CHAPTER 247

FORMATION OF HABITATS FOR BIVALVES BY PORT AND HARBOR STRUCTURES

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ABSTRACT

Impacts of the construction of large-scale port and harbor at open sandy beach on inhabitation of the Japanese surf clam (*Spisula sachalinensis*) have been studied. It has been found that the populations of the Japanese surf clam has been increasing with the extension of the breakwater since the start of the construction of Ishikari Bay New Port in 1972. A series of numerical simulation was carried out to estimate the changes over time in the currents distribution around Ishikari Bay New Port associated with the construction of the breakwater for each construction phase. The change in dominant areas of the Japanese surf clam in the harbor over the years is explained by patterns of nearshore currents around the port. The construction of Ishikari Bay New Port resulted in the formation of a new fishing ground of the Japanese surf clam and an increase in the populations of the clams.

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INTRODUCTION

In recent years, demand has been increasing for port and harbor construction to co-exist with nature and preserve the environment. It is becoming more important to examine the effect of the construction of port and harbor facilities on the accumulation and propagation of fish, shellfish and reef resources.

Figure 1 shows the relationship between the length of the breakwater extended and catches of Japanese surf clams (*Spisula sachalinensis*) around the Tomakomai Port located on southwest Hokkaido's Pacific coast. The Japanese surf clam catch in Tomakomai city began increasing gradually in 1985 and has increased sharply since 1987. The catch of this clam in Tomakomai in 1990 was 15% of the total catch in Hokkaido. This increase in the amount of the yearly total in Tomakomai is considered to be an effect of the Tomakomai east and west port facilities. Especially, the construction of the East Port District is assumed to have been playing a particularly important role.

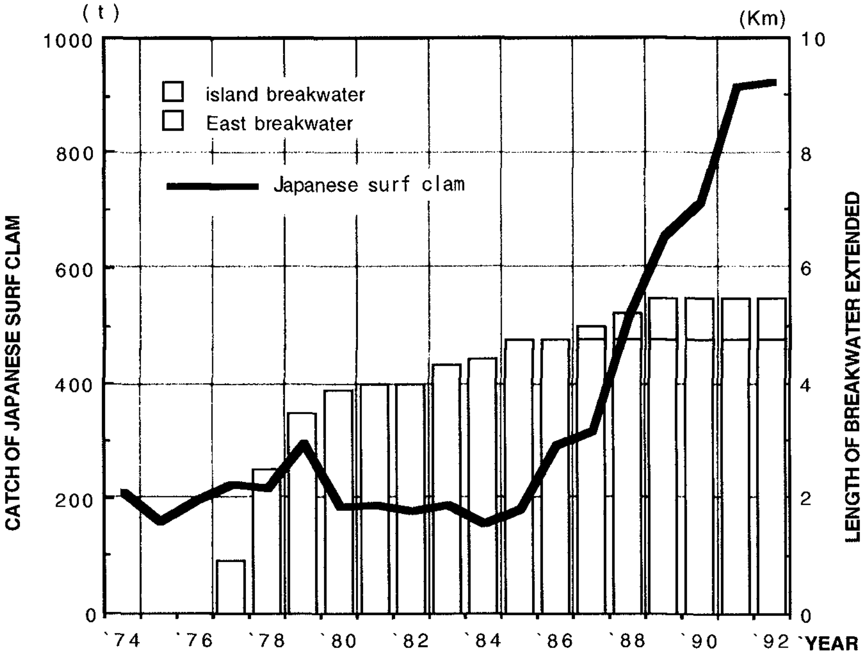

Figure 1: Catches of Japanese surf clams and the breakwater extension at Tomakomai Port (East Port District)

These effects of the port and harbor structures on inhabitation of fishery resources has received much attention from fishermen. The Hokkaido Development Bureau has been conducting studies on the functions of fishery harmony provided by port facilities such as breakwaters. Based on the results of these studies, the present paper describes resource-culturing effects on the Japanese surf clam by the port and harbor construction of Ishikari Bay New Port, whose construction began in 1972.

THE ECOLOGY AND FISHERY OF JAPANESE SURF CLAM

Sasaki (1992) reported the ecological characteristics of Japanese surf clam. The Japanese surf clam (Figure 2) is a large bivalve inhabiting in sandy, shallow zones along the wide coastal range of Tohoku and Hokkaido. It has been an important fisheries resource. In general, Japanese surf clams spawn in June and July in Ishikari. When the larvae have grown to about 0.2 to 0.3 mm in shell length, they shift to a benthic life after having drifted in the water for about one month. There is a considerable decrease after the clams shift to a benthic life, particularly marked soon after this shift. Less than 1% of those who start a benthic life reach the age of two years. The major factors for the decrease of juvenile and mature clams are being washed ashore by action of large waves (Figure 3) and natural mortality.

For the clams to mature and grow to a size that contributes to the reproduction of the resource, it takes about 4 years in southern Hokkaido and 5 years in Ishikari Bay and eastern Hokkaido. Most of the individuals with a shell length of more than 7.5 cm are mature. Hokkaido bans catching clams smaller than 7.5 cm.

CONSTRUCTION IN ISHIKARI BAY NEW PORT AND CHANGES IN CATCHES OF THE SURF CLAMS

Ishikari Bay New Port is located about in the center of the sandy shore and 7 km southwest of the mouth of Ishikari River in Hokkaido (Fig.4). The bottom slope is very gradual, and the average gradient from the shoreline to the depth of 50 m is about 1/500. The progress of the construction of the port between 1972 and 1992 is shown in the Figure. The entire current of Ishikari Bay moves north in summer and weakens in winter. At present, most of the north, island and east breakwaters, the eastern and central areas and the central channel are complete. The construction of the western area is under way.

Figure 2: Japanese surf clam (mature size)

Figure 3: Bivalves washed ashore

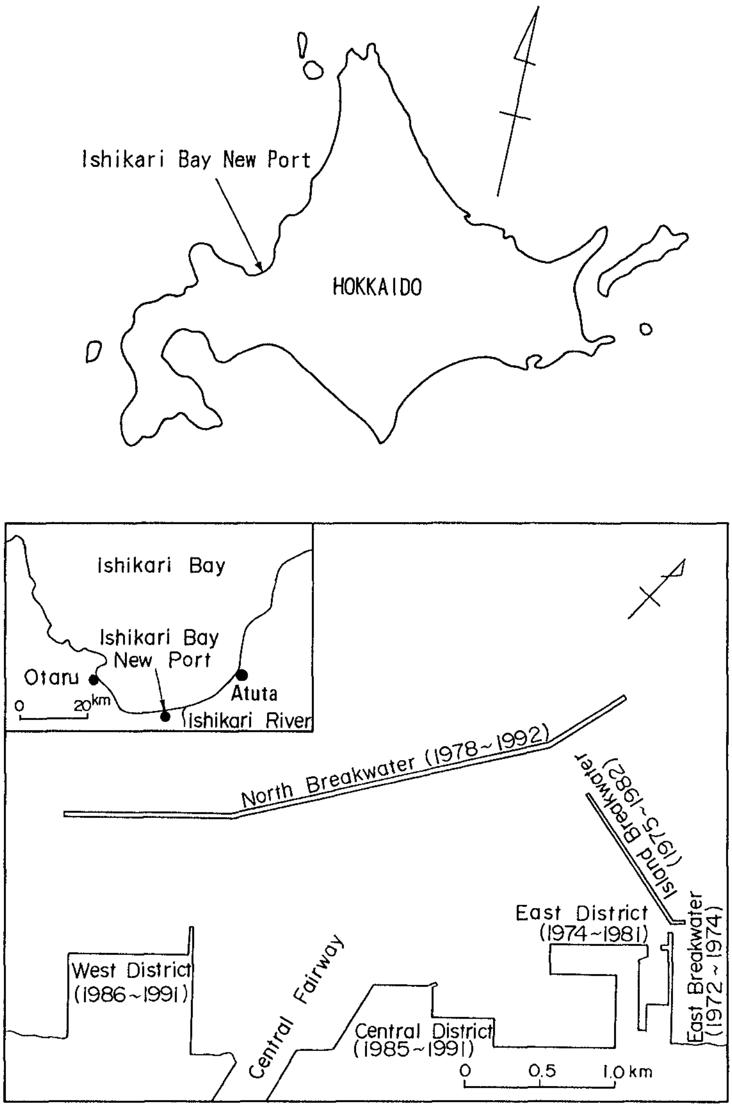

Figure 4: Location map and progress of the construction of Ishikari Bay New Port

To understand the influence of the extension of the breakwater in Ishikari Bay New Port on catches of Japanese surf clams, the relationship between the length of the breakwater extended and catches of Japanese surf clams in the town of Ishikari is shown in Fig. 5. As the figure shows, a sharp increase in the catch of the clams coincided with construction of the breakwaters. Considering the fact that 4- to 5-year-old clams are caught, the remarkable increase in that period seems to be related to the east breakwater built in 1972 to 1974. The catch has not been increasing since 1980 because they restricted the catch in order to preserve the resources. Furthermore, a drastic catch decrease in 1982 and 1983 can be attributed to extreme storm waves that occurred in December 1981, with the maximum wave height at 9.8 meters with a wave period of 10.1 seconds. A strict regulation on clam fishing was enforced after 1983 led to an increase in the catches in 1987. This increase trend continues today.

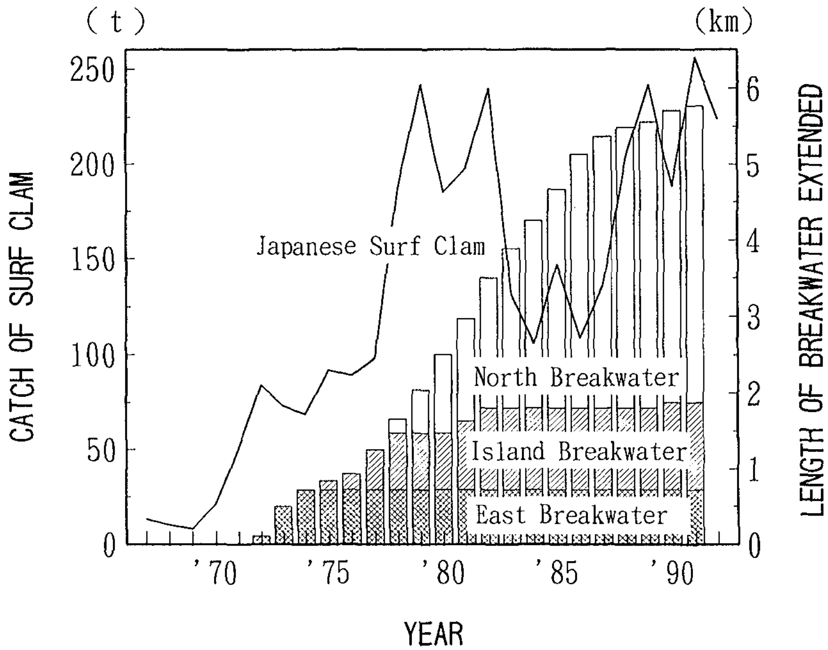

Figure 5: Catches of Japanese surf clams and breakwater extension at Ishikari Bay New Port(data of catches from Hokkaido Government)

COMPARISON OF THE POPULATIONS OF THE CLAM IN AREAS SURROUNDING ISHIKARI BAY NEW PORT

Figure 6 shows the changes over time in the density of mature Japanese surf clams (the number of mature clams per 100 m^2) in the Ishikari, Otaru and Atsuta areas, which was estimated from surveys on populations. As evident from the figure, the Otaru area had the highest density of mature clams for the decade after 1975, while the clam density in the Ishikari area was about half that of in Otaru. The major factor in this difference was probably that the median grain size of the sediment in Otaru was about 0.2 mm, which is suitable for the Japanese surf clam, while the diameter increased northward from Ishikari to Atsuta and these areas were not suitable habitats for the Japanese surf clam.

After 1985, changes in oceanographic conditions resulting from the construction of Ishikari Bay New Port, the accumulation of drifting larvae, the promotion of the settlement of immature clams and the fishing regulation were thought to have had a combined effect toward increasing the density of mature clams in the Ishikari Bay western area, including the Otaru area. The density of mature clams in the Ishikari area increased to almost the same level as in the Otaru area. On the other hand, the construction of Ishikari Bay New Port did not so contribute to the Atsuta area, an area influenced by the Ishikari River, and there was little change over time in the density.

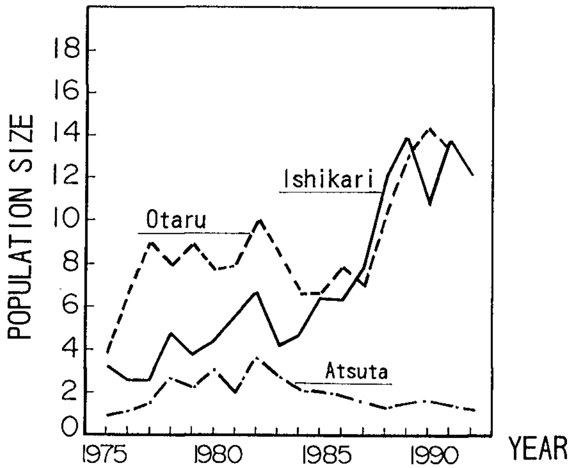

Figure 6: Change of regional population size of Japanese surf clam (data from Hokkaido Government)

CHANGES IN HABITATS OF THE JAPANESE SURF CLAMS

In order to clarify the effect of breakwaters on the formation of habitats for the surf clams, we calculated the nearshore current around Ishikari Bay New Port for 1979, 1984, 1989, and 1992, and examined the relationship between the pattern of nearshore current and the distribution of mature Japanese surf clams associated with the construction of port and harbor facilities. The nearshore current model using an energy balance equation was used to calculate the currents. The direction of waves, wave height and wave period used in the calculation are NW, 1.6 m and 6.0 seconds, respectively. Figure 7 diagrams changes in the dominant areas of Japanese surf clams around Ishikari Bay New Port, based on the existing references obtainable from fishermen's associations and on inquiries to fishermen. The nearshore currents calculated at different stages of the construction of the breakwaters are also indicated in the figure.

When one compares the phase of construction of the port and harbor facilities with changes in the distribution of Japanese surf clams, it seems that as construction in the eastern area (the east and island breakwaters) was completed and construction started on the north breakwater and moved to the central area, the central channel and to the western area, the distribution of the mature clams tended to shift from the eastern sea area to the west. It is clear from Figure 7 that the stagnant and eddy-current areas were created by the construction of port and harbor facilities, and mature Japanese surf clams were distributed in the areas.

In addition, in the beginning, the mature clams were distributed in the harbor where the water became calm due to the breakwater construction. However, as the water became even calmer, the diameter of sediment grains became finer, and became muddy, thus becoming unsuitable as a habitat for the Japanese surf clam. It was no longer a major distribution area of the mature Japanese surf clam after 1985 when Ishikari Bay New Port went into operation. Based on these facts, it is presumed that the distribution of mature Japanese surf clams changes along with the changes in stagnant and eddy-current areas caused by the construction of breakwaters; the distribution is concentrated in areas which are relatively calm in the beginning, and shifts along with the changes in the sediment and feeding environment.

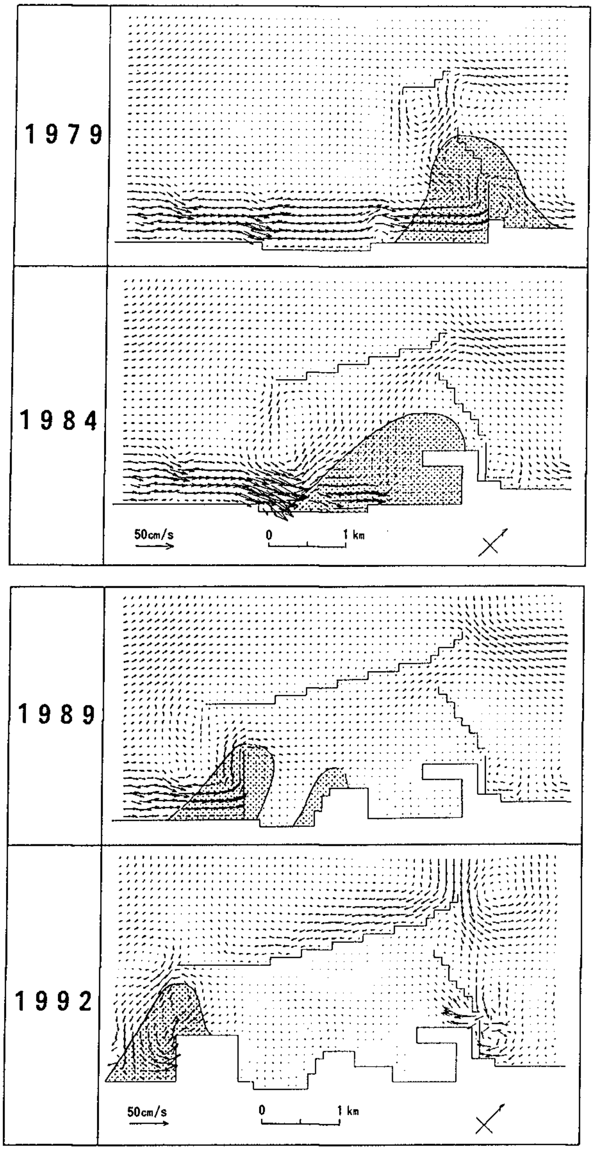

Figure 7: Change in calculated velocity field of nearshore current and dominant areas of highly dense distributions of mature Japanese surf clams

DOMINANT AREAS OF HIGHLY DENSE DISTRIBUTIONS OF JUVENILE SHELL

Figure 8 shows the distribution of juvenile Japanese surf clams in and around Ishikari Bay New Port in 1992 (Ohsaki et al., 1993). As indicated before, the eddy-current areas correspond to those of the areas of highly dense distribution of the juvenile shells. This was probably because the eddy-current areas formed by the near shore currents accumulated the planktonic larvae of the Japanese surf clams, or because they prevented the dispersal of the larvae to elsewhere. This, in turn, resulted in an increase in the number of juvenile shells settling on the sea bottom. Figure 9 shows change in the distribution of juvenile shells. The drastic decrease in March 1985 can be attributed to extreme storm waves that occurred in January 1985, with significant wave height at 4.9 meters with wave period at 9.9 seconds. In spite of these dispersion, the dominant areas of clams were unchanged.

Hydraulic experiments have confirmed that Japanese surf clams with shell lengths of 10-50 mm began to drift or to move as a result of overturning at a current velocity of 29-50 cm/s, and that about 10% died after having been vibrated in the sand for 24 hours (Watanabe,1982,1983). These are the reasons Japanese surf clams, which inhabit the wave breaking zone where the velocity of the nearshore current becomes greater, tend to be reduced due to being washed ashore. On the other hand, the eddy-current area formed around the breakwater can act as a relatively calm area in relation to waves coming from a certain direction. Therefore the eddy-current area is assumed to contribute to the survival of the Japanese surf clam when storm wave attack the coast.

SUMMARY

In this report, it is investigated the impact of the construction of the large-scale port and harbor at the open sandy beach on the Japanese surf clam. The principal results are as follows:

(1) Planktonic larvae of Japanese surf clams accumulated in the stagnant and eddy-current areas created by the breakwaters; this promoted the settlement of juvenile shells.

(2) Mature Japanese surf clams were found distributed around the stagnant and eddy-current areas, which were areas of relative calmness, and which were formed in association with the extension of the breakwaters.

(3) The construction of Ishikari Bay New Port resulted

in the formation of a new fishing ground of the Japanese surf clam and an increase in the populations of the clams.

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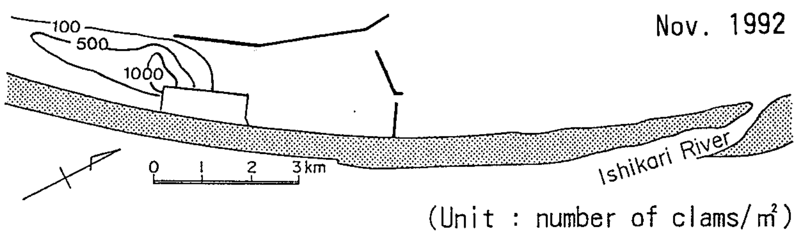

Figure 8: Distribution of juvenile Japanese surf clams in and around Ishikari Bay New Port (modified from Ohsaki, H.,et al.,1993)

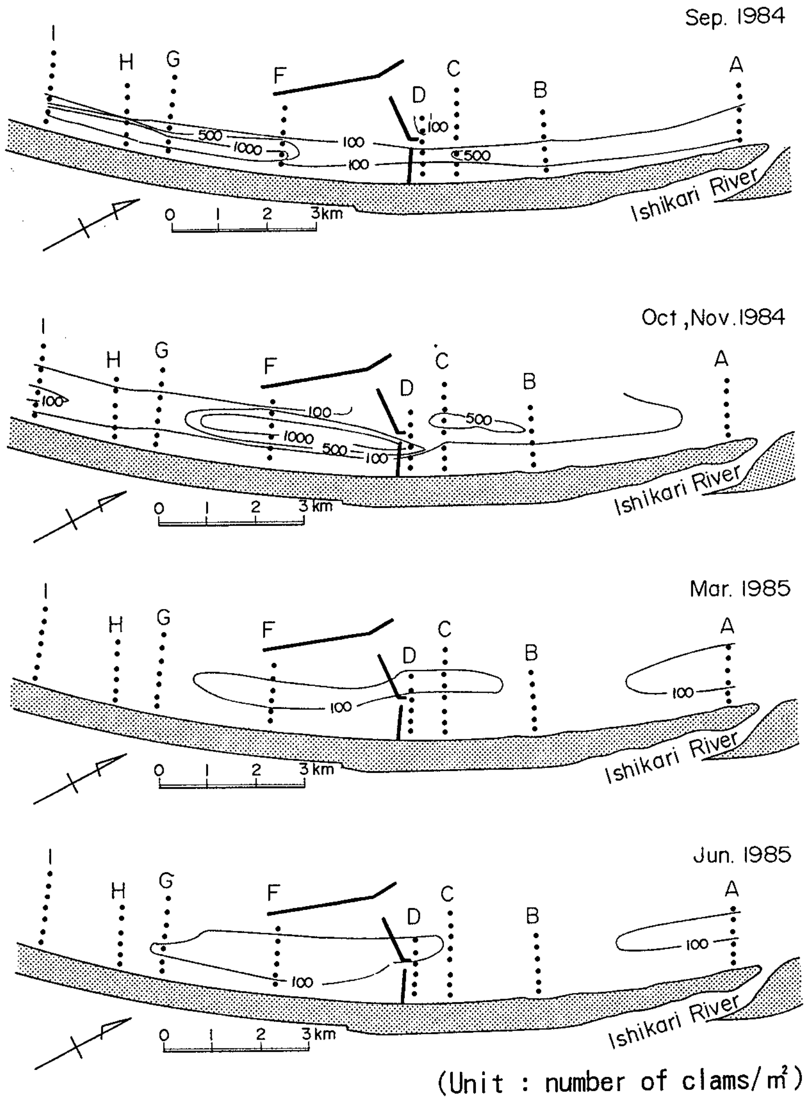

Figure 9: Change in density of juvenile Japanese surf clams in and around Ishikari Bay New Port (modified from Hokkaido Development Bureau, 1988)