RESEARCH ON THE STRUCTURE IMPROVING THE BOTTOM SEDIMENT BY CONTROLLING CURRENT FIELD

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In Kagawa Prefecture the fishery production has been declining for recent years, and deterioration of the water quality in bottom layer, especially the occurrence of the oxygen depleted water could be one of the reason for decline of the production due to its harmful impact both on the standing stock of the benthos and on the floating fry's settlement onto the sea bed. In this connection, we are going to examine whether it is possible that improvement of water quality such as elimination of the hypoxic bottom water by promoting the vertical mixing of sea water when we settle the structure which functions as a current regulator generating the upwelling water at the sea bottom.

We calculated the flow in a flow field representing the water tank with two open boundaries on both ends by giving a certain current velocity from one end. Results of current controlling in three cases were compared such as the experiment structure, square-shaped block and no object. A multi-level model (Suenaga et al., 1996, 1999, Fujihara et al., 1997, Nakata et al., 1999) presently employed is represented by the momentum equation on the rotating earth accepting f-plane and hydrostatic approximations, the continuity equation, equation of free surface, the diffusion equations of water temperature and salinity and state equation.

In order to perceive the state of controlled current, the particles were traced in the computed flow field using the Euler-Lagrangian Method. The velocity and shear at the particle position are calculated by interpolation using surrounding values. Particles were set at the bottom in front of the structure.

The computed domain was 1,860m×1,860m×80m square shaped channel. The whole body of water is described into 60m×60m staggered grid meshes horizontally and eight levels vertically (each level was 10m thick) for the computation. Certain velocity of flow was given from one boundary. The flow fields were first reproduced using a multi-level density flow model with observed velocities as boundary conditions.

We adopted a method of inpouring dye compound for flow visualization. The one 25th scale model of the experiment structure and a square-shaped block that has the same height were used and the results were compared with each other and with the case without any object in the constant flow rate water tank.

We researched the bottom sediment around the settled structure. Sediment sample was collected by the SCUBA diver and analysis on COD, sulfide and oxidation-reduction potential. In Yashima bay, located in the middle of Kagawa Prefecture, aquaculture is flourishing, though, eutrophication has progressed there and red tide is occurring frequently in summer season. We selected this area where is next to the aquaculture ground and we can gain a certain velocity by tidal current, and settled the experiment

structure.

We adopted an object made of 9 rectangular solids arranged in v-shape representing the experiment structure. The size of the rectangular solid settled on the bottom was 60×60×20m. According to the result of the numerical calculation, any strong upward flow and vertical mixing of water to rearward the single rectangular solid was not observed and of course the control case with no object showed the same result. Otherwise, the v-shape arranged object made complicated current around the structure such as the fast upwelling and the consecutive slow downward and upwelling current after passing over the object. This result suggests that the particles left behind the object will be dragged upward by the controlled current. This result of the calculation shows the good agreement with the hydraulic experiment, and it was examined that the validity of the calculation technique.

In terms of the flow pattern behind the v-shape arranged object, particles that passed over the center part of the v-shape wall flow fast in the upper layer, otherwise those particles passed over the outside of the v-shape wall flow downward once and go upward again. It was considered that this particular flow pattern is the reason for the longer area of the effect of vertical mixing than commonly used wall structure. The area of the effect reaches 20 times longer rearward than the structure height in length (Suenaga et al., 2004).

We examined that the rectangular solid made any specific upwelling current and it suggests that this shape has no function controlling the current. On the other hand, in the experiment structure, the strong upward flow exists to the front of the panel specially designed for controlling current. And behind the structure, there exists difference of the velocity between bottom and upper layer. The velocity of the upper layer was faster than the bottom layer. Besides the upward flow has been generated from the bottom layer as it was drawn (dragged) into the fast current in the upper layer.

In terms of the result of the research on the bottom sediment around the settled structure, right after the settlement, two COD values near the structure were higher than the control site (60m apart), though, they declined lower than the control site in 29th of November 2004. However in 20th of December 2004 values of all three sites were at the same level.

Sulfide was at the same level at first, though, values near the structure were declined lower than the control site as time advances (Figure 1).

In terms of oxidation-reduction potential (ORP), there was not significant disparity right after the settlement, though, two values near the structure declined lower than the control site. However in December they increased higher than the control site.

We have demonstrated that this structure has the characteristic function that it generates the upwelling current and promotes vertical mixing of water by numerical calculation and the hydraulic experiment. Results of these experiment verified the probability of the acceleration of vertical mixing by the current control function of the structure.

Concerning to the actual influence to the quality of bottom sediment by the structure settled in the coastal sea area, effect of the structure was observed temporarily. Continuous research and accumulation of data must be made from now on.

Having enough understanding of the specific effect of the single structure seems to be necessary when we estimate the structure's effect for improvement of the environment at the bottom layer in wider sea area in the future.

We will continue the research on this structure aiming for further contribution such as improvement of the bottom layer environment in coastal sea area and enhancement of marine resources such as fish, shellfish and so on.

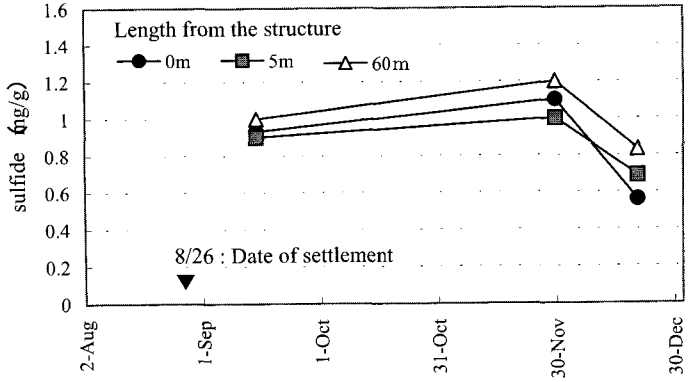

Fig. 1 Fluctuation of sulfide in bottom sediment