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Description of Quantity and Dispersion Distribution Changes of Mineral Suspensions Occurring in the Ezcurra Inlet Waters, King George Island within a year cycle

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ABSTRACT : This research describes quantitative and dispersal distribution of mineral suspensions occurring in the Ezcurra Inlet waters. The research was carried out during one year. Quantities of suspension present in surface waters and in the flood to depth of 100 m in this region were determined. It is ascertained that the highest suspension quantity (over 1.4×10^{12} pieces/m^3) appears in the surface waters to the depth of 2 m in March. The lowest is observed in November and is below 10^9 pieces/m^3. The largest changes of quantity occurred in the surface water to the depth of 20 m. The quantity of suspensions depends on the distance from the shore; the depth of water sampling, and meteorological and hydrodynamic conditions. Dispersion distribution of suspensions was analysed for samples taken from point A of the Inlet waters along with description of its dependance on time and depth of sampling and the depth.

Key Words: mineral suspensions, quantitative distribution, dispersion distribution.

Foreword

Quantities of mineral suspensions occurring in the sea water and their dispersion distribution depend on meteorological conditions present in the given region; consistence and shape of the sea bottom, water depth of the basin, its distance from the shore and river outlets, and on physical, chemical and biological phenomena taking place in the sea flood.

Quantitative concentration of mineral suspensions in the sea water changes considerably. The lowest suspensions concentration is present in the high distant from shores and other sources. There are about 10^9 pieces of suspensions in one/m^3 of water. Their quantity may surmount 10^{13} pieces /m^3 in the coastal waters (Dera, 1983 ; Gurgul, 1989, 1990, 1991). The above data deal with suspensions of diameter bigger than 1μm. There is very little information about suspensions of diameter less them 1μm. Based on research in which an projection microscope was used it was found that there are $5 \times 10^{12} \sim 10^{13}$ pieces in m^3 of suspensions of diameter 0.01~1.00μm(Optika Okeana, 1983).

There are not many publications where results of investigations regarding the quantity and size of mineral suspensions present in sea water are reported (Jonasz, 1974 ; Ivanoff, 1975 ; Epply et al., 1977 ; Ramana Murty et al., 1986). Apart from single particles, there are aggregated suspensions in the sea water. Most fequently they are found in surface waters. Research works carried out in the waters of Japanese bays show that diameters of suspensions are mainly from 2 to 5 μm while at the river outlets 3.5 μm (Jerlov, 1976). The mineral suspensions diameters occurring in the Admiralty Bay water were determined with a Coulter counter. The research was carried out in the summer and molecules of diameter from 2 to 32 μm were counted (Pecherzewski, 1987).

Suspensions dispersion distribution is described by analytic functions or statistical means (Jonasz, 1974, Gurgul et al., 1991). Proceeding of any physical, chemical and biological processes in the sea water depends on suspensions sizes. The suspensions sizes influence sedimentation and transport. Their spreading within the sea flood depends on turbulent movements, convection and diffusion and also on sea water layers (Kyle, 1979; Kosian, 1984; Robbins, 1986; Korotenko, 1987; Gurgul et al., 1991).

The results of research upon mineral suspensions quantity changes related with the season of the year, location and depth of water sampling have been presented herein. Based on obtained results of measurements, suspension dispersion distribution emerging from water samples taken from the vertical profile in point A (Fig. 1) in various months and depths has been analysed.

General Characteristics of the Ezcurra Inlet

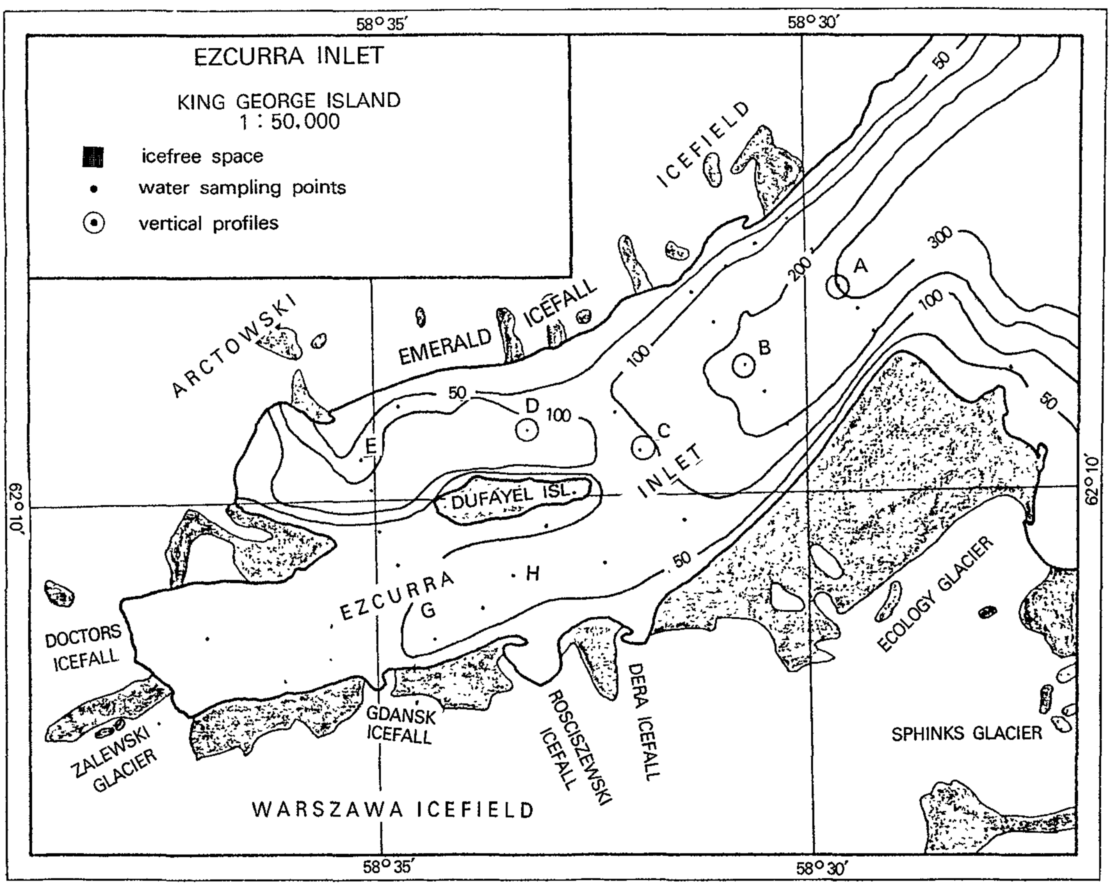

Fig. 1. The Ezcurra Inlet Map.

The Ezcurra Inlet is a part of the Admiralty Bay on the King George Island. It is formed in a long narrow basin cut westwatds into the land. Its bottom has a form of a trench. Its depth exceeds 305 m at the entry and the bottom rises towards the inner part of the Inlet. In front of the Dufayel Island (the northwest side) depth of the Inlet decreases to about 76 m (Battke, 1990). A threshold along the line Mirror Point - Italian Valley separates a caving in the northern part of the Inlet. Along the northwest shore of Dufayel Island depth of the Inlet increases again and reaches 150 m. The Inlet ends in two deep bays: Cardozo Cove (65~125 m) and Colden Cove (65~85 m). Most of the Inlet shoreline are covered with glaciers. In the summer a large part of its south coast is free from ice. Many streams outflow from under the glaciers in this part of the land.

The streams outflowing from the glaciers and water from melting ice are the main sources of mineral suspensions present in waters of the Inlet. A fraction of suspensions is brought by the wind blowing from the land. In the summer intensive melting of glaciers occurs and suspensions released from the ice are carried to the Inlet. During the winter these processes are slowed down or even stopped at all. Then the inflow of suspensions from the land is low.

During the period of extensive water exchange between the Admiralty Bay and the Ezcurra Inlet inflow of suspensions takes place especially with the north and northeast winds. Shape of the bottom has a considerable effect on transport of suspensions, too.

Methods of Measurements

Water samples were taken every month except June and August. The sampling was carried out at the surface or on vertical profiles. The surface water samples were taken in points A, B, C, D, E, F, G and H (Fig.1) on Feb.7, Feb.14, March 2 and 29, April 4, July 7, Sept. 30, Nov. 7, 10, 16 and 28, Dec. 15 and 28, in 1989 and Jan. 6 and 18, 1990. The vertical profile samples were taken in points A, B, C, D on Feb.14, March 2, April 4 and 21, May 19, July 25, Sept.30, Nov.7, 10 and 28, Dec.15, 1989 and on Jan.6, 1990, from the following depths 0, 1, 2, 3, 5, 10, 20, 30, 50, 100m. The samples taken with a bathometer and poured into plastic bottles were later brought to the laboratory for further elaborating.

Some drops of water from each sample were placed on a Bürker table. Using a projection microscope MP-3, to magnify 1,000x counting of each size class suspensions (every 1 μm) was made. Later their number in 100 elementary cubicoids (0.004 mm^3 each) was counted. To determine diameters of suspensions Feret method was used and the error of measuring was equall ±0.5 μm(Gurgul, 1989, 1990).

Testing of Mineral Suspension Quantity Changes in Yearly Cycle

Testing suspension in surface waters

This was performed for surface layer to the depth of 0.2 m. Six characteristic distribution of mineral suspension quantities in surface waters were chosen from the carried out research works for further description below. The results of measurement suspension quantity on March 2, are presented in Fig.2. They were showed with full lines. The lowest quantity of mineral suspensions was observed close to the southeast shore

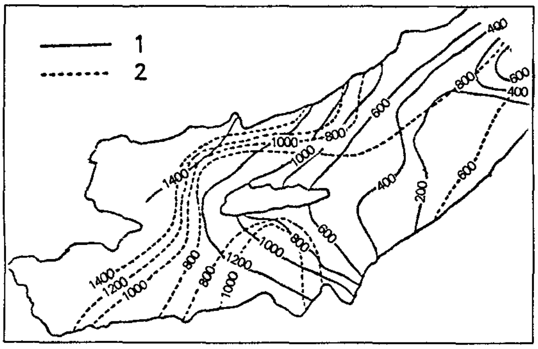

Fig. 2. Isolines of equal mineral suspension quantity. The given numbers should be multiplied by 10^9 pieces/m^3. 1-isolines on March 2, 1989, 2 - isolines on March 29, 1989.

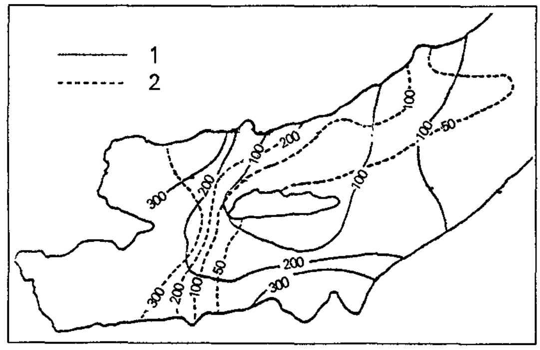

Fig. 3. Isolines of equal mineral suspension quantity. The given numbers should be multiplied by 10^9 pieces/m^3. 1-isolines on July 25, 1989, 2 - isolines on September 30, 1989.

of the Inlet and amounted 2×10^9 pieces/m^3. Towards the west the quantity increased. The highest quantity was met at the northeast shore of the Inlet and exceeded 1.4×10^{12} pieces/m^3. Decrease of suspension quantity concentration was almost uniformly towards the Inlet entrance. Fig. 2 also presents mineral suspension quantitative distribution which occured on March 29. The distribution presented here is different than the previous one. Maximum and minimum of mineral suspension quantities was in the same places as on March 2, but the highest gradient of suspension quantity are in the western part of the Inlet. Within the distance of some hundred meters its decrease was by 8×10^2 pieces/m^3. Maximum suspension quantity was observed in the region adjacent to the glaciers.

After four months the suspension concentration significantly decreased (Fig. 3). On July 25 over the large part of the Inlet area the quantity of suspensions did not eceed 3×10^9 pieces/m^3. In the western part of the Inlet the quantity was slightly higher than the one given above. Testing on September 9 showed further decrease of suspension quantity. Over considerable part of the

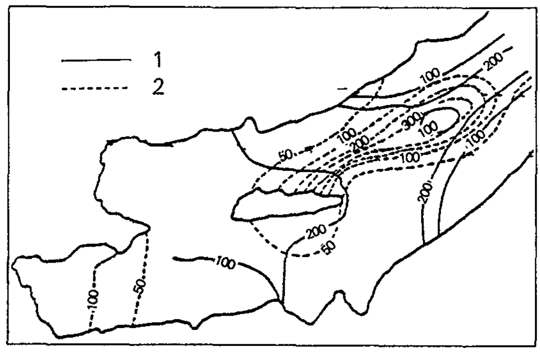

Fig. 4. Isolines of equal mineral suspension quantity. The given numbers should be multiplied by 10^9 pieces/m^3. 1-isolines on November 7, 1989, 2 - isolines on January 6, 1990.

surface of the Inlet the quantity was not higher than 10^9 pieces/m^3. Only in the western part this value was slightly surmounted 3×10^9 pieces/m^3. On November 11, 1989 (Fig. 4) the quantity of suspension did not reach 3×10^9 pieces/m^3 all over the area of the Inlet. The highest quantity was observed in the middle part of the Inlet. On January 6, 1990 an increase of suspensions was observed in the middle part of the Inlet slightly exceeding 3×10^9 pieces/m^3. In the regions adjacent to the glaciers the quantity of suspensions

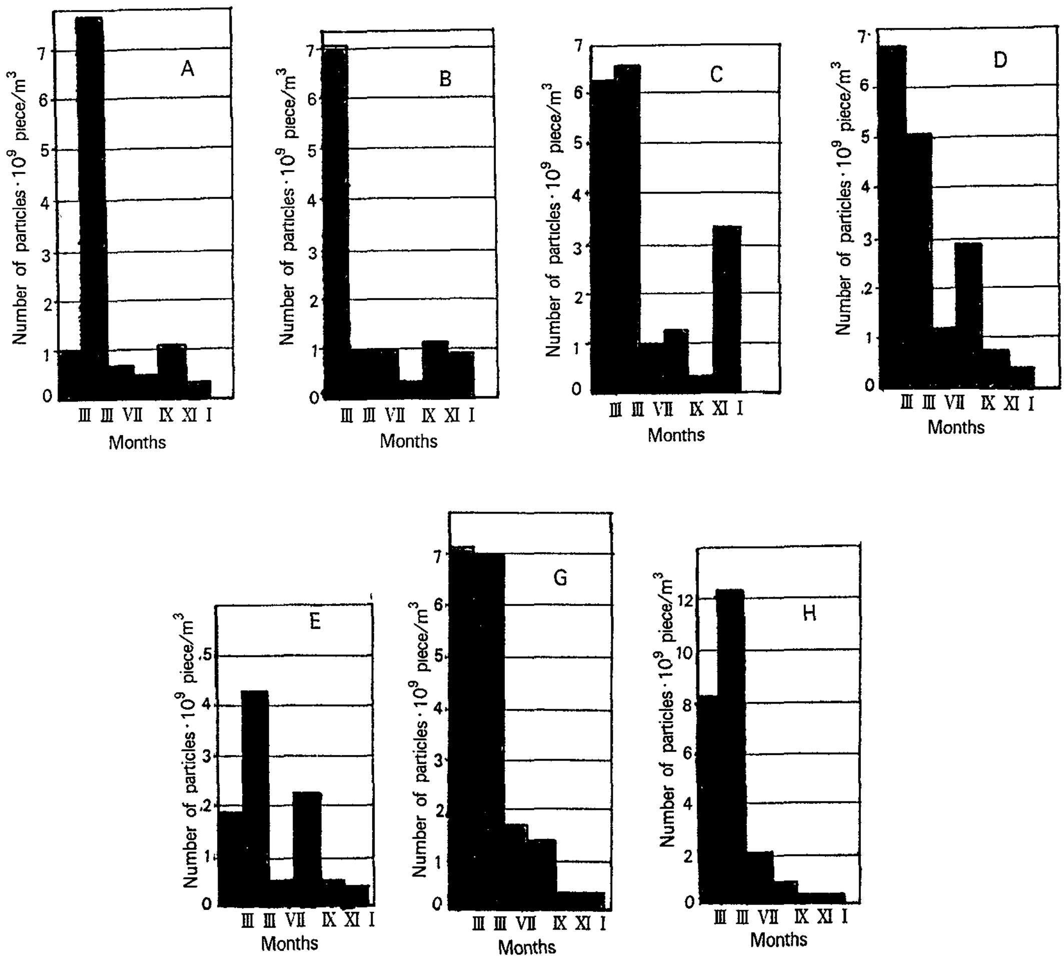

Fig. 5. Mineral suspension quantity diagrams for characteristic points of the Ezcura Inlet (A, B, C, D, E, F, G, H) in selected months.

was lowest.

Based upon counted quantities of suspensions present in the water samples taken from characteristic points of the Ezcurra Inlet diagrams were prepared for several months (Fig. 5). Seeing the diagrams it can be stated that the highest suspensions quantity for all points occurred in March 1989, and was between 12.2×10^9 and 4.3×10^9 pieces/m^3. The least apparent changes were observed for points A and B which are in the middle part of the Inlet. In points D, G, and H clear decreasing tendencies occured. It emerges from the above that the biggest changes of suspensions quantity within a year are observed in points being close to the shore.

Testing the suspensions present in the sea flood

An analysis of changes in suspension quantity depending depth and time is showed in Fig. 6. It has been performed based on vertical profile measurements in point A.

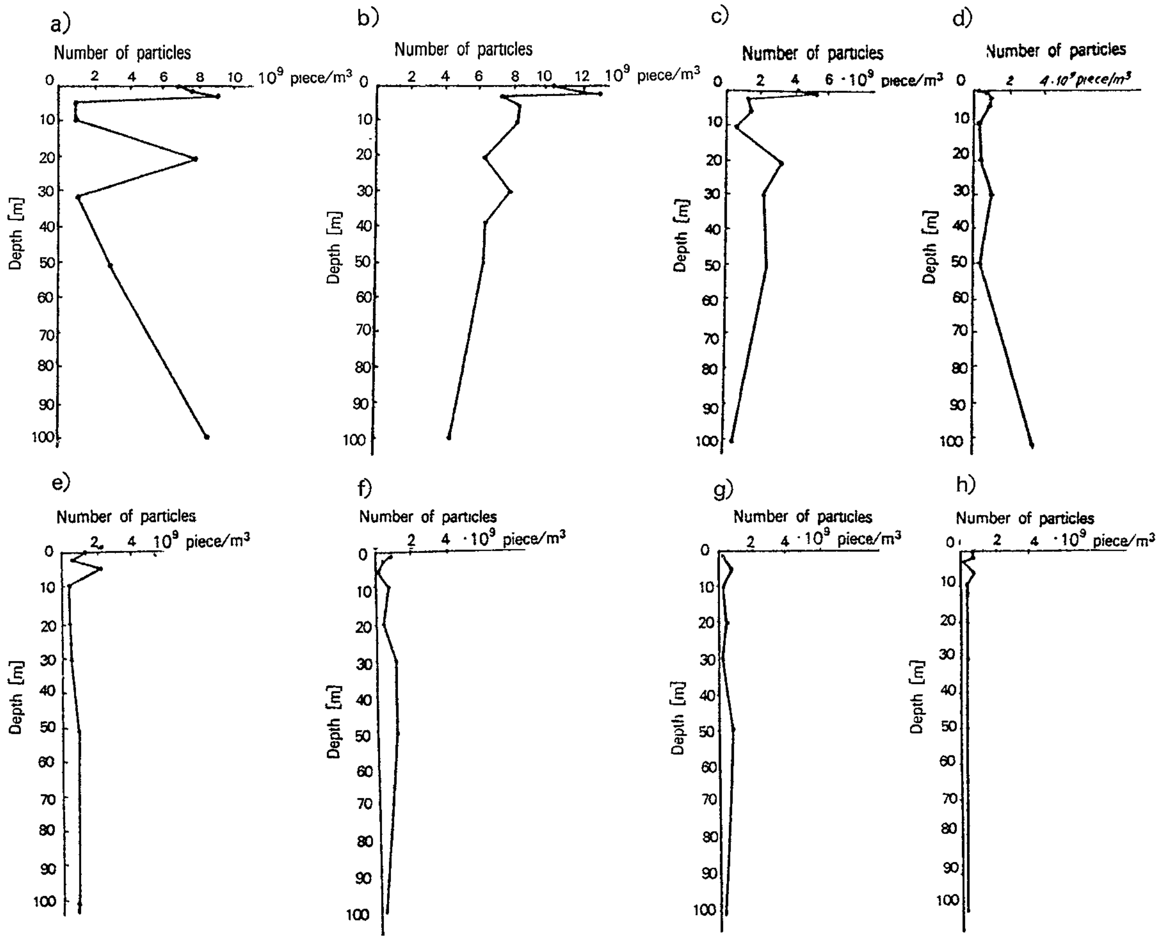

Fig. 6. Mineral suspension quantities present in specified depths in point A of the Ezcurra Inlet on: a) March 29, 1989; b) April 21, 1989; c) May 13, 1989; d) September 30, 1989; e) November 11, 1989; f) November 28, 1989; g) December 15, 1989; h) January 6, 1990.

Measured data obtained on March 28, 1989 show that the highest quantity of suspensions (9.4×10^9 pieces/m^3) was at the depth of 2 m. At 5 and 10 m depths a decrease and futher increase to 7.5×10^9 pieces/m^3 at the depth of 20 m was observed. At 30 m depth the quantity of suspension amounted 10^9 pieces/m^3 and a slow increase of their quantity in depth was observed. The results from July 21 showed considerable changes in suspension quantity distribution at given depths. Their maximum occurred at 1 m (13×10^9 pieces/m^3) and was lower at 2 m (7.2×10^9 pieces/m^3). Deeper the quantity of suspensions decreased with slight variations to reach 4.5×10^9 pieces/m^3 at the depth of 100 m. On May 15, were visible changes of suspensions quantity observed to 2 m depth although their maximal quantity occurred at 1 m (5.2×10^9 pieces/m^3). A second maximum was found at 20 m depth (3.4×10^9 pieces/m^3). Deeper the quantity of suspensions decreased in accordance with the depth and at 100 m amounted 0.6×10^9 pieces/m^3.

The measurements carried out in the other terms showed that changes in suspension quantities in dependance of the depth are not significant. Only on November 11, 1989 some bigger changes occurred. The maximum of concentration was registred at 5 m depth and amounted 2.4×10^9 pieces/m^3. From November 1989 to January 1990 at the depths greater than 50 m the decrease of suspension quantities occured. During all that time the suspension quantity concentration along the vertical profiles did not reach the amount 2×10^9 pieces/m^3. Slightly varying suspension quantity occurred to the depth of 10 m. Similar to the results described above were received on vertical profiles in points B and C.

Based on measurement results on profiles A, B and C there were made distributions of suspension quantities with the relationship to depth. The results of research on March 29 are presented in Fig.7. The highest suspension concentration occurred in the middle part of the Inlet to the depth 10 m. A stream of suspensions is apparent in the figure increasing its depth along the intersection C to A. The point C is placed close to the Dufayel Island and glaciers which are the sources of suspensions. In the intersection C suspension concentration maximum higher than 8×10^9 pieces/m^3 was present at the depth of 1～5 m. In the B intersection its depth was greater and equalled 35～45 m and in the A intersection reached the depth of 95～100 m.

To make a comparison in Fig.8 suspension quantity distribution was presented for the same intersection on May 19, 1989. The highest concentration of suspension occured to the depth of 20 m. Below that depth suspension quantity was lower than 10^9 pieces/m^3. The maximal

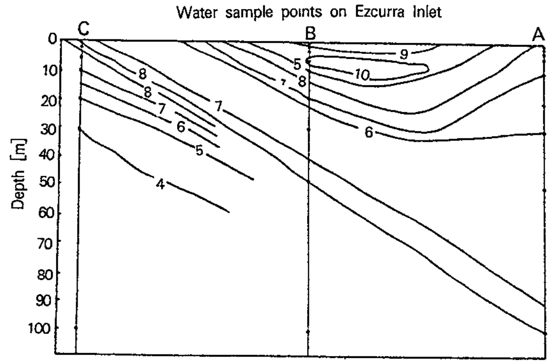

Fig. 7. Mineral suspension concentration distribution on March 29, 1989, (The given numbers are to be multiplied by 10^9 pieces/m^3) along the profile for points, A, B and C in the Ezcurra Inlet.

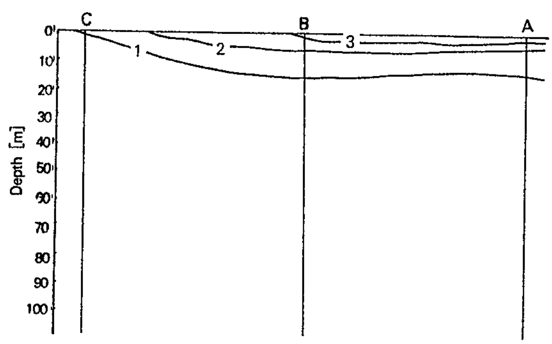

Fig. 8. Mineral suspension concentration distribution on May 19, 1989, (The given numbers are to be multiplied by 10^9 pieces/m^3) along the profile for points, A, B and C in the Ezcurra Inlet.

suspension concentration was present between profiles A and B and exceeded 3×10^9 pieces/m^3.

Similar suspension distribution was observed from July to December 1989.

Suspension Dispersion Distribution Research

Apart from the suspension quantites their dispersion distribution was investigated too. The speed of mineral suspension sedimentation depends on their size and specific gravity. The biggest in size suspensions fall down soonest. Basing on suspension quantity distribution of given diameter it is possible to carry out an analysis of sedimentation process proceeding.

As a presentation of situation occuring on the surface layer suspension quantities of diameters 1 μm, 3~4 μm, and bigger than 10 μm the results obtained on March 2, 1989 are presented (Fig. 9).

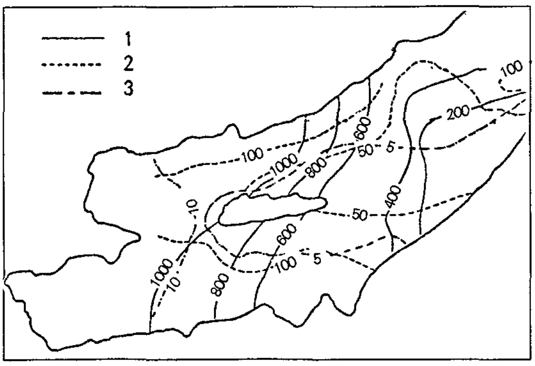

Fig. 9. Mineral suspension concentration in surface waters of the Ezcurra Inlet on March 2, 1989 according to their sizes: 1-diameter 1 μm, 2-diameter 3~4μm, 3-diameter 10μm (the given numbers are to be multiplied by 10^9 pieces/m^3).

As it emerges here most of the suspensions had diameter 1 μm. The lowest quantity (2×10^{11} pieces/m^3) was found at the entrance to the Inlet at the southern shore. The suspension highest quantity (over 10^{12} pieces/m^3) was present west of the Dufayel Island. The number of suspensions of this size increased towards north - west of the island. The number of suspensions of 3~4 μm diameter was considerably lower. The lowest quantity of them was registred in the middle part of the Inlet and in its southeast part (fewer than 5×10^9 pieces/m^3). Their highest number was present near glaciers and exceeded 10^{11} pieces/m^3. Suspensions of diameter over 10 μm were in lowest quantity. Almost over the whole area of the Inlet their number was under 10^9 pieces/m^3. The number of suspensions over that value was higher only in its western part. Figs. 10 and 11 show suspension dispersion distribution in point A at give depths. Individual curves represent dependance of occurrence frequency (n/N) of suspensions in accordance to their diameter. The number of suspension with the given diameter is denoted with n while N denotes total number of suspensions in the sample of water. Fig. 10a shows the results of measurements on March 29, 1989. The water samples were taken from the depths of 2, 5, 50 and 100 m. The shapes of curves are similar. Probability distribution of occurrence of suspensions at 2 m depth is slightly different. Suspensions with diameter exceeding 6 μm were met more often here than in rest of the samples of water. Fig. 10b shows the above relationships for water sampled on March 30, 1989 from 1, 5, 50 and 100 m depths. The curves presented here are different. Especially different is suspension dispersion distribution for the depth of 50m. The most frequent suspensions at this are the ones of size 2~3 μm while at the others suspensions of the diameter of 1 μm. There were not observed suspensions of diameter bigger than 6 μm at the depth of 100 m.

In samples of water taken from the depths of 1, 5 and 50 m on Dec. 15, 1989 dispersion distributions are more different than previously described. The shapes of frequency curves for 1 and 5 m are like one another. The all curves show significant increase of suspensions of the diameter 2~4 μm (Fig. 11a). A great variety of curves is showed in Fig. 11b. These are the suspension dispersion distributions which occurred in samples of water taken from the depths 1, 5, 50 and 100 m on January 6, 1990. The curves

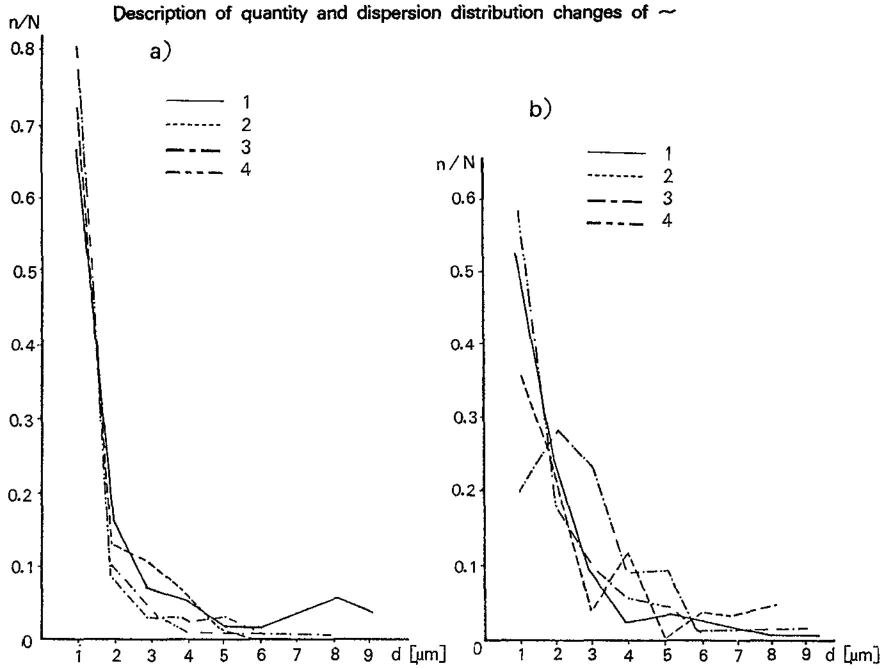

Fig. 10. Mineral suspension dispersion distribution present in water samples taken from point A of the Ezcurra Inlet on: a) March 29, 1989 from depths 1~2 m, 2~5 m, 3~50 m, 4~100 m; b) September 30, 1989 from depths 1~1 m, 2~5 m, 3~50 m, 4~100 m.

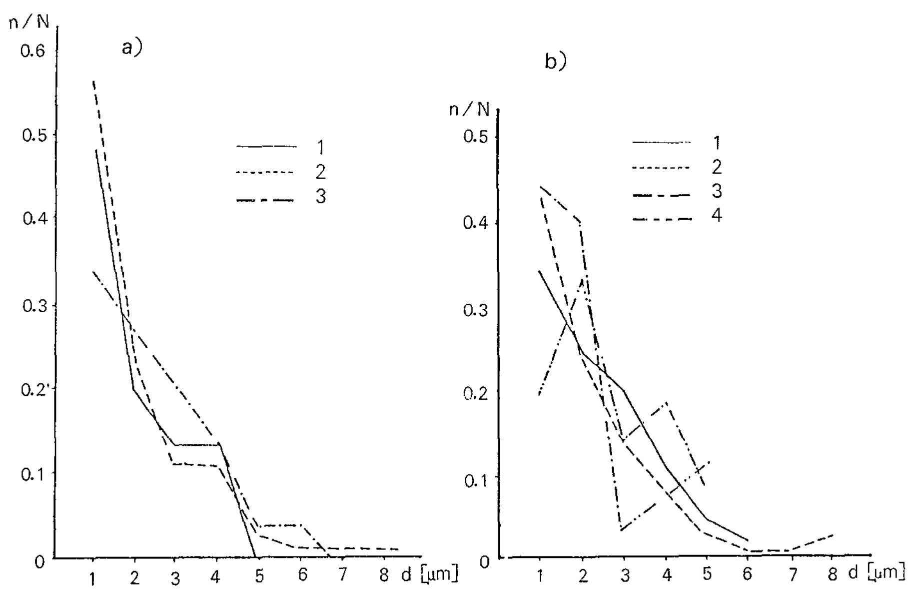

Fig. 11. Mineral suspension dispersion distribution present in water samples taken from point A of the Ezcurra Inlet on: a) December 15, 1989 from depths 1~1 m, 2~5 m, 3~50 m, 4~100 m; b) January 6, 1990 from depths 1~1 m, 2~5 m, 3~50 m, 4~100 m.

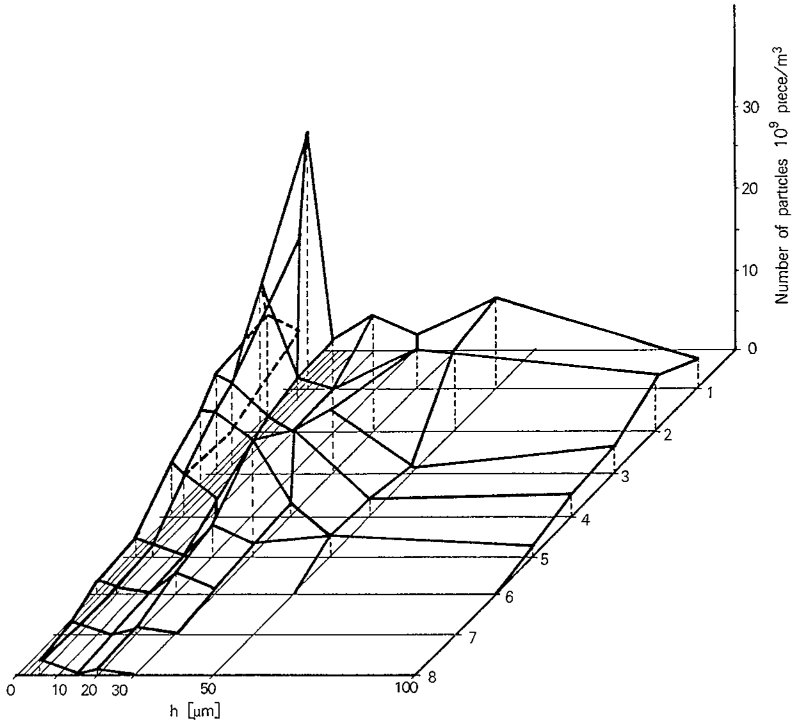

Fig. 12. Mineral suspension dispersion distribution along the vertical profile in point A of the Ezcurra Inlet on January 6, 1990.

for 1 and 5m depths are like each other. The biggest divirsification shows the suspensions dispersion distribution in water sampled from the depth of 100 m. Suspension of diameter larger than 5 μm were not identified in samples from 50 m and 100 m depth.

Suspension dispersion distribution depends contemporaneously on size of suspension and depth of sampling water which is showed in Fig. 12. Water samples were taken at point A from all earlier listed depths on January 6, 1990. As the figure shows it may be identified that the biggest changes of both the quantity of suspensions and their sizes can be observed at the depths 1~5 m. Suspensions of the diameter bigger than 6 μm do not occur deeper than 30 m. Dispersion distributions at low depths are "long". They contain suspensions of diameters from 1 μm to several micrometers. The same deals with the samples of water taken closed to the suspension sources. But in samples of water taken from deeper than 50 m depths suspension dispersion distributions are "short".

Discussion on Results

During a year period considerable changes of suspension quantity and size occur. The highest quantity of suspensions was present at the end of the summer and beginning of autumn, whereas the lowest during the winter and spring. The quantity of suspensions depends also on the depth of sampling. Maximal quantity of suspension concentration was present in the surface layer to the depth of 20 m. The quantity of suspensions depends also on the distance from their sources i.e. glaciers and outflows. In the matter of dispersion distribution it may be stated that the depth and time of water sampling influence this distribution. Suspension dispersion distribution will be "long" in surface water layer during the summer and beginning of autumn. The distance from suspension sources and hydrodynamic conditions also influence on their "length". Dispersion distributions become shorter in accordance to the increase of depth and distance from the source and the lapse of time from the summer.

Basing on the above presented data it is possible to carry out a mathematical description of dispersion distribution, suspension sedimentation phenomenon in the Inlet waters as well as suspension transport for meteorological and hydrodynamic conditions.

Conclusions

The particle size distribution of mineral suspensions in waters of Ezcurra Inlet was investigated in a year cycle. The experiment was carried out for superficial layers to 100 m depth.

It was confirmed that the higher concentration of suspension at the superficial layer (to 2 m depth) occurred in March. During antarctic winter concentration of suspension decreased. The lowest one was in November. Concentration of mineral suspensions ranged from 3×10^9 pieces/m^3 to 1.4×10^9 pieces/m^3. The highest changes of concentration was observed at the measuring sta tion near the shore and at the glaciers. The lowest one was noticed in the middle of fiord.

The concentration decreased with increase of depth from 20~30 meters. Concentration was lower than 10^9 pieces/m^3 in the layer above mentioned depth.

The highest change of particle size was observed at the superficial layer. Diameters of particles ranged mostly from 1 to 16 μm at the higher depth than 30 m.

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