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HYPOMESUS OLIDUS (PALLAS), IN LAKE KOGAWARA,  
AOMORI PREFECTURE, JAPAN. I. HABITS AND AGE  
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**BIOLOGICAL OBSERVATION ON THE POND SMELT,  
*HYPOMESUS OLIDUS* (PALLAS), IN LAKE  
KOGAWARA, AOMORI PREFECTURE, JAPAN.**

**I. HABITS AND AGE COMPOSITION  
OF THE SPAWNING FISHES**

By

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**Introduction**

The pond smelts, *Hypomesus olidus* (Pallas), are found along the coasts of Alaska, Siberia and Japan. They ascend estuaries as far as fresh water in order to spawn and some of them are often found landlocked in ponds or lakes such as Lakes Abashiri, Kogawara, Hachiro-gata, Kasumiga-ura and Shinji etc.

Observations, though fragmental; on the spawning habits of pond smelt have been reported by the Fishery Experimental Station of Ibaragi Prefecture (1912), Meek (1916) and others. This paper is the record of a synthetic observation on the spawning habits of pond smelt, carried on in Lake Kogawara and adjacent waters. Here I wish to express my sincere thanks to Prof. Takeo Imai for his kind direction and encouragement.

**Observation and discussion**

a). *Conditions of the Lake*

Lake Kogawara is situated along the Pacific coast of Aomori Prefecture, Japan. It has an area of about 64.80 sq. kilometers and a circumference of about 58 kilometers. It stretches southward taking the shape of the letter J and opens in the north-eastern corner, through the Takase River, to the sea. The bottom of its south-western part is mud, which is gradually replaced by sand towards the opening to the Takase River. It can be divided into two parts; a deep north-eastern part, clear and brackish, with a maximum depth of 27 meters, and a shallow south-western part, turbid and less saline, with a maximum depth of 15 meters. The surface water

temperature falls below zero during winter, while it rises as high as 27°C during summer.

Among several species of fishes and shell-fishes living there, pond smelt is the greatest in number. Though dwelling everywhere in the lake, it is most abundantly found in the brackish water of the north-eastern part and has a habit of swimming near the surface more frequently in summer than in winter.

b). *Racial Character of the Fish.*

The pond smelt belongs to the family Osmeridae. Its habitat is salt water area like that of other species of this family, but, in spring, its schools ascend to fresh water in order to spawn, as seen in streams and ponds of Alaska (Jordan & Everman 1896-1900). Likewise, in the region around Lake Kogawara, it has long been known that the schools of the pond smelt ascend the Takase River toward Lake Kogawara before the spawning season. Therefore morphological characters of two groups, i. e., one group caught in the sea near the mouth of the Takase River and the other caught in the lake, were subjected to close study in order to clear up the racial relation between them. The author recognized that some difference existed in the vertebral numbers among the races. For instance, the mean value of vertebral numbers including the urostyle of the Kogawara group was 55.05, that of the Kasumiga-ura group was 56.00 (Fujita 1926) and that of the Mutsu Bay group was 57.03. The counting of vertebral numbers thus plays an important role in distinguishing races. While judging from the statistical analysis as shown in Table I, it can be said that no racial difference exists within groups or between groups around Lake Kogawara.

Table I. Vertebral numbers, including the urostyle, of the pond smelts in Lake Kogawara and adjacent waters.

| Locality                   | Number of vertebrae |    |    |    |    |    | Average<br>( $M \pm \sigma$ ) | Skewness<br>of<br>frequency<br>distribution |
|----------------------------|---------------------|----|----|----|----|----|-------------------------------|---|
|                            | 52                  | 53 | 54 | 55 | 56 | 57 |                               |   |
| The sea near Lake Kogawara | 1                   | 0  | 2  | 12 | 4  | 1  | 55.04±0.94                    | 0.05  |
| Lake Kogawara              | 0                   | 0  | 14 | 68 | 17 | 1  | 55.05±0.58                    | 0.09  |
| The Anedo stream           | 0                   | 1  | 16 | 58 | 25 | 0  | 55.08±0.67                    | 0.12  |
| Ane-numa                   | 0                   | 1  | 14 | 32 | 2  | 1  | 54.86±0.60                    | -0.23                                       |

c). *Spawning Habits of the Fish.*

Before every spawning season, pond smelts ascend the Takase River as far as Lake Kogawara from the sea to join the groups of many other land-

locked pond smelts already gathered there. Then they swim around the lake in order to reach some shallow waters along the shore where they spawn in early spring after the ice over the surface water has been melted.

In order to grasp the details of their spawning migration, daily catches at the shoal of Kogawara and the Anedo stream were analysed as to the maturity condition. The result is shown in Fig. 1, and noteworthy facts were found.

1. All through the spawning season, the shoal of Kogawara holds many immature fish, while in the Anedo stream few of the immature but many of the mature and the spent were found.

2. Many ova were found on the bottom of the stream, but none on the shoal of Kogawara.

3. No racial difference can be recognized between the fish groups caught in both regions.

It is suggested from these observations that the schools first approach the shoal of Kogawara and then migrate to sandy spawning grounds around the shoal or the Anedo stream in full maturity after some days.

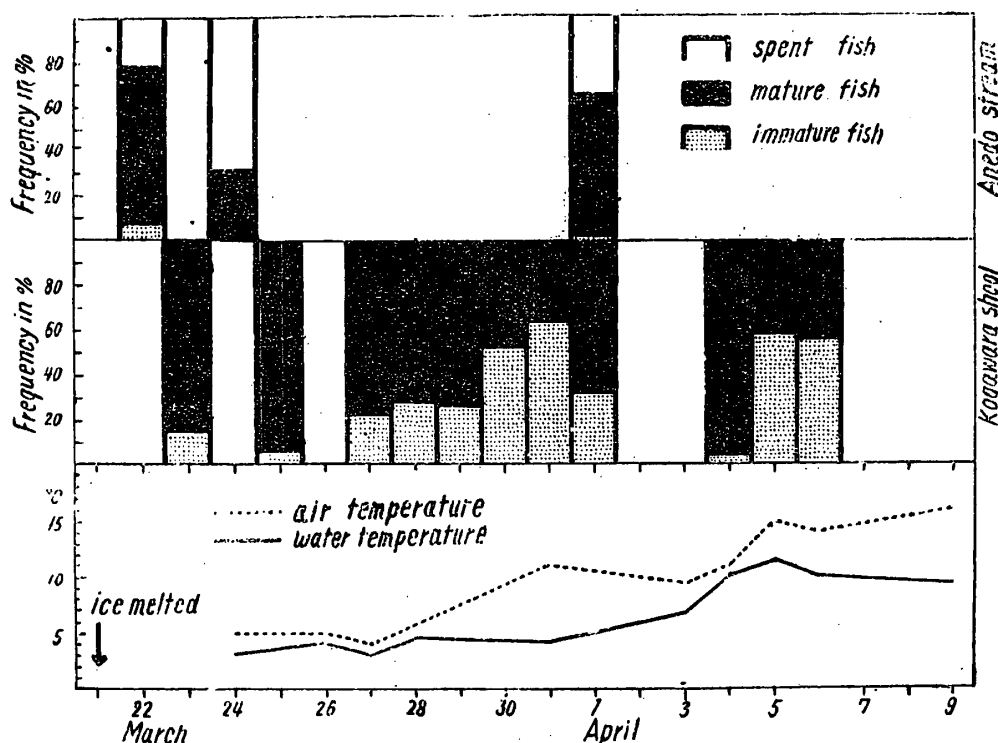


Fig. 1. Comparison of daily percentage composition of mature pond smelts between two groups caught in the shoal of Kogawara and the Anedo stream in 1948.

Table II shows the record of the catch by a trap-net in the Anedo stream

and indicates that pond smelts ascend the Anedo stream during the night. The same habit of migration was also reported in *Spirinchus sterksi* (Fish) by Fitch (1949) and in *Osmerus dentex* Steindachner by Nakamura (1948).

Table II. Catch of the spawning pond smelts by a trap-net in the Anedo stream.

| Time           | Catch of the fish in kg. | Water temperature, °C. |
|----------------|--------------------------|------------------------|
| March 20, 1949 | 15.30—16.30              | 0                      |
|                | 16.30—19.50              | 1.13                   |
|                | 19.50—22.00              | 0.75                   |
|                | 22.00—1.30               | 3.71                   |
| March 21, 1949 | 1.30—5.00                | 1.86                   |
|                | 5.00—8.00                | 1.86                   |
|                | 8.00—9.00                | 0                      |

Meek (1916), Hikita (1930) and Nakamura (1948) reported, that certain fishes belonging to Osmeridae attached their ova to stones, sand, piles and the like. In Lake Kogawara, the ova of the pond smelt were not found on stones, sand, shells and the like, but on the leaves and stalks of some hydrophytes such as *Ranunculus aquatilis* L., *Myriophyllum verticillatum* L., *Ruppia rostellata* Koch and *Potamogeton crispus* L. vegetating on sandy ground in shallow waters around the lake (Fig. 2). In the Anedo stream and also in other streams, however, they were found attached to pebbles, sand and roots or stalks of withered grasses (Fig. 3).

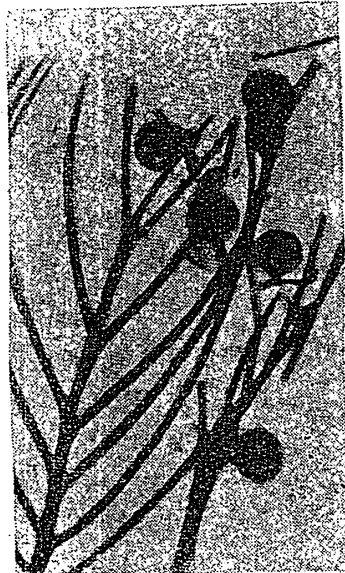


Fig. 2. Ova attached to leaves of *Ranunculus aquatilis* L., at the shoals of Osaki and Iwagasaki in Lake Kogawara,

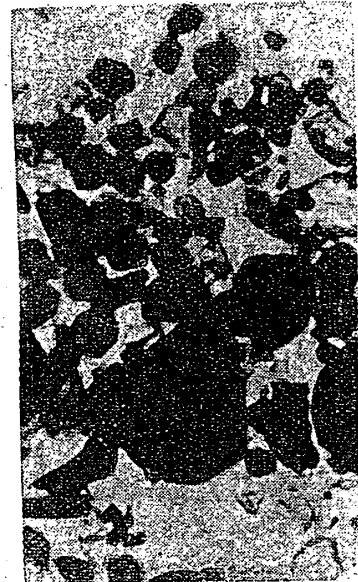


Fig. 3. Ova attached to pebbles and sand in the Anedo stream flowing into Lake Kogawara,

A thorough survey made from 9th to 19th of April, 1949, revealed several spawning grounds within the lake, with ecological conditions as indicated in Table III. Judging from the transparency of the water there, it is clear that the grounds are limited to the clear water area of the north-eastern part of the lake (Fig. 4).

Table III. Ecological condition of spawning grounds of the pond smelts in shallow waters of Lake Kogawara in spring of 1948.

| Location                           | Depth in m. | Character of bottom ground                   | Condition of water |                    | Ova | Substance on which the ova were laid                      |
|------------------------------------|-------------|--|--------------------|--------------------|-----|---|
|                                    |             |  | pH                 | Transparency in m. |     |   |
| Circumference of Kogawara shoal    | 2.0—4.0     | Sand and gravel; silts; abundant hydrophytes | 7.15               | 8.00               | (+) | Hydrophyte ( <i>Potamogeton crispus</i> L.)               |
| Center of Osaki shoal              | 1.5—3.0     | Sand; no silts; few hydrophytes              | 7.10               | 3.80               | ++  | Hydrophyte ( <i>Ranunculus aquatilis</i> L.)              |
| Center of Iwagasaki shoal          | 1.0—2.5     | Sand; no silts; few hydrophytes              | 7.10               | 3.80               | +++ | Hydrophytes ( <i>R. aquatilis</i> , <i>P. crispus</i> L.) |
| Circumference of Hachimandai shoal | 1.5—4.0     | Sand and gravel; silts; abundant hydrophytes | 7.20               | 3.80               | +++ | Hydrophyte ( <i>Ruppia rostellata</i> Koch)               |

As for the streams running into the lake, the water of the Anedo stream was the clearest, and a maximum density of about 10,000 ova of the pond smelt per 100 sq. centimeters was found on the ground there. Other stream flowing into Ane-numa and Uchi-numa also had ova-laid ground (Table IV and Fig. 4).

Table IV. Ecological condition of spawning grounds of the pond smelts in streams flowing into Lake Kogawara and connected small lakes in spring of 1948.

| Location                        | Breadth in m. | Depth in m. | Character of bottom ground                  | pH   | Ova | Substance on which the ova were laid |
|---------------------------------|---------------|-------------|---|------|-----|--------------------------------------|
| The Anedo stream                | 8.0           | 0.4—1.5     | Sand and gravel; no silts; no hydrophytes   | 7.35 | +++ | Sand, gravel, withered grass         |
| A stream flowing into Ane-numa  | 2.0           | 0.3—1.0     | Sand and mud; a little silts; no hydrophyte | 7.1  | ++  | Withered grass                       |
| A stream flowing into Uchi-numa | 0.6           | 0.3—0.6     | Sand and mud; a little silts; no hydrophyte | 6.9  | +   | Withered grass                       |
| A stream flowing into Uchi-numa | 0.6           | 0.3—3.6     | Sand and mud; a little silts; no hydrophyte | 7.0  | +   | Withered grass                       |

Their spawning season can be estimated from daily records of the percentage composition of mature fishes caught by a trap-net in shallow water

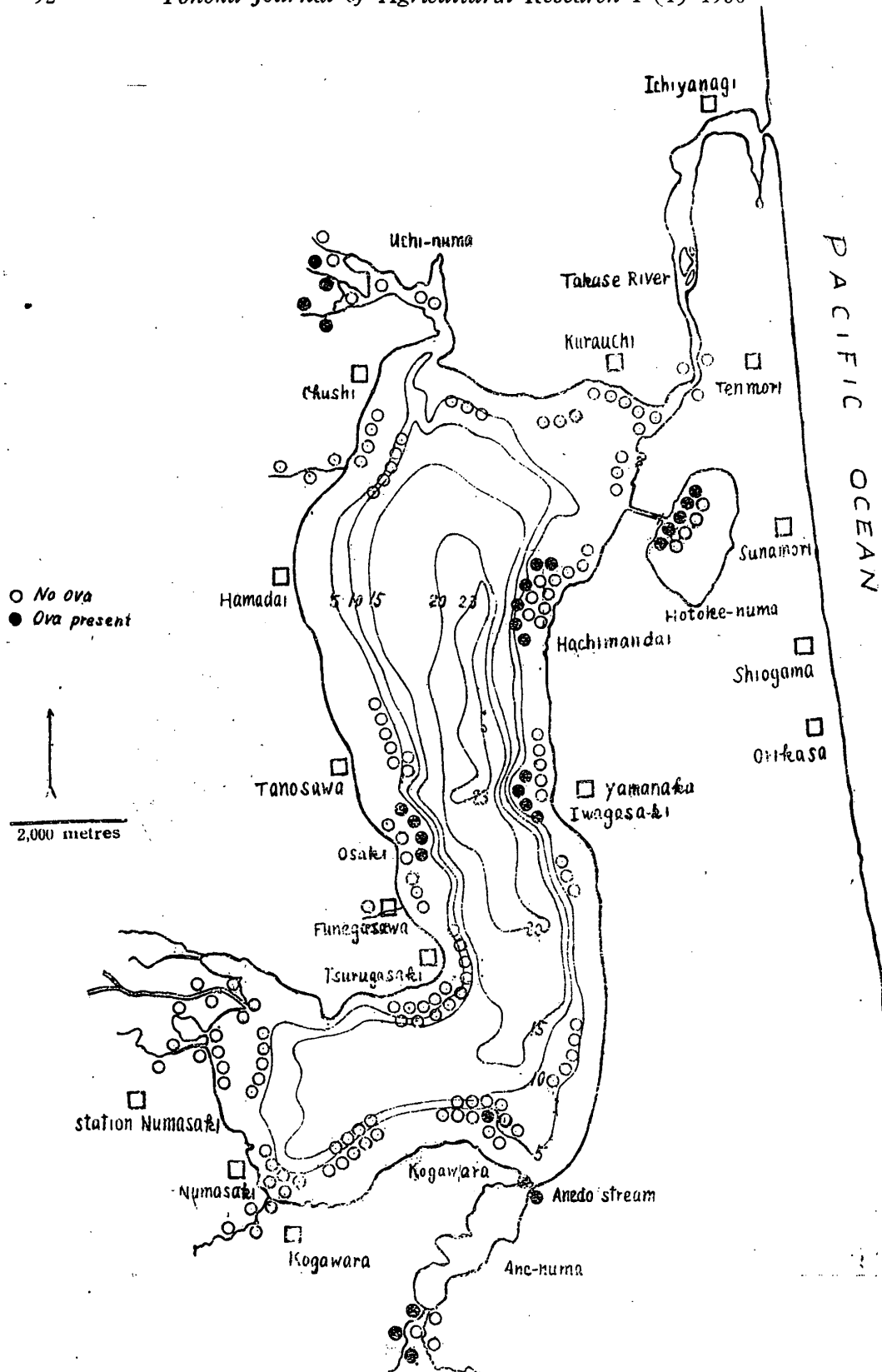


Fig. 4. Places where the ova of the pond smelt was found from the bottom ground in Lake Kogawara in spring of 1947.

near the shoal of Osaki where ova of the pond smelt were found. Fig. 5 shows that the maximum percentage appeared in the middle of April, 1947, when the surface water temperature was about 6°C.

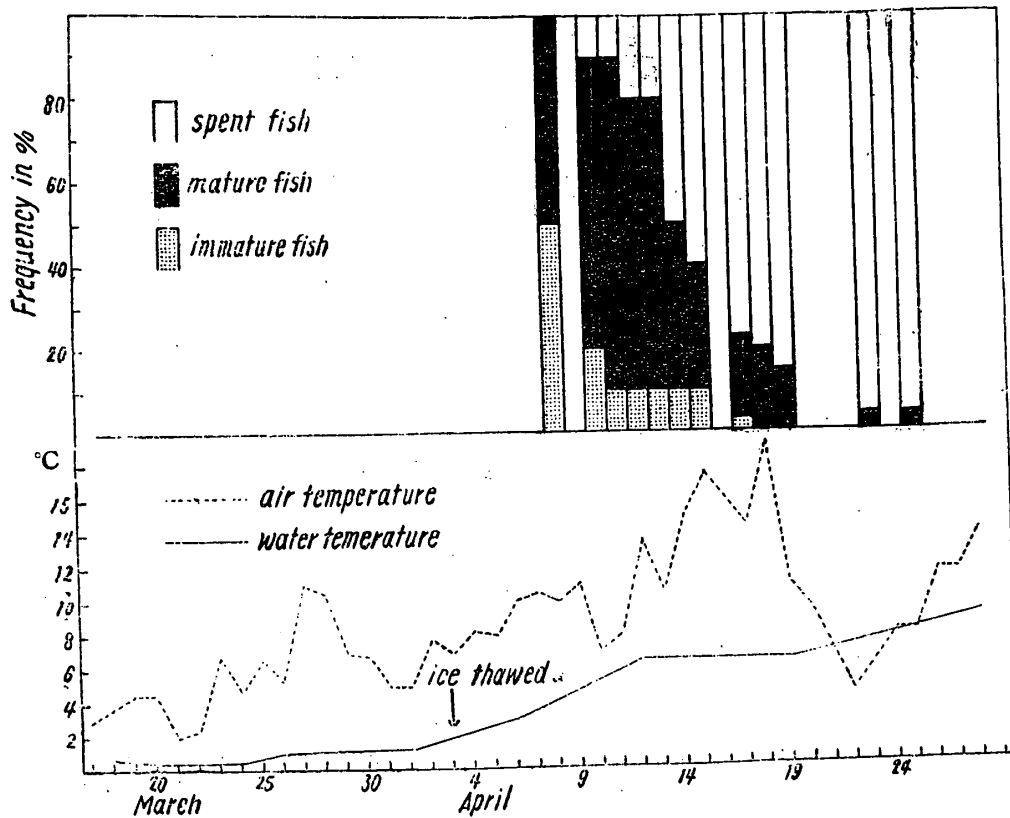


Fig. 5. Daily records of percentage composition of mature pond smelts migrated to a place near the shoal of Osaki in Lake Kogawara in 1947.

The beginning of the spawning season in the lake was somewhat different by years due to the water temperature. For instance, in 1949 it was in the beginning of April. The spawning season in the stream usually comes somewhat earlier than that in the lake, because the water temperature of the stream tends to rise in advance of that of the lake in spring.

#### d). Age Composition of the Spawning Fishes.

Masterman (1913) and Beckman (1912) established that the age of two species belonging to Osmeridae can be estimated from the number of annual rings of the scale. Likewise, Kobayashi (1936) and Amemiya & Hiyama (1940) ascertained the same facts from the pond smelt of Lake Kasumigaura and other lakes of Japan. In this study the percentage composition of each age group of the spawning fishes is also calculated from the number of annual rings of the scale and the length of body (Fig. 6). Most individuals of the spawning school in Lake Kogawara were of the 1-age group, mixed



with some of the 2-age and a few of the 3-age group, depending on the increase in death-rate with age and on the effect of the fishing. This coincided with the results of the observations of Amemiya & Hiyama (1940), performed in Lakes Yamanaka and Kawaguchi. Sometimes, for instance, in 1948, the 1-age group was less in number than the 2-age group owing to the very poor fry production. The mean value of body length of the 1-age group, at the time of their first spawning migration, was 55.7 mm. in 1947, 74.0 mm. in 1948 and 46.0 mm. in 1949.

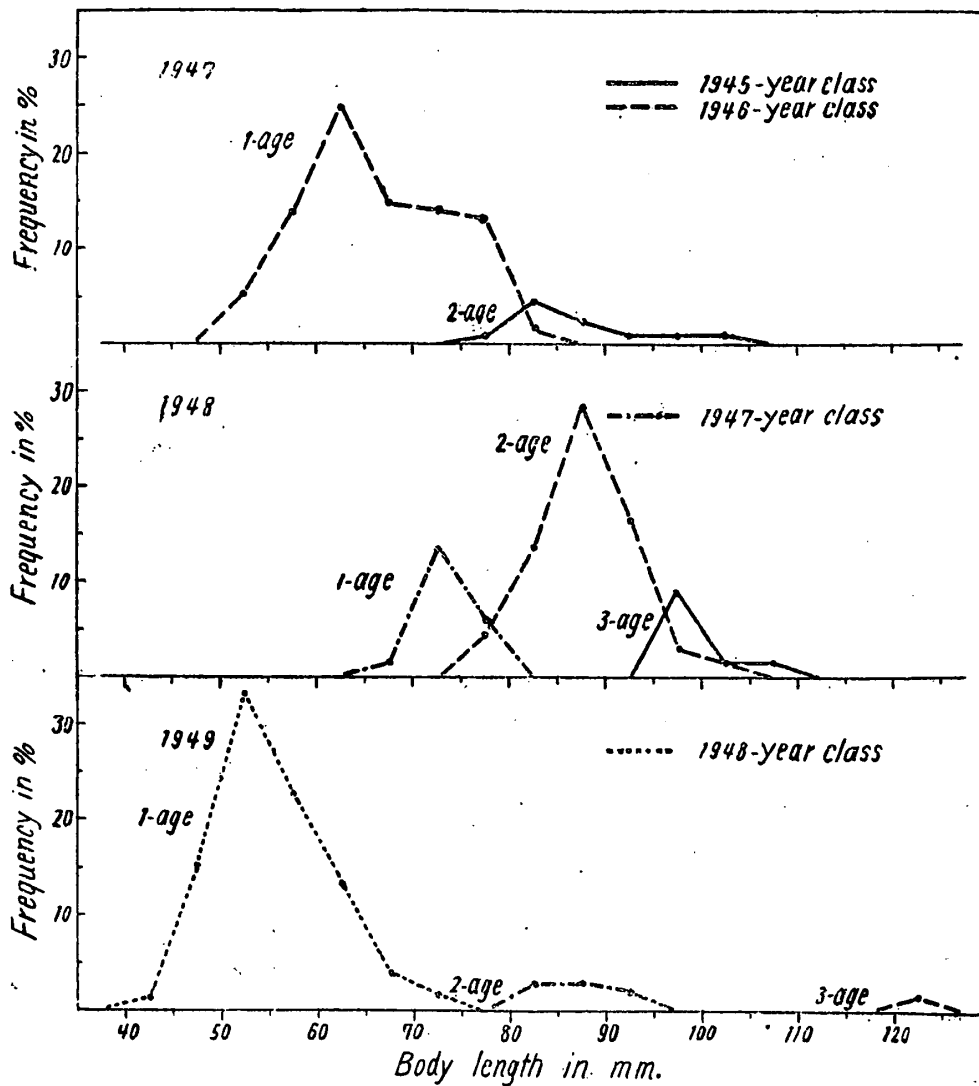


Fig. 6. Length frequencies of spawning fishes of the pond smelt during three years in Lake Kogawara-numa.

### Summary

- 1) Observations were performed on the spawning habits of the pond

smelt in Lake Kogawara in Aomori Prefecture.

2) Both the fishes living in the lake and those ascending from the sea belonged to the same race. The latter seemed annually to ascend the Takase river as far as Lake Kogawara, from the sea near by, before their spawning season came and to merge in the groups of many other land-locked smelts already inhabiting the lake.

3) Schools of the pond smelt first moved from the depth of the lake to some shoals along its borders just before their maturity, and then settled in their spawning grounds, such as sandy shoals or clear streams, in full maturity within several days.

4) The pond smelt spawned in shoals around the lake, and the ova were attached to the leaves and stalks of hydrophytes on the sandy bottom at a depth of 3-4 meters.

5) Some of the pond smelts ascended from the lake to the streams to spawn, and there the ova attached to pebbles, sand, shells and the like. The test counts showed a maximum of about 10,000 ova per 100 sq. centimeters in the spawning grounds of the Anedo stream on April 2, 1948.

6) The spawning of these pond smelts in the lake took place during the time from late March to the middle of April, when the ice covering the surface of the lake had been melted.

7) The pond smelts spawning in Lake Kogawara were mainly of the 1-age group, mixed with some of the 2-age and a few of the 3-age groups. The percentage composition of each age group, however, varied considerably in accordance with the amount of annual production of the fries.

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