother-calf pairs). Although the ranges of the two western calving grounds were located considerably to the east of the ranges indicated by the present study, they were apart for over 500 nm and the boundaries were distinct. Thus the cruise of Yoshioka* et al., *(1987) provided an additional support to our conclusion on the presence of two calving grounds of the* dalli-*type Dall's porpoise in the northwestern North Pacific.*

DISCUSSION

Dall's porpoises in the calving ground tended to avoid vessels and were difficult to harpoon (Kasuya and Jones, 1984). This was supported by later cruises in the western North Pacific with similar purpose (see above). However, the survey of closing mode in the central Bering Sea in 1985 showed that the number of Dall's porpoises that rode the ship's bow wave ranged from 0 to 69% (mean was 21%) of the total number of individuals sighted daily. This was apparently higher than the figures below 30% in 1982 (Appendix Table 1) and in 1983 (Appendix Table 2) cruises recorded in the same season for the calving ground in the south of the western Aleutian Islands. This can be attributable to two reasons. The first is that the segregation of breeding population may not have been so distinct in the Bering Sea as in the western North Pacific reported by Kasuya and Jones (1984). This was deduced from the fact that the proportion of mother-calf pairs declined from the highest value at 58°N latitude to the lowest near the USA FCZ (55°N) (and then to almost zero of the passing mode survey in USA FCZ, 49° to 54°N). The second reason can be a possible higher intensity of chasing schools during the 1985 Bering Sea cruise. Few members of a school could have approached the vessel and eventually been harpooned after a long intense chase. During the 14 day cruise of closing mode in the central Bering Sea, they caught only 12 Dall's porpoises (0.86 individuals/day). This is considerably lower than the total catch made during about one month cruises in the Pacific area including both calving grounds and other areas, i.e. 72 individuals in the 32 days cruise in 1982 (Kasuya and Jones, 1984), 95 in the 38 days cruise in 1983 (Kasuya and Shiraga, 1985), and 187 in the 43 days cruise in 1984 (Miyazaki and Fujise, 1985). Therefore, it will be accepted, in general, that the central Bering Sea area is one of the calving grounds for Dall's porpoises and the individuals in the area tended to avoid vessels.

Using the incidental take rate from 1981 to 1984 salmon gillnet fishing seasons (June and July) as an index of abundance, Ferrero and Jones (1986) analyzed distribution of Dall's porpoises by sex and maturity in the western Aleutian Islands area of the USA FCZ which was bounded by 168°E and 175°E longitude and 49°N and 55°N latitude. This area is between the two major calving areas in the Bering Sea and western North Pacific identified above, and partially overlaps with the latter. Their data indicate that (1) the density of immature individuals was higher in the northern latitude in all years/months and in both sexes, (2) adult female density in July was higher in the southern latitude except for the opposite trend in July 1983 (the density was low and had less distinct latitudinal change in June of these years), and (3) the density of the adult males was always lower than that of the adult females and the latitudinal trend was indistinct. The first two of these features can be explained by assuming that the segregation by sex and growth stages of the Dall's porpoise occurs parallelly in the Bering Sea as in the western

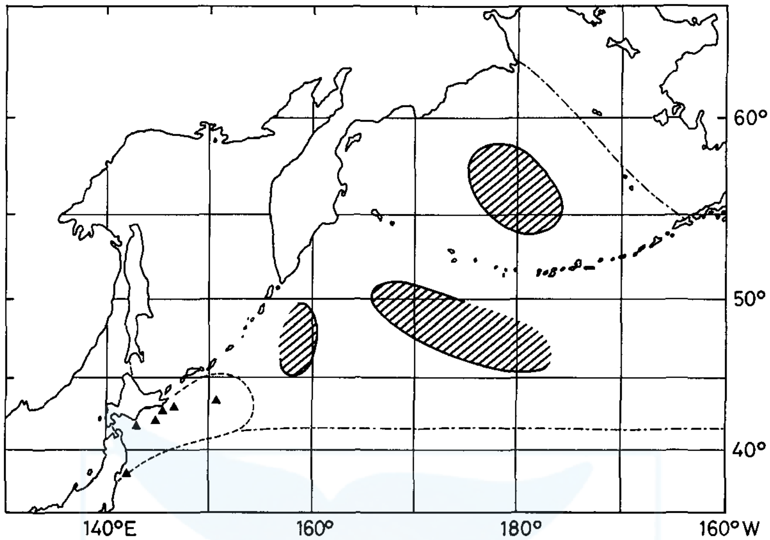

Fig. 4. Calving grounds of the *dalli*-type Dall's porpoise identified in the present study (shaded areas). Chain indicates ordinary summer range of the species where *dalli*-type predominates, and dotted line that of *truei*-type predominance. Triangles indicate three mother-calf pairs of *truei*-type sighted in July 1984 (*Toshimaru No. 25* cruise, Kasuya unpublished) and three mother-calf pairs of unidentified type sighted in the *truei*-type area in September (*Hoyomaru No. 12* cruise in 1982, Appendix Table 1). Information is not available on breeding ground of the Dall's porpoise in the Okhotsk Sea. Some *dalli*-types from the Sea of Japan-Okhotsk Sea stock summer in the southwestern coastal portion of the *truei*-type range (Miyashita and Kasuya, 1987)

North Pacific, and that the northern range of the Pacific stock (inhabited by the calving population) overlaps partially with the southern range of the Bering Sea stock (predominated by immature individuals). Therefore, we consider that the two independent calving grounds of Dall's porpoises are utilized by two isolated local stocks of the species. The adult males of the stocks probably live further north and south of the study area of Ferrero and Jones (1986).

The 1983 season was characterized by both the unusual distribution of adult female density (Ferrero and Jones, 1986) and the apparent eastern shift of the range of the calving area observed outside the USA FCZ south of the western Aleutian Islands (present data). These can be explained by assuming that the western portion of the calving ground of the western North Pacific stock was located further north during the 1983 season than other seasons.

The apparent overlap of the range of the two local stocks will offer only a limited chance of interbreeding because the breeding populations of the two stocks do not usually meet in an area (Fig. 4). The similar, but less influential, effect is also expected in the possible earlier occurrence of the mating season in the western North Pacific stock. Among 29 adult *dalli*-type Dall's porpoise females taken during the 1982 and 1983 cruises in the south of the western Aleutian Islands, five were pregnant (with fetal body lengths 0.32 to 13.1 cm and the mean of 4.0 cm), eight had embryonic membrane containing no identifiable embryo, and 16 females had only corpus luteum of ovulation (Kasuya, unpublished). However, among nine adult females in the Bering Sea collected in the same season and by the same method, seven had corpus luteum of ovulation and no fetus or embryonic membrane. The remaining two adult females had no corpus luteum (Yoshioka, 1986). Therefore, it is probable that the mating peak occurs late in the Bering Sea.

There are no direct data on migration of adult individuals between calving grounds in successive years, but we consider it uncommon from the regularity of reproduction of the species, i.e. narrow and successive parturition and mating seasons and one year cycle of female reproduction (Newby, 1982). Support for this was found for the *dalli*-type Dall's porpoise in the Bering Sea and western North Pacific in the concentration of heavy metals and organochlorines, and in the parasite load. Walker (1987) compared the occurrence of cestode, *Phyllobothrium* sp., and nematode, *Crassicauda* sp., between the Dall's porpoises of the same growth stage taken in the western North Pacific and the Bering Sea, and found significant difference of the infectation rates between the two areas. Subramanian, Tanabe, Fujise and Tatsukawa (1986) found geographical difference in the PCB and DDE concentrations and their ratios between individuals taken during the summer in the Bering Sea and northwestern North Pacific, and concluded that those individuals used different feeding grounds although two individuals from the western Aleutian Islands had intermediate values. Tatsukawa, Fujise, Honda and Mishima (in prep.) discovered higher cadmium concentrations and lower mercury concentrations in individuals from the Bering Sea and opposite ratios from individuals south of the western Aleutian Islands, and arrived at a conclusion which was similar to that of Subramanian *et al.* (in press). They also suggested the Aleutian Islands as an intermingling area. Their results agreed with the possible distribution of two stocks in the Aleutian Islands area deduced in the present study.

Our study indicated that *dalli*-type Dall's porpoises also calves in an area of the Pacific west of the major calving ground south of the western Aleutian Islands which was discussed above (Fig. 4). The two calving grounds in the western North Pacific did not merge each other, although the ranges probably fluctuated annually. This suggests that these calving grounds are used by two different populations of the *dalli*-type Dall's porpoise. Further study is needed on the extent of this calving ground along the east coast of the northern Kuril Islands and southern Kamchatka Peninsula. Additional research is also needed on how the Dall's porpoises in this calving ground are related to the Sea of Japan-Okhotsk Sea stock proposed by Kasuya (1978), because there remains a possibility of a local intrusion of the Sea of Japan-Okhotsk Sea stock as well as the possibility of existence of a local stock.

We found substantial agreement between the major ocean current systems and the calving grounds of the presently accepted stocks of Dall's porpoise. The majority of the Sea of Japan-Okhotsk Sea stock (*dalli*-types) seem to stay in the Okhotsk Sea Gyre during the breeding season, although some individuals of unknown reproductive status from the stock might summer off the Pacific coast of southern Hokkaido (Kasuya, 1978; Miyazaki and Fujise, 1985; Miyashita and Kasuya, 1987; Subramanian *et al.*, 1986). Distribution of the stock off the Pacific coast of Japan is limited to the waters under the influence of the Oyashio Current, with the Kuroshio and Tsugaru Currents as the southern and western boundaries, respectively. We are still unclear if this stock is composed entirely of the *truei*-type individuals (i.e. all the *dalli*-types found in the area are migrant from other stock), or a small proportion of *dalli*-type individuals are contained in it. We found that the breeding ground of the Bering Sea stock (*dalli*-types) is limited to the Bering Sea Gyre, and its breeding population does not intrude into the Western Subarctic Gyre south of the Aleutian Islands, which is inhabited during the summer breeding season by the breeding population of another stock of the *dalli*-type Dall's porpoises (western North Pacific stock). The non-breeding member of this western North Pacific stock is known to segregate in the Subarctic Convergence Zone south of the breeding ground (Kasuya and Jones, 1984).

Not denying the possibility of some additional local stocks or small scale intermingling across the current system as suggested by the breeding ground in the East Kamchatka Current area, we consider the above correspondence is important and presume that the eastern boundary of the calving ground of the western North Pacific stock will not extend into the Alaskan Gyre. The ranges of the Western Subarctic Gyre and Alaskan Gyre extends at least approximately to 160°W and 180° longitude, respectively (Favorite, Dodimead and Nasu, 1976). Therefore the eastern boundary of the western North Pacific stock (which breeds in the area east of 165° E) seems to be located somewhere between these longitudes. Recently the breeding ground of this western North Pacific stock has been confirmed to extend to 165°W (Yoshioka *et al.*, 1987) rather than 178°W (confirmed in the present study).

Available records of mother-calf pairs in *truei*-type area are scanty. Three (*truei*-types) were sighted by myself during the cruise of the *Toshimaru No. 25* in July 1984 (southern three records in Fig. 4), which scanned the major range of the *truei*-types outside the USSR FCZ (Kasuya, 1986). Other three sightings of mother-calf pairs of unknown type occurred during the 1982 cruise of this study off the east coast of Hokkaido at about 43°N (Fig. 4).

ACKNOWLEDGEMENTS

All the biologists on board of the *Hoyomaru No. 12* cruises cooperated in collecting sightings data while many of them were conducting their own biological tasks. Captain F. Ito and his crew supported every research activity on the vessel. The principal planning and organization of the cruise were done by Drs S. Odate, K. Takagi, J. Ito and M. Kato of the Salmon Division of the Far Seas Fisheries Research Laboratory. Dr R.L. Brownell and Mr W.A. Walker critically read the draft and corrected English.

REFERENCES

ANON., 1985. Survey of fur seal stocks and ocean environment in the Bering Sea in 1984. Far Seas Fish. Res. Lab., Shimizu (Japan). 71pp. (in Japanese).

ANON., 1986. Draft environmental impact statement and economic impact analysis on the incidental take of Dall's porpoise in the Japanese salmon fishery. Nat. Mar. Fish. Ser. (USA). 240pp.

FAVORITE, F., A.J. DODIMEAD and K. NASU, 1976. Oceanography of the Subarctic Pacific region 1960–71. *Bull. Int. North Pac. Fish. Comm.*, 33: 1–187.

FERRENO, R.C. and L.L. JONES, 1986. Distribution and movement patterns of Dall's porpoise (*Phocoenoides dalli*) in the western North Pacific Ocean during June and July 1981–1984. Document submitted to the Scientific Subcommittee, Ad Hoc Committee on Marine Mammals, International North Pacific Fisheries Commission, Tokyo. 24pp.

KASUYA, T., 1978. The life history of Dall's porpoise with special reference to the stock off the Pacific coast of Japan. *Sci. Rep. Whales Res. Inst.*, 30: 1–63.

KASUYA, T., 1986. Distribution and behavior of Baird's beaked whales off the Pacific coast of Japan. *Sci. Rep. Whales Res. Inst.*, 37: 61–83.

KASUYA, T. and L.L. JONES, 1984. Behavior and segregation of the Dall's porpoise in the northwestern North Pacific Ocean. *Sci. Rep. Whales Res. Inst.*, 35: 107–128.

KASUYA, T. and H. OGI, 1986. Segregation of Dall's porpoise in the Bering Sea and western North Pacific by color type and reproductive status. Document submitted to the meeting of the Scientific Committee, Ad Hoc Committee on Marine Mammals, International North Pacific Fisheries Commission, Tokyo. 11pp.

KASUYA, T. and S. SHIRAGA, 1985. Growth of Dall's porpoise in the western North Pacific and suggested geographical growth differentiation. *Sci. Rep. Whales Res. Inst.*, 36: 139–152.

MIYASHITA, T. and T. KASUYA, 1987. Distribution of Dall's porpoises off Japan. Document submitted to the meeting of the Scientific Committee of Ad Hoc Committee on Marine Mammals, International North Pacific Fisheries Commission, Tokyo, March 10–14, 1987. 24pp.

MIYAZAKI, N. and Y. FUJISE, 1985. Report of the survey by the dedicated vessel, *Hoyomaru No. 53*, in 1984. Document submitted to the meeting of the Scientific Subcommittee, Ad Hoc Committee on Marine Mammals, International North Pacific Fisheries Commission, Tokyo. 25pp.

MIYAZAKI, N., Y. FUJISE, T. KOMURO and H. TAKETOMI, 1984. Outline of the survey of the porpoises in the northern North Pacific by the *Hoyomaru No. 53* dedicated for the study of Dall's porpoise (10 May to 20 June 1984). Far Seas Fis. Res. Lab., Shimizu. 47pp.

MIYAZAKI, N., L.L. JONES and R. BEACH, 1984. Some observations on the schools of *dalli*- and *truei*-type Dall's porpoises in the northwestern Pacific. *Sci. Rep. Whales Res. Inst.*, 35: 93–105.

NEWBY, T.C., 1982. Life history of Dall porpoise (*Phocoenoides dalli*, True 1885) incidentally taken by the Japanese high seas salmon mothership fishery in the northwestern North Pacific and western Bering Sea, 1978 and 1980. Doctoral thesis submitted to University of Washington. 155pp.

OGI, H. and Y. FUJISE, 1984. Outline of the research on marine mammals by the *Hoyomaru No. 12* in 1983 (August 10 to September 11). Document submitted to the meeting of the Scientific Subcommittee, Ad Hoc Committee on Marine Mammals, International North Pacific Fisheries Commission, Tokyo. 14pp.

OGI, H., H. TANAKA, T. KURAMOCHI and Y. YAMAMOTO, 1986. Outline of the research on Dall's porpoise by the *Hoyomaru No. 12* in 1985. Document submitted to the meeting of the Scientific Subcommittee, Ad Hoc Committee on Marine Mammals, International North Pacific Fisheries Commission, Tokyo. 20pp.

Subramanian, A., S. Tanabe, Y. Fujise and Y. Tatsukawa, 1986. Organochlorine residues in Dall's and True's porpoises collected from northwestern Pacific and adjacent waters. *Mem. Natl Inst. Polar Res., Spec. Issue*, 44: 167–173.

Walker, W.A., 1987. Geographical variation of the parasites *Crassicauda* (nematoda) and *Phyllobothrium* (cestoda) in *Phocoenoides dalli* in the northern North Pacific and Bering Sea. Document submitted to the meeting of the Scientific Committee of the Ad Hoc Committee on Marine Mammals, International North Pacific Fisheries Commission, Tokyo, March 10–14, 1987. 17pp.

Yoshioka, M., 1986. Report on biological studies of Dall's porpoise taken by the dedicated vessel, *Hoyomaru No. 12*, cruise in 1985. Document submitted to the Scientific Subcommittee, Ad Hoc Committee on Marine Mammals, International North Pacific Fisheries Commission, Tokyo. 12pp.

Yoshioka, M., M. Ogura and C. Shikano, 1987. Results of the transpacific Dall's porpoise research cruise by the *Hoyomaru No. 12* in 1986. Document submitted to the meeting of the Scientific Committee, Ad Hoc Committee on Marine Mammals, International North Pacific Fisheries Commission, Tokyo. 22pp.

APPENDIX TABLE 1. SIGHTINGS OF DALL'S PORPOISES DURING THE CRUISE ABOARD *HOYOMARU NO. 12* IN 1982[5)]

Date		Noon position	No of individuals[6)]			Mother-calf pairs	Rode ship's[1)] wave (%)	Surface temperature (°C)[4)]
mo.	day		T	D	U			
8.	17	Lv. Kesennuma	0	0	0	0	–	20.8–23.4
8.	18	39°27'N, 146°30'E	0	0	0	0	–	20.9–22.6
8.	19	40°36'N, 151°31'E	0	0	0	0	–	20.2–23.7
8.	20	43°32'N, 155°54'E	4	0	0	0	50	18.5–19.6
8.	21	45°17'N, 158°21'E	1	27	0	0	82	17.5–18.7
8.	22	45°59'N, 159°15'E	0	23	33	0	32	16.6–17.8
8.	23	46°49'N, 160°00'E	0	43	41	1	87	12.5–16.6
8.	24	48°37'N, 162°22'E	0	24	8	0	63	11.8–12.5
8.	25	49°41'N, 163°58'E	0	10	28	0	5	9.8–10.2
8.	26	49°46'N, 166°55'E	0	12	12	3	4	9.1– 9.5
8.	27	49°13'N, 169°22'E	0	15	12	4	7	9.2– 9.9
8.	28	48°38'N, 172°41'E	0	22	34	20	0	9.5–10.0
8.	29	46°58'N, 174°02'E	0	15	11	8	0	9.7–11.1
8.	30	44°55'N, 173°47'E	0	13	3	1	6	11.6–12.8
8.	31	43°08'N, 173°31'E	0	7	0	0	71	12.1–16.7
9.	01	40°59'N, 172°01'E	0	0	0	0	–	16.0–18.0
9.	02	43°09'N, 169°37'E	0	17	2	0	100	13.7–17.6
9.	03	44°05'N, 167°44'E	0	31	7	1	45	13.1–14.0
9.	04	45°10'N, 165°13'E	0	7	2	0	22	13.7–14.1
9.	05	42°20'N, 167°48'E	0	1	0	0	100	15.0–18.9
9.	06	40°00'N, 168°49'E	0	0	0	0	–	19.4–19.8
9.	07	42°48'N, 165°23'E	0	4	0	0	100	15.8–18.4
9.	08	43°58'N, 163°37'E	0	2[3)]	0	0	100	14.4–15.4
9.	09	44°14'N, 161°41'E	1	23	2	0	85	14.6–17.1
9.	10	44°50'N, 161°27'E	1	59	25	0	76	14.8–16.8
9.	11	43°52'N, 161°30'E	No sighting surveys conducted					14.1–16.8
9.	12	41°29'N, 163°54'E	0	2	2	0	50	16.7–18.2
9.	13	41°31'N, 163°50'E	0	0	2	0	0	18.0–20.6
9.	14	42°50'N, 158°52'E	0	7	5	1	58	14.4–18.3
9.	15	42°56'N, 155°03'E	0	0	0	0	–	16.0–17.6
9.	16[2)]	43°02'N, 149°51'E	5	1	17	1	22	13.8–17.6
9.	17	42°46'N, 144°52'E	12	15	16	2	63	14.1–18.0
9.	18	42°14'N, 143°53'E	31	0	13	0	30	15.0–18.5
9.	19	Ar. Kesennuma	0	0	0	0	–	19.1–20.1
	Total		55	380	275	42	46	

1) Porpoise came to the ship's wave, either at bow or side.
2) No porpoises were chased or caught by the vessel.
3) Porpoises were sighted on bow, but sighting survey was not conducted due to rough weather.
4) Temperature ranges during sighting surveys, or during the day if surveys were not conducted.
5) Reproduced from Kasuya and Jones (1984).
6) T, *truei*-type. D, *dalli*-type. U, Dall's porpoise of unknown type.

APPENDIX TABLE 2. SIGHTINGS OF DALL'S PORPOISES DURING THE CRUISE ABOARD *HOYOMARU NO. 12* IN 1983[1)]

Date mo.	Date day	Noon position		Distance surveyed (nm)	No. of individuals[2)] T	D	U	sum	Mother /calf pairs	Porpoises rode bow wave	Surface water[3)] temperature (C°)
8.	12	Hakodate Port		28	0	0	0	0	0	0	19.2–22.8
8.	13	42°11′N,	145°00′E	124	12	5	6	23	0	10	12.5–19.9
8.	14	43°43′N,	149°40′E	149	18	1	0	19	0	3	13.3–16.2
8.	15	43°47′N,	155°14′E	169	3	59	16	78	0	12	11.5–15.0
8.	16	43°49′N,	160°00′E	121	0	23[4)]	0	23	0	16	13.0–18.4
8.	17	45°29′N,	160°04′E	84	0	56	38	94	0	19	11.7–12.6
8.	18	47°12′N,	159°52′E	97	0	35	54	89	1	3	10.5–12.0
8.	19	47°55′N,	164°01′E	119	0	29	11	40	0	1	10.0–10.9
8.	20	50°39′N,	165°00′E	120	0	1	7	8	0	0	9.9–10.9
8.	21	49°28′N,	167°28′E	89	1	4	0	5	0	0	9.4–10.3
8.	22	48°39′N,	168°34′E	0	0	0	0	0	0	0	no survey
8.	23	48°39′N,	170°10′E	84	0	0	0	0	0	0	9.2–9.7
8.	24	47°12′N,	171°08′E	126	0	4	3	7	0	1	9.6–9.9
8.	25	48°07′N,	174°28′E	112	0	34	18	52	8	10	9.8–10.8
8.	26	47°31′N,	179°33′E	111	0	13	19	32	6	0	10.9–11.5
8.	27	45°57′N,	178°05′W	103	0	21	17	38	1	17	11.6–13.2
8.	28	44°12′N,	178°13′W	80	0	2	2	4	0	0	13.3–16.2
8.	29	44°01′N,	177°53′E	113	0	3	3	6	0	3	13.1–14.9
8.	30	43°37′N,	174°04′E	62	0	4	0	4	0	0	13.9–15.9
8.	31	43°08′N,	169°38′E	30	0	0	0	0	0	0	13.9–14.5
9.	1	43°17′N,	165°46′E	94	0	49	7	56	0	8	12.4–13.0
9.	2	43°16′N,	163°04′E	43	2	83[5)]	60	147	0	63	13.3–13.8
9.	3	44°04′N,	163°07′E	70	0	96	34	130	0	47	12.6–13.8
9.	4	46°00′N,	164°33′E	63	1	65	60	126	0	35	11.6–12.7
9.	5	45°06′N,	161°26′E	38	0	20	5	25	0	40	13.3–16.2
9.	6	46°05′N,	160°21′E	0	0	0	0	0	0	0	no survey
9.	7	44°54′N,	156°11′E	84	0	45	36	81	0	31	11.8–13.8
9.	8	43°17′N,	151°01′E	141	0	0	0	0	0	0	12.1–17.3
9.	9	42°11′N,	145°22′E	130	0	0	0	0	0	0	15.2–20.0
9.	10	Hakodate Port		31	0	0	0	0	0	0	

1) Includes secondary sightings. All the sightings were chased.
2) T, *truei*-type. D, *dalli*-type. U, Dall's porpoise of unknown type.
3) Surface water temperature range during sighting survey.
4) Includes one black type.
5) Includes two black types.

APPENDIX TABLE 3. SIGHTINGS OF DALL'S PORPOISES DURING THE CRUISE ABOARD *HOYOMARU NO. 12* IN 1985[1)]

Date		Noon position		Distance surveyed (nm)	No. of individuals[2)]				Mother /calf pairs	Porpoises chased	Porpoises rode bow wave	Surface water[3)] temperature (C°)
mo.	day				T	D	U	sum				
8.	7	42°12′N,	144°02′E	131.4	3	5	1	9	0	0	1	14.0–21.0
8.	8	42°52′N,	144°25′E	68.5	0	5	8	13	0	0	0	14.0–19.3
8.	9	43°21′N,	149°22′E	160.0	4	10	3	17	0	0	5	10.9–13.0
8.	10	46°02′N,	154°21′E	160.1	0	10	13	23	0	0	4	7.5–10.1
8.	11	48°46′N,	159°24′E	167.2	0	6	53	59	6	0	0	9.8–10.9
8.	12	51°30′N,	164°44′E	166.9	0	3	40	43	0	0	3	8.7–9.1
8.	13	54°11′N,	170°20′E	167.0	1	52	185	238	1	0	28	8.8–9.4
8.	14	57°13′N,	175°32′E	156.2	0	16	11	27	0	24	1	8.7–9.4
8.	15	59°02′N,	177°58′W	149.3	0	15	13	28	0	10	1	8.7–9.5
8.	16	62°00′N,	174°00′W	150.1	0	7	0	7	0	0	2	8.0–9.0
8.	17	61°00′N,	174°46′W	159.2	0	0	3	3	0	0	0	8.2–8.9
8.	18	60°00′N,	177°00′W	164.5	0	11	9	20	0	0	5	8.2–9.0
8.	19	60°02′N,	174°30′W	26.9	0	1	0	1	0	0	1	8.4–8.6
8.	20	59°09′N,	173°00′W	144.5	0	0	0	0	0	0	0	8.0–9.1
8.	21	58°59′N,	177°27′W	154.5	0	11	12	23	0	0	8	8.6–9.0
8.	22	58°00′N,	178°20′W	30.6	0	1	0	1	0	0	0	9.0–9.2
8.	23	58°00′N,	179°58′W	57.2	0	14	1	15	0	14	7	8.6–9.1
8.	24	57°59′N,	177°07′E	115.0	0	8	18	26	5	21	4	8.6–8.9
8.	25	57°30′N,	177°27′E	108.2	0	15	10	25	4	23	5	8.4–9.0
8.	26	57°30′N,	178°50′W	97.0	0	11	24	35	5	35	9	8.8–9.1
8.	27	57°01′N,	176°57′W	69.7	0	0	12	12	1	12	0	8.7–9.1
8.	28	56°30′N,	178°44′W	99.2	0	0	4	4	0	2	0	8.5–8.8
8.	29	56°30′N,	177°14′E	115.1	0	17	8	25	2	23	6	8.5–8.9
8.	30	56°01′N,	175°00′E	127.4	0	12	15	27	0	14	4	8.3–9.1
8.	31	55°30′N,	178°00′E	124.8	0	3	17	20	1	3	2	8.3–9.1
9.	1	55°30′N,	178°34′W	122.9	0	14	8	22	1	22	9	8.6–9.0
9.	2	55°00′N,	175°58′W	166.4	0	8	17	25	1	4	0	8.6–8.8
9.	3	54°30′N,	178°00′E	111.9	0	5	17	22	1	0	1	8.6–9.1
9.	4	53°28′N,	173°17′E	132.9	0	15	44	59	0	0	2	9.2–9.7
9.	5	52°22′N,	176°10′E	124.2	0	16	19	35	0	0	0	5.9–8.8
9.	6	50°51′N,	170°24′E	135.6	0	5	16	21	0	0	0	9.5–10.2
9.	7	49°57′N,	164°54′E	111.8	0	14	40	54	5	41	13	10.2–10.3
9.	8	47°59′N,	160°53′E	109.6	0	10	15	25	0	15	5	9.6–10.6
9.	9	45°31′N,	157°11′E	45.0	0	2	1	3	1	0	0	11.5–12.1
9.	10	45°13′N,	153°50′E	89.5	1	24	12	37	0	37	11	15.7–17.7
9.	11	40°46′N,	150°45′E	119.1	2	0	0	2	0	0	0	17.1–21.0
9.	12	40°40′N,	147°11′E	110.0	19	2	6	27	0	26	11	16.1–19.9

1) Includes secondary sightings of 27 individuals in six schools.
2) T, *truei*-type. D, *dalli*-type. U, Dall's porpoise of unknown type.
3) Surface water temperature range during the sighting survey.