SCHOOL STRUCTURE OF THE STRIPED DOLPHIN OFF THE PACIFIC COAST OF JAPAN

NOBUYUKI MIYAZAKI

Department of Zoology, National Science Museum, Tokyo

AND

MASAHARU NISHIWAKI

Department of Marine Sciences, University of the Ryukyus, Okinawa

ABSTRACT

School structure of the striped dolphin, *Stenella coeruleoalba* (Mayen, 1833) was studied on 5,958 dolphins from 45 schools caught on the coast of Izu Peninsula from 1963 to 1973. The animals of the species may not be mixed with those of any other species. Most of the schools examined were formed with less than 500 individuals (85.8%). The southbound schools are larger than the northbound ones. The schools can be classified into three types, the juvenile, the adult, and the mixed schools. Each adult and mixed school can again be divided into two categories, mating and non-mating. In the years when the Kuroshio currents came closely to the fishing area in the coast of Izu, number of adult schools is superior, but in other year, number of juvenile schools is dominant. Calves remain in the adult schools for about one to two years after weaning and then move into the juvenile school. Young females which once left the adult school and got into the juvenile school, rejoin into the adult school. Major number of those females choose the non-mating school to go in ,and only remainders join into the mating school, while nearly equal number of males seems to go into the mating and non-mating schools after they reached sexual maturity. The males which chose the non-mating school change to the mating school when they attain social maturity. In the adult school, fully matured females seems to gather together and are joined by socially mature males, then they form a unit of mating school. One mating school holds one to several such units. After most of females fertilized, socially mature males seem to leave the mating school. The mating school naturally turned out to the non-mating school.

INTRODUCTION

The striped dolphin, *Stenella coeruleoalba* is widely distributed in the tropical and subtropical waters of the Pacific and Atlantic Oceans (Nishiwaki 1972). About ten thousand striped dolphins are caught annually by driving fishery or by the method of hand harpoon on the coast of Japan (Ohsumi 1972, Miyazaki *et al.* 1974). Considerable studies have been done till now by many scientists on age determination, growth, reproduction, food, distribution, migration, and stock etc.

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of the species ; (Nishiwaki and Yagi 1952, Hirose *et al.* 1970, Hirose and Nishiwaki 1971, Kasuya 1972, Ohsumi 1972, Miyazaki *et al.* 1973 and 1974, Nishiwaki 1975, Kasuya and Miyazaki 1976, Kasuya 1976 and Miyazaki 1977). To study school structure of *S. coeruleoalba* is to recognize the mechanism within the school of the animals and instinctive behavior for maintenance and evolution of the species.

There have been limited number of reports on the school structure of smaller cetaceans until recently. Kleinenberg *et al.* (1964) studied on the herd structure of the beluga, *Delphinapterus leucas* caught in the tangle net in reproductive season. From the analysis of herd composition they reported that there are family groups in a school, which consist of adult females with calves of variety of ages, they also reported that males form independent groups but immature animals never form groups separately, and more distinct separation by sex and age appears within the herd at the end of the main breeding season. Sergeant (1962) described that there are two kinds of the unit of herd organization on *Globicephala melaena*, that is, a small breeding herd with excess of mature females over mature males and with a group of females in much the same stage of reproduction, and a probable non-breeding herd with larger number of adult males and fewer juvenile females. Kasuya *et al.* (1974) suggested a hypothetical school formation and its breakup by reproductive activities in the Japanese population of the spotted dolphin, *Stenella attenuata*, and they mentioned that juveniles of the population leave breeding schools and form a school separately and sometime rejoin in a breeding school at puberty. Perrin *et al.* (1976) reported, however, that juveniles probably do not form a school separately in the population of the spotted dolphin in the eastern Pacific. Study on the school structure of the striped dolphin has done little except by Kasuya (1972). He reported on the changing of school structure by condition and activities of breeding. However, he analized the composition of relatively fewer number of schools and did not examine in detail of the sexual condition of all the individuals of the nine schools.

This study was done in order to know the school structure of *S. coeruleoalba* more clearly and more in detail.

MATERIALS AND METHODS

Biological data were obtained from 5,958 striped dolphins of 45 schools caught during seven years from 1963 to 1973 (Table 1) by the driving fisheries at Kawana and Futo, located on the east coast of the Izu Peninsula (Fig. 1). The data of the five schools, Nos 1, 2, 3, 4 and 7 were taken by Dr Tabayama and those of other two schools, Nos 5 and 6, were by Dr Kasuya and those of one more school (No. 13) were examined by Dr Hirose. The compositions of the four schools, Nos 8, 22, 44 and 45, were examined by the help of Dr Kasuya. Fishing records and catch statistics on the east coast, and only catch statistics on the west coast of Izu Peninsula were investigated and used in this study.

Body length was measured in centimeter, straightly from the tip of snout to the notch of tail flukes.

Mammary glands were observed on the spot and individuals were classified

TABLE 1. LIST OF MATERIALS USED IN THIS STUDY. J) JUVENILE SCHOOL, A) ADULT SCHOOL, MI) MIXED SCHOOL, A—M) MATING ADULT SCHOOL, A—N) NON-MATING ADULT SCHOOL, MI—M) MATING MIXED SCHOOL, AND MI—N) NON-MATING MIXED SCHOOL

School No.	School type	Date killed	Time found	Number of dolphins caught	Number of dolphins examined	Percentage of examination	Researcher
1	—	22 Oct. '63	—	453	30	6.6	Tobayama
2	Mi	5 Nov. '63	—	242	54	22.3	Tobayama
3	A	9 Nov. '63	—	34	31	91.2	Tobayama
4	J	14 Nov. '64	—	36	36	100	Tobayama
5	A —N	16, 18, 22 Nov. '68	—	1,700	413	24.3	Kasuya
6	Mi—N	17 Nov. '68	—	344	322	93.6	Kasuya
7	A	18 Nov. '68	—	423	168	39.7	Tobayama
8	A	12 Oct. '70	—	265	89	33.6	Miyazaki and Kasuya
9	J	13 Oct. '70	—	293	64	21.8	Miyazaki
10	A	21 Oct. '70	08:00	324	68	21.0	Miyazaki
11	A	24 Oct. '70	08:15	49	44	89.8	Miyazaki
12	Mi	29 Oct. '70	08:20	48	34	70.8	Miyazaki
13	A —N	22 Nov. '70	08:00	1,832	125	6.8	Hirose
14	—	25 Nov. '70	05:00	365	16	4.4	Miyazaki
15	Mi	2 Dec. '70	09:00	260	260	100	Miyazaki
16		10 Dec. '70	06:30	84	84	100	Miyazaki
17	J	2 Oct. '71	07:25	393	176	44.8	Miyazaki
18	A —N	4 Oct. '71	06:10	101	58	57.4	Miyazaki
19	Mi	5 Nov. '71	06:44	25	25	100	Miyazaki
20	J	17, 18 Nov. '71	07:37	636	362	56.9	Miyazaki
21	A —M	20 Nov. '71	07:15	140	100	71.4	Miyazaki
22	J	15 Dec. '71	08:30	903	306	33.9	Miyazaki and Kasuya
23	A —M	3 Oct. '72	07:23	31	30	96.8	Miyazaki
24	Mi—M	4 Oct. '72	07:25	225	96	42.7	Miyazaki
25	A —M	7 Oct. '72	10:25	120	32	26.7	Miyazaki
26	A —M	8 Oct. '72	08:45	94	41	43.6	Miyazaki
27	A —M	13, 15, 16 Oct. '72	05:51	574	217	37.8	Miyazaki
28	Mi—M	14, 18, 19 Oct. '72	06:20	305	124	40.7	Miyazaki
29	A —N	17, 19, 20 Oct. '72	05:45	238	124	52.1	Miyazaki
30	J	23 Oct. '72	10:00	48	48	100	Miyazaki
31	J	26 Oct. '72	10:05	54	40	74.1	Miyazaki
32	A —M	1 Nov. '72	07:15	63	63	100	Miyazaki
33	Mi—N	5 Nov. '72	07:30	284	122	43.0	Miyazaki
34	A —M	9 Nov. '72	08:05	239	127	53.1	Miyazaki
35	J	10 Nov. '72	09:00	45	27	60.0	Miyazaki
36	A —N	15 Nov. '72	06:18	243	126	51.9	Miyazaki
37	A —N	16 Nov. '72	07:35	200	76	38.0	Miyazaki
38	A —N	17, 20 Nov. '72	07:30	372	212	57.0	Miyazaki
39	Mi—N	21 Nov. '72	05:35	293	132	45.1	Miyazaki
40	A —M	23, 26 Nov. '72	06:40	535	140	26.2	Miyazaki
41	—	26 Nov. '72	—	}2,327	}415	}17.8	Miyazaki
42	—	26 Nov. '72	—				Miyazaki
43	Mi—N	7, 9 Dec. '72	05:50	912	180	19.7	Miyazaki
44	A —N	19 Nov. '73	—	414	251	60.6	Miyazaki and Kasuya
45	A —M	20, 22 Nov. '73	—	1,724	470	27.3	Miyazaki and Kasuya
Total				18,240	5,958	32.6	

into the lactating and the nonlactating stages.

Ovaries were collected from majority of the female specimens and fixed in 10% formalin solution, and later, each ovary was weighed and number of corpora lutea and albicantia were counted in the laboratory.

Sexual condition of the female specimens were determined by presence or absence of corpora lutea or albicantia, weight of left ovary, and observation on mammary glands. The females which had ovaries with corpus luteum or albicans, were calssified as the mature, those which had ovaries with corpus luteum, were classified as the pregnant, those which had lactating mammary glands were classified as the lactat ing, and among the mature females, those which were neither pregnant nor lactating, were classified as the resting. Among the immature females, the animals in which left ovary had weighed more than 2.0 g, were calssified to be the puberty.

Testes were collected from majority of the male specimens, and their weight was measured. Sexual condition of males was determined by usual histological examination (Miyazaki 1977). The males which had testis containing exclusively

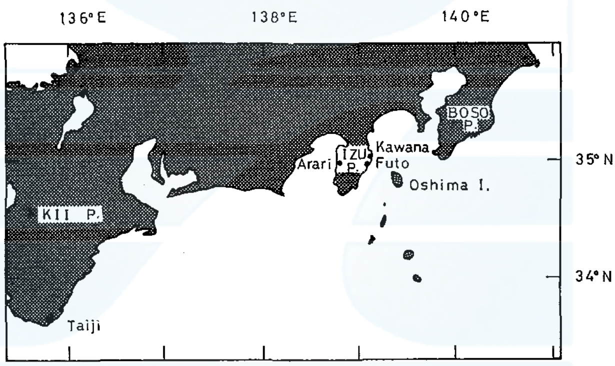

Fig. 1. Map showing the positions of collection.

spermatogonia, were classified as immature, the ones which had spertmatogonia and spermatocytes, were classified as puberal, and those which had spermatozoa were classified as mature; To make the matter clearer, 20 tubules in one slide section of each testis were selected at random and examined. The animals having the testis containing spermatozoa in only one tubule are classified as Type MI and those in all 20 tubules are Type MIII, and Type MII contains those of between the two types. It is apparent that the more testis weight increase, the more development of testis progress. There was no distinct differences between the weight of left and right testes in the examination. In the case that histological examination was not able, sexual condition of males was determined only by the weight of left testis. The males with left testis weight less than 6.8 g were classified into the immature, those between 6.8 g and 15.4 g were in the puberal, and those more than 15.5 g were in the mature, respectively. The mature males of the left testis weight 15.5 to 39.2 g are Type MI, those from 39.3 to 68.8 g are MII and those more than 68.9 g are MIII, respectively.

From each dolphin, several teeth were collected from middle of the tooth row. After usual preparation, opaque layers of dentine in the longitudinal thin section of the teeth were counted under binocular microscope ($\times 20-\times 50$) by transmitted light.

Age determination of 930 dolphins from six schools, Nos 5, 6, 22, 28, 44, 45 were done by Dr Kasuya. Until 13 layers lamination reading is not varied much by readers, but usually it is difficult after 14 layers.

Recognition of the school at field

Kawana and Futo Fishermen's Unions on the east coast of the Izu Peninsula operate dolphin-fishing in cooperation, harvest of which is mostly *S. coeruleoalba* migrating into Sagami Bay and nearby waters in autumn and winter. The main fishing season is from October to January. On fine days, four driving boats, each three or more fishermen on board, (size of boat: 6–8 m in length, capacity 8–10 tons, maximum speed: 20 knot) start from Kawana and Futo fishing ports at about five o'clock in the morning. They reach the main fishing ground at about seven. The four boats disperse each other, three to six miles apart, to search dolphin schools. When one of the boats discovers a school of dolphins it calls other three through wireless and then they circle the school together, drive the dolphins to the direction of port by making underwater sound of high frequency (50 or more kHz). Ten to twenty small boats (5 to 6 tons) are waiting at the mouth of port and they help the former four boats to drive dolphins into the port and then block them at the mouth of the port with fishing nets (Fig. 2). Then the fishermen haule dolphins out of water. When two schools were sighted at the same time, it is said that they skillfully maneuver the two schools into one and drive them to the port. We observed however, that those two schools seemed not to be mixed completely and they were driven to the port swimming separately. But as

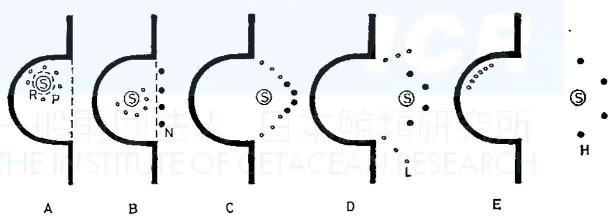

Fig. 2. Schematic figures of the catching process of striped dolphins in driving fishery (cited from Ohsumi (1972) with slight modification). A: Picking up the dolphins on board after squeezing them with net, B: Closing of the mouth of the bay after the driving of the school into the bay, C: Driving of the school into the bay with help of slower driving boats, D: Driving of the school into a bay by high-speed scouting boats, E: Finding of a school of dolphins by four high-speed scouting boats, S: School of dolphins, H: High-speed scouting boat, L: Slower driving boat, N: Set net, P: Picking up boat and R: Surrounding net. The driving fishery is oparated in the order from E to A.

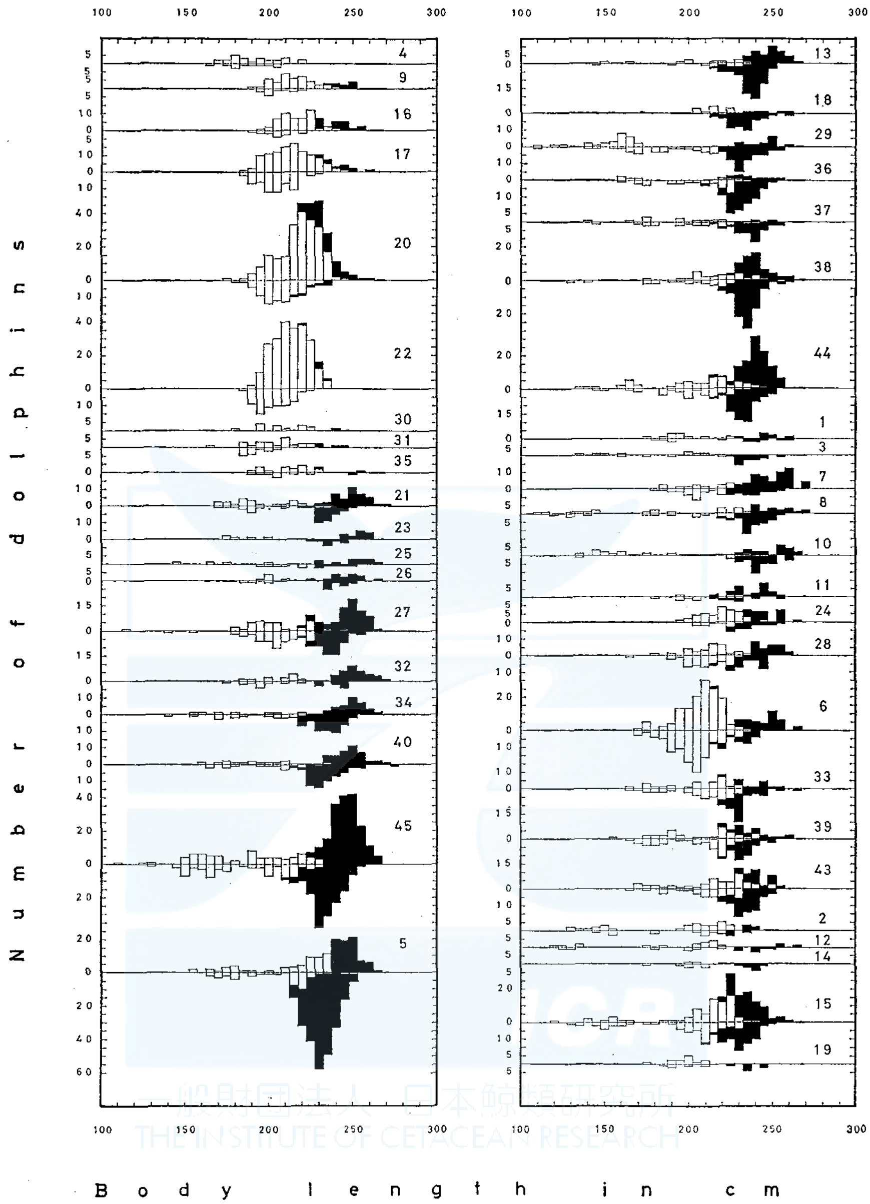

Fig. 3. Body length frequencies of 43 schools of striped dolphins. White areas indicate the immature or puberal dolphins, and black the mature. Areas above the horizontal line indicate males and those below females in each school. Numbers at the right indicate the school no.

a matter of fact it was difficult to separate individuals in the two schools when examining the school composition, because dolphins belonged to both schools were coming in rush and hauled in a short period of time. Therefore, in such

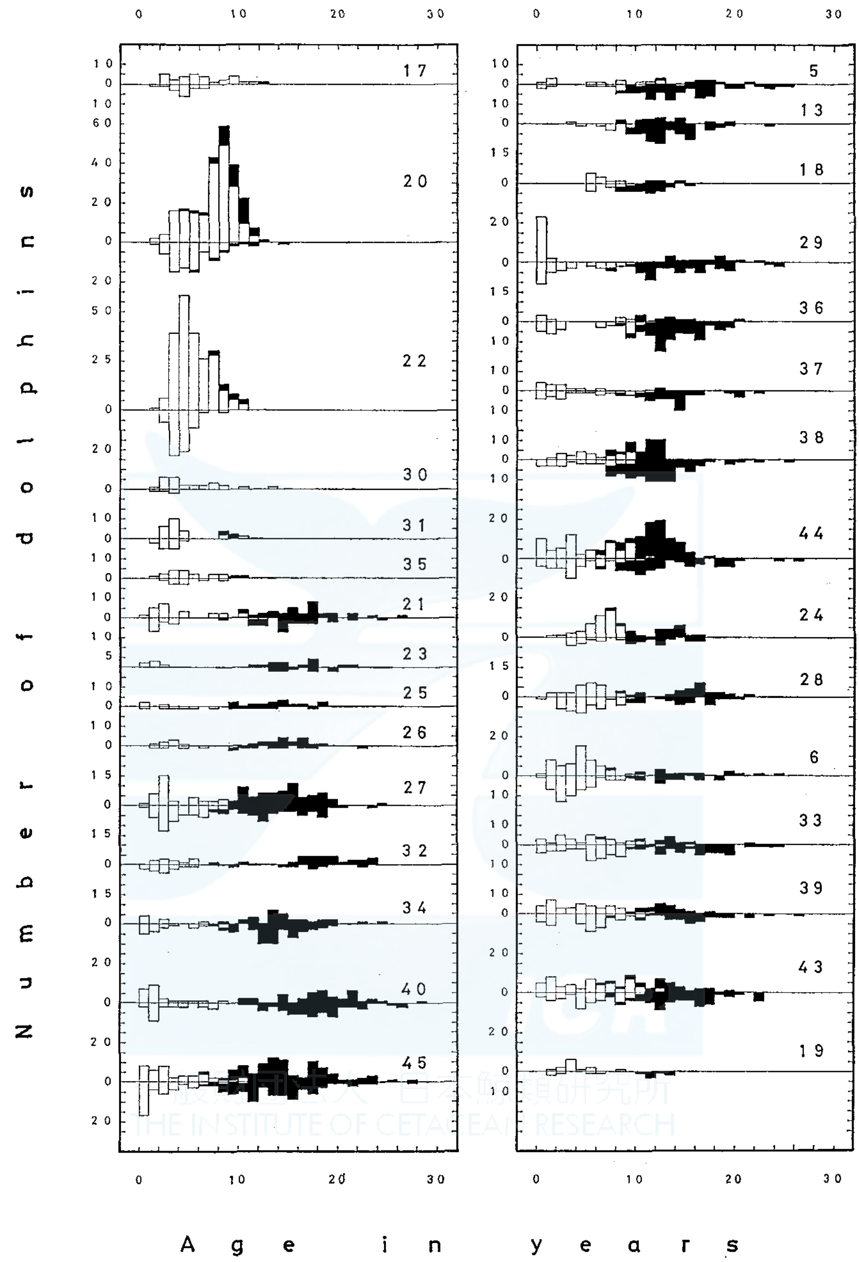

Fig. 4. Age frequencies of 30 schools of striped dolphins. White areas indicate the immature or puberal dolphins, and black the mature. Areas above the horizontal line indicate males and those below females in each school. Numbers at the right indicate the school no.

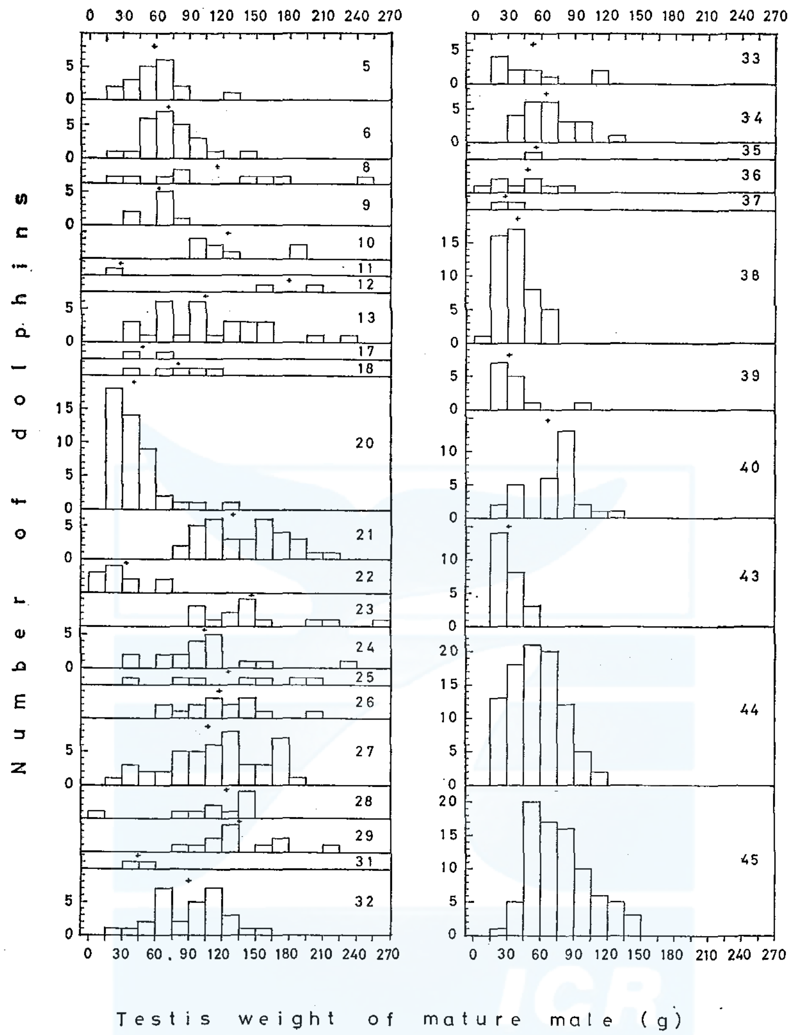

Fig. 5. Frequencies of the left testis weight of mature males of 33 schools of striped dolphins. Crosses indicate average. Numbers at right indicate the school no.

cases, the two schools is studied collectively.

The frequency of body length of the 43 schools is shown in Fig. 3, the age frequency of 30 schools is shown in Fig. 4, and the frequency of the weight of left testis of mature males in the 33 schools is in Fig. 5. And Table 2 shows the life history parameters which are thought to be necessary for analysis of the school composition and discussion on the school structure on *S. coeruleoalba*.

TABLE 2. OUTLINE OF LIFE HISTORY OF STRIPED DOLPHINS CITED FROM MIYAZAKI (1977)

Gestation (months)	12
Mean length at birth (cm)	100
Length at 50% weaning (cm)	174
Length at 50% puberty (cm)	
male	210
female	209
Length at 50% sexual maturity (cm)	
male	219
female	216
Length at physical maturity (cm)	
male	238
female	225
Age at 50% weaning (years)	1.5
Age at 50% puberty (years)	
male	6.7
female	7.1
Age at 50% sexual maturity (years)	
male	8.7
female	8.8

SCHOOL SIZE

In this chapter, the school size of *S. coeruleoalba* is studied, i.e. its seasonal change, diurnal fluctuation, geographical variety, and relation between size and composition are examined based on the catch statistics, fishing records and biological investigations.

School size

Analysis of the school size of *S. coeruleoalba* (Tables 3 and 4) was made based on the catch statistics of 307 schools caught on the east coast of the Izu Peninsula from 1949 to 1974 and of 214 schools caught on the west coast of the peninsula from 1949 to 1970. Among those schools the smallest was formed by 8 individuals and the largest was as many as 2,136 animals. Most schools (85.8% of all) held less than 500 animals and only a few schools had more than 1,000 animals. During the observation from a driving boat or from land, there were three schools which held small units inside, (School Nos 27, 33 and 34). School No. 27 held three small units of approximately 50, 200 and 300 individuals, respectively. School No. 33 also held three small units of about 30, 50 and 200. And school No. 34 held two small units of each about 100. Each small unit of animals swam separately from others. On the other hand, at least 8 schools (School Nos 11, 12, 19, 23, 30, 31, 32, 35) are considered to be such a small unit, because their 50 or so individuals were not apparently swimming separately when they were seen. These sorts of school behavior of striped dolphins were also seen at open sea. From above, it can be said that the size of the small unit may be 30 to 300 individuals. A large

TABLE 3. SCHOOL SIZE OF STRIPED DOLPHINS CAUGHT ON THE EAST COAST OF IZU PENINSULA FROM 1949 TO 1974

Season		School size			
		Range	Total	No. of schools	Average
Sep.	E	—	—	—	—
	M	408	408	1	408
	L	132	132	1	132
Oct.	E	29– 507	3,946	17	232
	M	19– 574	3,756	16	235
	L	19– 604	5,479	23	238
Nov.	E	11– 459	4,747	26	189
	M	17–1,840	12,043	35	344
	L	9–2,136	19,300	46	419
Dec.	E	11–1,976	11,281	35	322
	M	16–2,133	13,049	37	353
	L	23–1,053	8,999	31	290
Jan.	E	33–1,659	7,165	18	398
	M	8– 420	1,526	10	153
	L	30– 553	986	9	110
Feb.	E	24– 109	161	3	54
	M	—	—	—	—
	L	—	—	—	—
Total		8–2,136	92,978	308	302

E: Early; M: Middle; L: Late

school of more than 1,000 individuals has often had several small units similar to those.

Seasonal change

Figure 6 shows the seasonal change of school size based on the catch statistics on the east coast of the Izu Peninsula, where dolphin fishing is operated in autumn and winter. But on the west coast, there has been harvested throughout the year whenever dolphins were avairable. On the west coast, small schools of less than 300 animals have been caught in any season, but large schools of more than 1,000 animals have been caught in the seasons from April to May and again December through January. While on the east coast, larger schools are caught only in the main fishing season from November to January.

Figure 7 shows the size frequency of the schools caught on the both sides of the Izu Peninsula. The figure indicates that there is no significant difference in school size between the two localities in autumn-winter season, but apparent size difference can be seen in the schools caught on the west coast in spring-summer season. Some scientists consider that the schools caught in autumn-winter must be southbound and those in spring-summer must be northbound. The figure is one of the proofs of this consideration.

Table 5 shows size of southbound and northbound schools. The southbound schools are generally larger (average 306) than northbound ones (average 156).

TABLE 4. SCHOOL SIZE OF STRIPED DOLPHINS CAUGHT ON THE WEST COAST OF IZU PENINSULA FROM 1949 TO 1970

Season		School size			
		Range	Total	No. of schools	Average
Jan.	E	53–1,321	4,622	15	308
	M	24– 615	2,083	12	174
	L	31– 486	3,040	14	217
Feb.	E	21– 846	1,255	7	179
	M	—	—	—	—
	L	50– 260	310	2	155
Mar.	E	93	93	1	93
	M	—	—	—	—
	L	10— 88	98	2	49
Apr.	E	16– 254	516	6	86
	M	24– 800	2,365	12	197
	L	45–1,114	3,503	12	292
May	E	44– 358	933	5	187
	M	49– 358	1,797	10	180
	L	11–1,026	3,277	19	172
June	E	16– 386	1,237	13	95
	M	24– 459	2,230	14	159
	L	19– 253	1,038	9	115
July	E	47– 326	640	5	128
	M	20– 48	148	4	37
	L	10– 320	392	4	98
Aug.	E	67	67	1	67
	M	—	—	—	—
	L	—	—	—	—
Sep.	E	63	63	1	63
	M	—	—	—	—
	L	—	—	—	—
Oct.	E	—	—	—	—
	M	—	—	—	—
	L	613	613	1	613
Nov.	E	11	11	1	11
	M	—	—	—	—
	L	—	—	—	—
Dec.	E	41– 80	121	2	61
	M	46–1,289	8,371	19	441
	L	26–2,005	10,151	23	441
Total		10–2,005	48,974	214	229

E. Early, M: Middle, L: Late

From this phenomenon it may be that schools of *S. coeruleoalba* are going up north in smaller school and coming down south in larger school. This change may come from their school structure which reformed in the north.

Diurnal and geographical variation of school size

Among the data of 307 schools caught on the east coast of the Izu Peninsula

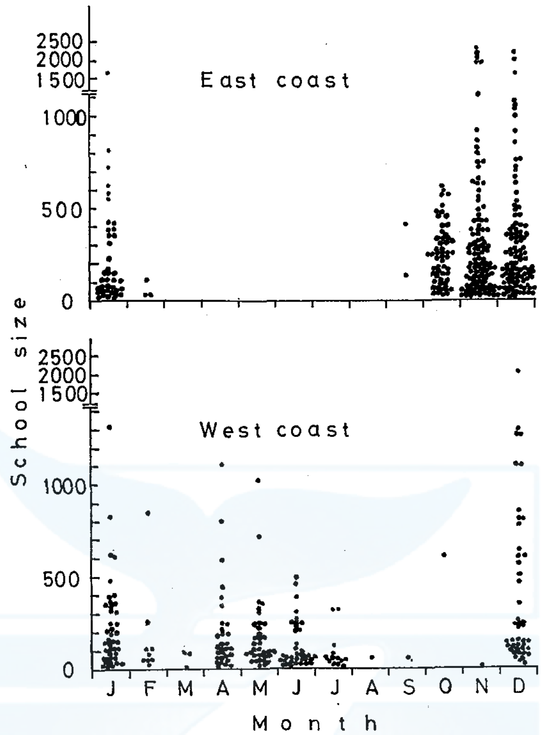

Fig. 6. Scatterplot of school size of striped dolphins caught on the east and west coats of the Izu Peninsula.

from 1949 to 1974, those of 112 schools were useful to be analyzed in diurnal and geographical variation of school size, because they are recorded on a fishermen's log book in detail. All the 112 schools were sighted in the period between 05:00 and 15:00, especially concentrated (75% of all) between 05:00 and 09:00 and biggest number of schools were sighted between 07:00 and 08:00 (Fig. 8).

Figure 9 is the sighted positions of the schools in early morning (05:00–09:00) and in daytime (09:00–15:00) are compared by school size group. The smaller schools of less than 1,000 animals were sighted around Ohshima Island and at the mouth or inside the Sagami Bay in early morning and daytime but the larger schools of more than 1,000 animals were sighted around Oshima Island only in early morning. Table 6 shows the ratio of schools sighted in daytime against those in all through the sighting hours by school size group. The ratio suggests that larger schools come more frequently in early morning than in daytime. From this data, it can be said that larger schools of *S. coeruleoalba* may come close to or be formed at Ohshima Island in early morning.

Relation between school size and school composition

The schools of *S. coeruleoalba* can be divided into three types by school com-

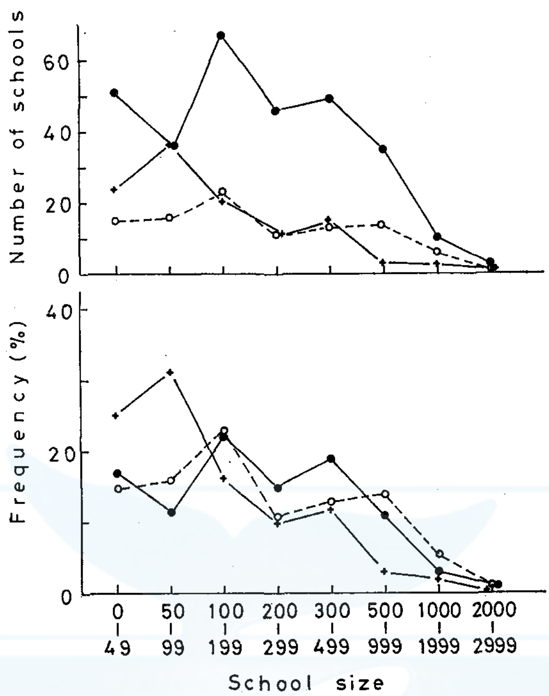

Fig. 7. Number of schools of striped dolphins and its frequency in each school size group. Closed circle and solid line: east coast, autumn-winter catch. Open circle and dotted line: west coast, autumn-winter catch. Ccross and solid line: west coast, spring-summer catch.

TABLE 5. SIZE DISTRIBUTION OF SCHOOL OF STRIPED DOLPHINS CAUGHT ON THE EAST AND WEST COASTS OF IZU PENINSULA FROM 1949 TO 1974

Locality (season)	School size								Total	Ave.
	0–49	50–99	100–199	200–299	300–499	500–999	1000–1999	2000–2999		
East coast	51	36	67	46	59	35	10	3	307	303
(autumn-winter)	(16.6)	(11.7)	(21.8)	(15.0)	(19.2)	(11.4)	(3.3)	(1.0)		
West coast	15	16	23	11	13	14	6	1	99	316
(autumn-winter)	(15.2)	(16.2)	(23.2)	(11.1)	(13.1)	(14.1)	(6.1)	(1.0)		
West coast	29	36	20	11	14	3	2	0	115	156
(spring-summer)	(25.2)	(31.3)	(17.4)	(9.6)	(12.2)	(2.6)	(1.7)	(0)		
Total	95	88	110	68	86	52	18	4	521	273
	(18.2)	(16.9)	(21.1)	(13.1)	(16.5)	(10.0)	(3.5)	(0.8)		

Figures in parentheses indicate percentage.

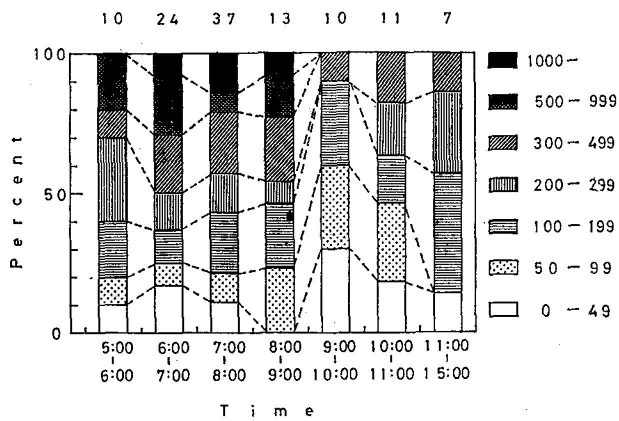

Fig. 8. Diurnal change of frequency of school size of striped dolphins. Numbers at the top indicate sample size.

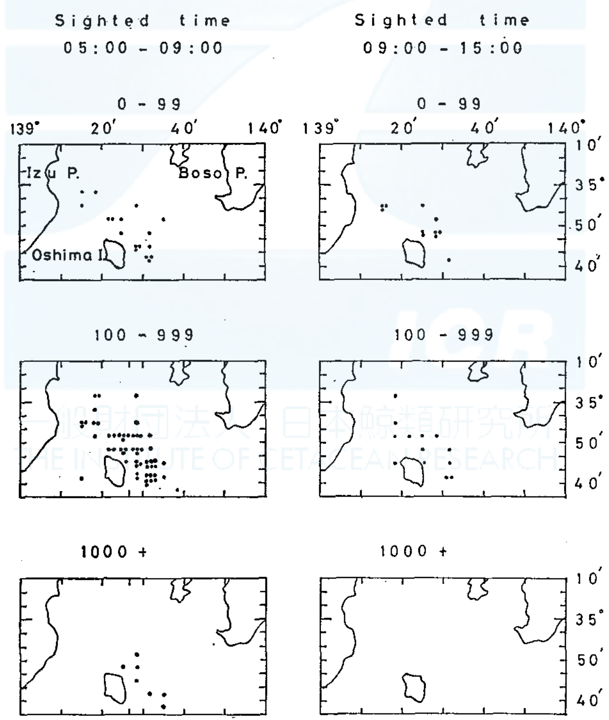

Fig. 9. Sighting positions of schools of striped dolphins by each school size group in the early morning (05:00–09:00) and in the daytime (09:00–15:00).

TABLE 6. RELATION BETWEEN SIZE AND SIGHTED TIME OF SCHOOLS OF STRIPED DOLPHINS

School size	Sighted time		Total	Ratio (Daytime/Total)
	Early morning (05:00–09:00)	Daytime (09:00–15:00)		
0– 99	17	11	28	0.39
100–999	54	13	67	0.20
1,000–	7	0	7	0

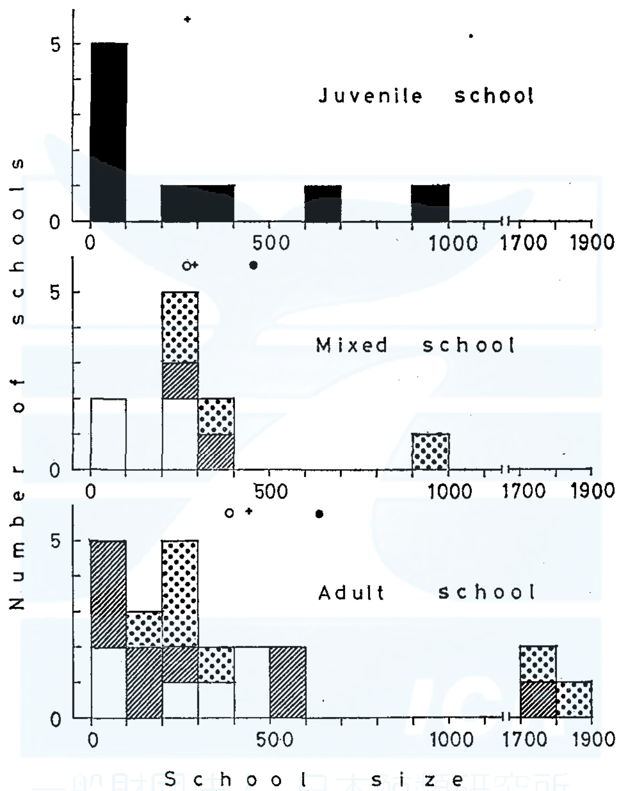

Fig. 10. Frequencies of the school size of striped dolphins in the juvenile, mixed and adult schools. Hatched areas indicate the mating school, dotted the non-mating, white the unidentified, and black the juvenile. Open circle indicates the average school size of the mating schools, closed circle that of the non-mating, and cross the total.

position, such as juvenile, adult and mixed schools (see page 81). More in detail, both adult and mixed schools are to be distinguished one from the other by categories as mating and non-mating schools. Figure 10 shows the size frequency of 9 juvenile, 22 adult and 10 mixed schools. Size of the juvenile schools is of 36–903 animals, (average 277, standard deviation: 295), that of the adult is 31–1,832, (average 442, s.d.: 543) and that of the mixed is 25–912 (average 294, s.d.: 299), respectively. There seems to be no significant meaning in the differences among the three types of school in average size. Analyzed from school composition, all of the very large schools of more than 1,000 animals are the adult type (Fig. 10). If these very large schools are excluded, average size of adult school is 235 animals. The number is similar to those of the juvenile and the mixed schools. School size frequency of each type has a peak at 300 animals or less. From these informations it can be said that the unit of school of *S. coeruleoalba* seems to be 300 animals or less. Size of 9 mating and 8 non-mating schools belong to the adult type, ranges from 31 to 1,724 (average 391, s.d.: 507) and 101 to 1,831 (average 638, s.d.: 659), respectively. On the other hand, 2 mating and 4 non-mating schools of the mixed types ranges from 225 to 305 (average 265, s.d.: 40) and 284 to 912 (average 458, s.d.: 263), respectively. Compared the adult and mixed schools, there seems no apparent differences in average size between the mating and non-mating schools.

CLASSIFICATION AND CHARACTERISTICS OF THE SCHOOLS

Classification

As a criterion, the schools, of which more than 20% of all animals or more than 100 animals of a school had been examined, were applied for analysis. So two schools Nos 1 and 14 were excluded. The schools, Nos 41 and 42 were also excluded because the animals of the two schools mixed themselves before they were hauled. Then 41 out of 45 schools were used for analyzing the school composition or discussion on the school structure.

The animals younger than 1.5 years or smaller than 174 cm in body length are considered as sucking calves and they are accompanied by mother. Then these sucking calves were excluded in calculation of the immaturity rate of the school. Ratio of immature and puberal animals excluding sucklings, against the total number of animals in a school is a useful indicater in knowing character of school composition. The immaturity rate of the school was also calculated as above. In cases that histological examination of the testes or detailed examination of ovaries were not able, testis weight, age, and body length of male and age and body length of females were taken to substitute them in order to know whether the animals have attained sexual maturity.

Figure 11 is the frequency of immaturity rate of the 41 schools, in which three modes are appeared. The first peak is seen between 20% and 40%, schools in this peak can be classified as adult schools because they hold mature animals mostly. The third peak is appeared between 90% to 100%, those in this peak are juvenile schools which hold immature animals as a majority, and the second peak is between 50% and 60% and the schools of this peak are mixed schools. These mixed schools are mixture of immature and mature animals, and they have the school composition between former two school types. The immaturity rates of school No. 2 and No. 6 are 77.5% and 80.3%, respectively. Although both immaturity rates are closer to the rate of the juvenile school than that of the mixed school, those two schools are put into the mixed school group because two schools, No. 2 and No. 6 hold many sucklings (No. 2 had 14 individuals: 25.9% of all in the school) (No. 6 had 18 individuals: 5.6% of all) and school No. 6 also hold many older males of more than 13.5 years (17 individuals: 11.8% of animals whose age were able to be identified).

As a result of above classification, 9 juvenile, 22 adult and 10 mixed schools are counted. Immaturity rates of juvenile schools range from 77.4% to 100%, that of adult schools are from 7.4% to 35.9%, and that of mixed schools are from 44.6% to 80.3%, respectively.

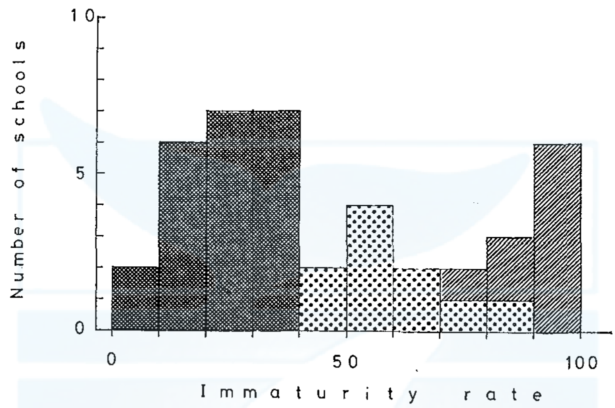

Fig. 11. Frequency of the immaturity rate of schools of striped dolphins. Double hatched areas indicate the adult school, dotted the mixed, and hatched the juvenile.

The juvenile school

Sex ratio indicates number of males by every one female. Sex ratio of the juvenile schools ranges from 1.93 to 6.25, and the ratio of all the juvenile schools in total is 3.07 (Table 7). The juvenile schools are in any case formed by both males and females, and number of males always exceeds.

The maturity rate compares the number of sexually matured individuals against the total number of animals in each school, excluding sucklings. Out of 9 juvenile schools, 8 schools (School Nos 9, 16, 17, 20, 22, 30, 31, 35) had small number of mature males (maturity rate: 8.0% to 27.9%) and only one school, No. 20 had a few mature females (maturity rate: 9.5%) (Tables 7 and 8). The maturity rate of females in all the juvenile schools (2.9%) is lower than that of the males (9.5%).

Figure 12 shows the total age composition of the 6 juvenile schools. In the figure, age of males ranges from 1.5 to 13.5 years and that of females are from 1.5 to 14.5 years. There are two modes seen at the age of 4.5 and 8.5 among males, and one mode appears at the age of 3.5 among females. The age composition

TABLE 7. RATIO OF REPRODUCTIVE CONDITION OF FEMALE AND SEX RATIO IN JUVENILE SCHOOL

School no.	Suckl-ing	Imma-ture**	Mature						Total	Sex ratio***
			un-known	preg-nant	p. & l.	lactat-ing	resting	total*		
4	0	11	0	0	0	0	0	0	11	2.27
		100%		0	0	0	0	0		(—)
9	0	10	0	0	0	0	0	0	10	5.40
		100%		0	0	0	0	0		(—)
16	0	16	0	0	0	0	0	0	16	4.25
		100%		0	0	0	0	0		(—)
17	0	60	0	0	0	0	0	0	60	1.93
		100%		0	0	0	0	0		(—)
20	0	76	3	0	0	2	3	5	84	3.31
		90.5%		0	0	40.0	60.0	100		(8.00)
22	0	69	0	0	0	0	0	0	69	3.43
		100%		0	0	0	0	0		(—)
30	0	4	0	0	0	0	0	0	4	6.25
		100%		0	0	0	0	0		(—)
31	0	13	0	0	0	0	0	0	13	2.08
		100%		0	0	0	0	0		(—)
35	0	9	0	0	0	0	0	0	9	2.00
		100%		0	0	0	0	0		(—)
Total	0	268	3	0	0	2	3	5	276	3.07
		97.1%				40.0	60.0	100		(15.4)

*: Excluding the unkown mature female. **: Percentage of the total excluding the suckling
***: Sex ratio of the total excluding the suckling and sex ratio of the mature animals (in parentheses).

(Fig. 4) shows that most animals in the juvenile schools are immature but a few animals are in the puberal or mature stage. The figure also shows the number of individual of both sexes increasing after weaning at the age of 1.5, and number of females begin to decrease at the age of 4.5 years or about 3 years before the attainment of puberal stage. At the age of 8.5, that of males is decreasing just after attaining sexual maturity at the age of 8.7. Although sex ratio of the animals younger than 8 years is 2.0, that of older than that age is 12.0. This means the difference between sexes in the time of leaving and joining the schools.

The average testis weight of 75 mature males obtained from 7 juvenile schools is 42.9 g (Table 8), and eleven individuals (14.7%) had testes heavier than 68.9 g, which may be a proof of highly activated spermatogenesis. The weight of testes shows that the sexual conditions of mature males in the juvenile school is naturally less developed than those in the adult schools (see page 84).

Considering from detailed examination on the ovaries obtained from the juvenile school No. 20, five mature females are all in the resting stage. Number of corpora albicantia of each individual ranges from one to three. The age of the five females is from 8 to 12 years suggesting that the females have just attained sexual maturity.

TABLE 8. MATURITY FREQUENCIES OF MALE OF JUVENILE SCHOOL

School no.	Suckl-ing	Imma-ture*	Mature*	Testis weight in g. 6.7	6.8–15.4	15.5–39.2	39.3–68.8	68.9	Total**
4	0	25	0	0	0	0	0	0	25
		100%	0	0	0	0	0	0	
9	0	23	3	16	4	1	2	5	54
		42.6%	5.6	29.6	7.4	1.9	3.7	9.3	
16	0	49	19	0	0	0	0	0	68
		72.1%	27.9	0	0	0	0	0	
17	0	103	8	1	2	1	0	1	116
		88.8%	6.9	0.9	1.7	0.9	0	0.9	
20	0	209	15	1	4	32	13	4	278
		75.2%	5.4	0.4	1.4	11.5	4.7	1.4	
22	0	78	1	132	16	7	2	1	237
		32.9%	0.4	55.7	6.8	3.0	0.8	0.4	
30	0	23	1	0	0	1	0	0	25
		92.0%	4.0	0	0	4.0	0	0	
31	0	22	0	0	1	0	4	0	27
		81.5%	0	0	3.7	0	14.8	0	
35	0	16	1	0	0	0	1	0	18
Total	0	548	48	150	27	42	22	11	848
		64.6%	5.7	17.7	3.2	5.0	2.6	1.3	

*: Maturity of testis was identified by eye in the field
**: Excluding the suckling

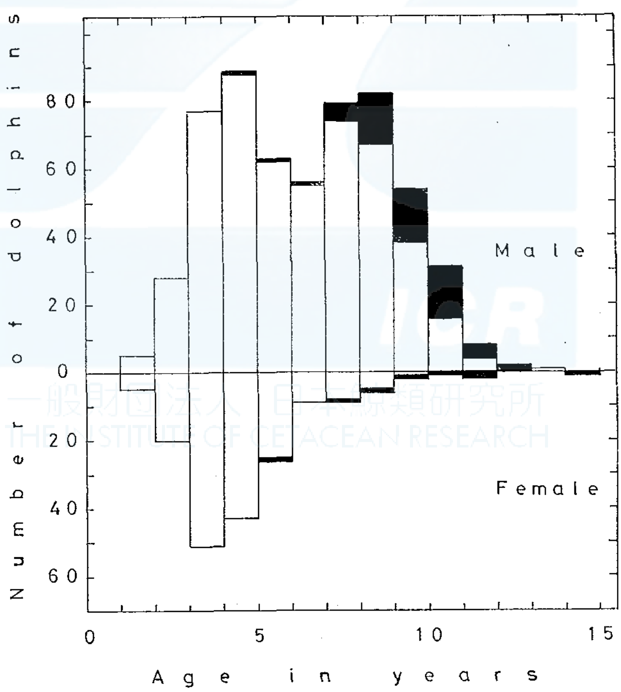

Fig. 12. Age composition of the total juvenile schools of striped dolphins. White areas indicate the immature or puberal dolphins, and black the mature.

The adult school

The adult school may in any case holds both sexes of animals. Sex ratio of the adult schools of this study is varied (from 0.12 to 2.32) (Table 9). Summing up the whole animals in the 22 adult schools, the sex ratio of males against females is 0.78 (Table 9), and then number of females is larger than that of males. School composition of adult schools is somewhat different from that of juvenile schools. The ratio of the number of socially mature males, which are considered to take part in reproduction (see page 99), against the total number of lactating and resting females, which are considered as waiting fertilization is 1.43. The ratio shows a female might mate with more than single socially mature male at the time of reproduction.

The maturity rate of every school shows big varieties in both sexes (male; from 0 to 93%, female; from 42.9% to 100%). In all adult schools in total, maturity rate of males is 77.8%, very close to the rate of females (78.4%) (Tables 9 and 10). The result is a big difference from the sex maturity ratio of the juvenile schools.

Figure 13 shows the clearly recorded age composition of 17 adult school in total. According to the figure, the adult schools are formed with males of 0 to 26.5 years old and females of 0 to 29.5 years old. There are two modes seen at the age of 0 to 1 year and 12 to 13 years of both sexes. The number of animals of both sexes begin to decrease at 1.5 years. The age composition indicates that the animals of both sexes leave the adult school after weaning. Although the number of animals younger than 1.5 years are almost same between sexes (sex ratio: 1.16), the age from 1.5 to 7 years, females than males may remain in the adult school after the weaning stage. Once decreased number of animals of both sexes is increasing from the age of 7 years and goes up till 12–13 years. The sex ratio from 7 to 9 years is 0.71 and after 9 years is 0.76. From this data it is considered that young animals from outside may rejoin the adult school when they become puberal stage. After newcomers joined the schools, sex ratio is almost unchanged through puberal and mature stages.

Average testis weight of the 579 mature males obtained from 22 adult schools is 82.9 g, and 346 individuals (59.8%) had testes heavier than 68.9 g suggesting that they had highly activated spermatogenesis, that is, roughly 60% of mature males of the adult schools are in the highly developed reproductive conditions.

Compared the average testis weight of mature males of 22 schools, there is a big variety, from 29.1 to 147.2 g (Table 13). Checking the average testis weight of the adult schools from the viewpoint of monthly catch, that of individuals caught in October is 113.6 g; there is one mode seen at 110–140 g, and that in November is 70.2 g; one mode is noticeable at 40–80 g (Fig. 14). Apparently testes weight are heavier in October catch than in November catch. On the other hand, age compositions of adult school caught in October and November are almost similar each other. According to Miyazaki (1977) testis weight of males of more than 9 years old is lighter in November and heavier in October. These informations suggest that the difference in testis weight between two months is naturally not by

TABLE 9. RATIO OF REPRODUCTIVE CONDITION OF FEMALE AND SEX RATIO IN ADULT SCHOOL

School no.	Suckling	Immature**	Mature: unknown	Mature: pregnant	Mature: p. & l.	Mature: lactating	Mature: resting	Mature: total*	Total	Sex ratio***
3	1	3	16	0	0	0	0	0	20	0.21
		15.8%		0	0	0	0	0		(0)
5	12	40	30	84	4	87	22	197	279	0.46
		15.0%		42.6	2.0	44.2	11.2	100		(0.44)
7	0	24	20	0	0	0	0	0	44	2.82
		54.5%		0	0	0	0	0		(5.60)
8	8	10	4	7	0	19	4	30	52	0.59
		22.7%		23.3	0	63.3	13.3	100		(0.47)
10	1	2	5	6	0	10	10	26	34	0.64
		6.1%		23.1	0	38.5	38.5	100		(0.55)
11	1	8	2	0	0	0	4	4	15	2.07
		57.1%		0	0	0	100	100		(4.00)
13	0	10	4	29	6	22	4	61	75	0.63
		13.3%		47.5	9.8	36.1	6.6	100		(0.60)
18	0	8	16	17	0	1	0	18	42	0.38
		19.0%		94.4	0	5.6	0	100		(0.15)
21	7	7	1	5	0	18	4	27	42	1.49
		20.0%		18.5	0	66.7	14.8	100		(1.36)
23	0	0	1	7	0	3	0	10	11	1.45
		0%		70.0	0	30.0	0	100		(1.27)
25	1	5	1	5	0	2	0	7	14	1.23
		38.5%		71.4	0	28.6	0	100		(1.88)
26	0	5	0	10	0	2	0	12	17	1.41
		29.4%		83.3	0	16.7	0	100		(1.50)
27	7	42	18	29	0	9	4	42	109	1.02
		41.2%		69.0	0	21.4	9.5	100		(1.25)
29	16	16	3	21	0	29	0	50	85	0.19
		23.2%		42.0	0	58.0	0	100		(0.25)
32	4	8	2	3	0	2	1	6	20	2.63
		50.0%		50.0	0	33.3	16.7	100		(4.00)
34	8	8	15	45	1	10	1	57	88	0.44
		10.0%		78.9	1.8	17.5	1.8	100		(0.44)
36	9	19	34	24	1	20	3	48	110	0.12
		18.8%		50.0	2.0	41.7	6.3	100		(0.10)
37	6	17	11	15	0	11	2	28	62	0.14
		30.4%		53.6	0	39.3	7.1	100		(0.05)
38	6	17	1	99	0	7	2	108	132	0.62
		13.5%		91.7	0	6.5	1.9	100		(0.45)
40	10	11	3	27	3	17	6	53	77	0.72
		16.4%		50.9	5.7	32.1	11.3	100		(0.71)
43	5	32	21	19	0	21	5	45	103	1.38
		32.7%		42.2	0	46.7	11.1	100		(1.44)
44	29	33	14	62	20	45	4	131	207	1.24
		18.5%		47.3	15.3	34.4	3.1	100		(1.26)
Total	131	325	222	514	35	335	76	960	1,638	0.79
		21.6%		53.5	3.6	34.9	7.9	100		(0.78)

*: Excluding the unknown mature female. **: Percentage of the total excluding the suckling.
***: Sex ratio of the total excluding the suckling and sex ratio of the mature animals (in parentheses).

TABLE 10. MATURITY FREQUENCIES OF MALE IN ADULT SCHOOL

School no.	Suckl-ing	Imma-ture*	Mature*	Testis weight in g. 6.7	6.8–15.4	15.5–39.2	39.3–68.8	68.9	Total**
3	4	4	0	0	0	0	0	0	4
		100%	0	0	0	0	0	0	
5	12	18	81	2	2	4	10	5	122
		14.8%	66.4	1.6	1.6	3.3	8.2	4.1	
7	0	12	50	0	0	0	0	62	124
		9.7%	40.3	0	0	0	0	50.0	
8	9	6	7	3	1	1	2	6	26
		23.1%	26.9	11.5	3.8	3.8	7.7	23.1	
10	11	2	9	2	0	0	0	8	21
		9.5%	42.9	9.5	0	0	0	38.1	
11	0	5	22	0	0	2	0	0	29
		17.2%	75.9	0	0	6.9	0	0	
13	3	5	10	2	1	3	4	22	47
		10.6%	21.3	4.3	2.1	6.4	8.5	46.8	
18	0	11	0	0	0	1	0	4	16
		68.8%	0	0	0	6.3	0	25.0	
21	6	14	4	0	0	0	0	34	52
		26.9%	7.7	0	0	0	0	65.4	
23	3	2	0	0	0	0	0	14	16
		12.5%	0	0	0	0	0	87.5	
25	2	1	8	0	0	1	0	6	16
		6.3%	50.0	0	0	6.3	0	37.5	
26	0	4	3	2	0	0	2	13	24
		16.7%	12.5	8.3	0	0	8.3	54.2	
27	4	22	29	4	3	4	5	37	104
		21.2%	27.9	3.8	2.9	3.8	4.8	35.6	
29	26	0	1	0	0	0	0	12	13
		0	7.7	0	0	0	0	92.3	
32	1	10	2	0	0	1	8	21	42
		23.8%	4.8	0	0	2.4	19.0	50.0	
34	4	2	9	1	0	3	12	8	35
		5.7%	25.7	2.9	0	8.6	34.3	22.9	
36	4	0	1	2	2	3	2	2	12
		0%	8.3	16.7	16.7	25.0	16.7	16.7	
37	6	6	0	0	0	2	0	0	8
		75.0%	0	0	0	25.0	0	0	
38	1	18	3	1	10	28	16	2	78
		23.1%	3.8	1.3	12.8	35.9	20.5	2.6	
40	15	7	2	1	0	4	14	20	48
		14.6%	4.2	2.1	0	8.3	29.2	41.7	
43	12	2	3	24	14	23	41	28	135
		1.5%	2.2	17.8	10.4	17.0	30.4	20.7	
44	36	11	99	24	2	7	31	46	220
		5.0%	45.0	10.9	0.9	3.2	14.1	20.9	
Total	159	162	343	68	35	87	147	350	1,192
		13.6%	28.8	5.7	2.9	7.3	12.3	29.4	

*: Maturity of testis was identified by eye in the field.
**: Excluding the suckling.

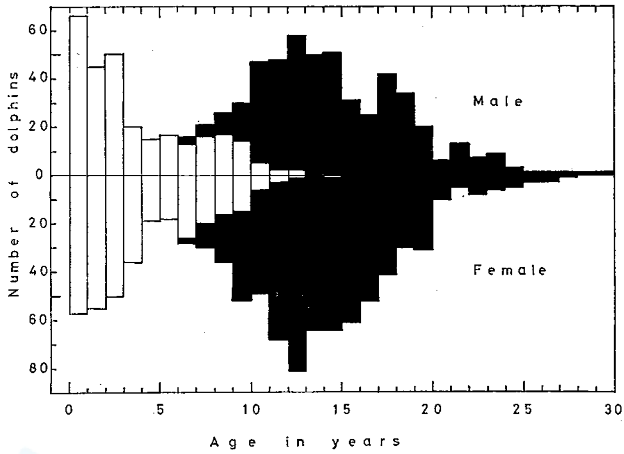

Fig. 13. Age composition of the total adult schools of striped dolphins. White areas indicate the immature or puberal dolphins, and black the mature.

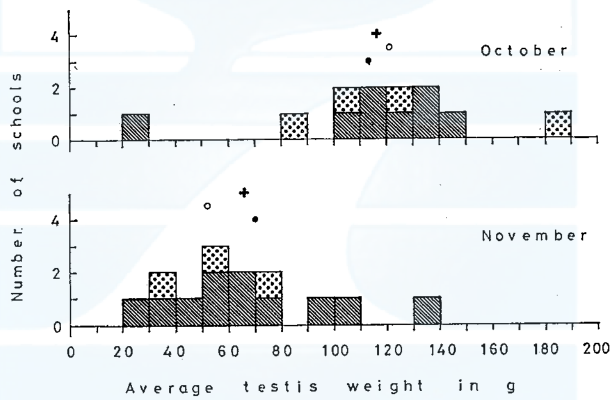

Fig. 14. Frequencies of the average testis weight of the mature males in each school of striped dolphins. Hatched areas indicate the adult schools, and dotted the mixed. Closed circle indicates the average of adult schools, open circle that of the mixed, and cross the total.

age composition but by some reproductive condition of animals.

Among 20 adult schools, 14 schools (70.0%) hold females of all pregnant, lactating, and resting stages, 5 schools hold those of pregnant and lactating but not resting, and only one school (5%) had neither pregnant nor lactating females (Fig. 15). There is, however, no school holds females exclusively in pregnant stage nor those in lactating (Table 9). These facts may suggest that the adult school structure is commonly holding all pregnant, lactating, and resting females. There seems to be small number of schools which lack resting females, or pregnant but school structure otherwise may be rare. There are six schools which had females

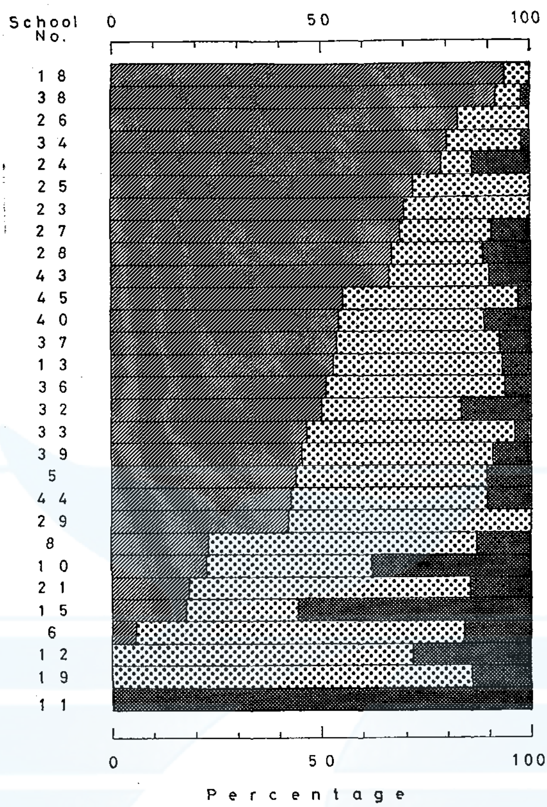

Fig. 15. Percentage of the pregnant, the lactating, and the resting females to the total mature females in each school of striped dolphins. Hatched areas indicate the pregnant females, dotted the lactating, and double hatched spots the resting.

who showed simultaneously pregnant and lactating stages, the number of those females is only 35 all through the adult schools and the ratio of them against the number of all mature females is very small (3.6%). Figure 15 shows frequency of the pregnant, lactating and resting females against all mature females, excluding unknown individuals, in ratio by each school. The ratio of the pregnant females varies, from 0 to 94.4% (average: 53.5%); one mode is seen at 40–60%, that of lactating ones ranges from 0 to 66.7% (average 34.9%); one mode is appear at 30–50%, that of resting ones shows widest variety, from 0 to 100% (average: 7%), there is one mode at 0–10%. Above data suggests that the average structure of the adult school includes 40–60% of pregnant, 30–50% of lactating and less than 20% of resting females.

The mixed school

As well as the adult school, the mixed school holds, in any case, both sexes of animals and sex ratio varies (from 0.47 to 2.32). Summing up the number of animals in whole ten schools, number of males is slightly larger than that of females ; sex ratio is 1.06 (Table 11). This ratio is situated at the middle between those of juvenile and adult schools. Maturity rate of males of the whole mixed schools is 35.4%, the rate is just middle of those of juvenile and adult schools (Table 12). While maturity rate of females in each school is from 15.3 to 70.0% (Table 11), and that of the whole mixed school is 46.3%, the rate is a little higher than that of male.

Figure 16 shows total age composition of 7 mixed schools. According to the figure, age of males ranges from 0 to 24.5 years and of females from 0 to 26.5 years ; peaks are seen at 5–6 years, and 12–13 years of both sexes, the former 5–6 years is similar to the age composition of the juvenile schools and the latter 12–13 years is so to that of the adult schools.

In the age composition (Fig. 4), it is understood that fundamentally the mixed school has two types of composition, one holds both sexes of immature and puberal animals as majority and the other holds those of mature animals as majority. However, there are a few mixed schools with other type of composition. School

TABLE 11. RATIO OF REPRODUCTIVE CONDITION OF FEMALE AND SEX RATIO IN MIXED SCHOOL

School no.	Suckl-ing	Imma-ture**	Mature						Total	Sex ratio***
			un known	preg-nant	p. & l.	lactat-ing	resting	total*		
2	4	9	4	0	0	0	0	0	17	2.08
		69.2%		0	0	0	0	0		(1.25)
6	9	111	1	1	0	15	3	19	140	1.33
		84.7%		5.3	0	78.9	15.8	100		(2.00)
12	3	4	0	0	0	5	2	7	14	1.27
		36.4%		0	0	71.4	28.6	100		(0.43)
15	17	45	4	9	0	14	29	52	118	1.32
		44.6%		17.3	0	26.9	55.8	100		(1.20)
19	2	3	0	0	0	6	1	7	12	1.20
		30.0%		0	0	85.7	14.3	100		(0)
24	0	11	3	11	0	1	2	14	28	2.32
		39.3%		78.6	0	7.1	14.3	100		(1.35)
28	1	36	7	12	0	4	2	18	62	0.92
		59.0%		66.7	0	22.2	11.1	100		(1.08)
33	6	36	13	13	0	14	1	28	83	0.47
		46.8%		46.4	0	50.0	3.6	100		(0.27)
39	13	32	2	14	0	14	3	31	78	0.68
		49.2%		45.2	0	45.2	9.7	100		(0.61)
43	4	32	15	33	0	12	5	50	101	0.75
		33.0%		66.0	0	24.0	10.0	100		(0.43)
Total	59	319	49	93	0	85	48	226	653	1.06
		53.7%		41.2	0	37.6	21.2	100		(0.81)

*: Excluding the unknown mature female. **: Percentage of the total excluding the suckling.
***: Sex ratio of the total excluding the suckling and sex ratio of the mature animals (in parentheses).

TABLE 12. MATURITY FREQUENCIES OF MALE IN MIXED SCHOOL

School no.	Suckling	Immature*	Mature*	Testis weight in g. 6.7	6.8–15.4	15.5–39.2	39.3–68.8	68.9	Total**
2	10	22	5	0	0	0	0	0	27
		81.5%	18.5	0	0	0	0	0	
6	8	87	15	40	7	2	11	12	174
		50.0%	8.6	23.0	4.0	1.1	6.3	6.9	
12	5	11	1	0	0	0	0	2	14
		78.6%	7.1	0	0	0	0	14.3	
15	9	66	67	0	0	0	0	0	133
		49.6%	50.4	0	0	0	0	0	
19	1	12	0	0	0	0	0	0	12
		100%	0	0	0	0	0	0	
24	1	23	6	10	9	2	0	15	65
		35.4%	9.2	15.4	13.8	3.1	0	23.1	
28	2	26	18	2	1	0	0	9	56
		46.4%	32.1	3.6	1.8	0	0	16.1	
33	3	20	0	2	3	5	4	2	36
		55.6%	0	5.6	8.3	13.9	11.1	5.6	
39	10	19	1	1	4	15	3	1	44
		43.2%	2.3	2.3	9.1	34.1	6.8	2.3	
43	8	33	2	1	9	20	6	0	71
		46.5%	2.8	1.4	12.7	28.2	8.5	0	
Total	57	319	115	56	33	44	24	41	632
		50.5%	18.2	8.9	5.2	7.0	3.8	6.5	

*: Maturity of testis was identified by eye in the field.
**: Excluding the suckling.

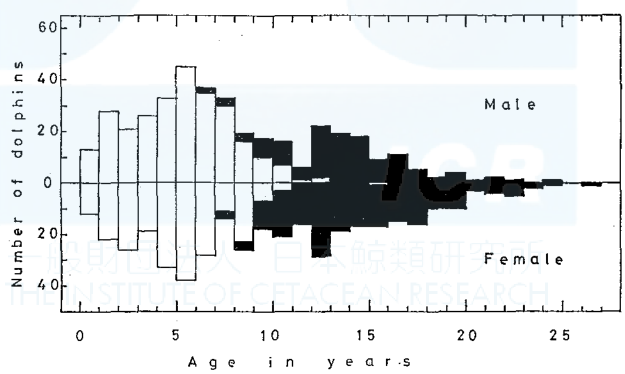

Fig. 16. Age composition of the total mixed schools of striped dolphins. White areas indicate the immature or puberal dolphins, and black the mature.

No. 19, for example holds mature individual of exclusively females and immature ones of both sexes, and school No. 24 for another example, holds mature animals of both sexes and individual in puberal stage of exclusively males.

Average testis weight of mature males in all the mixed schools is 65.3 g, among those animals, 37.6% (namely 41 mature males) had testes heavier than 68.9 g suggesting that they had possibly active spermatogeneses. The rate 37.6% is a little lower than that of the adult schools. Average testis weight of every mixed school also ranges widely from 31.2 to 180.4 g (Table 13). Apparent testis weight variety can be seen between the animals caught in October and in November (Fig. 14). Weight of testes from the schools caught in October ranges from 104.4 to 180.4 g (average 136.5 g) and those from November caught are from 32.4 to 70.2 g (average 51.8 g) (Fig. 14). Namely, weight of testes are heavier in October and become lighter in November. This phenomenon is common in the adult schools.

Out of ten mixed schools, nine were examined of sexual condition of females. Most of the school held (77.8%) females of all pregnant, lactating and resting stages, but a few schools lacked pregnant females (Fig. 15). There was no female who showed simultaneously pregnant and lactating stages, in any school.

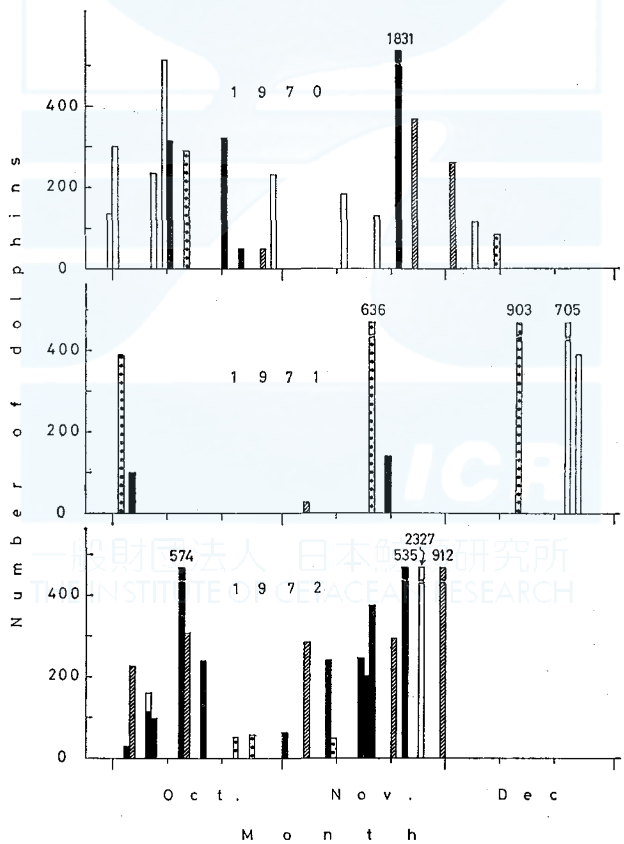

Fig. 17. School size, date of catch, and school composition of striped dolphins are shown in each year during 1970 through 1972. Black areas indicate the adult school, dotted the juvenile, hatched the mixed, and white the unidentified.

DISTRIBUTION OF THE SCHOOLS

Distribution of the schools was presumed from the compositions of 33 schools investigated over the three fishing seasons in the period from 1970 to 1972, from the catch record of Kawana and Futo Fishermen's Union over the five fishing seasons in the period from 1970 to 1974, and from the location of the Kuroshio Current was taken up as a big factor to influence distribution of this species.

Generally, the isothermal layer of 15°C at about 200 m depth was an indicator to tell the location of the Kuroshio. According to the data on the Kuroshio by the Maritime Safety Agency, distance between the main fishing area of this species and the Kuroshio in the season from October to December was 7.0 nautical miles in 1970, 52.5 n.m. in 1971 and 9.4 n.m. in 1972. That is, the Kuroshio was closer to the area in 1970 and 1972 than in 1971. In 1970 and 1972, 5 juvenile, (18.5%), 15 adult (55.6%) and 7 mixed (25.9%) schools were caught. While in 1971, 3 juvenile (50.0%), 2 adult (30.0%) and 1 mixed (20.0%) schools were

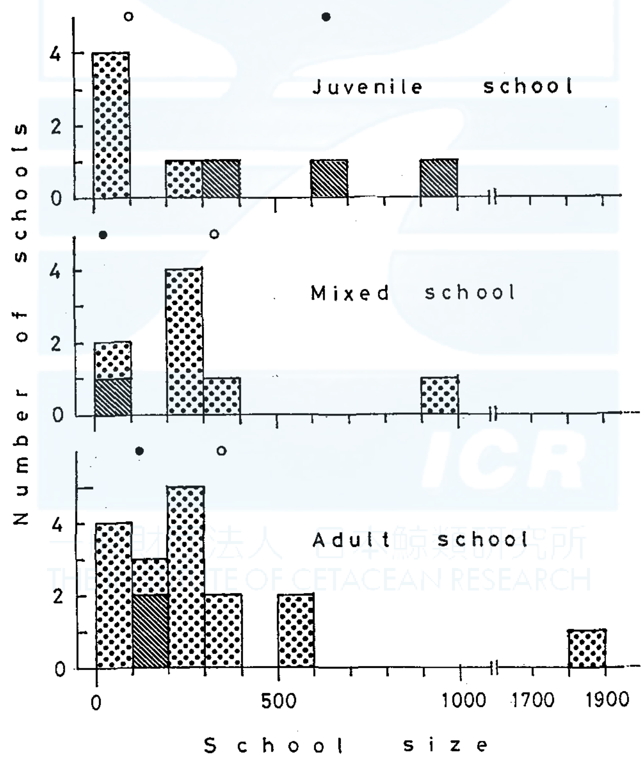

Fig. 18. Frequencies of school size of striped dolphins in the juvenile, mixed, and adult schools. Dotted areas indicate the catch in the year when the Kuroshio currents close to the coast, and hatched the catch in the year when the Kuroshio distant from the coast. Open circle indicates average size of the schools caught in the former year, and closed circle that in the latter year.

harvested (Fig. 17). Namely, in the year when the Kuroshio was closer, comparatively larger number of adult schools but lesser number of juvenile schools came into the area. Figure 18 is the school size frequency by school type. The figure shows that in the year when Kuroshio was closer, size of adult schools varies widely as

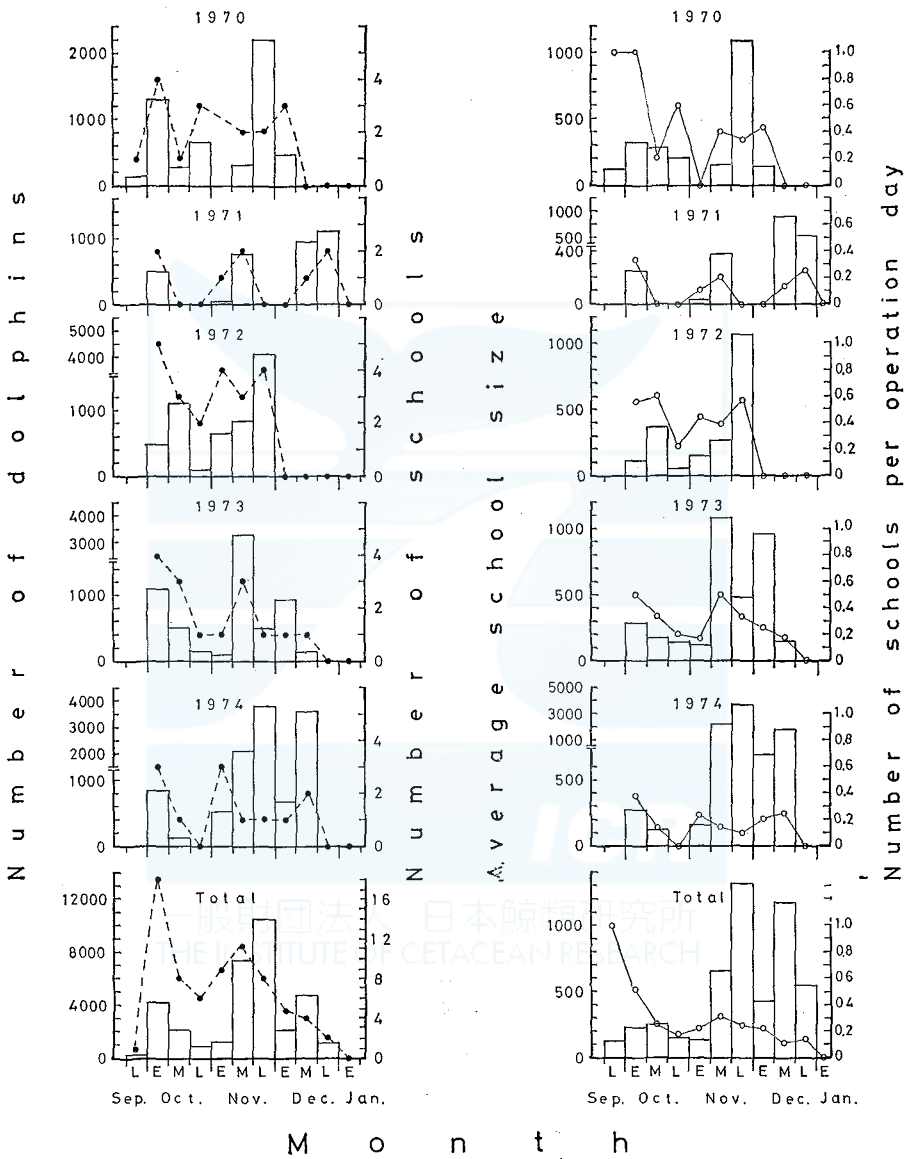

Fig. 19. Frequencies of number of striped dolphins, number of schools, average school size, and number of school per operation day are shown in five fishing seasons during 1970 through 1974. Closed circle and dotted line indicate number of schools, open circle and solid line number of schools per operation day.

from 31 to 1,832 individuals (average: 345), while in the year of distant Kuroshio, range of adult school size is narrow as 101 to 140 animals (average: 120). On the other hand size of the juvenile schools were relatively smaller in the years when the Kuroshio is closer as from 45 to 293 animals (average 105), while the Kuroshio was distant, size of those ranged from 393 to 903 animals (average 664). The average size in the latter year is almost six times as large as that of the former. Apparently, school size as well as distribution of the schools of this species were influenced by the location of the Kuroshio.

Figure 19 shows number of animals and schools caught, and average school size and number of schools per operation day, by the year. In every graph of the four items, based on the data of five fishing seasons during 1970–1974, two peaks are seen in October and November. Number of animals form higher peaks in November than in October. On the other hand number of schools form higher peaks in October. Accordingly, the peaks of average size are higher in November but those of number of schools per operation day is higher in October. As the fishing ground of *S. coeruleoalba* along the east coast of the Izu Peninsula is a limited area, number of schools per operation day can be an indicator of density of schools coming to the area seasonally.

RELATIONAL COINCIDENCE OF ANIMALS WITHIN THE SCHOOL

Puberal males

In the age composition of males in school Nos 17, 22, 30, 31 and 35, each one mode is recognized at the age of 4.5 years. This mode is formed with immature males. While in the age composition of an unique school, No. 20, there are two modes at 4.5 and 8.5 years, and the latter mode is higher. Presumed from age, animals of the latter mode mostly are puberal males with some mature ones. Presumably, school No. 20 was formed in the case when puberal males coming out of a juvenile school joined by a group of immature males. Based on the age compositions of Nos 24, 28, 33, 39 and 43, puberal male group is perceived (Fig. 4), however, acutally, puberal males seem not to form the school without coincidence of immature or mature individuals.

Immature and mature animals

Examined the frequency of coincidence of immature and mature animals in 22 adult schools in Fig. 20, numbers of immature males and females against mature females show positive co-relation. And numbers of immature males and females against mature males also show positive co-relation. These mean that both sexes of immature animals frequently coincide with mature males and females in adult schools. Considering age composition of striped dolphins after weaning stage, immature females may more often remain in the adult school than immature males.

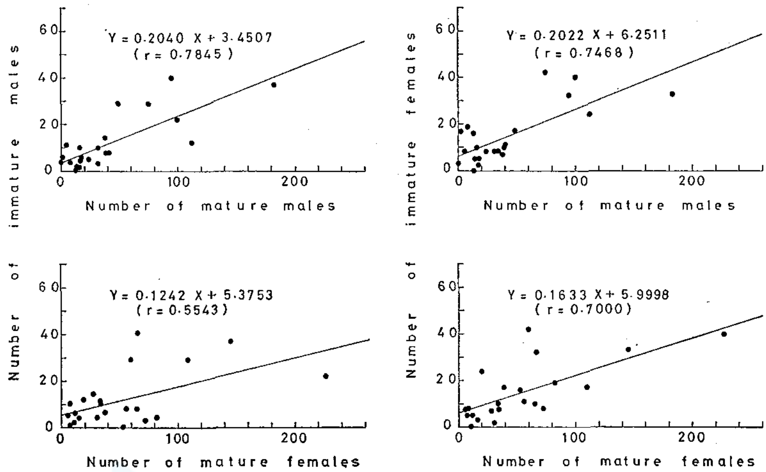

Fig. 20. Relation between the immature and the mature striped dolphins. Immature dolphins in this case mean the puberal or immature dolphins excluding the suckling.

Mature females

In the frequencis of body length of fetuses and newborn calves (less than 182 cm in length) in every 27 schools (Fig. 21), there are two or more peaks in most schools. It is suggested that the mature females who had fetuses in the same size were fertilized in a same mating season as well as the females who accompanied with newborn calves in the same size. It seems likely that females fertilized nearly at same time, do not change their schools spontaneously one by one, but move out and in as a group. Considering that many schools have plural modes in themselves, it can be said that groups of females nearly simultaneously fertilized may gather together to form a bigger group within a school.

In order to analize the relation between mature females in detail, adult females are divided into five stages by corresponding body length of fetuses or newborn calves. First, pregnant females are divided into three stages, early pregnancy (had fetuses of less than 32 cm in length), middle pregnancy (had fetuses of 33–67 cm) and late pregnancy (had fetuses of more than 68 cm), and remainders are divided into lactation (accompanied by calves of less than 174 cm) and post lactation (accompanied by young animals of 174–182 cm). In the present study the actual relation between calves and their mothers can not be obtained. Then, trying to know how frequently coincide each stage of females in the schools, the relation between peaks of body length composition of fetuses and newborn calves was shown in Fig. 22. As in the case of school No. 45, for example, three peaks were seen in the school composition, the relation between the first and second peaks of length composition of fetuses and newborn calves, that between the second and third peaks, and that between the third and first peaks were plotted in Fig. 22. These plots suggest that the band of early pregnant and lactating females, that of

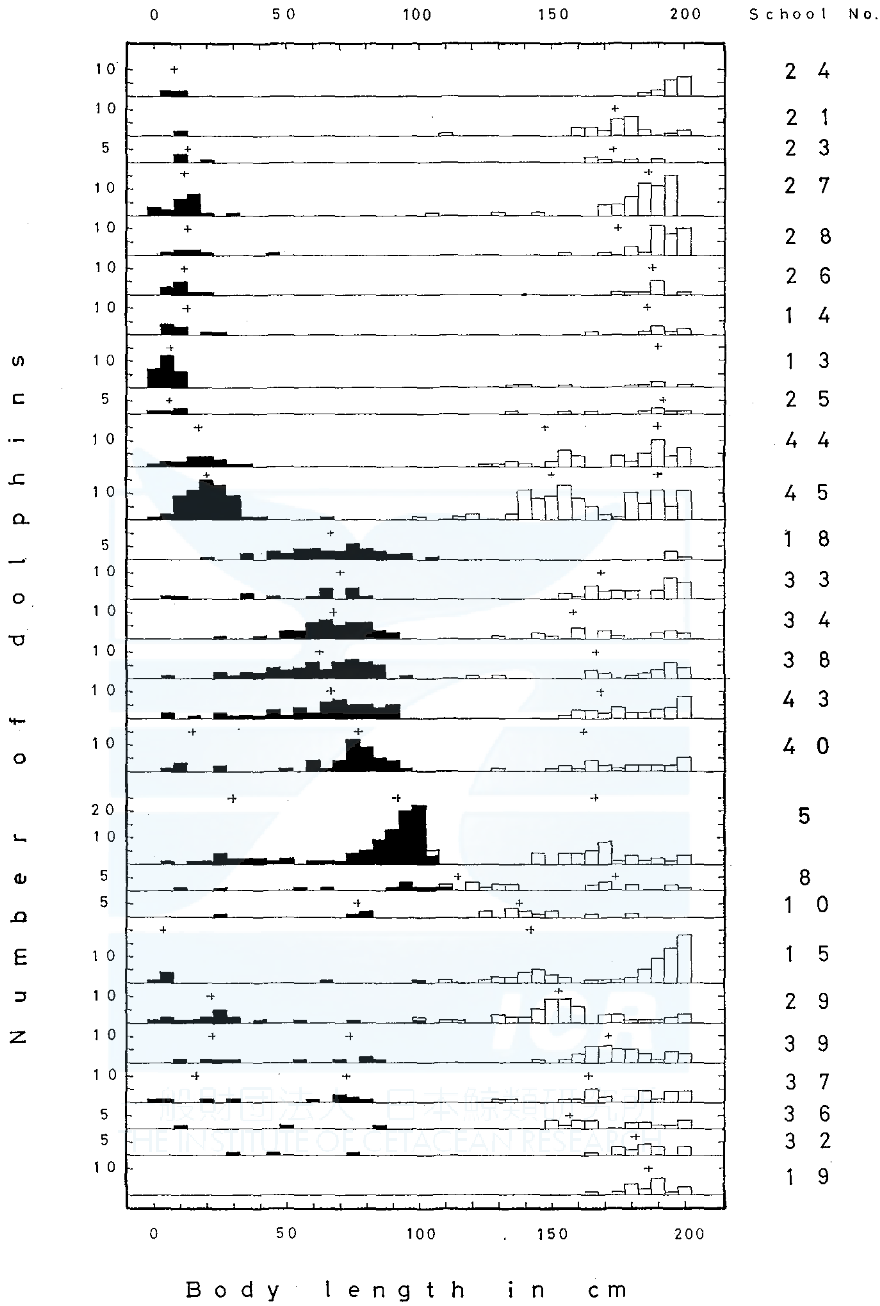

Fig. 21. Body length frequencies of collected fetuses and newborn calves of striped dolphins in each school. Black areas indicate fetuses, white newborn calves and cross the peak.

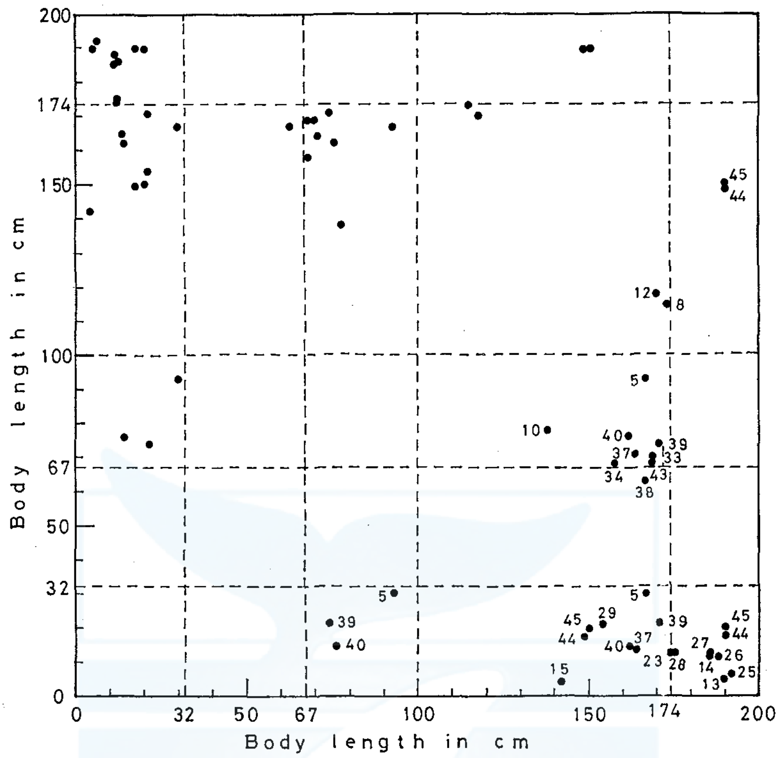

Fig. 22. Relation between peaks in body length frequencies of fetuses or newborn calves of striped dolphins in each school. Numbers indicate the school no.

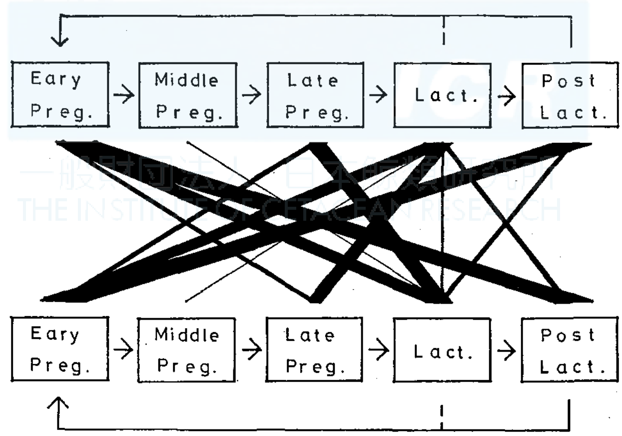

Fig. 23. Relation between the mature females. Thickness of line indicates the degree of relational coincidence of mature females. Arrows mean the direction of the change of sexual conditions.

lactating and post lactating females, and that of post lactating and early pregnant females appear to closely associate each other. Total plots of 22 adult schools are summed up and they are schematically figured in Fig. 23. This suggests that groups of females waiting for or shortly after fertilization, or those of shortly before or after partulition have higher coincidence.

Mature males

As mentioned before, 222 mature males can be divided into three stages as MI, MII and MIII according to the histological examination of testes. Ratio of the males of type MIII against all the mature males at each age is shown in Fig. 24. At 13.5 years, males of MIII reach 50% and naturally, the ratio grow higher with age. As the males of MIII proved in examination their highly activated spermatogenesis, males of older than 13.5 years are in full maturity of reproduction.

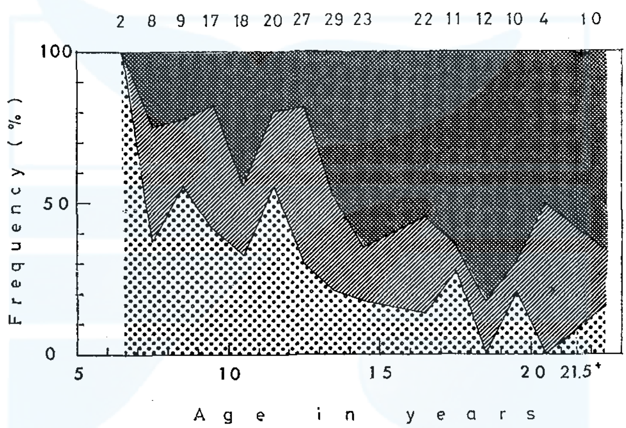

Fig. 24. Relation between age and percentage of mature striped dolphins of MI, MII, and MIII types to the total mature males (from bottom to top). For MI, MII and MIII types see text. Numbers at the top indicate sample size.

In juvenile schools most mature females have just reached maturity but are not yet fertilized, and most mature males have light testes and not yet participate in mating. As the oldest male is 13.5 years, it may be that males of about this age go out of juvenile schools. In the age composition of school Nos 6, 24, 28, 33 and 39, there are two modes of males in each, the first one is understood as indication of immature and puberal males and the second one is that of mature males. Those five schools are considered to be mixed schools, the mature males belonged to the first mode seems to have been originated in a juvenile school, not yet participate in mating, but the mature males belonged to the second mode seems to have originated in an adult school and already have participated in mating. Making these reading of figure as a standard, the youngest males which have participated in mating in each school, were presumed. It was around 13.5 years in age except one younger individual in school No. 39. Considering this age of youngest par-

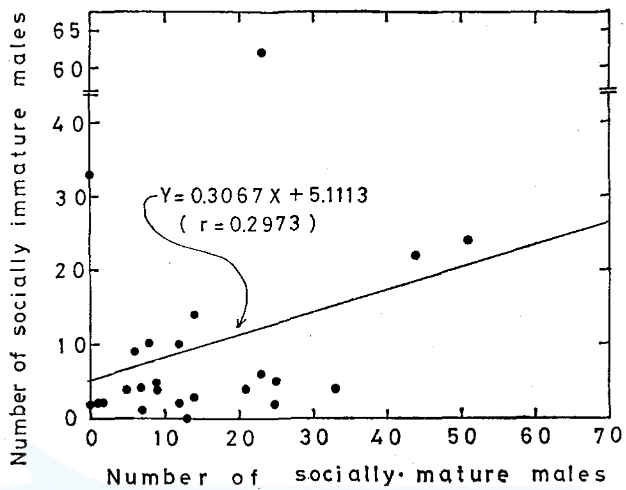

Fig. 25. Relation between socially immature males and socially mature males.

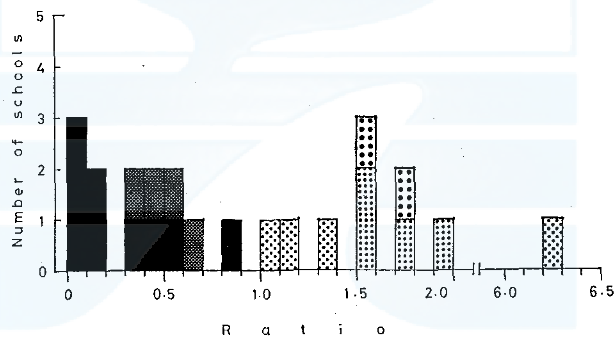

Fig. 26. Frequency of the ratios of the socially mature males to the mating females. Black areas indicate the non-mating adult schools, black with white spot the non-mating mixed, small dotted the mating adult, and large dotted the mating mixed.

ticipant with the results of histological examinations of testes, it may be that, males become socially mature at about 13.5 years old. The mature males younger than this age is defined as socially immature males in this study. In order to know coincidence of socially mature males and socially immature males, both stages of males were plotted in Fig. 25 from 24 schools. It seems that there are no apparent relational coincidences.

Mature females and males

The females in early pregnant, lactating, and resting stages are considered as waiting or shortly after fertilization, and defined as mating females. On the other hand, females of middle and late stages of pregnancy are considered not to participate in mating for a time being and defined as non-mating females. Fre-

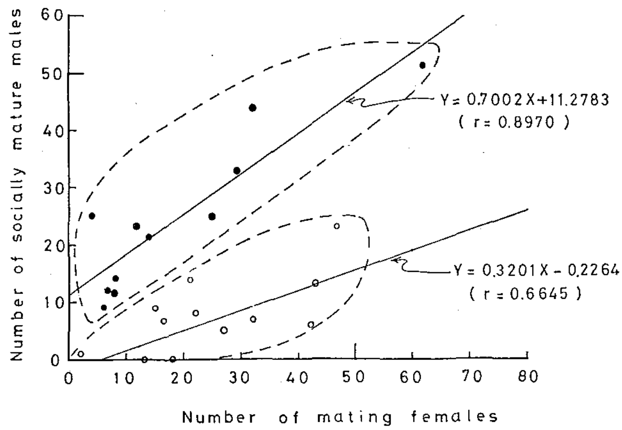

Fig. 27. Relation between the socially mature males and the mating females. Open circles indicate the non-mating schools and closed circles the mating.

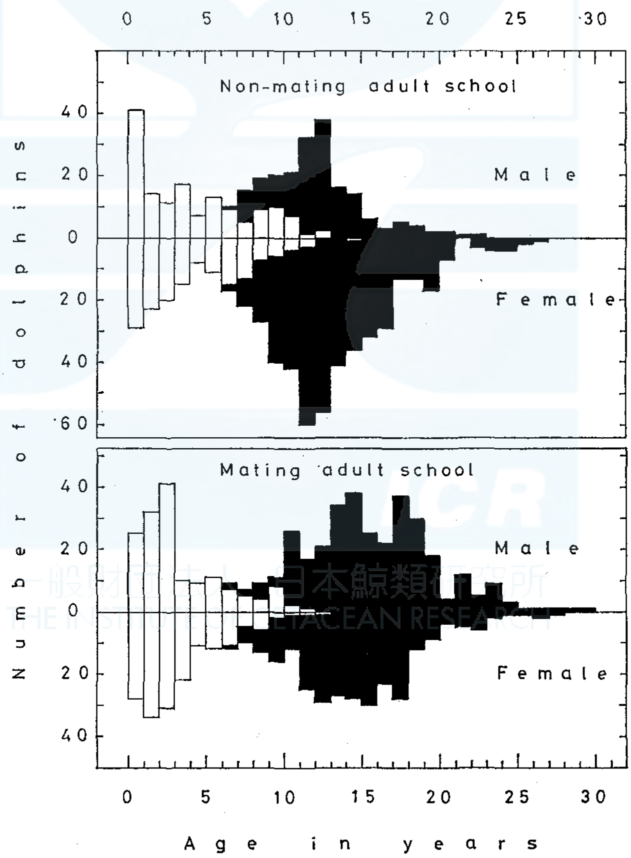

Fig. 28. Age compositions of the mating and non-mating adult schools of striped dolphins. White areas indicate the immature or puberal dolphins and black the mature.

quency in ratio of number of socially mature males against mating females of 17 adult and 6 mixed schools are shown in Fig. 26. In this figure there are two peaks at the ratio 0–0.1 and 1.5–1.6. According to the above definition, the total 23 schools are able to be divided into two categories. Those schools, of which the ratio of socially mature males against mating females is lower than 0.9, are called as non-mating schools and those, of which ratio is higher than 1.0, are called as mating schools. Eight adult schools (Nos 5, 13, 18, 29, 36, 37, 38, and 44) and four mixed schools (Nos 6, 33, 39 and 43) are in the non-mating category, and nine adult schools (Nos 21, 23, 25, 26, 27, 32, 34, 40 and 45) and two mixed schools (Nos 24 and 28) are in the mating category. Number of mating females and socially mature males of every school are plotted in Fig. 27. This figure seems to rationalize the division of mating and non-mating schools, and socially mature males and mating females are frequently coincident in the schools. Collective age composition of both categories of adult school is in Fig. 28 and that of mixed schools is in Fig. 29. Compared the age compositions of those two categories of schools, it is a matter of course that socially mature males are recognized more frequently in mating schools and the males in mating schools have better developed heavier testes than males of non-mating schools (Fig. 30). As majority of females in mating schools are waiting or shortly after fertilization, and majority

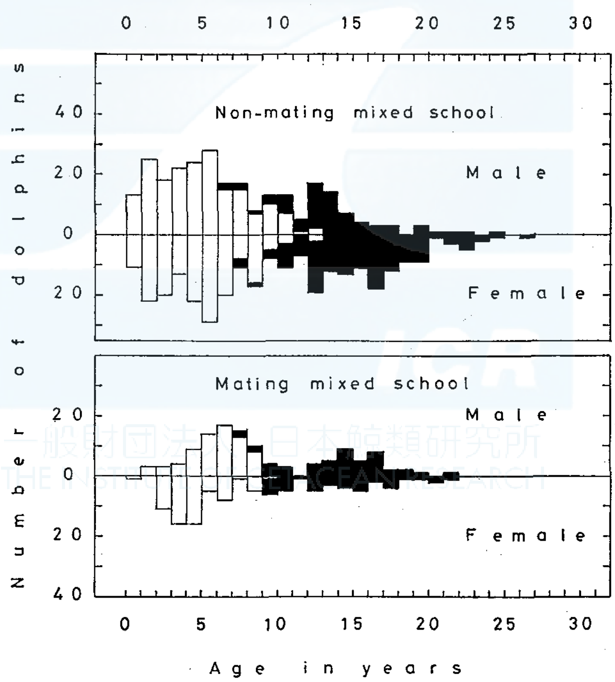

Fig. 29. Age compositions of the mating and non-mating mixed schools of striped dolpins. White areas indicate the immature or puberal dolphins and black the mature.

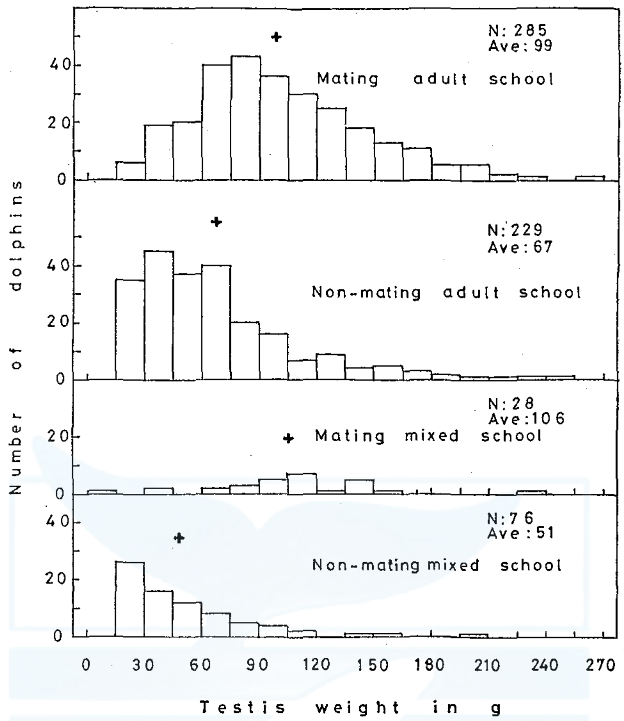

Fig. 30. Frequencies of testis weight of mature males in the mating and non-mating schools. Cross indicate average testis weight.

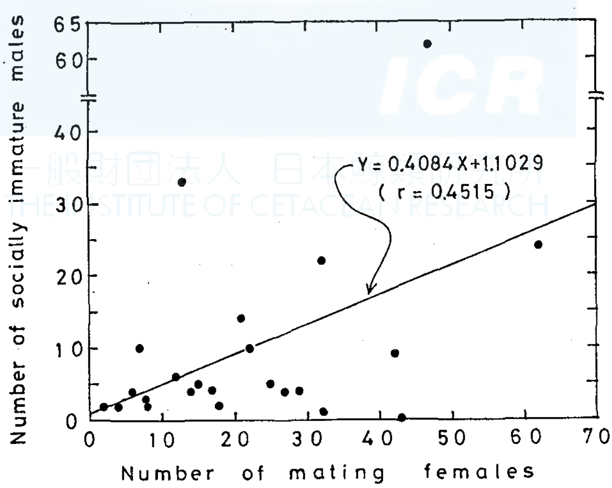

Fig. 31. Relation between the socially immature males and the mating females.

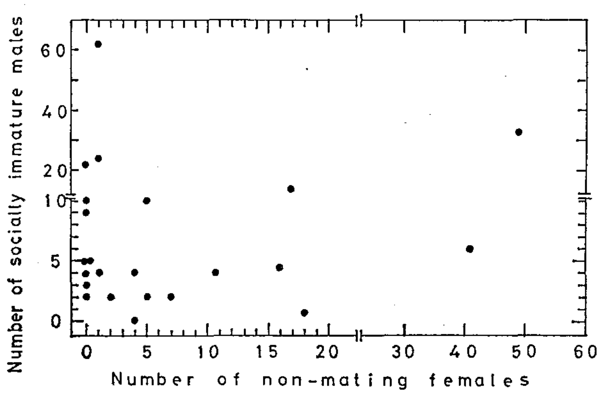

Fig. 32. Relation between the socially immature males and the non-mating females.

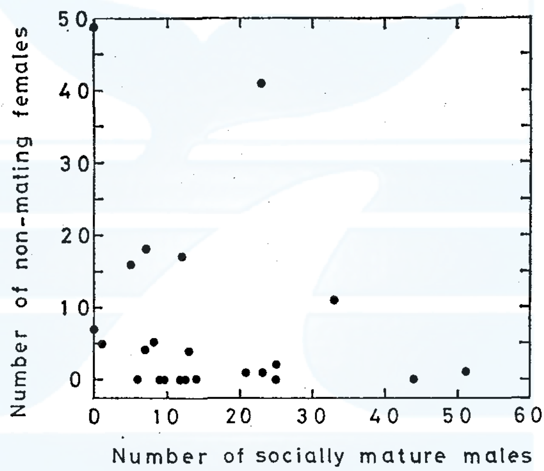

Fig. 33. Relation between the non-mating females and the socially mature males.

of females in non-mating schools are expecting or shortly after parturition, socially mature males are considered to move between mating and non-mating schools according to the reproductive conditions of mature females. Figure 31 shows that mating females have some coincidental relations with socially immature males, but not so high frequency as with socially mature males. In Figs 32 and 33, non-mating females have little or no such relational coincidence with socially mature males nor socially immature males.

BEHAVIOR, IN AND OUT OF THE SCHOOLS

Immature animals from the adult to the juvenile school

Age composition of all the adult schools is in Fig. 12 and that of the juvenile schools is in Fig. 13. In the juvenile schools number of juveniles of both sexes is

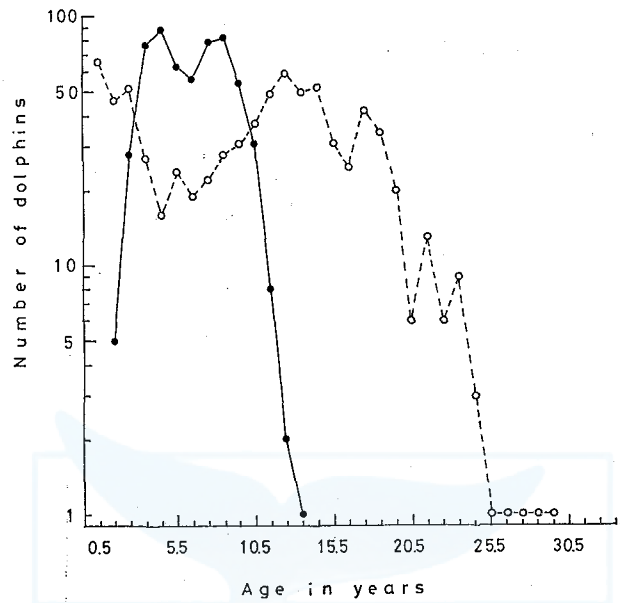

Fig. 34. Comparison of age compositions of males between the juvenile and the adult schools. Open circle and dotted line indicate the males in the total adult schools, and closed circle and solid line the males in the total juvenile.

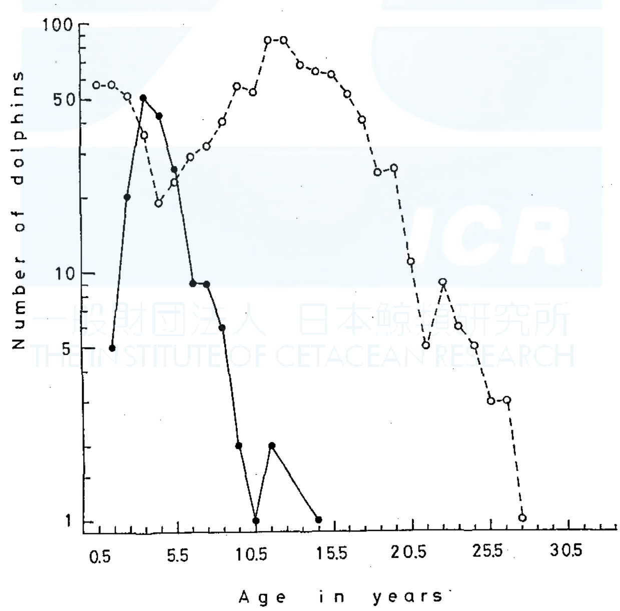

Fig. 35. Comparison of age compositions of females between the juvenile and the adult schools. Open circle and dotted line indicate the females in the total adult schools, and closed circle and solid line the females in the total juvenile.

increasing gradually from the age from 1.5 to 5 years. But in the adult school, reverse tendency is seen. Both tendencies suggest that juveniles get out from the adult school into the juvenile school.

Based on the body length composition of fetuses and newborn calves in the adult schools and age composition of all the juvenile schools, it is understood how long animals stay in the adult school, and when they get out of the adult school. Figure 21 shows that there are groups of newborn calves born in a same season in the adult schools, and if these young animals moved into the juvenile school as a group, the age composition of the juvenile school should have shown big increase at a certain age. But there is a gradual upward curve after 1.5 years. Accordingly, it may be reasonable to consider that juveniles get out of an adult school spontaneously one by one, not as a group.

In average, 2.5 years of males (Fig. 34) and 3.0 years of females (Fig. 35) get out of the adult school and join into the juvenile school. The average age is obtained as the age of coincidence of decrease and increase between both types of the schools. The figure also means that after weaning, males remain in the adult school for about one year and the females for about 1.5 years before they get out one by one.

Females from the juvenile to the adult school

According to the age composition of females in every juvenile schools (Fig. 4), the juvenile schools hold many immature females and a small number of puberal ones. Number of animals is decreasing from the age of 4.5 years and puberal ones appear just at this age. There are few females older than 8.5 years, the time of just reaching puberty. Weight of the left ovaries of 60 females in school No. 22 proves that only one (1.7%) is in the puberal stage; the individual had left ovary more than 2.0 g. That is, young females leave the juvenile school before the time of reaching puberty.

Compared the age composition of the juvenile and the adult schools, the juvenile schools have a peak at 3.5 years and the number of animals gradually decrease from 4.5 years while in the adult school animals are increasing at the same age. Females leave the juvenile school in age between 4.5 to 9.5 years (Fig. 35). Decrease in number of females of the juvenile schools coincide with increase in that of the adult school at 5.7 years, before the attainment of puberty. There are mature females, though very small in number, also rarely seen in the juvenile schools as in the school No. 20.

From the viewpoint of mating conditions, both adult and mixed schools can be divided into two categories, namely mating and non-mating schools. In the age composition of females, compared the two categories of schools at the age from 1.5 to 6.5 years, numbers of females of the two show almost same values, and again compared at the age older than 12.5, values are almost same again (Fig. 36). But compared the number of females at the age from 7.5 to 12.5 years, the number is large in the non-mating schools while in the mating schools the number is small. Referring to the fact that in the juvenile schools the number at the same age is

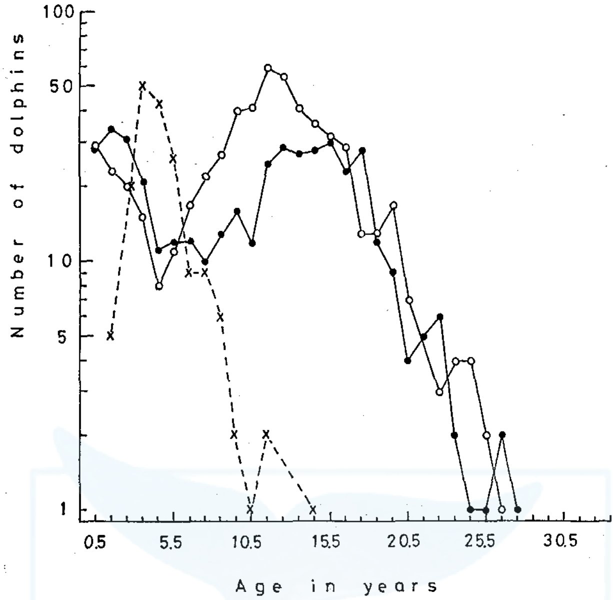

Fig. 36. Comparison of age compositions of females among the juvenile, the mating adult, and the non-mating adult schools. Open circle and solid line indicate the females in the non-mating adult school, closed circle and solid line the females in the mating adult, and cross and dotted line the females in the juvenile.

very small, females leaving from the juvenile schools might move first into a non-mating school and then move again into a mating school when they attain sexual maturity.

Males from the juvenile to the adult school

According to the age composition of the juvenile schools, school Nos 17, 22, 30, 31, 35 (Fig. 4), they hold males among immature animals as majority and small number of puberal ones. Number of males is decreasing from 4.5 years and puberal males appear at the same age. Very few males remain in the school after 8.7 years (50% of males presumed to attain sexual maturity at this age.) Result of histological examination on the testes of the males in school No. 22 tells that puberty rate is maximum 12.5% at 8.5 years (Fig. 37). And after 8.5 years, sexual maturity rate is increasing, but there is no male who had highly developed testis with active spermatogeneses like the males of type MIII. Although histological examination on animals of school Nos 17, 30, 31 and 35 was impossible, males of those schools were likely to have developed similar stage of sexual condition as males in school No. 22 because of almost the same age composition. On the other hand, age composition of school No. 20 shows two modes at 4.5 and 8.5 years. The former peak is composed of a big number of immature males and the latter is of big number of puberal males with small number of mature males. Figure 4

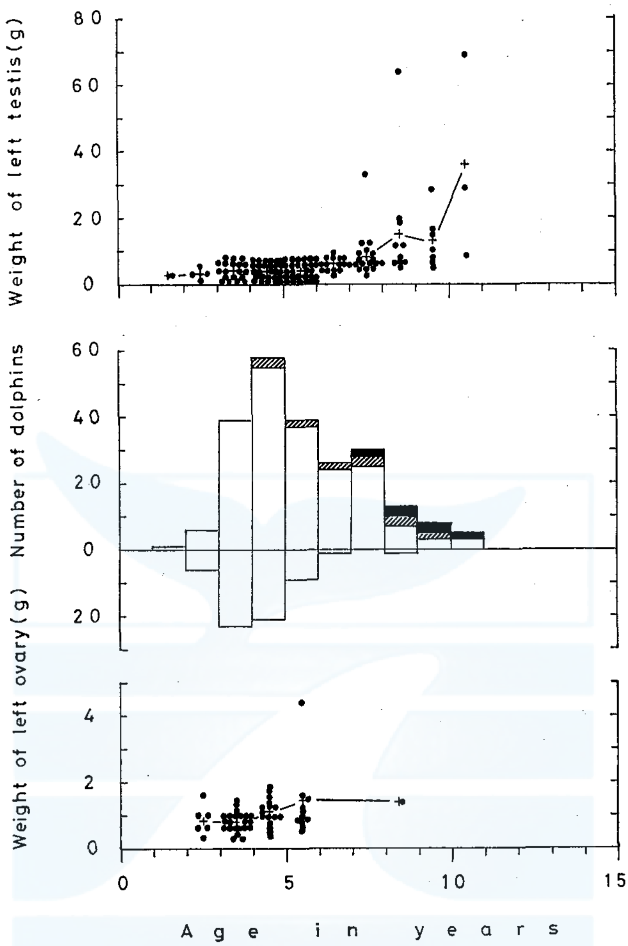

Fig. 37. Age composition, relation between age and the left testis weight, and relation between age and the left ovary weight in school No. 22. Black areas indicate the mature dolphin, hatched the puberal, white the immature and cross average.

suggests the fact that most of the juvenile schools hold major number of immature males and smaller number of puberal ones, and a few of them hold many puberal males with small number of mature ones.

Observing the age composition of males of all the adult and juvenile schools together (Figs 12 and 13), the number of males at the age from 8.5 to 11.5 years is small in juvenile schools but big in adult schools. As the condition of school No. 20 shows, the males seem to leave from the school at the stage of reaching sexual maturity. Regarding the increase and decrease in number of males from 8.5 to 11.5 years, decrease in the juvenile schools coincide with increase in the adult schools at 10.5 years (Fig. 34). The fact may prove that males in the juvenile school rejoin into the adult school just after they attained sexual maturity. However, some males seem to leave the juvenile school a little earlier, within the age of puberal stage.

As mentioned before, the adult schools can be divided into the mating and non-mating schools by reproductive condition. In the age composition, number of animals is decreasing after 12.5 years in the non-mating and after 17.5 years in the mating school (Fig. 28). The decrease of number in the non-mating schools seems to have been caused by some sexual condition, because the males attain social maturity at 13.5 years in average (ready to court females), and the decrease begin at this age. In younger years, from 1.5 to 12.5 years, fluctuation of number is similar in the both categories of schools (Fig. 38). Taking all the above ten-

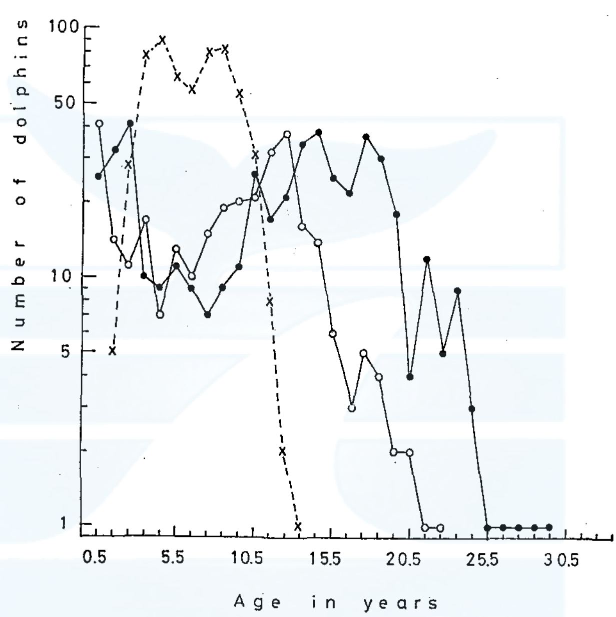

Fig. 38. Comparison of age compositions of the males among the juvenile, the mating adult, and the non-mating adult schools. Open circle and solid line indicate the males in the non-mating adult school, closed circle and solid line the males in the mating adult, and cross and dotted line the males in the juvenile.

dencies into consideration, it can be said that males from juvenile schools move into both mating and non-mating schools, and stay there till they attain social maturity. Among those males, individuals who joined non-mating school seems to move again into the mating school after socially matured.

Mature animals' behavior in the both categories of adult schools

Table 13 shows (1) ratio of number of socially mature males against mating females, (2) average body length of fetuses, (3) average age of sucklings and (4) average testis weight of mature males. From those data, something can be considered related to the animals in and out of the schools.

TABLE 13. SCHOOL COMPOSITION OF STRIPED DOLPHINS CAUGHT ON THE COAST OF IZU PENINSULA. A) IMMATURE RATE, B) AVERAGE BODY LENGTH OF FETUSES IN CM, C) AVERAGE AGE OF SUCKLING, D) AVERAGE LEFT TESTIS WEIGHT OF MATURE MALES IN G, E) NUMBER OF SOCIALLY MATURE MALES, F) NUMBER OF SOCIALLY IMMATURE MALES, G) NUMBER OF MATING FEMALES, H) NUMBER OF NON-MATING FEMALES, AND I) RATIO OF SOCIALLY MATURE MALES TO MATING FEMALES

School no.	A	B	C	D	E	F	G	H	I
1	53.3	—	—	—	—	—	—	—	—
2	77.5	—	—	—	—	—	—	—	—
3	30.4	—	—	—	—	—	—	—	—
4	100	—	—	—	—	—	—	—	—
5	15.9	79.0	—	57.8	7	1	32	18	0.21
6	80.3	—	—	70.2	9	5	15	0	0.60
7	21.4	—	—	—	—	—	—	—	—
8	28.6	76.8	—	114.4	—	—	—	—	—
9	82.5	—	—	63.9	—	—	—	—	—
10	11.1	65.0	—	126.1	—	—	—	—	—
11	30.2	—	—	29.1	—	—	—	—	—
12	60.0	—	—	180.4	—	—	—	—	—
13	14.8	4.5	—	104.9	6	9	42	0	0.14
14	46.7	12.5	—	—	—	—	—	—	—
15	47.4	19.2	—	—	—	—	—	—	—
16	77.4	—	—	—	—	—	—	—	—
17	94.3	—	—	48.5	0	1	—	—	—
18	32.8	56.1	—	80.2	1	2	2	5	0.50
19	68.2	—	—	—	1	2	—	—	—
20	80.1	—	—	40.3	0	44	—	—	—
21	24.1	11.1	1.64	139.9	25	5	25	0	1.00
22	96.4	—	—	35.4	0	10	—	—	—
23	7.4	12.6	1.19	147.2	12	2	8	0	1.50
24	57.0	7.0	1.25	104.4	12	10	7	0	1.71
25	20.7	6.8	0.38	127.9	9	4	6	0	1.50
26	26.8	9.1	1.88	118.8	14	3	8	0	1.75
27	34.5	11.1	1.14	108.8	44	22	32	0	1.38
28	55.6	15.9	1.44	124.7	21	4	14	1	1.50
29	19.5	29.5	0.41	136.8	13	0	43	4	0.30
30	93.1	—	—	—	—	—	—	—	—
31	90.0	—	—	44.3	0	4	—	—	—
32	31.0	50.3	0.63	90.8	25	2	4	2	6.25
33	54.0	51.8	1.36	52.9	7	4	17	4	0.41
34	9.6	68.3	0.68	65.0	23	6	12	41	1.92
35	92.6	—	—	55.0	0	2	—	—	—
36	20.4	62.2	0.99	47.9	5	4	27	16	0.19
37	35.9	48.0	0.68	28.5	0	2	18	7	0
38	22.5	62.1	0.89	38.2	0	33	13	49	0
39	51.4	45.9	0.88	32.4	8	10	22	5	0.36
40	16.5	62.1	0.99	66.7	33	4	29	11	1.14
41	—	—	—	—	—	—	—	—	—
42	—	—	—	—	—	—	—	—	—
43	44.6	55.2	0.89	31.2	14	14	21	17	0.67
44	30.9	17.3	1.09	56.8	23	62	47	1	0.49
45	17.9	20.0	—	75.7	51	24	62	1	0.82

Comparing the reproductive level of mature males and females, relation between average body length of fetuses and the average testis weight of mature males shows negative correlation (Fig 39). Then it can be said that those adult schools hold big number of females in early gestation and relatively large number of well matured males. Investigating the relation between the age of sucklings and the level of testis development (in weight), average testis weight is getting heavier when sucklings reached 1.5 years, the age is just at the beginning of weaning in average (Fig. 40). Meaning of this relation is that those schools where there are many calves at the end of sucking hold many well matured males. The relation between the average body length of fetuses and the average age of sucklings (Fig. 41) indi-

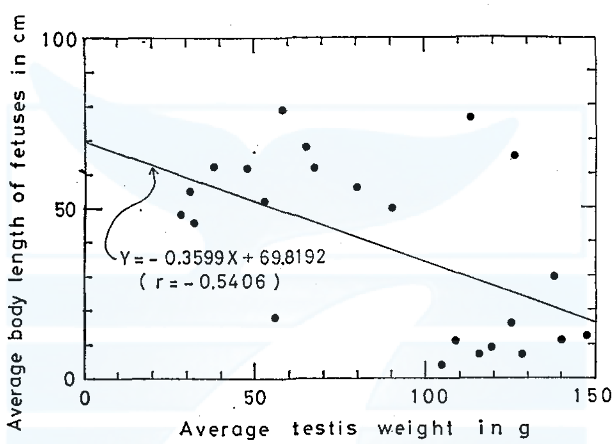

Fig. 39. Relation between the average body length of fetuses of striped dolphins and the average weight of the left testis of mature males in each school.

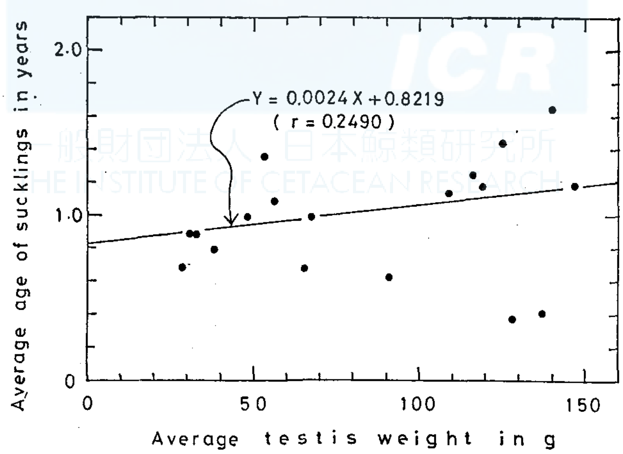

Fig. 40. Relation between the average age of the sucklings of striped dolphins and the average weight of the left testis of mature males in each school.

cate negative correlation. This relation shows that those schools hold many females in early gestation as well as large number of females in later lactation. Comparing the ratio of the number of socially mature male with that of mating females and the average testis weight of mature males (Fig. 42), the result is positive correlation. This means that those schools having lots of mature males with heavier testis have higher rate of socially mature males against mating females. The results might tell that well matured males get out from the school, in which many non-mating females are staying, and are drawn to the school where many mating females are in.

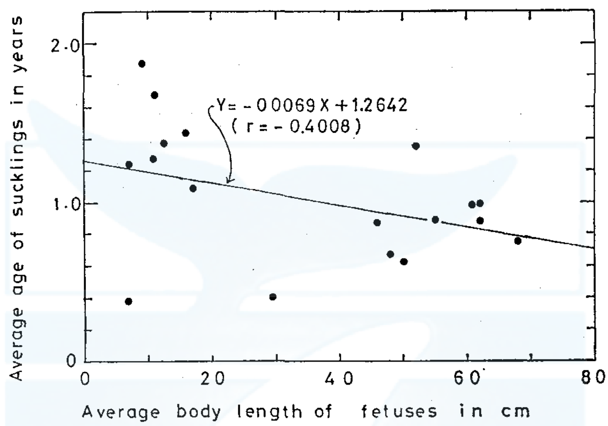

Fig. 41. Relation between the average age of the sucklings of striped dolphins and the average body length of fetuses in each school.

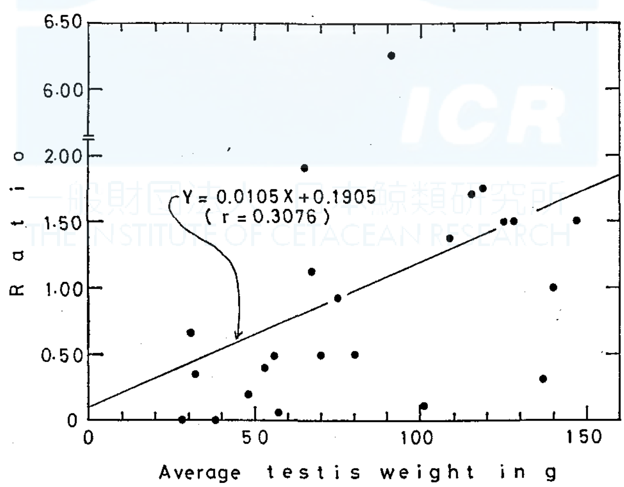

Fig. 42. Relation between the ratio of socially mature males to the mating females and the average testis weight of the lef testis of mature males in each school.

DISCUSSION AND SUMMARY

It is known that the schools or individuals of different species of dolphins sometimes swim together not only in captive but also in wild. However, in cases of *S. coeruleoalba*, it has never been observed in wild that animals of the species swam in any connection with those of other species. In the case that schools of *S. coeruleoalba* and *S. attenuata* were chased together into Futo harbor and kept in captive for three days from November 16 to 18, 1973, individuals of each species swam separately without mixing each other. This reveals that animals of *S. coeruleoalba* may not mix with those of other species as their characteristic behavior.

From observation on board and the analysis of school size, it is known that a large school of *S. coeruleoalba* holds several small schools of about 30 to 300 individuals in it. Such small schools hold the basic units of a mature female with a calf, of the mature male and female, and of young animals. Those observation prove a characteristic behavior of the striped dolphin in making schools.

Kasuya *et al.* (1974) studied on the schools of *S. attenuata* caught on the coast of Izu Peninsula and reported size frequency of the schools, in which 85% of the total catch of animals are from the smaller schools of less than 500 individuals and 4.5% were from bigger schools of more than 1,000 individuals. This school size frequency fits well to that of *S. coeruleoalba* of the present study. Comparing the size frequencies of the southbound and the northbound schools, it can be said that the species of animals are going up north in smaller schools and then coming down south in larger schools. But in the main fishing season of the coast, in southbound schools from November to January and northbound schools from April to May, large schools of more than 1,000 animals are seen in south or north bound schools. In the year when the Kuroshio is closely located to the fishing area, number of adult schools is larger, and in the other year when the Kuroshio is distant, that of juvenile schools is larger and school size in the latter year is remarkably large. But the adult school size is similar in both years. Accordingly the school size change of *S. coeruleoalba* may have been caused by the changes of school structure, of migration route, and of oceanographic condition. According to Saayman and Tayler (1973), the schools of *Tursiops aduncus* expands and shrinks during a day. As the result of this study, larger schools more than 1,000 animals may come close to or be formed at Oshima Island in early morning. It can be said that school size of striped dolphins may change largely by gathering and dispersing movement during a day, but further study is needed to explain this size change more exactly.

By the frequency of maturity rate of both sexes, the schools can be classified into three types, (1) the juvenile school which mainly composed of immature animals of after weaning and puberal ones, (2) the adult school which is of mature animals and sucklings, and (3) the mixed school of immature, puberal and mature animals together. As mentioned before, the mixed schools' composition is just middle of the juvenile and adult schools, and mostly caught in the year when the Kuroshio is closer. That is, abundant schools come to the area and tend to mix themselves, the mixed school seems to be formed naturally or during the driving schools are forced to be mixed.

Juvenile schools of *S. coeruleoalba* are often observed as schools of exclusively immature animals, but schools of only puberal animals is not found. Nevertheless, the group of puberal animals seems to exist in a school together with groups of immature or mature animals of the school. The analysis of school composition of *S. attenuata* on the Pacific coast of Japan (Kasuya *et al.* 1974) suggests that the species have the immature school similar to the juvenile school of *S. coeruleoalba.* Perrin *et al.* (1976) described that juveniles probably do not school separately in the eastern Pacific population of *S. attenuata.* This is only a presumption, but difference in school structure between the findings by Perrin and this study on *S. coeruleoalba* might have occurred in a different fishing method or in the divergency of the stages of dolphins examined in the studies.

Both the adult and the mixed schools can be divided into two categories, namely mating and non-mating schools. Mating schools are of animals ready to mate and non-mating schools are of animals not yet ready for mating. And in the adult schools, number of socially matured males (ready to court) seems to move between those mating and non-mating schools. In the mating school of *S. coeruleoalba,* slightly excess number of socially matured males over mating females suggests that this species has efficient mating system. They may have no such intense fighting among males as seen among the bulls of *physeter catodon,* and all socially matured males may take part in the mating.

There are variety of modes of fetuses and newborn calves seen in Fig. 21. It can be presumed from this figure that individuals of this species do not stay in a certain school, they may have mobility, if they were stable, there would be more periodical modes of fetuses and newborn calves.

As a conclusion of this study, dolphin's movements between schools are as follows. Male calves in the adult schools stay for about a year after weaning and then they move into the juvenile school when they grown up to 2.5 years in average. Female calves also stay in the adult school for about a year and a half after weaning and move into the juvenile school at 3.0 years in average. That is, young males leave the adult school a little earlier than young females. Similar behavior is seen in the animals of *S. attenuata* (Kasuya *et al.* 1974). However, some immature individuals remain in the adult school after weaning. Females in the juvenile school rejoin into the adult school about three years before they reach puberty and there they are growing up to mature females, then, most of them move first into the non-mating school but some of them directly into the mating school. And the females in the non-mating attain sexual maturity after three years, then they move again into the mating school. Immature males grow up to mature through puberal stage in the juvenile school. Puberal males in the juvenile school seem to form a group among themselves within the school and will stay for about a year and a half after they attained sexual maturity, then they move into the adult school. When animals of both sexes move into the adult school, they chose mating or non-mating schools by some instinct and will attain social maturity there. The males who attained social maturity in the non-mating school seem to move again into the mating school. When mature females become ready to mate, they leave the non-mating school and form a small mating school with socially matured males. And several such mating school seem to gather together to a large mating school. After most of females in the mating school fertilized, socially mature males and some mature females seem to leave the school. Then the mating school naturally turned out to the non-mating school, in which fertilized females before or after parturition and some socially mature males remain. Those movements of dolphins in and out of schools are shown in Fig. 43. As shown in Fig. 43, all animals of *S. coeruleoalba* do not fix themselves in a certain school, but they move in and out of schools instinctively in accordance with their growth and sexual conditions.

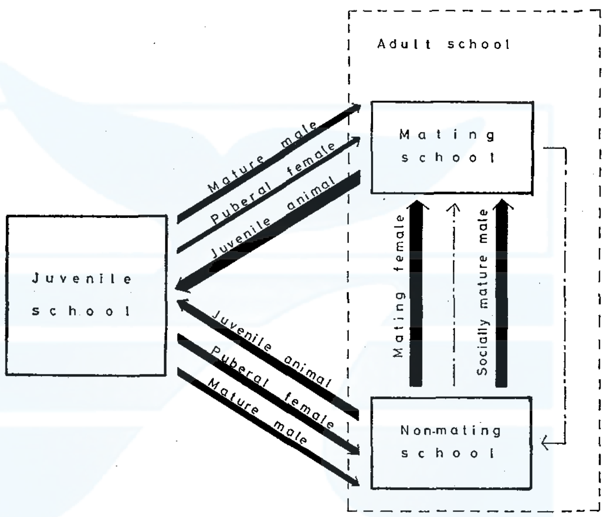

Fig. 43. Schematic figure showing the exchange of dolphins between schools. Thickness of line indicates relative amount of dolphins, arrows direction of movement of the dolphins, and chain line shift of school composition.

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