PHOTOGRAPHIC STUDY OF SUSPENDED MATTER AND PLANKTON IN THE SEA*

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During the exploring cruise for undersea observations by the Undersea Observation Chamber, KUROSHIO-GO (Inoue *et al.*, 1953), the authors have succeeded in taking many photographs of the suspended matter and plankton *in situ* under the sea surface off Otaru, Hokkaido. Many particles of suspended matter, usually yellowish-white in the reflection of the search-light outside the Chamber, were always observable by naked eye through the window glass of the Chamber, though they were not apparent in the upper layer, shallower than about 10 m depth, probably due to the light background.

Several investigations have been made on these suspended matter in the sea, e. g., chemical analysis (Armstrong, 1950), microscopic observation (Tsujita, 1953; Suzuki & Kato, 1953) and optical characterization (Jerlov, 1952, 1953), these having all dealt with the materials sampled from the depth by means of ordinary oceanographic water bottles.

According to the direct undersea observation, however, some of the suspended matter has a considerable size as can be easily observed by naked eye, and those particles are apparently very fragile, so it may be supposed to be disintegrated when sampled by such a rough treatment as water bottle sampling. The direct measurement of size and density of suspended matter *in situ* by means of photography will reveal more correct feature of them.

In the photographs taken under the surface, plankton animals were caught together with suspended matter. Some discussion of the swimming motion of plankton as shown by tracing the locus of their movement in the figure, is also offered in the present study.

Apparatus

The illumination is given by a mercury vapour lamp of 300 w from the side so as to project the light beam 5 cm thick and 14 cm wide, parallel with the face of window glass of the Undersea Observation Chamber, apart from it by about one meter.

In some cases, a small transparent plastic box, 15 cm in height, 20 cm in width and 5 cm in thickness, is set in front of the window glass of the Chamber. The top and bottom plates of the box can be closed or opened by handling the gear

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inside the Chamber. Thus the suspended matter and plankton captured in the box are not disturbed by the turbulence of water outside. The water contained in the box was kept in constant relation to the posotion of the observers, notwithstanding of the movement of the Chamber.

Setting the camera close to the window glass and using the FOCABELL of Orion Camera Co., Ltd., Tokyo, the box is brought into focus.

Suspended Matter in the Middle Layer

Figure 1 shows the suspended matter caught in camera in the middle layer quite distant from the sea bottom. These are typical suspended particles found in the coastal water. Most of the suspended particles are larger than about one mm in diameter, the largest one being about 3 mm. Goldberg *et al.* (1952) stated that there are not any suspended particles larger than 130 micron in diameter, after they are combined with some reagent, while Jerlov (1953) assumed from photometric examination that size of the suspended matter in general equals or exceeds one micron and finer materials is of minor importance. He added that big particles above one mm are occasionally present in the samples but never observed in the deep-sea samples.

Since the size determination of the above preceding authors was done on the sampled water, the disintegration of the particles might have occured during the process of sampling.

In the present observation, the suspended particles were sometimes found to be connected togetherm forming an elongated mass (fig. 1, a) or more loosely connected, forming something like a string of beads (fig. 5).

Particles Stirred up from the Bottom

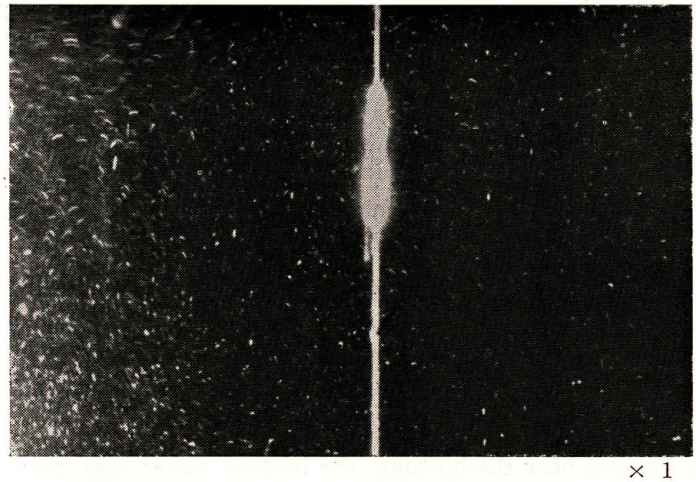
When the Chamber was lowered near the bottom, the bottom water was much disturbed due to the pitching movement of the Chamber itself, resulting in the stirring up of many particles which had been settled on the bottom. Figure 2 was taken near the bottom at about 50 m depth by allowing the outflow and inflow of water through top and bottom openings of the box. In the figure the distribution of the stirring particles will indicate the stream lines of eddy motion of the water, some of them drawing curved locus. It was perceived that the particles in this case were rather small, below one mm in size, and more abundant as compared with the ordinary suspended matter in the middle layer.

Movement of Plankton

Comparatively large animal plankton, such as arrow worms and copepods, are often present in the figures. Although it is very difficult to distinguish the bodies of plankton from the ordinary suspended particles, some of the images can be

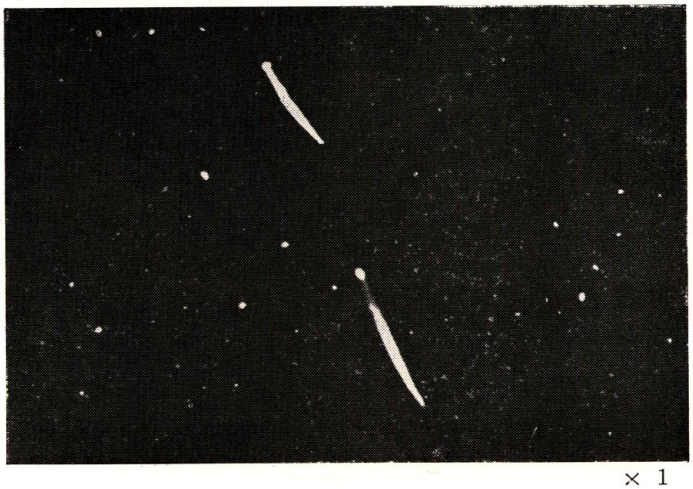
× 1

Fig. 1. Typical suspended particles found in the middle layer of coastal water, photographed at 50 m depth where the sea depth is 75 m



× 1

Fig. 2. Particles stirred up from the sea bottom, photographed at 50 m depth

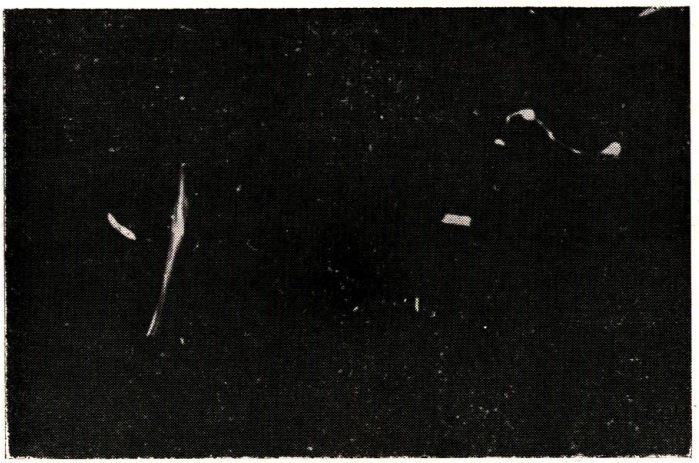


× 1

Fig. 3. Swimming animal plankton (*Sagitta* and copepods) and suspended particles photographed at 40 m depth

× 1

Fig. 4. Swimming animal plankton (*Sagitta* and copepods) and suspended particles photographed at 50 m depth



× 1

Fig. 5. *Sagitta* and suspended particles. A train of particles forming something like a string of beads is clearly shown. Photographed at 50 m depth.

× 1

Fig. 6. Locus of the swimming motion of copepods photographed at 50 m depth

identified to be copepods by their comparatively sharp and somewhat elongated contour (figs. 1 and 4). Their antennae are also perceived in the figure, appearing as minute projections (fig. 4, a). The image of arrow worms (*Sagitta*) is clearly shown in some figures (figs. 3 and 4).

Inasmuch as the mercury lamp was supplied with 50 cycle alternating current, the light being produced intermittently with a short period of about 1/100 second, the tracks of the motion of copepods were graphed as a series of intermittent dots (fig. 6). Some of the dotted lines are straight, but others are curved, corresponding to the movement of copepods (fig. 6).

An approximate swimming velocity, correctly speaking, the velocity component along the plane of photograph, can be calculated by measuring the length of tracks and number of dots. The mean velocity is calculated to be about 12 cm per second in the case of fig. 6. Some tracks are acutely bent at a point (fig. 6), probably indicating that copepod moved toward one direction, then stopped and darted again toward another direction. Time of rest of copepod at the point is calculated to be about 1/50 second.

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