STUDIES ON SUSPENDED MATERIALS *MARINE SNOW* IN THE SEA
PART I. SOURCES OF *MARINE SNOW*

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For several years, the junior author[1-4] has been making investigations on marine deposits which are an important factor affecting the biological environment in fishing grounds. But the investigations would not be satisfactory, unless characteristic properties of suspended materials in sea water and their sedimentation process become clear. Carson[5] imagined the existence of suspended materials as a stupendous "Snowfall" in the sea. However, numerous flake-like substances in sea water were actually observed in underwater survey by the undersea observation chamber "Kuroshio", designed by Prof. N. INOUE, of Hokkaido University, and his collaborators[6]. The flake-like substances might be the same as Carson's "snowfalling" particles. As yet only few investigations on the particles have been made and none has clarified their true characters.

Jerlov[7] made an interesting investigation on the distribution of the suspended particles, of which the biological or chemical characters were not conceivable. Fox and his collaborators[8] investigated on colloidally or finely particulate organic and inorganic detritus suspended in natural bodies of water and measured the chemical composition and relative quantities with reference to depth, latitude and proximity to land.

During a 1952 voyage aboard the "Oshoromaru" (617tons), the training ship of the Faculty of Fisheries, Hokkaido University at Hakodate, the writers observed suspension of the particles in sea water through the window of the chamber "Kuroshio", hanging from the ship, at several different stations around Japan. Sea water containing the suspended materials was sampled with a specially prepared water sampler (20 liters in volume), from which the water was transferred into some vessels by careful scooping with a cup and brought the laboratory without disturbance. By standing for several hours the suspended materials were sedimented on the bottom of the vessel. Then those sedimented materials were pipetted for microscopic observation.

As shown in the photographs appended, it is clear that the suspended materials are chiefly the aggregates of the remains of plankton, sinking in some stages of disintegration by marine bacteria. The main component of the suspended materials may be the skeletal residues of diatom which are fairly stable against the attacks of bacteria. There is no essential difference as regards the biological components among materials from the different stations. The species of organisms composing the aggregate show some characteristics as the locality of observation differs. From the appearance of the suspended materials the authors propose to give the name *Marine Snow* to them. The *Marine Snow* seems to be identical to the *Marine Leptopel* named by Fox and his collaborators[8]. But it is still

necessary to ascertain the identification between them, because actual undersea observation and microscopic detection of the marine leptopel have not been made.

The underwater photograph (Fig. 1) shows a large amount of *Marine Snow*, ranging from sharply defined points, vague cluster and strings of dots, to elongated streakes.

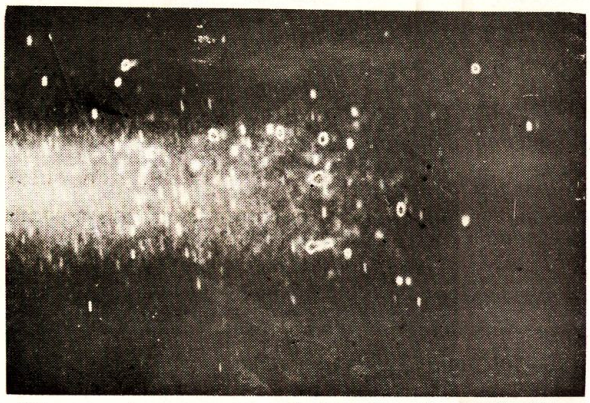

Fig. 1. Appearance of *Marine Snow* falling in Water, Tsugaru Strait (Depth 50m) (photographed by S. SUGIMOTO)

A) Actual View of *Marine Snow* from the Undersea Observation Chamber "Kuroshio"

The underwater observations of *Marine Snow* aboard the "Kuroshio", were carried out at different stations, viz., at Tsugaru Strait, Mutsu Bay and Kagoshima Bay.

(1) In Tsugaru Strait off the Cape of Esan (Hokkaido) (Oct. 7, 1952)

Through this Strait the flow of Tsushima Current passes from the Japan Sea to the Pacific; its water is fairly transparent. The flake-like substances luminously scattered light, and were rather more compact than in the other areas of water observed. With an increase of water depth, the distribution of the *Marine Snow* showed a gradual decrease and also the particles become smaller in shape.

(2) In Mutsu Bay (Aomori Prefecture) (Oct. 9-10, 1952)

The junior author[1] has investigated the bottom deposits in Mutsu Bay. According to those investigations, it seems that currents in the bay are very weak and an enormous amount of detrial mud settles on the bottom, where the dwelling of shell-fishes may be affected by the characters of the deposits.

However, from the present observations, the bottom was found to be almost entirely muddy. The distribution of the suspended materials was obviously dense and also the flakes of *Snow* were in flocky clusters containing a pretty good amount of water. The photographs (Pl. I, 1-6) show the characteristic appearance of the *Marine Snow* in the station of the Bay (Lat. 41°7.7′ N, Long. 140°57.2′ E, water depth 25m).

(3) In Kagoshima Bay (Kagoshima Prefecture) (Nov. 10-12, 1952)

For the sake of contrast with the northern areas, such as above-described ones, Kagoshima Bay was selected as an observation area in southern Japan.

The distribution of *Marine Snow* in that Bay appeared rather thinner than in the northern areas, but the flakes showed some vague clusters of which the biological constituents were characterized by the species of diatom in comparison with the northern sea.

The photographs (Pl. I. 7, 8, Pl. II, 9-14) are those of *Marine Snow* sampled according to the depth, from water at 30, 60, 90 meters and near the bottom (Lat. 31°25.2′ N, Long.

130°13.5' E, water depth 95m).

B) Process of *Marine Snow* Formation Observed through the Photomicrographs.

Characteristic aggregation states of *Marine Snow* are indicated in Plate I, 1 and 2, where the cellular substances of plankton destroyed by bacteria aggregate around the larger materials suspended in water. It appears that the remains of organisms or debris carried from land play the chief rôle of nuclei in this aggregation process.

On the other hand, the different stages of disintegration process of plankton are indicated in Plate I, 3-6, in which there are different features of *Coscinodiscus sp.*, most common species of diatom, as in the examples of the disintegration stages of plankton. The biological components of *Marine Snow* are chiefly the remains of diatom which show some differences with the different areas.

The microscopic appearance of the bottom deposits ought to be almost the same as that of the *Snow* flakes. Plate II, 15 & 16, shows photographs of the bottom deposits. The similarity between them indicates that the detritus on the bottom is an accumulation of the falling flakes of the *Snow*.

C) Discussion

The distrbution of *Marine Snow* in the sea should be influenced by the variation of the oceanographical environments, viz., by currents, inflow of rivers, transportation of debris from land or by configuration of bottom. Accordingly it should be possible to make an analysis of the masses of water in the area. Also it seems to be clear that the distribution of the *Snow* is intimately related to the production of living matter, because the nutrient substances, viz., carbon, nitrogen, phosphorus, sulfur and silicon, circulate through *Marine Snow* in a cycle of metabolism in the ocean, transmuting from water, to living matter and then to the earth, Consequently it would hardly be possible to solve the problems of the organic production in the ocean, unless the characters of *Marine Snow* are clarified satisfactorily.

When the aggregates of the destroyed plankton are sinking, not only will be nutritious substances of the organisms be dissolved into the water, but also certain chemical constituents or gases in water would be adsorbed in the *Snow* flakes.

On the other hand, in conducting chemical analyses of sea water, the practical methods or the treatments of sample have to be considered sufficiently because of the existence of the *Snow*. Moreover, the catalytic activity of sea water emphasized by MATSUDAIRA[9] seems to be influenced by the presence of the *Snow* according to the results of preliminary experiments. In relation to the effect of the *Snow* upon the catalytic activity of sea water, the problem of oxygen dissolved in water will develop a new field of research.

After all, it seems to be necessary that geochemical investigation on sea water or the problem of metabolism in the ocean be respectively re-considered in consequence of the

clarification of the characters of *Marine Snow*.

The authors are greatly indebted to Prof. N. INOUE, who afford them facilities to make the undersea observation and to Assist. Prof. T. FUJII, Captain of the training ship, and his crew for able collaboration in the course of the work at sea. Further they wish to thank Prof. K. KASHIWADA, Kagoshima University, for all possible help in providing room and apparatus for the investigation at Kagoshima Bay. They also are deeply grateful to the Fishery Agency, Ministry of Agriculture, for financial aid.

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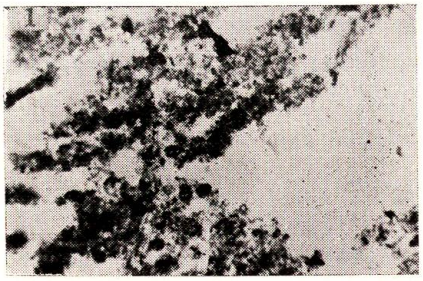
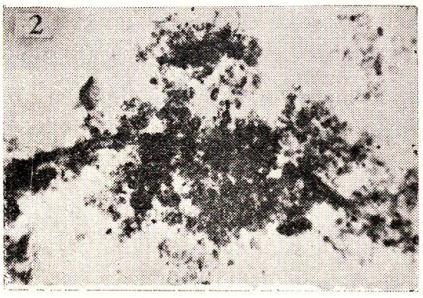
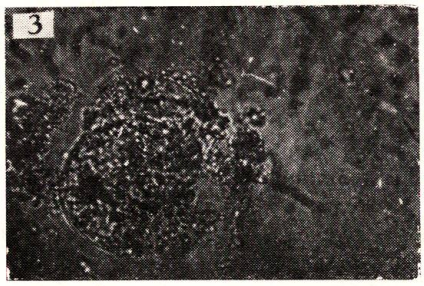
PLATE I.

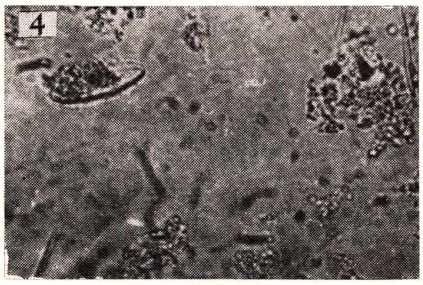
(A) Aggregation States of Flakes of *Marine Snow*. (Mutsu Bay) ×80

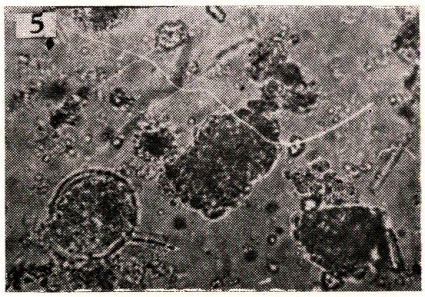


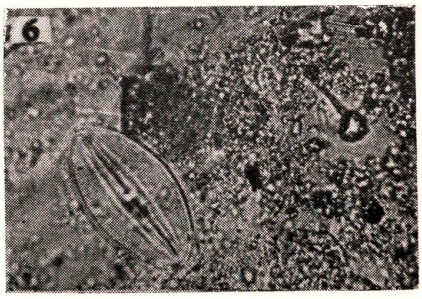


(B) Some Stages in Disintegration Process
of Diatom, *Coscinodiscus* sp.
Mutsu Bay ×360





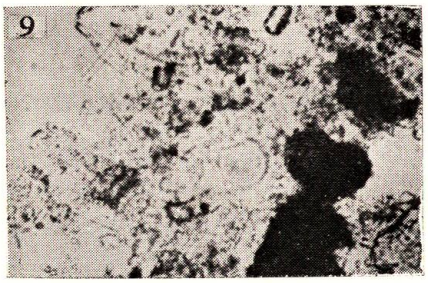


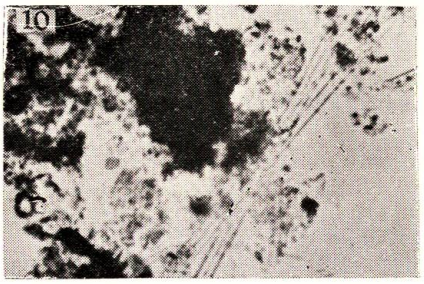


(C) Biological Constituents of *Marine Snow*.
Kagoshima Bay ×360
Surface water

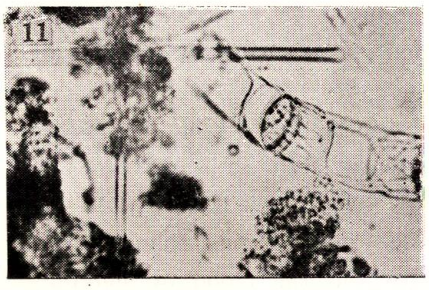
PLATE II.

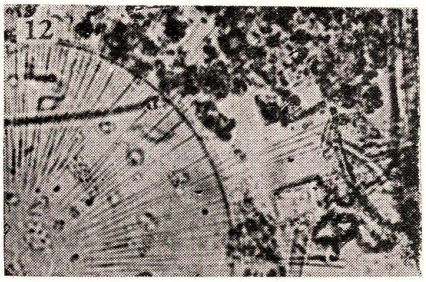
(C) Biological Constituents of *Marine Snow*. (2)
(continued)
Kagoshima Bay ×360
Water depth 60m



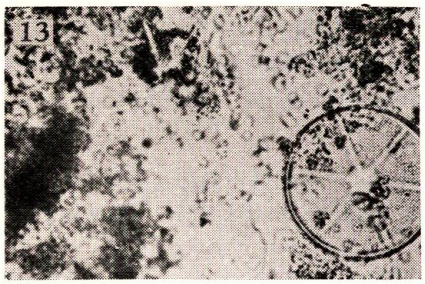


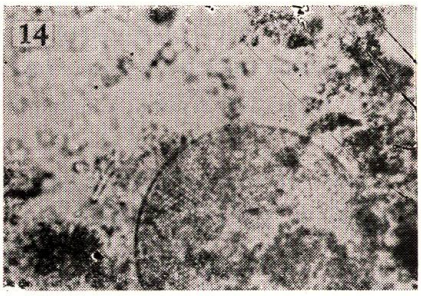
Water depth 90m





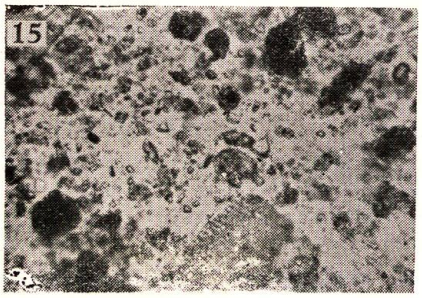
Water near bottom (depth 95m)





(D) Bottom Deposits ×360

Mutsu Bay



Kagoshima Bay