

SEGREGATION OF DALL'S PORPOISE IN THE BERING SEA
AND WESTERN NORTH PACIFIC
BY COLOR TYPE AND REPRODUCTIVE STATUS

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ABSTRACT

Dall's porpoise sightings data collected during the Hoyomaru No. 12 cruise in August through September 1985 in the western North Pacific and Bering Sea were analyzed in comparison with those of previous studies. The offshore boundary between dalli and truei-types which was indicated by the position of equal frequency situated at latitude between 42°N and 45°N. The eastern boundary at this latitude was between 150°E and 155°E. This boundary showed limited seasonal change from June to September. The density of Dall's porpoise was apparently highest in the surveyed area in the western Aleutian Islands area. Dall's porpoise was found to breed both in the central Bering Sea and in the North Pacific south of the western Aleutian Islands. Further study is needed to clarify the geographical extent of the breeding ground of the species.

INTRODUCTION

Using sightings data of Dall's porpoise in the western North Pacific south of the Aleutian Islands in August and September 1982, which corresponds to the mating season following parturition peak of the species (Newby, 1982), Kasuya and Jones (1984) indicated that the mother and 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 to approach vessels. The cruise of Ogi and Fujise (1984) conducted in the same season of the next year showed the similar geographical difference of the behavior (Kasuya and Shiraga, 1985)

Miyazaki and Fujise (1985) reported the results of a similar cruise in May and June 1984, conducted before the parturition peak of the species. Although the records of mother and calf pairs were not sufficiently obtained during this cruise due to the difference of the season, their data indicated the presence of latitudinal difference of catchability, which presumably reflected the difference in the behavior of the Dall's porpoise. This suggested that the segregation of the species by the growth stage, sex and reproductive status probably existed prior to the parturition season in the waters south of the Aleutian Island.

Above studies brought on a question if such segregation, especially that of the breeding group indicated by mother and calf pairs, extends further north into the Bering Sea. In order to solve this question, the Japan Fisheries Agency conducted a 47 days cruise of the Hoyomaru No. 12 for sightings of the Dall's porpoise and collecting the biological sample of the species by harpooning (Ogi, Tanaka, Kuramochi and Yamamoto, 1986). The present study analyses, using data obtained by this cruise, the segregation of the Dall's porpoises in the western North Pacific and Bering Sea.

MATERIALS AND METHODS

Present study is based on sighting records of the Dall's porpoise obtained during the cruise of the Hoyomaru No. 12 conducted by the Japan Fisheries Agency from 6 August to 17 September 1985. The vessel left Kesenuma on 6 August, having one day stop at Kushiro, directed straight to the northern

Bering Sea. Arriving at the northernmost point in the cruise (62 N) on 16 August, she started to scan the Bering Sea toward the Aleutian Islands, finished the survey in the Bering Sea on 5 September, and returned to Kesennuma on 16 September after one night stop at Hakodate. The sightings survey lasted for 37 days. The biologists on board were H. Ogi, H. Tanaka, T. Kuramochi, and Y. Yamamoto. The details of the cruise and cetacean sightings were reported by Ogi *et al.* (1986).

Sighting was conducted as the previous cruises (Kasuya and Jones, 1984). It was discontinued in rough weather (27 August), but continued even on some days of poor visibility (7 to 11, and 25 August). These were taken into consideration of the analysis of the density analysis. Another deficit of the present data came from the fact that all the Dall's porpoise schools were not approached or chased for harpooning, but the closing was done more intensively in a particular part of the research area mainly in the central Bering Sea and on the southbound trip in the Pacific area. This caused difficulty in analyzing the geographical variation of ship approaching (or ship avoiding) behavior of the species and relative abundance of density or mother and calf pairs. The noon position and daily summary of the Dall's porpoise sightings are listed in Table 1.

RESULTS

Segregation between the dalli and truei-type

The northernmost record of the truei-type in this cruise was at 53°35'N, 169°07'E in the North Pacific close to the western Aleutian Islands, but all the other sightings of the color type (24 individuals in 10 schools) occurred south of 43°40'N and west of 154°30'E. The dominant color type altered approximately at 43°N, 150°E during the northbound cruise in August and at 42°N, 152°E during the westbound cruise in September.

Table 2 summarizes the approximate position of equal frequency of the two color types cited from previous studies. It shows that the northern boundary between the two color types situated in June to September at a latitude between 42°N and 45°N and that the offshore boundary at this latitude between 150°E and 155°E. During this season (June to September) there was detected no clear seasonal shift of the boundary.

Kasuya and Jones (1984) reported proportion of the two color types changing while the vessel cruised from east to west along the latitude of 43°N. They showed that the proportion of truei-types, which once exceeded that of the dalli-type at around 43°N and at 148° to 152°E, again declined in the coastal waters off Hokkaido (43°N, 145°E). This suggests that there is a limited area of dalli-type concentration off the Pacific coast of Hokkaido as indicated by Kasuya (1978), although we do not know the origin of these individuals.

Since the proportion of truei-type is negligible in the main objective area of the present study in the offshore waters, we combined all the sightings of the Dall's porpoises in the following analysis.

Density distribution

Figure 1 shows geographical distribution of the density of Dall's

porpoises expressed by the number of individuals sighted per 10 searching hours. The density on 7 through 11 and 25 August includes data obtained during poor visibility, and can be an under estimate.

In general the density was high in the waters surrounding the western Aleutian Islands (44°N and 55°N), which gradually declined toward northern Bering Sea north of 60°N.

Distribution of mother and calf pairs

All the 34 mother and calf pairs sighted in the 37 days effort were present outside of the major range of the truei-type distribution (see above), and none of them were identified as truei-type (Fig.2).

Twelve pairs of them were found in the Pacific area south of the Aleutian Islands at latitude between 45°N and 50°N and west of 167°E, 21 pairs in the central Bering Sea between 54 N and 58 N, and one pair in the Aleutian Islands area. No mother and calf pairs were sighted north of the 58°N in spite of the sightings of 82 Dall's porpoises. In the southern Bering Sea, the proportion of mother and calf pairs gradually declined toward the Aleutian Islands, from the highest figure of over 39% in the central Bering Sea at 58 N to 8% at 55 N north of the Aleutian Islands while survey used closing mode (to approach the schools for observation or harpooning) on 24 August to 2 September.

During the five days survey spent in the Aleutian Islands area (12-13 August and 4-6 September, surveyed using passing mode), only one mother and calf pair was identified among 396 Dall's porpoises.

The mother and calf pairs were identified even on the day of passing mode when no porpoise schools were closed or chased (nine mother and calf pairs were identified among 322 individuals sighted on 11 and 13 August, and 3 and 9 September), but no mother and calf pairs were sighted on some of the subsequent days of closing mode (e.g. 14 and 15, 23 August and 10 and 12 September, when 134 Dall's porpoises were sighted). This suggests that the finding of mother and calf pairs in certain part of the surveyed area was not entirely the artefact of the different survey mode, but reflected geographically biased distribution of those schools. However, we feel that the recognition of mother and calf pairs would be easier in closing mode than passing mode, and we are uncertain if the relative abundance of such schools can be directly comparable between the two modes.

Response to the vessel

As mentioned above the sighting mode changed daily, from closing all the Dall's porpoise sightings to passing all schools, and there were days of intermediate survey mode when only some of the sightings were closed for capture (Table 1). The closing mode was used only in the middle Bering Sea and on the southbound trip in the North Pacific area (Fig. 3).

During the closing mode, some schools or individuals tended to ride bow wave when they were chased for a considerable length of period (Kasuya and Jones, 1984; Ogi *et al.*, 1986). Additionally, on the day of intermediate mode (closing part of the schools), there were usually no reliable records of

individuals that approached the vessel before being chased. Thus, closing mode can give higher proportion of porpoises that rode ship's wave, and figures of the two different modes are not directly comparable in the present study. Additionally, it is not possible to compare result of the present study with the corresponding figures of previous cruises of the same vessel, because intensity of the chase may not be the same between cruises.

In the central Bering Sea where sightings were conducted using closing mode, the daily proportion of Dall's porpoises that rode ships wave ranged from 0 to 69% with a mean of 21%. This figure is apparently higher than the figure of a few percent reported by Kasuya and Jones (1984) for the calving area south of the western Aleutian Islands. Most probably one of the cause of this difference will be able to attribute to the intense effort of chasing in the present cruise. During the present cruise, they caught only 12 Dall's porpoises spending 14 days in the breeding ground in the Bering Sea. This figure is considerably smaller than the total number of the Dall's porpoise samples taken spending about 40 days in the waters south of the Aleutian Islands including both breeding and nonbreeding grounds, i.e. 72 individuals in 1982 (Kasuya and Jones, 1984), 95 in 1983 (Kasuya and Shiraga, 1985), and 187 in 1984 (Miyazaki and Fujise, 1985). This will mean that the Dall's porpoises in the central Bering Sea were not well attracted to the ship's wave and were hard to harpoon (Ogi et.al, 1986).

DISCUSSION

Kasuya and Jones (1984) found concentration of mother and calf pairs in the Pacific area south of the western Aleutian Islands in 47°N to 50°N and 165°E to 174°E, which was distinctly separated from the concentration of nonbreeding individuals in the Subarctic Convergence zone. Although they identified the area as a part of the breeding ground of the species, due to the limitation of survey area they were unable to indicate the northern limit of the breeding ground.

One of the concentrations of mother and calf pairs found in the present study in middle August in the waters south of the Aleutian Islands was in 45°N to 50°N and 156°E to 167°E. Although this area located southwest to the breeding area indicated by Kasuya and Jones (1984) and they found only one mother and calf pair in this area in late August 1982, we consider that these closely situated concentrations found in the different years are equivalent and represent a breeding area of the species. The minor change in the geographical position might be the result of annual or seasonal fluctuation.

The present study provided an evidence indicating that the Dall's porpoise breeds both in the Bering Sea waters south of the western Aleutian Island. Not denying the possible presence of two core areas of breeding in the season in the central Bering Sea and south of the western Aleutian Islands, obstructed by the geographically biased survey mode we were unable to draw firm conclusion on the north and south extension of these breeding areas, and on their relationship. Since suggestion was obtained in the present study on the presence of annual fluctuation of

breeding area of the Dall's porpoise, it is desirable to collect further information on the seasonal and annual fluctuation of the extent of the breeding ground.

Biological data have been accumulated since 1978 from the Dall's porpoises incidentally taken by the Japanese salmon gillnet fishery in the Bering Sea and in the US Fishery Conservation Zone south of the Aleutian Islands (Jones, Rice and Goshu, 1985). If the composition of these samples is analyzed seasonally and latitudinally, it will provide additional information on the above question on the geographical range of the breeding ground(s) of the Dall's porpoise.

ACKNOWLEDGEMENTS

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Table 1. Daily sightings of the Dall's porpoise during the Hoyomaru No. 12 cruise in 1985.

A date mo.day	B noon position	C sighting hours	D* schools sighted	E* porpo- ises sighted	F* mother /calf pairs	G* porpo- ises chased	H* porpises that rode ship wave	H/E	H/G	E/C** porpo- ise density
8. 7	42°12'N, 144°02'E	11.10	3	9	0	0	1	0.11	-	0.81
8. 8	42°52'N, 144°25'E	6.42	2	13	0	0	0	0	-	2.02
8. 9	43°21'N, 149°22'E	14.50	6	17	0	0	5	0.29	-	1.17
8.10	46°02'N, 154°21'E	14.75	8	23	0	0	4	0.17	-	1.56
8.11	48°46'N, 159°24'E	15.00	22	59	6	0	0	0	-	3.93
8.12	51°30'N, 164°44'E	15.25	18	43	0	0	3	0.07	-	2.82
8.13	54°11'N, 170°20'E	15.00	56	238	1	0	28	0.12	-	15.87
8.14	57°13'N, 175°32'E	13.63	8	27	0	24	1	0.04	0.04	1.98
8.15	59°02'N, 177°58'W	14.08	9	28	0	10	1	0.04	0.10	1.99
8.16	62°00'N, 174°00'W	12.17	2	7	0	0	2	0.29	-	0.58
8.17	61°00'N, 174°46'W	15.33	1	3	0	0	0	0	-	0.20
8.18	60°00'N, 177°00'W	15.82	3	20	0	0	5	0.25	-	1.26
8.19	60°02'N, 174°30'W	2.92	1	1	0	0	1	1.00	-	0.34
8.20	59°09'N, 173°00'W	14.42	0	0	0	0	0	-	-	0
8.21	58°59'N, 177°27'W	15.33	7	23	0	0	8	0.35	-	1.50
8.22	58°00'N, 178°20'W	8.42	1	1	0	0	0	0	-	0.12
8.23	58°00'N, 179°58'W	8.73	4	15	0	14	7	0.47	0.50	1.72
8.24	57°59'N, 177°07'E	12.33	8	26	5	21	4	0.15	0.19	2.11
8.25	57°30'N, 177°27'E	10.22	8	25	4	23	5	0.20	0.22	2.45
8.26	57°30'N, 178°50'W	10.05	13	35	5	35	9	0.26	0.26	2.69
8.27	57°01'N, 176°57'W	8.82	4	12	1	12	0	0	0	1.36
8.28	56°30'N, 178°44'W	10.62	2	4	0	2	0	0	0	0.38
8.29	56°30'N, 177°14'E	11.48	6	25	2	23	6	0.24	0.26	2.18
8.30	56°01'N, 175°00'E	12.45	8	27	0	14	4	0.15	0.29	2.17
8.31	55°30'N, 178°00'E	12.25	8	20	1	3	2	0.10	0.67	1.63
9. 1	55°30'N, 178°34'W	10.88	6	22	1	22	9	0.41	0.41	2.02
9. 2	55°00'N, 175°58'W	11.58	9	25	1	4	0	0	0	2.16
9. 3	54°30'N, 178°00'E	10.17	6	22	1	0	1	0.05	-	2.16
9. 4	53°28'N, 173°17'E	12.75	16	59	0	0	2	0.03	-	4.63
9. 5	52°22'N, 176°10'E	12.08	10	35	0	0	0	0	-	2.90
9. 6	50°51'N, 170°24'E	12.17	9	21	0	0	0	0	-	1.73
9. 7	49°57'N, 164°54'E	10.93	12	54	5	41	13	0.24	0.32	3.75
9. 8	47°59'N, 160°53'E	10.57	8	25	0	15	5	0.20	0.33	2.18
9. 9	45°31'N, 157°11'E	4.50	2	3	1	0	0	0	-	0.67
9.10	43°13'N, 153°50'E	8.63	7	37	0	37	11	0.30	0.30	4.29
9.11	40°46'N, 150°45'E	11.83	1	2	0	0	0	0	-	0.17
9.12	40°40'N, 147°11'E	10.93	7	27	0	26	11	0.41	0.42	2.10

*: Includes secondary sightings of 27 individuals in 6 schools.

** : Excludes secondary sightings.

Table 2. Approximate position of equal frequency of dalli- and truei-type Dall's porpoise observed during cruises that crossed the boundary area.

Month	Year	Position	References
May	1984	39 N, 152 E	Miyazaki and Fujise (1985)
June	1984	41 N, 140 E	Miyazaki and Fujise (1985)
August	1979	45 N, 151 E	Miyazaki <u>et al.</u> (1984)
	1979	44 N, 155 E	Miyazaki <u>et al.</u> (1984)
	1982	44 N, 157 E	Kasuya and Jones (1984)
	1983	44 N, 152 E	Ogi (1983)
September	1985	45 N, 152 E	Present study
	1982	43 N, 153 E	Kasuya and Jones (1984)
	1982	43 N, 145 E	Kasuya and Jones (1984)
	1983	43 N, 151 E	Ogi (1983)
	1985	42 N, 152 E	Present study

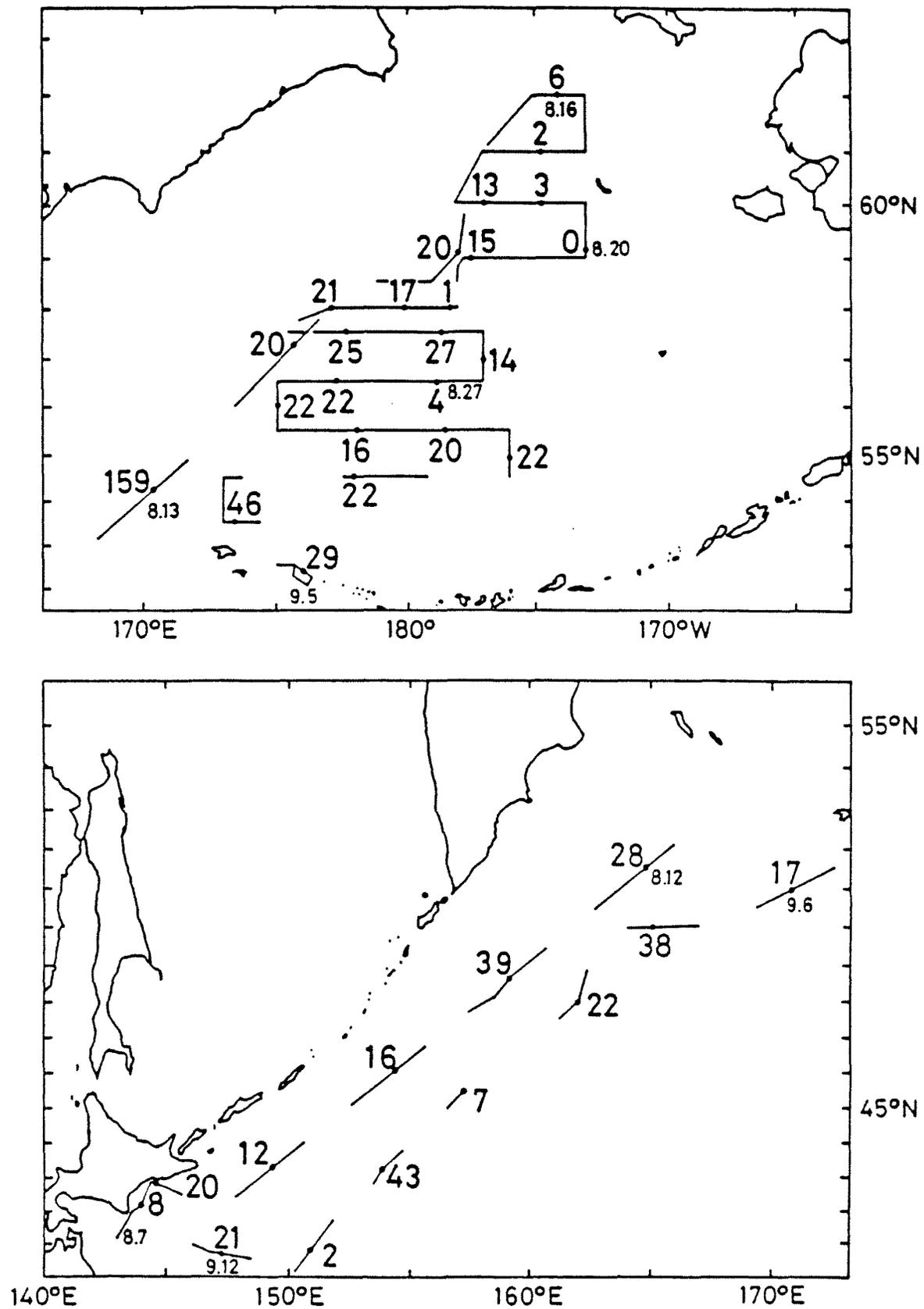


Fig. 1. Geographical variation of density of Dall's porpoise (number of individuals sighted per 10 hour's sighting) observed during the Hoyomaru No. 12 cruise, 7 August to 17 September, 1985. Line indicate the surveyed track line, closed circle the noon position, and small numerals the month and day of the position. All the color types are combined. Sightings were made under condition of poor visibility on 7 through 11 and 25 August.

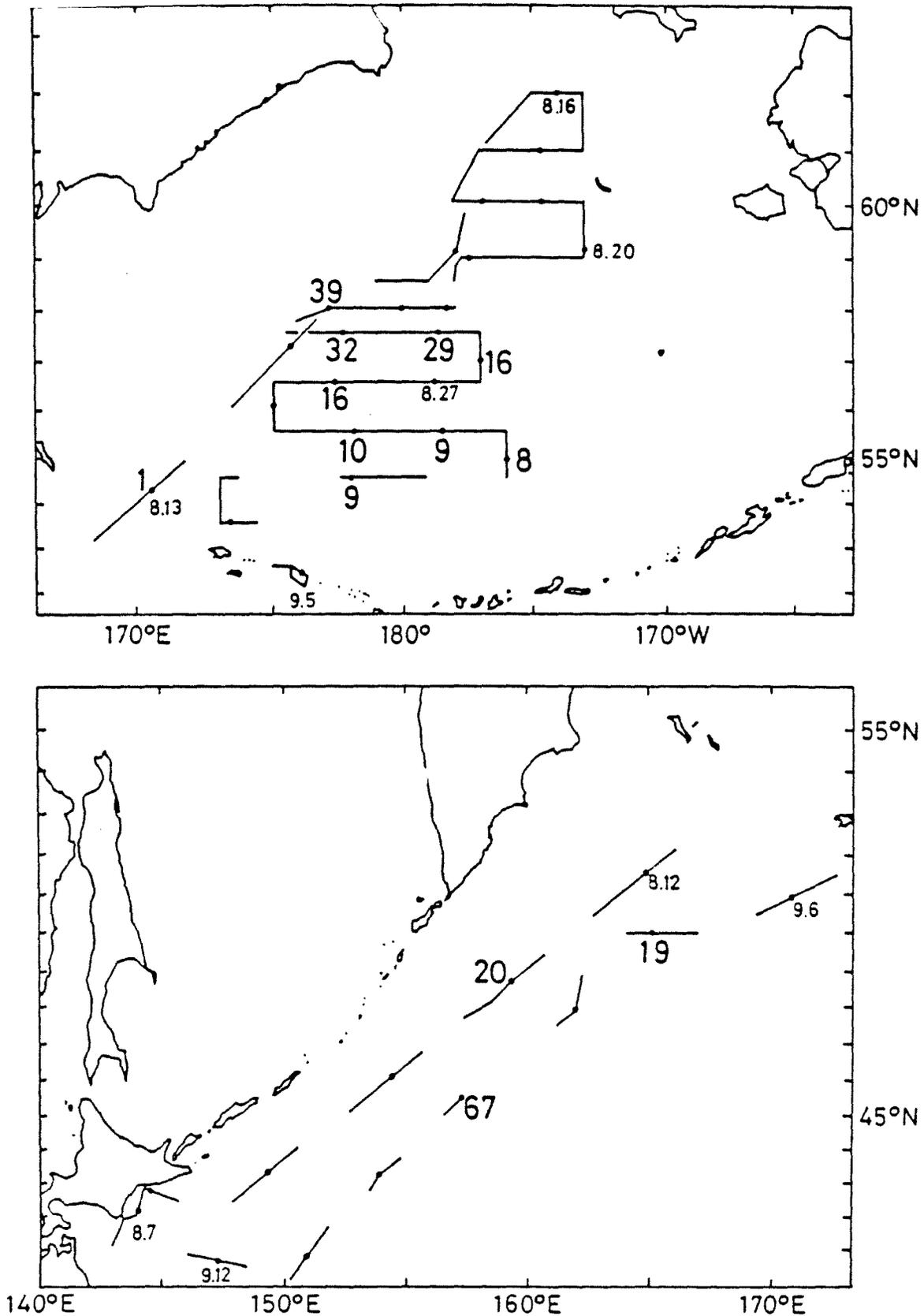


Fig. 2. Abundance of mother and calf pairs indicated by the percentage of such individuals in the total number of individuals sighted (no indication means zero frequency). Based on data obtained during the Hoyomaru No. 12 cruise, 7 August to 17 September, 1985. Line indicate the surveyed track line, closed circle the noon position, and small numerals the month and day of the position. All the color types are combined.

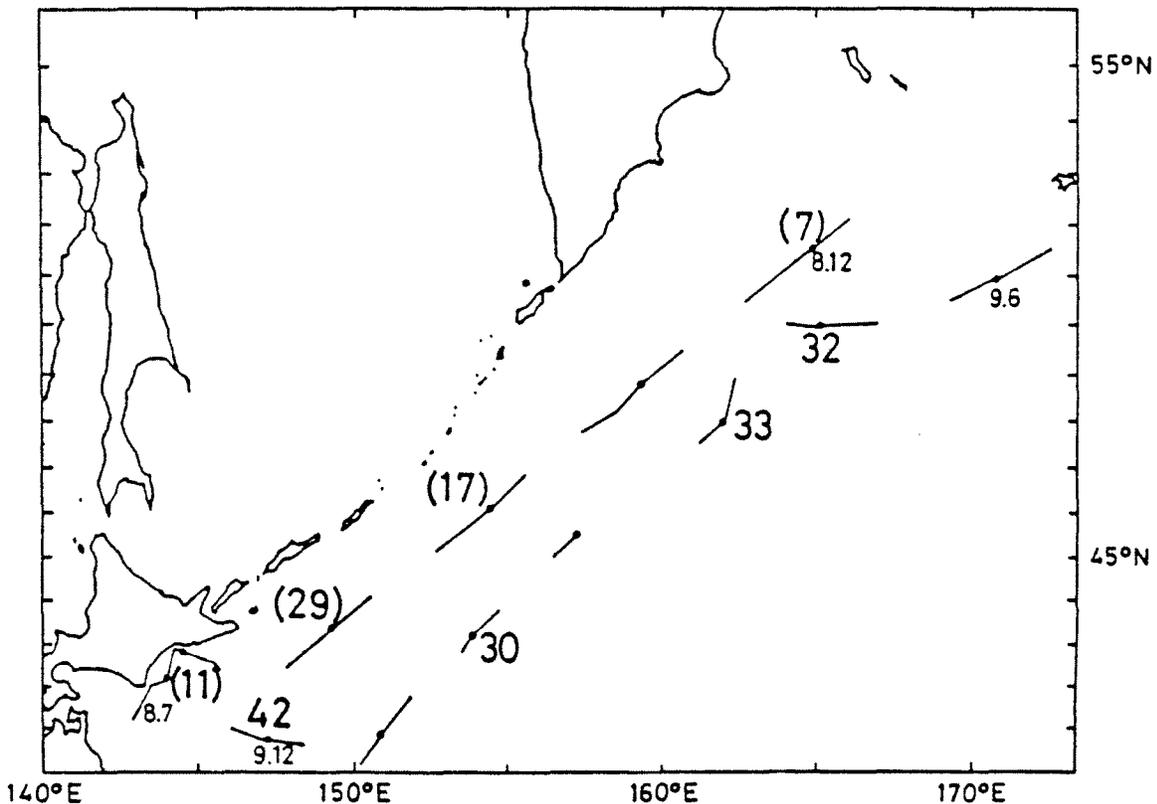
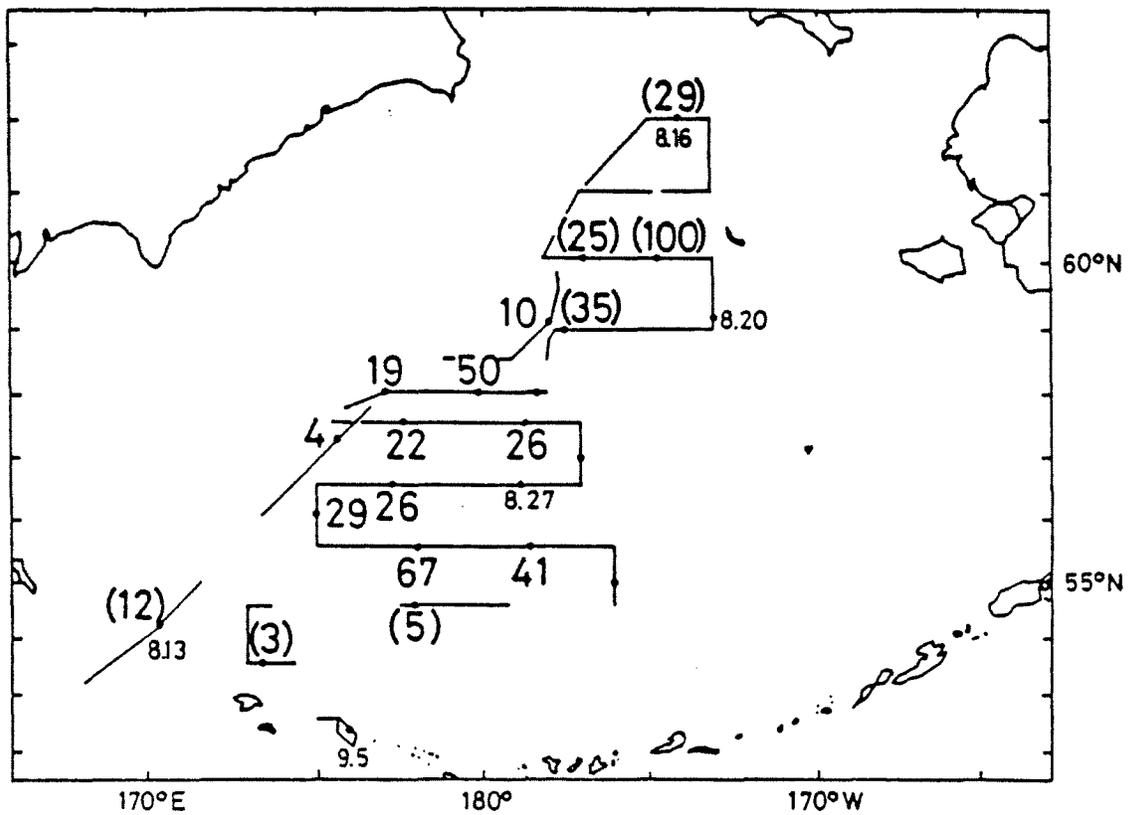


Fig. 3. Percentage of the Dall's porpoise that rode ship's wave in the total individuals sighted (under passing mode, without parentheses), or that in the individuals chased (under closing mode or mixed mode, indicated in parentheses). Based on data obtained during the Hoyomaru No. 12 cruise, 7 August to 17 September, 1985. Line indicate the surveyed track line, closed circle the noon position, and small numerals the month and day of the position. All the color types are combined.