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Author(s)	SATO, Shinichi
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A NOTE ON THE PACIFIC DOG FISH (*SQUALUS SUCKLEYI* GIRARD) IN THE COASTAL WATERS OF HOKKAIDO, JAPAN[1)]

BY

Shinichi SATO

I. Introduction

EVERMAN and GOLDSBROUGH ('07), REGAN ('08) and JORDAN and HUBBS ('25) studied the distribution of the Pacific dog-fish ascertaining that it is restricted to the arctic and subarctic regions of the Pacific coast including the northern part of Japan, Bering Sea, Aleutian and Commander Islands and the North American coast extending to the southern end of California. In Japan the fish abounds on the coasts of the northern part of Honshu, Hokkaido, Saghalien and the Kurile Islands.

The life history of the fish has been reported by QUIGLEY ('28) only from the vicinity of Nonaimo, but in Japan because of the low economic value of the fish, little attention has been paid to its habits even by fishermen. However, the number of the fish caught around Hokkaido is not small and subsequently the use of it has recently been considered quite seriously. Since several years ago, from June 1932, the writer has had the opportunity to investigate the fish from the biological as well as the economical point of view in the coastal waters of Hokkaido, chiefly to observe the seasonal migration, feeding and breeding habits.

Here the best thanks of the author are offered to Dr. T. INUKAI in the Zoological Institute of the University, under whose constant advice and criticism this work has been finished. He also should

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like to express his gratitude to the staffs of the Government Marine Experimental Station of Hokkaido, to the Marine Products Guilds in Hokkaido who allowed him to look through their data bearing upon the investigation and also to Mr. Y. HADA of the Akkeshi Marine Biological Station, for his kindness in collecting material in Akkeshi Bay.

II. Migration

Japan Sea and Okhotsk Sea. (cf. Fig. 1.)

In the early Spring, the dog-fishes first appear in the coastal waters of the southern district of the Japan Sea in Hokkaido, including Esashi and Suttsu where they disturb the herring fishing which is in full swing at this season. The fishes are captured by the

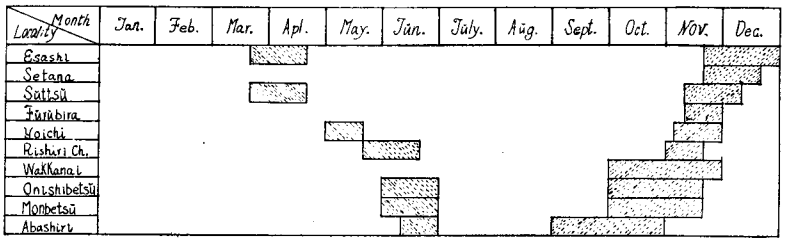

Fig. 1

nets, at depths from 20 to 70 fathoms. In April and May they make their appearance offshore at Otaru, accompanying the herring, and then migrate further to the waters of Rishiri Channel at the end of May. In the channel dog-fish catching by means of gill nets lasts till the middle of June, most prosperously at the beginning of the month. There the depth of water is about 20 fathoms.

In June the fishes are captured on the coast of the Okhotsk Sea beyond Cape Soya, that is, along the coasts of Onishibetsu, Monbetsu and Abashiri. Set nets and trawl nets, and frequently the long lines for the Alaska cod are prepared for the dog-fish in this region. They occur mostly in depths from 30 to 80 fathoms.

In summer, July and August, they diminish in number in these coastal waters, except off Onishibetsu, probably due to the far off

migration of the fish from the coast. At the fishing ground off Onishibetsu, they are captured throughout the summer months by set nets at about 20 fathoms depth.

The reappearance of the fish in the above fishing grounds of the Okhotsk Sea takes place at the beginning of September, when they are captured at about 30–80 fathoms deep. The taking continues until the end of November. The fishes landed at Abashiri market are said to number more than 15,000 per day in October. The fishing ground is gradually transferred northwards along the coast, and then the fishes are captured most frequently in the straits of Soya at the beginning of October. The fishing is continued at depths of 17–37 fathoms until the beginning of November.

According to Mr. Y. Yokoyama who studied the takings of the dog-fish in the waters offshore Rebun and Rishiri Islands and mainly in the Rishiri Channel, extending from the headland of Kaneda to the mouth of the Teshio River, the fishing was carried on from the 17th of October to the 19th of November in 1933, most actively from the 1st to the 5th of November in waters 44–96 fathoms deep. Further southwards along the coast from Yakijiri Island[1] to the headland of Ofuyu[2] fishes become rare from the 24th of November until about the first of December.

The southward migration of the fish is quite clear. At the beginning of November the first arrival is noted yearly at the fishing grounds off the headland of Shyakotan,[3] being caught mainly with set nets. Farther southward, near Suttsu and Setana, the takings are made from the middle of November to the middle of December. At Esashi the fishes are landed continuously until the end of December. In this region the set nets and the long line are used for fishing in waters about 60–100 fathoms deep.

Pacific coast. (cf. Fig. 2.)

There has been no special fishing for dog-fish in the waters of the Pacific side of Hokkaido but a large number of them are sup-

1) and 2) between Rishiri and Mashike. 3) near Yoichi.

plied in the fish market as side-takings with other kinds of fishes. Off Muroran and Urakawa they are captured in April and May by the drift-nets which are set for the taking of *Salmo milkitschitsch* and *S. gorbuscha*. Eastward, appearance along the coast of Birō, Kushiro and Akkeshi occurs in June and July. At the market of Akkeshi they were landed from June 15th to July 8th in 1933 and July 9th in 1934, and after that time they became very few in the surrounding waters. The fishing season probably lasts from the middle of June until the beginning of July. Then they are

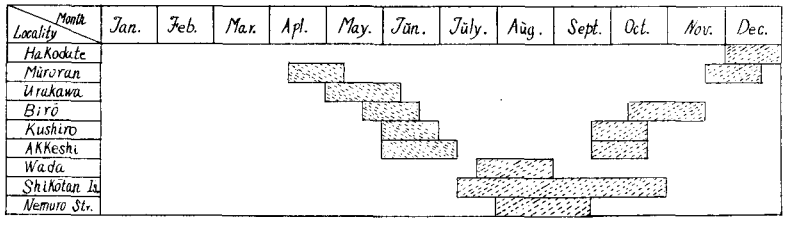

Fig. 2

caught in the waters off Wada from the middle of July to the end of August, and also in Shikotan Island, from the beginning of July to November. They are found in the straits of Nemuro from the beginning of August and remain until the beginning of September. The fishes appear again in the coastal waters of Akkeshi in October with *Salmo keta*, and later migrating westward, in October and November they are captured in the set nets off Birō. From the end of November the fish is landed at Muroran, and in December at Hakodate.

From the above it is quite clear that there are two schools of the fish, one passing along the coast of the Japan Sea northwards and reaching the Okhotsk Sea, while the other is migrating along the coast of the Pacific Ocean. (Fig. 3)

The schools of the Japan and Okhotsk Seas appear in early Spring offshore from Esashi and Suttsu, moving to the north-east. After passing the Rishiri Channel in May and June the school is divided into two branches, the one moving northwards along the

coast of Saghalien and the other passing through the straits of Sōya into the Okhotsk Sea and turning southwards along the coast of Kitami as far as Monbetsu and Abashiri. In July and August no school of the fish is found in these districts, leaving only the young fishes in detached condition. At the fishing grounds off Onishibetsu there are some fishes making a shoal. In the early Autumn, on the contrary, the schools move northwestward returning along the

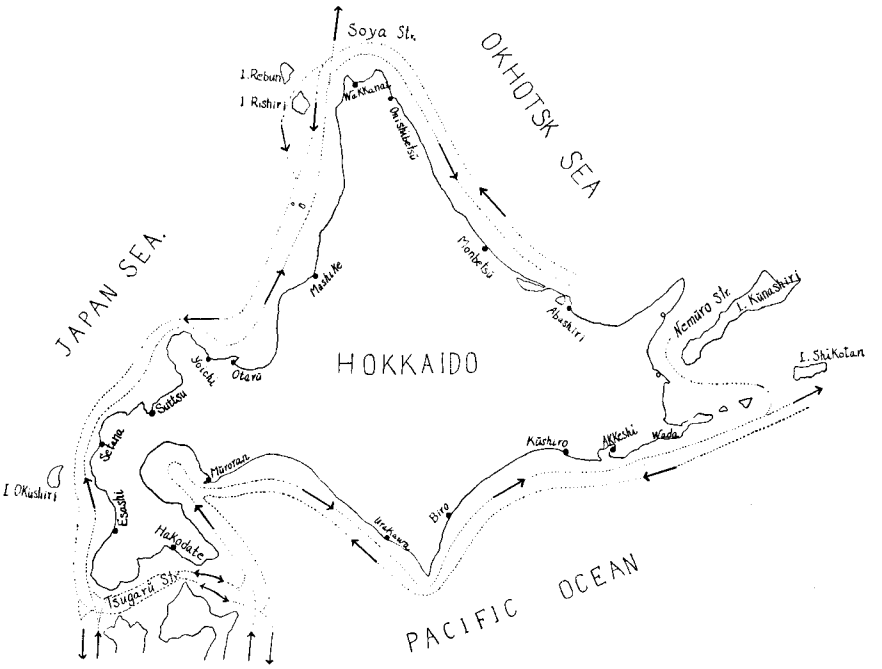

Fig. 3

coast. They pass the straits of Sōya from October to November. From the middle of this month they appear off the headland of Shyakotan, and at the end of the month they are also found offshore from Setana and Esashi. Here they are found as late as the end of December. The schools are again divided into two groups at the entrance of the straits of Tsugaru; the one moves to the south along the west coast of Honshu in the Japan Sea, and the other passes through the straits and goes along the east coast of Honshu in the Pacific Ocean.

The northeastward migration of the schools in early Spring takes place on the Pacific side of Hokkaido at the same time as that of the Japan Sea. In the Spring, mainly in May, they migrate along the coast of Muroran and Urakawa. After this, in June and July, they are found offshore from Birō and Akkeshi, and in July and August offshore Shikotan Island and also in the straits of Nemuro where they probably stay through the summer months. The returning migration takes place in Autumn; the schools move westwards along the coast, until they come off Hakodate in December. It has not yet been decided whether the schools of the Pacific join with the schools of the Japan Sea. Anyway they move farther southwards in the waters of the Pacific coast of Honshu.

The above facts are also partly ascertained by experiments with marked fish by the Government Marine Experimental Station of Hokkaido mainly in the waters of the Japan and Okhotsk Seas from 1931 onwards.

It is noted that the fishes are found in late Autumn and Winter in deeper water than in Spring, Summer and early Autumn. In the latter case they migrate at depths from 20 to 70 fathoms, while in the former at from 60 to 100 fathoms, usually at 70–80 fathoms deep. The phenomenon concides with what MEEK ('16) states about the *Acanthias vulgaris*. In his case the dog-fishes reach maturity migrating into shallow water in Summer and to deep water for Winter, keeping together in large companies. According to him the fish undergoes the anadromous migration for liberation of the young. In Hokkaido anadromous migration is also found in certain districts within one season. For example, offshore from Suttsu, the nets are set in the depth of 90–100 fathoms at the beginning of the fishing, and thereafter the nets are moved in to shallow water, about 60–70 fathoms deep, following the movement of the shoals.

A diurnal movement of the dog-fish occurs, the fishes swimming near the surface of the water by night but near the bottom by day. In fact, off Akkeshi Bay the fishes are captured in the drift net for salmon in the middle of the night, but also they are caught near the

bottom by the shortened long line for the Alaska cod in the daytime, about 50–60 fathoms depth.

In connection with the depth of the water in which the fish lives, the temperature of its body seems to be most important for explaining the fact. Table 1 is the result of observation on 58 living individuals, cases I and II having been fishes captured in the waters about 6 nautical miles S.E. off Daikoku Island near Akkeshi. Cases III and IV are the data from the waters about 6 nautical miles N.N.E. off the headland of Notoro near Abashiri. In the former the fishes were captured in the drift net in the night time, while in the latter they were taken with a long line in the daytime; the depth of the sea was about 60–70 fathoms and the surface temperature was 9–12,2°C.

Table 1.

Case	Sex	Individual numbers	Body-length (cm.)	Body-temperature	Mean value of B.T. (C)
I	♂	5	58– 98	9,5–10,0	9,6
	♀	15	77–125	8,5–10,0	9,6
II	♂	4	76– 89	11,0–11,2	10,6
	♀	6	70–100	10,6–11,0	10,1
III	♂	1	62	5,5	5,5
	♀	15	58–117	5,0–5,8	5,4
IV	♂	1	37	4,0	4,0
	♀	11	80–115	3,5–4,5	3,8

From these data it is clear that the body temperature of the fish ranges from 4°C. to 10,6°C. according to the environment. It is highly probable in this case that the fish makes a diurnal vertical migration.

III. Food and Feeding habits

On the feeding habits of *Squalus suckleyi* we have little knowledge, though the fish is only believed to be destructive to the herring and salmon fishery. For the purpose of gaining further information 128 stomachs were examined.

Table 2 shows the body length of the fishes obtained at Abashiri and Akkeshi. Among 128 fishes 28 individuals were captured by the long line at the waters of ca. 6 nautical miles N.N.E. off the headland of Notoro near Abashiri, the depth being about 60–70 fathoms, 49 fishes were captured by drift nets for salmon in the midnight offshore from Akkeshi, ca. 6 nautical miles S. off Daikoku Island, and 51 fishes were caught in the set net for sardines in inshore shallow waters of Akkeshi Bay. The comparison of the stomach contents of the fish from the two localities is shown in table 3.

Table 2.

Locality	Date	Number		Body-length in cm.	
		♂	♀	♂	♀
Abashiri.	1934. VI. 23	1	15	62	58–117
	VI. 25	1	11	37	80–124
Akkeshi.	1933. VI. 28	—	5	—	111–118
	VI. 30	—	8	—	110–127
	1934. VI. 30	4	6	70–89	70–100
	VII. 3	4	9	87–95	90–120
	VII. 5	4	9	76–98	79–128
	VII. 12	24	27	40–82	42– 63

Seventeen kinds of animals including Pices, Crustacea, Cephalopoda and Annelida were found in the stomachs. There were 9 species of fishes, 5 of Crustaceans, and 2 of Cephalopods, and only 1 of Annelida. Judging from these data it seems that the dog-fish feeds on nekton as well as benthos animals, those two frequently being found in the same stomach.

Among the fishes *Sardinia melanosticta* occurred very commonly, herring, salmon and cod came next. Yearlings of *Salmo keta* with a 100 mm. body length were found in the stomach. The adult fish of *S. keta* were also found frequently. Inshore migration in Akkeshi Bay apparently accompanies the migration of the sardine. (Table 2, 1934. VII. 12)

The fishes in the Okhotsk Sea seem to feed more frequently on the benthos animals as compared with those in the Pacific. In the former the crustacea were very common, and *Echiurus* sp. was also found frequently. However this difference of food chiefly results from

Table 3.

Kinds of food found in the stomach	Frequency				Total number
	Abashiri		Akkeshi		
	♂	♀	♂	♀	
Pisces:					
Sardinia melanosticta	—	8	13	27	48
Clupea pallasii	—	—	1	—	1
Salmo keta	—	—	2	1	3
Gadus macrocephalus	—	2	—	1	3
Theragra chalcogramma	—	—	—	1	1
Eugralis japonica	—	—	1	—	1
Arctoscopus joponicus	—	—	1	—	1
Hemilepithodes gilberti	—	1	—	—	1
Podothecus sachi	—	1	—	—	1
Crustacea:					
Pandalus sp.	—	3	—	—	3
Telmessus cheiragonus	—	1	—	—	1
Paralithodes camtschaticus	—	1	—	—	1
Tecticeps japonicus	—	—	1	—	1
Anonyx ampulloides	—	—	—	1	1
Mollusca:					
Polypus dofleini	—	3	6	—	9
Loligo sp.	—	1	—	—	1
Annelida:					
Echiurus sp.	—	6	—	—	6

the vertical movement of the fish, as the former were obtained in the day time but the latter in the night time. Incidentally it is clear that the migration of the *Squalus suckleyi* is not influenced solely by the food animal they may take.

IV. Body length of the fish and the constitution of the shoals

The fishes captured around Hokkaido vary from 130 cm. in body length at the largest to 32.5 cm. at the shortest. The young fish of both sexes are nearly equal in size, being mostly 35 cm. (male) and 32,5 cm. (female), while the mature adults vary considerably in length, the largest male being 100 cm. long and the largest female 130 cm. long.

On the other hand the size of the fish is variable according to the different locality and subsequently to the different fishing season. At the beginning of the season at any place adult females predominate and then decrease towards the end of season, until they are scarcely found. The adult males, on the contrary, appear in increasing numbers, so as to displace the females. Thus the increased number of males in any place means the ending of the season.

The body length of the fish in relation to sex was examined at Akkeshi, during the season from June 30th to July 12th 1934 with results which follow: (Table 4. and Fig. 4)

Table 4.

Length Limits (cm.)	Number of fish obtained	Sex		Percentage		Average Length	
		♂	♀	♂	♀	♂	♀
30–39	2	2	0	100,0	0	35,5	0
40–49	40	17	23	42,5	47,5	45,1	45,5
50–59	28	14	14	50,0	50,0	54,2	54,4
60–69	11	9	2	80,9	19,1	65,2	63,0
70–79	26	15	11	57,6	42,4	76,0	74,5
80–89	16	13	3	81,2	18,8	86,0	83,3
90–99	8	5	3	62,5	37,5	93,6	92,3
100–109	13	1	12	7,7	92,3	100,0	102,7
110–119	10	0	10	0	100,0	0	113,3
120–129	3	0	3	0	100,0	0	122,6

Of 157 individuals 76 are males, making 49% of the total number and 81 are females, making 51%. In the investigations of QUIGLEY

('28) and CRAIGIE ('27) who observed the fishes in the waters of the Straits of Georgia near Departure Bay, Vancouver Island, an almost equal number of males and females were captured as in Hokkaido.

It may also be seen that the fishes of shorter body length include an almost equal number of males and females. Considering altogether, as the fishes become larger the number of males increases, but above a length of 100 cm. there are no males at all. (Fig. 4.)

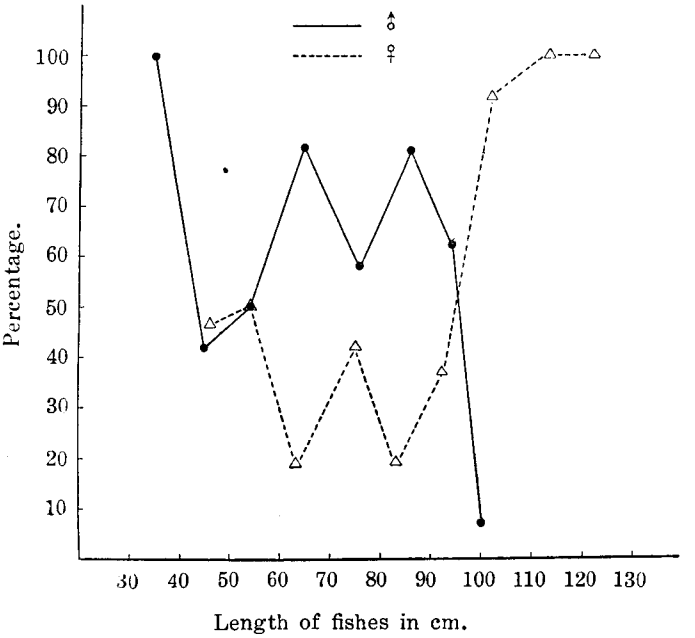

Fig. 4

This sudden decrease of the males was also observed by QUIGLEY ('28), who stated that the weight of 400 grams and the length of 90,5 cm., are the critical point for sex declination.

Accordingly it is certain that the mature males and females constitute separate shoals, each containing, however, immature males and females, as QUIGLEY ('28) has described on the same species. FORD ('21) described the same fact in *S. acanthias*.

V. Breeding

Pregnancy: In the present investigation only the mature females larger than 100 cm in length were found to carry the embryo. There was only one pregnant measuring 95 cm. in length and this was the smallest so far observed. The table (Table 5) shows the result of observations on 146 individuals obtained from June 23rd, 1932 to July 12th, 1934.

Table 5.

Length Limits (cm.)	Number of Fish	Number of		Percentage of Pregnant	Average length (cm.)
		Pregnant	Non-pregnant		
95–99	10	1	9	10,0	95,9
100–104	20	9	11	45,0	101,0
105–109	27	18	9	66,6	105,2
110–114	35	34	1	97,1	110,4
115–119	29	29	0	100,0	116,3
120–124	14	14	0	100,0	120,5
125–129	8	8	0	100,0	125,6
130	3	3	0	100,0	130,0

The relation between the body length and the frequency of pregnancy are also shown in table 5 from which it is recognizable that the minimum length of the pregnant females is 95 cm. Among 146 females 116 (72.6 per cent) carried the embryos. It will be seen that the females over 115 cm in length were all pregnant, and in the females of 110–114 cm body length 97.1 per cent were pregnant. The pregnancy decreased to 10 per cent at the length of 95–99 cm.

It is also clear that the pregnant fishes of 110–114 cm length occur most frequently, being 29.3% of the 116 females, and next come 115–119 cm. showing 25%. The number of pregnant measured from 110 to 119 cm. makes about a half of the total, being 54.3 per cent. It is remarkable that the occurrence of the pregnant females decreases gradually to 0.8% and then 2.5% in 95 cm. and 130 cm. long individuals respectively. (Fig. 5)

Number and sex-ratio of the embryos: The number of embryos of *S. suckleyi* has been described by QUIGLEY ('28) and EVERMAN and GOLDSBOROUGH ('07). QUIGLEY examined 16 fishes obtained in the vicinity of Nonaimo, and found that the number varied from 3 to 11, with an average number 6.87. EVERMAN and GOLDSBOROUGH state regarding 5 fishes obtained in Cleveland Passage and in Nonaimo that it varied between 4 and 11.

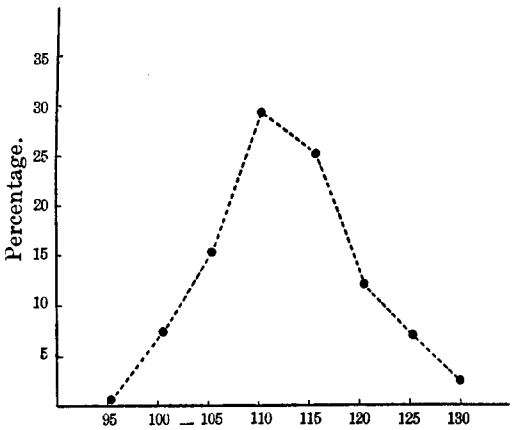

Fig. 5

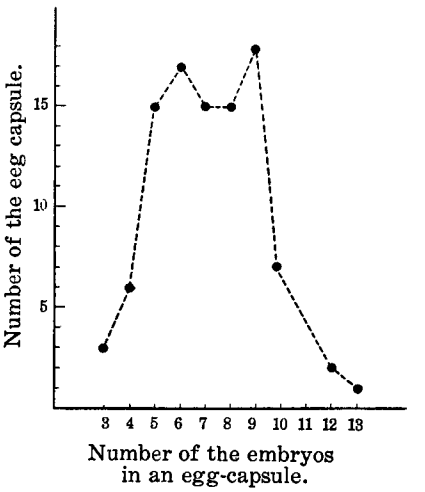

Fig. 6

In the present investigation the variation in number of embryos found in 100 egg capsules is shown as a graph in Fig. 6, from which it will be discernable that the number varies from 3 to 13 with an average number 7.1. The capsules containing from 5 to 9 embryos in number are most frequent. The number of embryos found in both uteri is not always equal.

An investigation on the embryos of larval stage in 16 batches shows a variation between 3 and 25 in number in both uteri, the average being 12.8 (Table 6).

From this observation it is seen that the highest number is 26, and this is twice as great as the number described by QUIGLEY.

The sex-ratio of the embryos of larval stage is found to be almost the same as that of young or adult fishes as shown in table 6; of 180 embryos 95 (52.7%) are males. (Table 6)

Breeding season: The embryos obtained at Akkeshi in June and July show the stage of development from gastrulation to one 2.5 mm. long, sometimes from 200 to 285 mm. long. The largest embryo 285 mm. long has the complete umbrical scar healed and is apparently ready for birth.

Table 6.

Serial No. of Batches	Number of Embryos	Number of	
		Male	Female
1	14	9	5
2	12	8	4
3	16	7	9
4	18	7	11
5	15	7	8
6	20	10	10
7	9	3	6
8	8	6	2
9	11	7	4
10	12	10	2
11	3	2	1
12	12	6	6
13	7	2	5
14	14	7	7
15	25	—	—
16	9	4	5

The 200–250 mm. long stage of development are found throughout the fishing season of any region in the coastal waters of Hokkaido, with some very early embryos. When the shallow water migration of the young fishes occurs, the very young fishes with a trace of the umbrical scar are frequently observed, which are apparently just liberated in these regions.

From these facts it is seen that the *S. suckleyi* breeds at all times throughout the year in the coastal waters of Hokkaido.

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