

SOME OBSERVATIONS ON THE SCHOOLS OF  
*DALLI*- AND *TRUEI*-TYPE DALL'S PORPOISES  
IN THE NORTHWESTERN PACIFIC

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ABSTRACT

During 349 hours of sighting surveys conducted from late June to early August 1979 in the northwestern North Pacific Ocean and the southern Bering Sea, 167 schools of *Phocoenoides dalli* were sighted. Three kinds of schools (*dalli*-type, *truei*-type and mixed schools composed of both types) were observed in the southern areas surveyed while only *dalli*-type schools were seen in the northern areas. School size of *dalli*-type schools was smaller than that of the *truei*-type or mixed schools. *Truei*-type as well as mixed schools tended to occur in warmer waters (above 13°C) than *dalli*-type schools during the second part of the survey. Behavior of animals in mixed schools was not apparently different than in the segregated schools. Mixed schools were composed of all sizes of animals including an adult-calf pair. The relationship between the two color types is discussed.

INTRODUCTION

*Phocoenoides dalli* (True, 1885) is widely distributed in the cold waters of the northwestern North Pacific (Nishiwaki, 1972; Ohsumi, 1975; Kasuya, 1976; Kasuya, 1978). Two major color types exist but little is known concerning the systematic relationship of the two types. Based on five external morphological differences Andrews (1911) described them as two species: *P. truei* and *P. dalli*. Kuroda (1954) described them as two subspecies. He concluded based upon sighting records of mixed schools of the *truei*-type and the *dalli*-type, and the presence of a *truei*-type fetus in a *dalli*-type pregnant female, that the *truei*-type is a small population (race) evolved in the Japanese waters by a dominant mutation from the *dalli*-type distributed in the North Pacific Ocean, the Okhotsk Sea and Sea of Japan. However Kasuya (1978) questioned whether the fetus in the *dalli*-type female was a *truei*- or *dalli*-type. Houck (1976) observed a mixed school of the two color forms off

northern Honshu, Japan. Based on the ecological and morphological considerations of the genus, he concluded that *P. dalli* is polymorphic in color pattern with two major color morphs, the *dalli*- and the *truei*-types, and that there are not separate geographical races or subspecies.

From sighting records of *P. dalli* and an analysis of the school structure, Kasuya (1978) concluded that the school formation is to some degree dependent on color pattern and that all the *dalli*-type individuals found off the Pacific coast of Japan may not be from the Japanese coastal population, but that at least some of them, especially those in the schools not containing the *truei*-type, migrate from the offshore population in the northwestern North Pacific and the western Bering Sea or from the Sea of Japan-Okhotsk Sea population. He considered that interbreeding between the populations would be less frequent than expected on the basis of the apparent coexistence of the two color types.

The discussion above makes it clear that the taxonomic problem of the two color forms of *P. dalli* has not been completely resolved. This report provides additional information on school composition and distribution for two color types of Dall's porpoises and a discussion on their relationship, including the possibility of interbreeding between the two color types.

## METHODS

A Japanese salmon research vessel, the R/V *Hoyomaru No. 67* (size: 299 gross tons; cruising speed: 10 knots), was chartered by the Japan Fisheries Agency for a US-Japan cooperative Dall's porpoise research project. A marine mammal sighting survey was conducted on board this vessel in the northwestern North Pacific Ocean and the Bering Sea from 29 June to 9 August, 1979. The cruise track is shown in Fig. 1. Total observation time was 349 hours. Observations were made by Miyazaki and Beach from the upper bridge except during night time, heavy rain and heavy fog. Since the main objectives of this cruise were experimental salmon gillnetting and study of the incidental catch of Dall's porpoises, most of the survey effort was spent during the transits between the coast of Japan and the western Bering Sea.

For each sighting, data were recorded on estimated body size, color type and number of porpoise and surface water temperature. Estimates of body size were made for Dall's porpoises coming close to the bow of the vessel, within about 20 m. Animals were classified as small (less than 150 cm in body length), medium (150-180 cm) or large (more than 180 cm). Calves were distinguished by their small size and continued association with a larger animal.

## RESULTS

### *Distribution*

During this survey, 655 Dall's porpoises were sighted in 167 schools. There were 68 schools of the *dalli*-type, 24 schools of the *truei*-type and 7 mixed schools

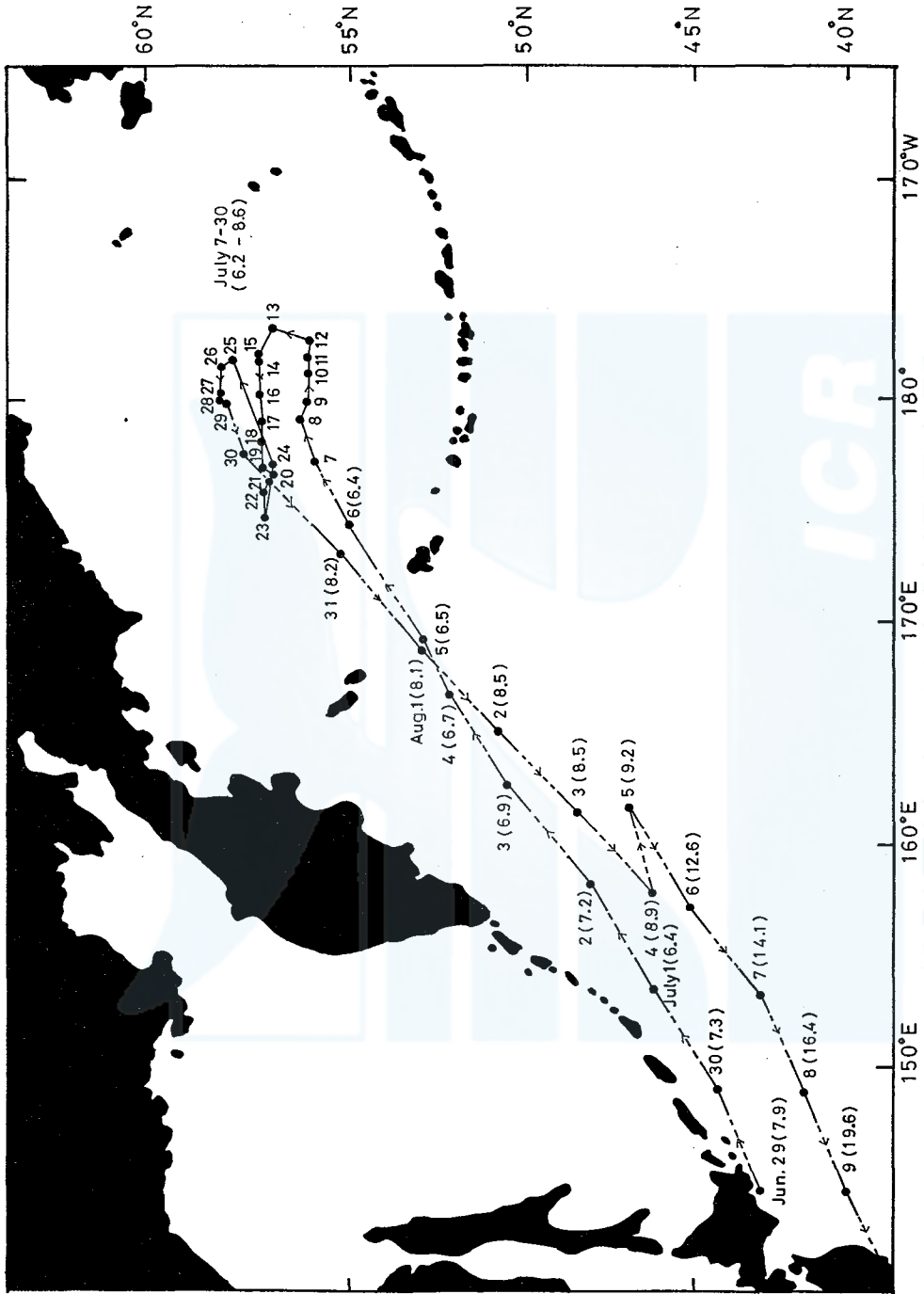


Fig. 1. The cruising course of the R/V 67th-Hoyomaru during 29 June and 9 August, 1979. Numbers indicate dates, closed circles, noon position; solid lines, sighting course; and broken lines, course passed in darkness. Figures in parentheses indicate the surface water temperatures (°C) at noon. The temperatures of noon positions during 7 July and 30 July range from 6.2° to 8.6°C.

TABLE 1. SIGHTING RECORDS OF THE SCHOOLS OF DALL'S PORPOISES IN THE NORTHWESTERN NORTH PACIFIC AND THE BERING SEA IN 5° BY 10° AREAS

Areas	Schools of color type							Total No.
	<i>dalli</i> -type		<i>truei</i> -type		mixed		unknown	
	No.	%	No.	%	No.	%	No.	
I 40°-45°N 140°-150°E	4	25.0	10	62.5	2	12.5	8	24
II 40°-45°N 150°-160°E	4	21.1	13	68.4	2	10.5	11	30
III 45°-50°N 150°-160°E	7	77.8	1	11.1	1	11.1	9	18
IV 45°-50°N 160°-170°E	4	100	0	0	0	0	0	4
V 50°-55°N 160°-170°E	11	84.6	0	0	2	15.4	3	16
VI 50°-55°N 170°E-180°	5	100	0	0	0	0	5	10
VII 55°-60°N 170°E-180°	13	100	0	0	0	0	8	21
VIII 55°-60°N 180°-170°W	20	100	0	0	0	0	24	44
Total	68	68.7	24	24.2	7	7.1	68	167

of the two types. The remaining 68 schools could not be identified as to color type.

The sighting records were grouped into eight areas of 5° latitude by 10° longitude (Table 1). All three kinds of schools, *dalli*-type, *truei*-type and mixed, were sighted in areas I, II and III, while only schools of the *dalli*-type were observed in areas IV, VI, VII and VIII. The ratio of the *dalli*-type schools to total identified schools was about 21-25% in the southern areas (I and II), increased to 78% in area III, and to 84% or more in the remaining northeast areas. The ratio of mixed schools to total identified schools was 10-12% in the areas where both the *dalli*-type and the *truei*-type schools were sighted.

As shown in Fig. 2, the *truei*-type schools were sighted more frequently in the southern part of the northwestern North Pacific than in the northern region. The area where the *truei*-type schools were sighted was south of 45°46'N and west of 153°39'E, while *dalli*-type schools were observed north of 42°52'N and east of 144°32'E. All mixed schools of the two color types were observed in the area between 41°09'N to 50°56'N and 147°55'E to 163°58'E. Three of them were sighted in the area where the *dalli*-type schools were predominant (Fig. 2, Areas III and V), and four in the area where the *truei*-type schools were predominant (Fig. 2, Areas I and II).

Table 2 shows a comparison of the density and school structure of *P. dalli* in the North Pacific and the Bering Sea areas. Although the total number of Dall's porpoises per observation hour is the same in the two areas, the number of schools per observation hour is somewhat larger in the Bering Sea. Especially, the number of *dalli*-type schools per observation hour in the Bering Sea is about twice as large

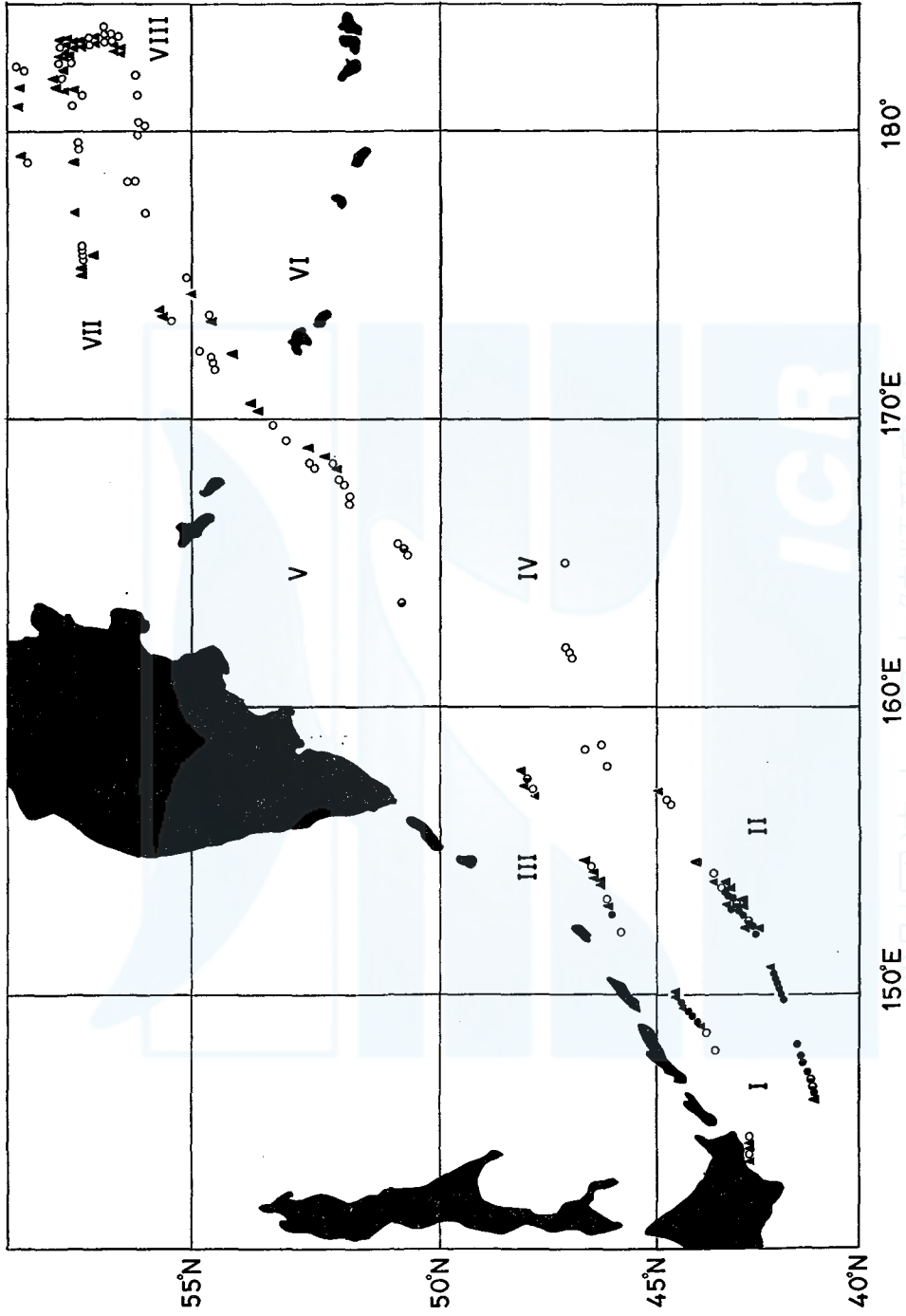


Fig. 2. Sighting records of the school of *Phocoenoides* in the northwestern North Pacific. Open circles indicate the schools of the *dalli-* type; closed circles, the schools of the *truzi*-type; half closed circles, the mixed schools of the *dalli*-type and the *truzi*-type; and closed triangles of the schools of unknown color type of *Phocoenoides*. For I, II, III, IV, V, VI, VII and VIII see text and Table 2.

TABLE 2. COMPARISON OF RELATIVE DENSITY OF DALL'S PORPOISES

Areas and color types	Pacific area				Total
	T	D	M	U	
No. of schools	24	30	7	33	94
No. of porpoises	133	114	38	128	413
Mean school size	5.5	3.8	5.4	3.9	4.4
Observation hours	—	—	—	—	220
No. of school/hour	0.11	0.14	0.03	0.15	0.43
No. of porpoises/hour	0.61	0.52	0.17	0.58	1.88

T indicates a school of *truei*-type; D, a school of *dalli*-type; M, mixed school of two color types; and

as that in the North Pacific.

### School size

Table 3 shows the school size of the various types of *P. dalli*. School size ranged from 1 to 16 individuals. Schools of 10 or less individuals were 91.7% (22 out of 24 schools) of the *truei*-type schools and 98.5% (67 out of 68) of the *dalli*-type. About 60% of all the schools were composed of two to four individuals. The range in school size was similar in the three types of schools (*truei*, *dalli*, and mixed schools). The mean school size of the *dalli*-type was about 3.8 individuals in both the Bering Sea and the Pacific (Table 2). The mean school size of the *truei*-type was 5.5 individuals and was significantly larger than that of the *dalli*-type in both areas (t-test,  $p < 0.01$ ). The mean school size of the mixed schools was 5.4 individuals, and was not significantly different from either the *truei*-type or the *dalli*-type (t-test,  $p > 0.8$ ), however, the sample size is small ( $n = 7$ ).

TABLE 3. SCHOOL SIZE OF DALL'S PORPOISES IN THE NORTHWESTERN NORTH PACIFIC AND THE BERING SEA

School size	School type				Total
	<i>truei</i> -type	<i>dalli</i> -type	mixed	unknown type	
1	0	11	0	7	18
2	3	8	3	22	36
3	5	19	1	17	42
4	3	9	0	8	20
5	4	6	0	7	17
6	2	9	0	1	12
7	3	2	1	2	8
8	0	3	1	1	5
9	1	0	0	0	1
10	1	0	0	2	3
11	0	1	0	0	1
12	1	0	0	0	1
13	0	0	0	0	0
14	0	0	1	1	2
15	0	0	0	0	0
16	1	0	0	0	1
Total	24	68	7	68	167

## BETWEEN THE NORTHWESTERN NORTH PACIFIC AND THE BERING SEA

Bering Sea					Total				
T	D	M	U	Total	T	D	M	U	Total
0	38	0	35	73	24	68	7	68	167
0	139	0	103	242	133	253	38	231	655
0	3.7	0	2.9	3.3	5.5	3.7	5.4	3.4	3.9
—	—	—	—	129	—	—	—	—	349
0	0.29	0	0.27	0.57	0.07	0.19	0.02	0.19	0.48
0	1.08	0	0.80	1.88	0.38	0.72	0.11	0.66	1.88

U, a school of unknown color type.

Table 4 shows the observed percentages of each school type for each school size in the area between 41°N and 51°N, and between 144°E and 166°E, where the three school types were observed in the present survey. Of the 247 Dall's porpoises in 52 schools sighted in this area, 157 individuals (63.6%) were the *truei*-type and 90 (36.4%) were the *dalli*-type. The probability of these two color types for each school size was calculated using this proportion, assuming random combination of two color types. The calculated percentages for the mixed schools were higher than those actually observed. These data suggest that the schools of *P. dalli* are not formed by the random combination of the two color types, but that school formation of the species is related to color type. This is the same conclusion reached by Kasuya (1978) based on observations off Sanriku coast of Japan during January, February, May and June.

TABLE 4. THE OBSERVED AND CALCULATED PERCENTAGES OF EACH COLOR TYPE FOR EACH SCHOOL SIZE OF DALL'S PORPOISES IN THE SOUTH OF 51°N, WHERE THREE COLOR TYPES ARE DISTRIBUTED

School size	No.	Observed			Calculated		
		<i>truei</i>	mixed	<i>dalli</i>	<i>truei</i>	mixed	<i>dalli</i>
1	3	0	0	100	63.6	—	36.4
2	10	30.0	30.0	40.0	40.4	46.3	13.3
3	11	45.5	9.0	45.5	25.7	69.3	4.8
4	6	50.0	0	50.0	16.3	81.9	1.8
5	6	66.7	0	33.3	10.4	89.0	0.6
6	3	66.7	0	33.3	6.6	93.2	0.2
7	4	75.0	25.0	0	4.2	95.7	0.1
8	4	0	25.0	75.0	2.7	97.3	0
9	1	100	0	0	1.7	98.3	0
10	1	100	0	0	1.1	98.9	0
11	0	—	—	—	0.7	99.3	0
12	1	100	0	0	0.4	99.6	0
13	0	—	—	—	0.3	99.7	0
14	1	100	0	0	0.2	99.8	0
15	0	—	—	—	0.1	99.9	0
16	1	100	0	0	0.1	99.9	0
Total	52	46.2	13.5	40.4	20.9	73.0	6.0



TABLE 5. SURFACE WATER TEMPERATURE OF THE SIGHTING POSITIONS OF

Surface water temperature (°C)	School							
	<i>truei</i> -type				<i>dalli</i> -type			
	J to B	B to J	Be	T	J to B	B to J	Be	T
5	0	0	0	0	1	0	0	1
6	1	0	0	1	6	0	7	13
7	4	0	0	4	2	0	16	18
8	0	0	0	0	1	7	6	14
9	0	0	0	0	0	6	0	6
10	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0
12	0	0	0	0	0	2	0	2
13	0	3	0	3	0	0	0	0
14	0	7	0	7	0	0	0	0
15	0	0	0	0	0	1	0	1
16	0	6	0	6	0	0	0	0
17	0	2	0	2	0	0	0	0
Total	5	18	0	23	10	16	29	55

J to B indicates transit from Japan to the Bering Sea; B to J transit from the Bering Sea to Japan;

#### *Surface water temperature*

The frequency of sightings of each school type and surface water temperatures is shown in Table 5. The temperature for the *dalli*-type ranged from 5.9° to 15.8°C, similar to that for the *truei*-type (6.5° to 17.1°C). On the way from Japan to the Bering Sea (late June to early July), the number of sightings is low and the temperature ranges of the two types overlap, however the mean surface water temperature of the 5 *truei*-type schools was 7.4°C (range: 6.0°–7.9°C) while the mean for the 10 *dalli*-type schools was slightly lower, 6.8°C (range: 5.0°–8.9°C). On the return from the Bering Sea (early August), the mean temperature of the sightings of the 18 *truei*-type schools was 15.3°C (range: 13.6°–17.7°C) and was higher than the mean temperature of 9.8°C for the 16 *dalli*-type schools (range: 8.0°–15.8°C) which were predominantly in waters below 10°C (13 out of 16 schools). These results indicate that the *truei*-type school tends to be distributed in relatively warmer waters than the *dalli*-type school. The water temperatures during sightings of the mixed schools were from 5.9° to 16.4°C (mean: 11.7°C) and therefore were within the range of both the *truei*-type and *dalli*-type. During the return to Japan from the Bering Sea, the mixed schools tended to be in the warmer waters (4 out of 5 schools).

#### *Observations of the mixed schools*

Seven mixed schools (two in July and five in August) were observed in this survey (Table 6).

At 1215 hour (Japanese standard time) of 7 August, a mixed school of 14 porpoises were sighted. A mixed group of 12 porpoises among them firstly approached the vessel and rode the bow wave. Several minutes later, a mixed pair



## DALL'S PORPOISES IN THE NORTHWESTERN NORTH PACIFIC AND THE BERING SEA

type

mixed				unknown				Total			
J to B	B to J	Be	T	J to B	B to J	Be	T	J to B	B to J	Be	T
1	0	0	1	0	0	0	0	2	0	0	2
1	0	0	1	4	0	3	7	12	0	10	22
0	0	0	0	1	0	14	15	7	0	30	37
0	1	0	1	3	2	3	8	4	10	9	23
0	0	0	0	0	0	0	0	0	6	0	6
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	1	0	1	0	3	0	3
0	0	0	0	0	4	0	4	0	7	0	7
0	2	0	2	0	5	0	5	0	14	0	14
0	0	0	0	0	1	0	1	0	2	0	2
0	2	0	2	0	1	0	1	0	9	0	9
0	0	0	0	0	0	0	0	0	2	0	2
2	5	0	7	8	14	20	42	25	53	49	127

Be, the Bering Sea; and T, Total.

of large *truei*- and *dalli*-type porpoises joined the first group. In this mixed pair, one swam slightly ahead of the other (Plate 1, Figs 1 and 2), alternating the lead and these two porpoises behaved similarly swimming side by side, keeping a direction and surfacing simultaneously to breathe (Plate 1, Figs 3 and 4). This may indicate that there is no dominant-recessive relationship in social status between them. The mixed pair left the bow after several minutes but the other 12 porpoises remained without apparent change in their behavior. In the other 12 porpoises, one *dalli*-type and two *truei*-type small porpoises (about 1.5 m in body

TABLE 6. COMPOSITION OF MIXED SCHOOLS OF DALL'S PORPOISE SIGHTED IN 1979 IN THE WESTERN NORTH PACIFIC OCEAN

School no.	Date	Time	Total group size	<i>Truei</i> -type		<i>Dalli</i> -type		Unknown type	Comments
				No.	Size	No.	Size		
1	2 July	0805	7	1	large	1	large	5	mixed pair moved some distance from other porpoises
2	3 July	1540	3	1	medium	2	medium	0	
3	2 August	1045	2	1	medium	1	large	0	
4	7 August	1215	14	11	{ 2 small; 9 medium and/or large	3	{ 1 small; 2 medium and/or large	0	
5	7 August	1700	8	5	2 large; 1 large with a calf; 1 medium	1	large	2	
6	8 August	1545	2	1	large	1	large	0	
7	8 August	1700	2	1	large	1	large	0	

length) were found. As these three young porpoises were not accompanied by large porpoises, they seem to be at the stage after the weaning.

Later in the day (1700 hour) a mixed school of 8 porpoises was observed in an apparent feeding behavior, swimming in a circle, making frequent dives. Five of them came to the bow in three groups (a pair of *truei*-type of adult size; an adult *truei*-type with a calf of *truei*-type and an adult *dalli*-type; and a medium *truei*-type). These two adult porpoises with the calf swam together throughout the 30-minute observation period.

From these observations, we conclude that the two color types of different growth stages, including adults with a calf, can form a single group and there were no apparent differences in the behavior of the mixed school compared to schools of uniform color type.

#### *Formation of mixed schools*

Only three mixed schools of the *truei*-type and the *dalli*-type have been studied off Hokkaido on 13 July 1954 (Kuroda, 1954), off northern Honshu in February (Houck, 1976) and off Sanriku in winter (Kasuya, 1978). However, present sightings of seven mixed schools and Miyazaki's observations of other two mixed schools off the Sanriku coast of Japan on 27 March 1972 and on 8 March 1979 (unpublished data) suggest that the mixed school is not necessarily rare in the overlapped area of two color types. There is no trend in the sighting time of the mixed school during the observation time (0500–0900 hour) (Table 6). The mixed school was sighted not only in the coastal waters (Kasuya, 1978; Miyazaki, unpublished data) but also during the present cruise in the waters up to approximately 180 nautical miles offshore. From these informations it can be safely said that in the overlapped area of two color types the mixed school seems to be formed in any time in the day, throughout most of the year and in both coastal and offshore waters.

Composition of seven mixed schools sighted in the present cruise (Table 6) suggests that there are three types of mixed schools, Type I: Combination of single *truei*-type porpoise with single *dalli*-type porpoise; Type II: Combination of single porpoise of one color type with two or more porpoises of other color type; Type III: School containing two or more porpoises of *truei*-type and two or more porpoises of *dalli*-type. Three mixed schools (school nos 3, 6 and 7 in Table 6) and one mixed school (school no. 2) belonged to Type I and II, respectively. The mixed school no. 4 (11 *truei*-type and 3 *dalli*-type porpoises) belonged to Type III. This was sighted in the higher density area, where 52 porpoises in 6 schools were sighted in the 51 minute-observation (1215 to 1306 hour on 7 August) corresponding to approximately  $3 \times 10^5$  m<sup>2</sup> research areas. Two mixed schools (school nos 1 and 5) should be classified into Type II or III when several individuals of unknown color type are considered.

## DISCUSSION

Based on information on *P. dalli* in the northwestern North Pacific Ocean off the Kuril Islands, Ohsumi (1975) indicated that the northern limit of the *truei*-type was 48°N and the eastern limit was 167°E. Kasuya (1978) reported that the *truei*-type seemed to be distributed in the summer season from 42° to 54°N and from the east coast of the Kuril Islands to 168°E. Sightings of the *truei*-type have been made subsequently to 180° (NMML, unpublished data). The sighting positions of the *truei*-type obtained in the present study are distributed within the limits of these studies. Most of the *truei*-type were distributed in the southern areas off the Pacific coast of Japan whereas the *dalli*-type were less in number in this area.

During the present survey, *P. dalli* were sighted in surface water temperatures from 5.8° to 17.1°C. Within this range, there is no significant difference in the temperature preference between the two color forms. However, in August during the transit from the Bering Sea to Japan, the *truei*-type schools were usually sighted in warmer waters than the *dalli*-type. Mixed schools also tended to be in warmer waters at this time (4 out of 5 schools).

In the winter season, *P. dalli* (mostly *truei*-type) migrates into the waters off the Sanriku region (Pacific coast of Japan) where the surface water temperature is 5° to 8°C (Miyazaki, unpublished data). Few *dalli*-type schools are reported there at this season (Kasuya, 1978). Small numbers of mixed schools are seen during the same season (Kasuya, 1978; Miyazaki, unpublished data). From February to March, the southern range of the *truei*-type schools reaches off Choshi (34°44'N, 140°50'E) where the surface water temperature is about 14°–17°C (Kasuya, 1978; Miyazaki, unpublished data). Thus, most of the *truei*-type schools appear not to migrate into areas warmer than 18°C. On the contrary, the water temperature of the *truei*-type in the northern range certainly overlaps that of the *dalli*-type. From these informations it can be said that the northern range of the *truei*-type schools may not be limited by the surface water temperature only but also by other factors such as competition with the *dalli* type.

Sightings of the mixed school of the large *dalli*- and *truei*-types porpoises (body length  $\geq$  180 cm) in the present cruise during 29 June to 9 August suggest that the two color types may interbreed because of the beginning of the breeding season for *P. dalli* in early to mid-August (Mizue *et al.*, 1966; Kasuya, 1978). Kuroda (1954) reported a *dalli*-type female having a *truei*-type fetus, although Kasuya (1978) questioned whether the fetus was a *truei*-type because of his belief on the difficulty of separating two color types in the fetal stage. Newby (1982) also reported that a *dalli*-type fetus was found in a *truei*-type female and the reverse case, and a *dalli*-type fetus was found in a black variant female. These evidences support the hypothesis that the two color types may interbreed.

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## EXPLANATION OF PLATE

## PLATE I

A portion of a mixed school (no. 4 in Table 6) composed of 11 *truei*-type and 3 *dalli*-type porpoises sighted at 42°48'N, 153°05'E, 1215 hour, 7 August 1979.

Fig. 1. A pair of adult *truei*-type and adult *dalli*-type (the left two porpoises) were coming close to the bow of the research vessel.

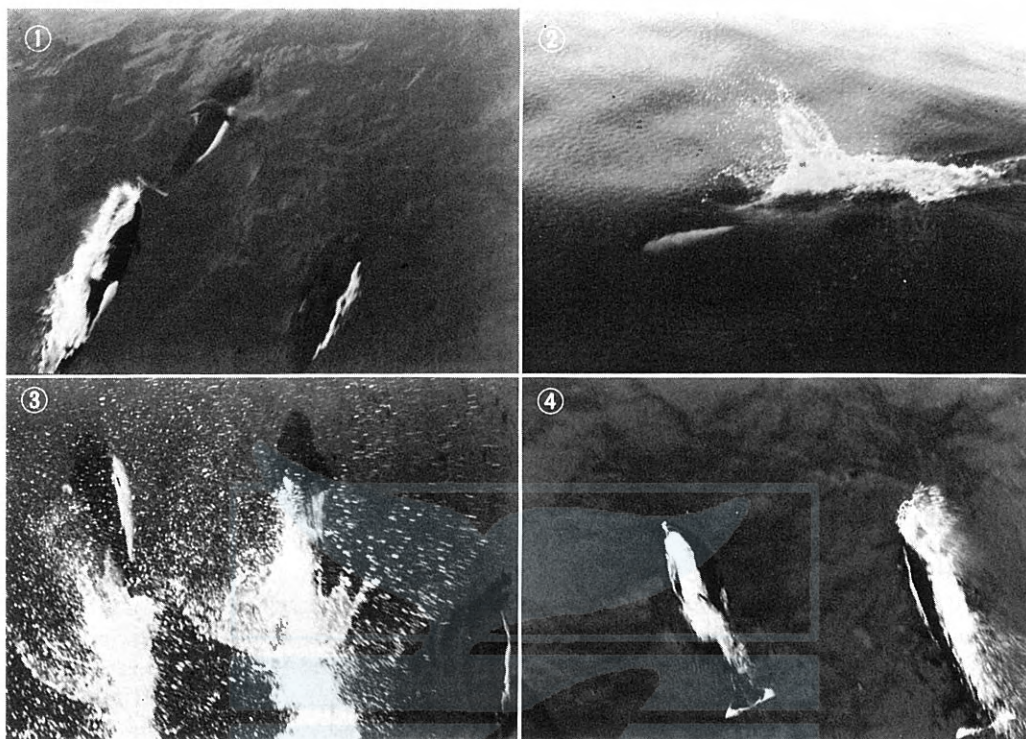
Fig. 2. The *dalli*-type was swimming behind the *truei*-type in a line with a characteristic splash of water.

Fig. 3. A pair of the *truei*-type and the *dalli*-type were surfacing simultaneously to breathe with turning their heads to a direction.

Fig. 4. A pair of the *truei*-type and the *dalli*-type were just diving into water after breathing.



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