# Vertical distribution of the floating eggs of *Maurolicus japonicus* ISHIKAWA, a gonostomatid fish, in the sea

By

Saburo NISHIMURA

The egg referred to as *Maurolicus japonicus* ISHIKAWA in the present paper had been called "Macrurus egg" or "Macrouroid fish egg" by previous researchers in this country, for they had believed that it might be spawned by a certain fish belonging to the Family Macrouridae. Recently I pointed out the incorrectness in identifying so and made an attempt to give the correct connection with its spawner, with the result obtained that it might be spawned by a species mentioned in the title belonging to the Family Gonostomatidae, Clupeida (NISHIMURA, 1957).

This species is, though fished only in poor quantity, conjectured to live in great abundance in the deep waters of the Japan Sea; since it is found very commonly in the stomack of various deep layer swimming or bottom dwelling carnivorous fishes such as *Theragra chalcogramma, Hippoglossoides dubius, Cleisthenes herzensteini* and so forth (KATOH, 1954; NISHIMURA, *op. cit.*).

It spawns pelagic or floating eggs, which are captured by plankton net hauling rather commonly. This floating egg has a gelatinous envelope of peculiar structure, to which is attributed its characteristic confetto like appearance, so it is easily distinguished from the eggs of other species.

During the surveying cruise on board the research vessel of our laboratory in the Bay of Toyama in the spring of 1954, I obtained a considerable number of this egg by net sampling, and was able to acquire some informations concerning its vertical distribution in the sea.

Before going further, I wish to acknowledge my indebtedness to Messrs. Gendi KATOH and Sukekata ITO for reading the manuscript and giving valuable criticisms. My grateful thanks are also due to Messrs. Kazuharu WATANABE and Shogo KASAhARA who were eager to help me in the tedious works of sampling the materials. Further I wish to express my hearty thanks to Capt. Ichisaburo TSUNA and the crew of the research vessel "Asahi-Maru II".

## Method of sampling

The sampling of the eggs was carried out with a gear especially designed for

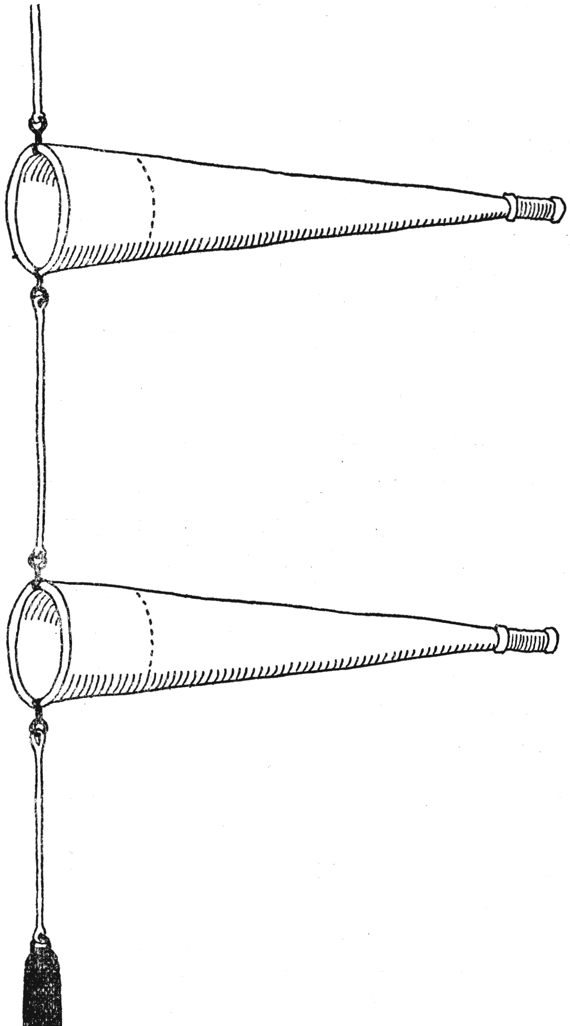

Fig. 1. Schematic representation of the sampling gear used in the experiments.

the purpose of studying the vertical distribution of plankton in the sea. The gear was made up of seven small conical nets which were joined together one to another with a flag line as in the way shown in Figure 1. The mesh size of the bolting silk was nearly equivalent to No. 3 Müller gauze, the caliber and the length of the nets being 20 cm. and 100 cm. respectively. A plumb was attached to the tip of the flag line and was sent down perpendicularly into the sea, so that the nets might sample the plankton at seven different depths.

During the sampling, the ship was laid at anchor, so the plankton organisms which had been driven by water currents only were filtered through the silk and were caught; that is, the gathering of plankton was resorted wholly to the transportation by water currents. This method of sampling was conveniently called "horizontal drift".

In addition to the samplings by the above-said method, "stepped vertical" haulings with a plankton net of an ordinary type were also carried out. Namely, at every sampling time, four vertical haulings were successively made from 10 m., 25 m., 50 m. and 100 m., respectively, to the surface. The mesh size of bolting silk of this net is the same as that of the small ones mentioned before, the caliber being 45 cm.

## Results

I. May 17–18, 1954.

In the first experiment, the horizontal drift as well as the stepped vertical method were resorted to.

The sampling station was located at a position (37°26.4′ N, 137°25.8′ E) in Toyama Bay where the depth was 130 m.

Throughout the experiment, the sea surface was very calm and the flow was slow, the stray angle of the flag line in the horizontal drifts being small.

Out of 13 horizontal drifts, each of which sampled for 30 minutes at the seven layers of different depths : 3, 8, 13, 23, 33, 53 and 73 meters, only the collection from the 73 meter depth layer in the first and the second drift contained respective one gonostomatid fish egg.

The results from seven trials of stepped vertical hauls are tabulated below. The figures indicate the number of eggs caught.

| Depth of haul | Hauling series | | | | | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII |
| 0 ← 10 m. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 ← 25 m. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 ← 50 m. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 ←100 m. | 1 | 1 | 1 | 0 | 3 | 0 | 0 |

These reults show that the gonostomatid fish eggs are floating below the mid-depth layer, say, 50 meter layer in this case, and not or very sparsely, if any, above that.

II. May 23, 1954.

In the second experiment, only the horizontal drifts were conducted.

The samping station was located at a point (37°21.8′ N, 137°20.8′ E) in the same bay, the very vicinity to the station in the first experiment. The sea depth was 82 meters.

Throughout the sampling, the water current was steadily very strong, the direction of which was standing and unchanged. The stray angle was large in amount and varied between 41° to 59°.

According to the data afforded by the Wajima Meteorological Station, Wajima, during three days prior to the observation day, wind had blown steadily from north, but with the beginning of May 23 the wind direction suddenly changed, hereafter southern wind prevailing. This change in wind direction was accompanied by a rapid rise in air temperature.

All these phenomena suggest us that a line of discontinuity passed through over this district from May 22 to 23.

Thus, from the oceanographical observation *in situ* and the meteorological records on the preceding days, it was assumed that a steady, uniform gradient current, caused by piling up or removal of sea water owing to wind transportation, might have been developed from surface to fairly deep layer on that day; and consequently is it supposed either that the variation of the current velocity with depth had, therefore, been rather small, presumably negligible for drawing an outline of the vertical distribution of plankton from the results by this sampling method, or, as is more likely the case, that the velocity had gradually been lowered with increasing depth.

The number of eggs that were caught after 30 minutes' drift is given in the following table, in which the figures indicated as "depth sampled" are the approximate depths of sampling in meter corrected for the mean stray angle of the flag line.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1st drift, 6:15–6:45, Mean stray angle 43° | | | | | | | |
| Depth sampled (m) | 2 | 6 | 10 | 17 | 24 | 39 | 53 |
| Number of eggs | 0 | 0 | 0 | 0 | 0 | 2 | 50 |
| 2nd drift, 8:00–8:30, Mean stray angle 48° | | | | | | | |
| Depth sampled (m) | 7 | 10 | 13 | 20 | 27 | 40 | 54 |
| Number of eggs | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 3rd drift, 10:00–10:30, Mean stray angle 49° | | | | | | | |
| Depth sampled (m) | 7 | 10 | 13 | 20 | 26 | 40 | 53 |
| Number of eggs | 0 | 0 | 0 | 0 | 0 | 1 | 13 |
| 4th drift, 12:00–12:30, Mean stray angle 48° | | | | | | | |
| Depth sampled (m) | 7 | 10 | 13 | 20 | 27 | 40 | 54 |
| Number of eggs | 0 | 0 | 0 | 0 | 0 | 1 | 12 |
| 5th drift, 14:00–14:30, Mean stray angle 48° | | | | | | | |
| Depth sampled (m) | 7 | 10 | 13 | 20 | 27 | 40 | 54 |
| Number of eggs | 0 | 0 | 0 | 0 | 0 | 1 | 34 |
| 6th drift, 16:00–16:30, Mean stray angle 48° | | | | | | | |
| Depth sampled (m) | 7 | 10 | 13 | 20 | 27 | 40 | 54 |
| Number of eggs | 0 | 0 | 0 | 0 | 0 | 0 | 32 |
| 7th drift, 18:00–18:30, Mean stray angle 57° | | | | | | | |
| Depth sampled (m) | 5 | 8 | 10 | 16 | 21 | 32 | 43 |
| Number of eggs | 0 | 0 | 0 | 0 | 0 | 3 | 15 |

Namely, from the waters shallower than 30 meters, no egg was sampled; for the 30–49 meter and the 50–59 meter depth layer, on the other hand, the mean number of eggs caught in a single drift was 2.9 and 23.8, respectively. When the vertical change in current velocity, if any, is taken into account, the actual increase in the relative distributional density of eggs with increasing depth might be somewhat more radical than the above-given apparent grade of increment.

## Discussion

As for the vertical distribution of the gonostomatid fish egg or the so-called "Macrurus egg" in the seas adjacent to Japan, there have scarcely hitherto been

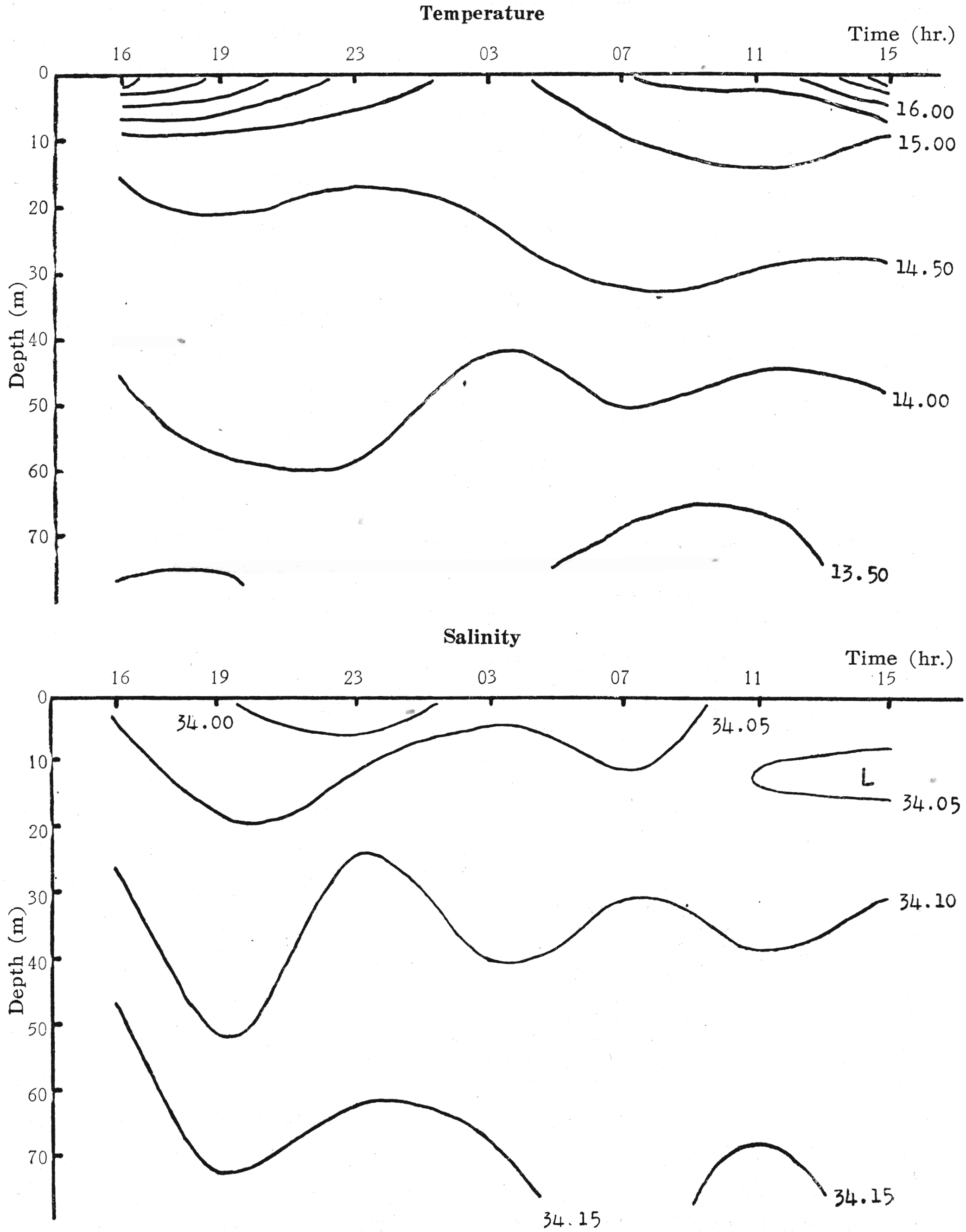


Fig. 2A. Temperature and salinity distributions on May 17-18.

any particular studies. Only KAMIYA (1916) and ITO *et al.* (1951), both of whom, however, had committed an error of referring these eggs to a macrouroid fish,

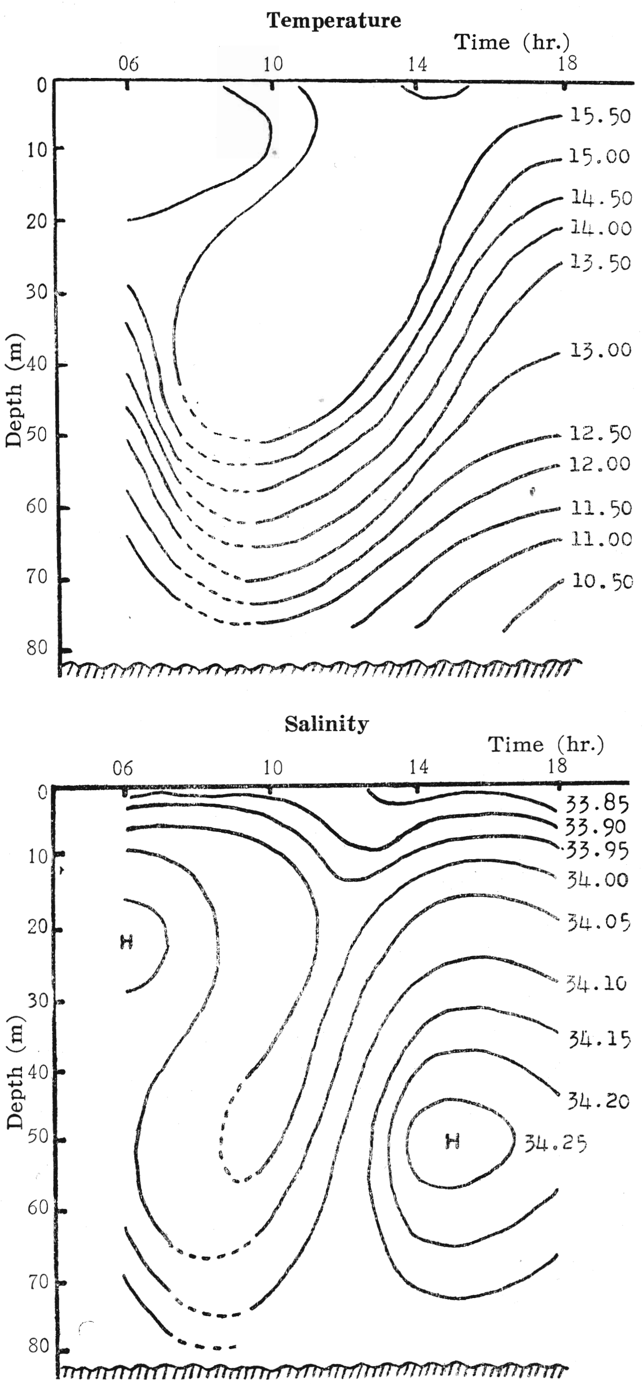


Fig. 2B Temperature and salinity distributions on May 23.

conjectured, from the results of the catches in the Bay of Tateyama and in the Noto Peninsula to Sado Straits area respectively, that the eggs might have been spawned in the deep sea, as their parents were abyssal forms, and gradually floated upwards to a certain depth or sometimes transported even to the surface by upwelling currents, and surmised that the "Macrurus eggs" might be more abundant in the deeper layers than in or near the surface.

The present study now can be said to have given a positive proof to their conjectures, in so far as they regarded these eggs as the floaters of subsurface layer rather than of surface. From the data given before, particularly from that of the second experiment, it is quite clear that the above-mentioned is actually the case. Concerning the spawning depth, however, I have shown elsewhere that these eggs cannot be spawned in the great depth but that they must be spawned in a relatively shallow layer (NISHIMURA, 1957).

Attention may then be concentrated on the hydrographic correlation. Below are given the charts of water temperature and salinity distributions when the sampling was made (Fig. 2), together with their T - S diagrammatic representations (Fig. 3).

From Figure 2, it can be soon recognized that on May 17–18 both water temperature and salimity changed gradually and monotonuously with depth and time, and that on May 23, on the other hand, the changes in these values were rather abrupt and their distributions were very complicated.

Inspection into the T - S diagrams further reveals the following with respect to water mass distribution. In the first case, three types of water masses are to be discriminated in the layers shallower than 75 meters: the warmer and less haline Surface water (S) in the upper layer, the colder and more haline Warm current water (W) in the deeper layer, and lastly the water of intermediate nature occupying most of the mid-depth layers which might be mixture of the preceding two waters and hereby called Mixed water I (MI). The core of the warm current would be located a little deeper (Fig. 3A).

In the second case (May 23), as might be seen from the complicated temperature and salinity distributions, "shiwome" or a convergence passed through the station in the course of time 10 to 14 hrs. with a marked submergence of surface water into the deep layer, the distal portion of which went in direct contact with by far the colder and less haline water near the bottom. The latter water is considered to have been formed as a result of thermal convection during winter, though slightly raised in temperature from its original degree through vernal vertical mixing with the upper warmer waters, and hence is tentatively called "Central water". Thus, in this occasion, five types of water masses are possibly distinguishable: Surface water (S), Warm current water (W), Mixed water I (MI), Central water (C) and Mixed water II (MII). The last is the mixture of the first and the fourth water type (Fig. 3B).

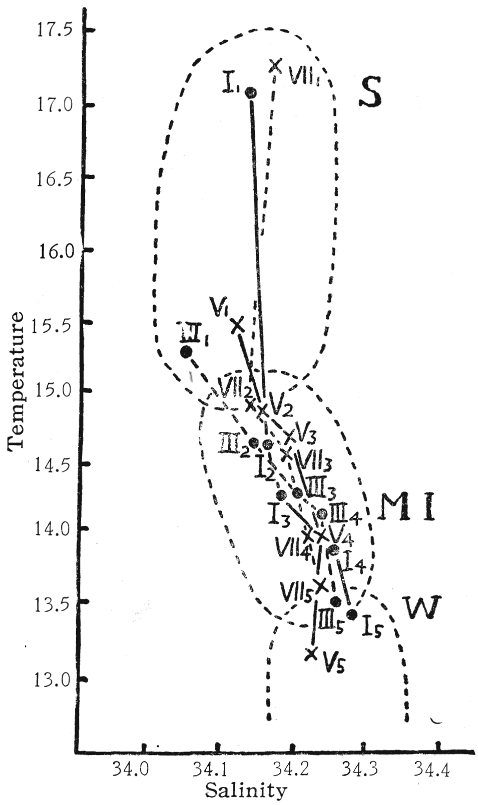


Fig. 3A. T - S diagrammatic analysis of water types. May 17–18.

Now attention may be turned to the possible relationship between the water

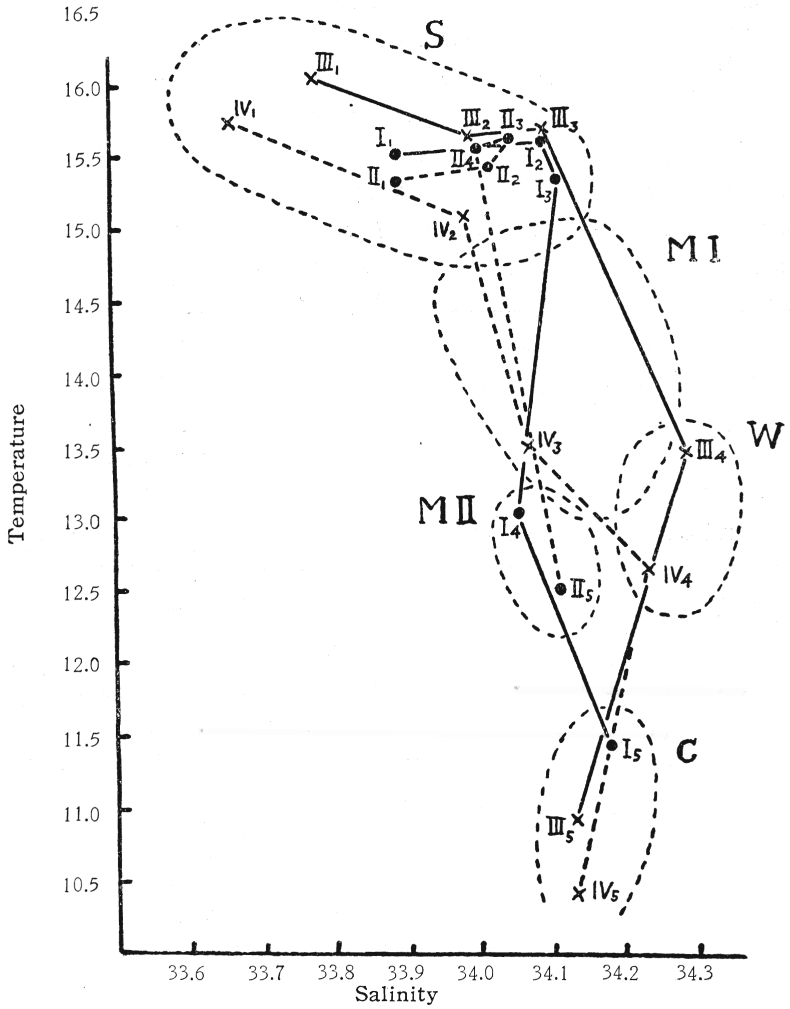


Fig. 3B. T - S diagrammatic analysis of water types. May 23.

types and the relative numbers of eggs contained in them. Below are, for reference, given the equal captivity curves of eggs in relation to depth and time in the second experiment (Fig. 4). For the sake of simplicity, it is postulated that the variation in current velocity with depth is small enough to neglect. We see from this figure that Mixed water II (I4 and II5) contained about 30-50 eggs, Warm current water (III4 and IV4) 15-30 eggs, Mixed water I (IV3) about one egg and Surface water (all excepting the above-cited as well as I5, III5 and IV5) contained none with the exception of II4, which contained extraordinarily some 10 eggs.

This may suggest the gonostomatid fish eggs would be contained in larger amount in the Central water (I5, III5 and IV5) which were though not tried to sample

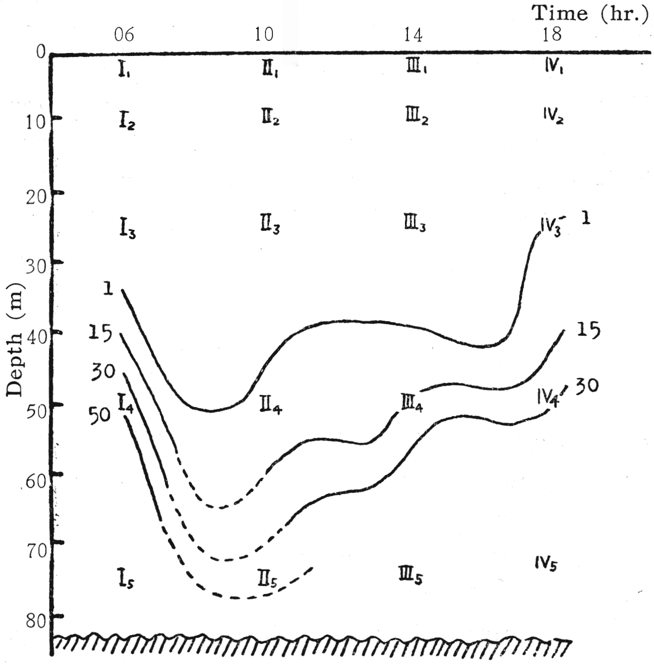


Fig. 4. Equal captivity curves of the gonostomatid fish egg.

this case, since it seems more valid to think that the eggs would have their center of abundance in the Central water and would have been shifted from that to both the Mixed water II and the Warm current water through vertical mixing or diffusion, than to think that the Mixed water II, which is considered to be hardly formed except when active upwelling or sinking taking place and therefore to be temporary nature, would be the center of their distribution.

On the other hand, the gonostomatid fish egg is known to be sometimes sampled by surface towing (NISHIMURA, *op. cit.*). In the Japan Sea, Wakasa Bay and Toyama Bay are especially remarked for the frequent occurrence of this fish egg in the surface or very near the surface, though more abundant eggs no doubt are expected to be distributed in the deeper layers.

This speciality may perhaps be interpreted by taking into account the distinguished development of upwelling in these bays; that is, in the region where upwelling is prevailing along with the ascent in Central water, the matured gonostomatid fish which is a marked representative of the so-called twilight fishes would be allowed to go up further nearer to the surface at night and would spawn, with the result that its eggs would be found floating very near the surface or even in the surface itself, kept off from sinking down as the surrounding water is heavy enough to retain them buoyant. Thus, concerning the cause of the rich and frequent appearance of the gonostomatid fish egg in the upwelling region, I am somewhat divergent in view from ITO *et al.* (*op. cit.*).

It may thus conclusively be stated that the gonostomatid fish eggs are contained mostly in the Central water, and that where upwelling is prevailing the fish eggs would get within the bounds of possibility to be captured from the upper layers, even from the surface.

What is then the cause for the limitedness to or the preference of the subsurface sea waters in their intact distribution ? KAMIYA (1916) observed that these eggs sank down in standing sea water. This informs us that the eggs are larger, and undoubtedly slightly larger, than the surface water in specific gravity, and that as a result they will go down, even if once brought up to the shallow layers, into the deep waters until they will arrive at the depth where they may get kept in balance with the water around as to the buoyancy, thus leading to the understanding that the specific gravity of the eggs may be responsible for their characteristic vertical distribution in the sea.

## Summary

1. The gonostomatid fish eggs found in the Bay of Toyama are distributed in the subsurface layers, and not or very sparsely, if any, in or just beneath the surface.

2. From the T - S diagrammatic analysis, it has been shown that the eggs might have the Central water as the core of their abundance.

3. The specific gravity of the egg may be responsible for the limitedness to or the preference of the subsurface sea water in its vertical distribution. Namely, it is estimated to be slightly larger than that of usual surface water, with the above-mentioned pattern of distribution resulting.

4. In the region where upwelling is prevailing, however, the eggs which have been spawned by adult fishes coming up till the proximity of the surface at night may be retained there and get within the bounds of possibility to be sampled also from the surface layers.

## References

1) ITO, S., WATANABE, K & ITO, K. (1951) Investigation of migrating fish stock in the north of the Japan Sea (I). Bull. Jap. Sea Reg. Fish. Res. Lab., No. 1, 40 p. (Japanese with English abstract).

2) KAMIYA, T. (1916) The floating fish eggs and larvae from the Bay of Tateyama. J. Imp. Fish. Inst., Vol. 11, No. 5, 92 p. (Japanese).

3) KATOH, G. (1954) Special baits found in the stomack of the Alaska pollack. Ann. Rep. Jap. Sea Reg. Fish. Res. Lab., No. 1, p. 53–55. (Japanese).

4) NISHIMURA, S. (1957) What is the spawner of the so-called "Macrurus egg" from the adjacent waters to Japan ? Ann. Rep. Jap. Sea Reg. Fish. Res. Lab., No. 3, p. 1–11. (Japanese with English abstract).