High Food Productivity in Tidal Flat

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High Food Productivity in Tidal Flat

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Abstract

Fisheries productivity in Ariake Bay, where tidal flat is most developed in Japan, of 80.5 ton/km^2/year in 1979 is 20 times as that in the North Sea and 25 times as that in Chesapeake Bay. Such high fisheries productivity in Ariake Bay is due to high productivity of benthic algae on tidal flat and short food chain from primary producer to commercially important fish (clam in the case of Ariake Bay). The protein productivity in tidal flat of Ariake Bay is nearly the same as the starch productivity in rise field on land. It is very important to preserve the environment of tidal flat as the food source for the people in the 21st century.

Key words : *tidal flat, primary production, food production*

1. Introduction

Ariake Bay is a semi-enclosed coastal sea with an area of 1,690 km^2 and an average depth of 20 m, and is located in the western part of Japan. Ariake Bay is very famous for the largest spring tidal range of about 6.5 m in Japan and developed tidal flat. The fishing activity has been very prosperous in Ariake Bay. Figure 1 shows the comparison of fish catches per unit area in the representative semi-enclosed coastal seas over the world. The fish catch in Ariake Bay was largest as 80.5 ton/km^2/year in 1979 and has decreased to 16.0 ton/km^2/year in 1999. The decrease of fish catch in Ariake Bay is mainly due to the decrease of clam catch though its reason is not clear. Similarly the fish catch in the Seto Inland Sea, Japan was largest as 20.6 to/km^2/year in 1981 and has decreased to 13.1 ton/km^2/year in 1999[1)]. The decrease of fish catch in the Seto Inland Sea is mainly due to the decrease of catch of Japanese sardine which has a variability with the period of about 50-60 years[2)]. The fish catch of 0.8 ton/km^2/year in the Mediterranean Sea in 1987[3)] is smallest in Fig.1. The fish catch of 1.4 ton/km^2/year in the Black Sea in 1981-1986[4)] and that of 2.2 ton/km^2/year in the Baltic Sea in 1973-1982[5)] are also small. The fish catch of 5.7 ton/km^2/year in the North Sea in 1990[6)] and that of 6.5 ton/km^2/year in Chesapeake Bay in 1990[7)] are rather large but smaller than those of the Seto Inland Sea and Ariake Bay.

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2. Transport of Nutirents

It is very difficult to compare quantitatively the fisheries productivity in these coastal seas from the fish catches data shown in Fig.1 because the fishing endeavor and efficiency are different in these coastal seas. However, the main reason of such difference of fish catches in these coastal seas over the world shown in Fig.1 is already discussed qualitatively from the physical viewpoint[8),9)] and it is schematically shown in Fig.2. Primary production is very low in the Mediterranean Sea with low nutrients concentration in the euphotic layer because the loaded nutrients from the land sink to the aphotic layer and flow out through the Gibraltar Strait due to large evaporation in the Mediterranean Sea. In the Black Sea and the Baltic Sea, fish cannot live in the deep layer, where the oxygen deficiency develops, because the shallow sill at the mouth prevents the water exchange of deep water. Therefore fish catches in the Black Sea and the Baltic Sea are not so large. In the North Sea, nutrients mainly supplied from the Atlantic Ocean are advected by the barotropic counter-clockwise mean current and flow out to the Norwegian Sea. Then the moderate primary production and fish catch are obtained in the North Sea.

On the other hand, loaded nutrients from land stay for long time in Chesapeake Bay with dominant estuarine circulation because the sinking organic matters go back to the bay head, are decomposed by bacteria and upwell to the euphotic layer. Such mechanism is called a trapping effect of nutrients in the estuary[10]. In cases of the Seto Inland Sea and Ariake Bay, Japan nutrients stay for longer time in the bay because in addition to a trapping effect of nutrients the strait in the bay re-distributes the nutrients and organic matters horizontally and vertically due to the strong tidal current there.

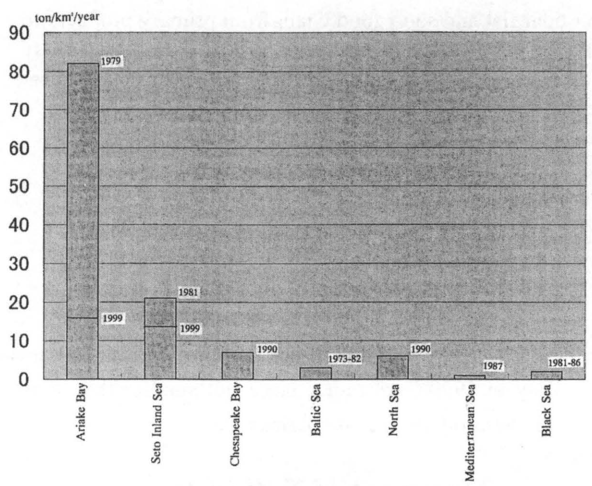

Fig.1 Fish catches in representative semi-enclosed coastal seas in Japan and over the world.

3. Tidal flat

The difference of fish catches in the Seto Inland Sea and Ariake Bay is explained by Table 1. The Seto Inland Sea has wide sea area of 23,200 km^2, where demersal fish is mainly caught, and narrow tidal flat of 117 km^2 but Ariake Bay has narrow sea area of 1,690 km^2 and very wide tidal falt of 232 km^2, where clam is mainly caught (Table 1). The primary productivity by phytoplankton in the sea area is 285 gC/m^2/year[11] and that by benthic algae in the tidal flat is 447 gC/m^2/year[12] in the Seto Inland Sea. We may assume that both numbers are applicable to Ariake Bay, where we have no quantitative data of primary production, because both semi-enclosed coastal seas in Japan are located at nearly the same latitude and are similarly eutrophicated. The possible fish catch in the sea area is estimated by the primary production of phytoplankton times 0.04 times area, when we assume that the transfer efficiency is 20% from the primary production to the secondary production[13] and that is also 20% from the

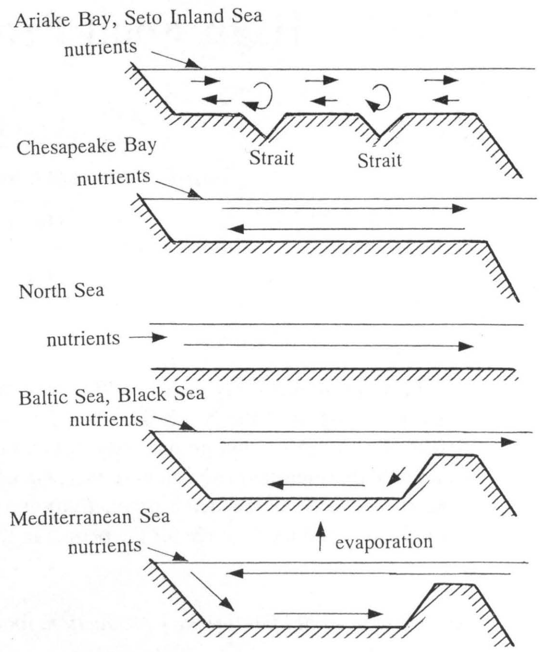

Fig.2 Schematic representation of nutrient behavior in semi-enclosed coastal seas over the world.

secondary production to the production of commercially important fish[13]. It is 265,000 tonC/year in the Seto Inland Sea and 19,300 tonC/year in Ariake Bay. The possible fish catch in tidal flat is estimated by the primary production of benthic algae times 0.2 times area, when we assume that the transfer efficiency from the primary production to the production of commercially important fish is 20%[13] because clam directly preys on benthic algae in tidal flat. It is 15,700 tonC/year in the

Table 1 Area, primary production, food chain, possible fish catch and total possible fish catch in Ariake Bay and the Seto Inland Sea.

		area (km^2)	primary production (gC/m^2/year)	food chain	possible fish catch (tonC/year) {ton/year}	total possible fish catch (ton/year) {ton/km^2/year}
Ariake Bay	sea	1,690	285	2 (x 0.04)	19,300 (193,000)	1,750,000 (1,030)
	tidal flat	232	447	1 (x 0.2)	31,100 (1,555,000)	
Seto Inland Sea	sea	23,200	285	2 (x 0.04)	265,000 (2,650,000)	3,440,000 (148)
	tidal flat	117	447	1 (x 0.2)	5,700 (785,000)	

Seto Inland Sea and 31,100 tonC/year in Ariake Bay. Possible fish catches in sea area of the Seto Inland Sea and Ariake Bay are 2,650,000 ton/year and 193,000 ton/year, respectively, when we assume that the carbon content of commercially important fish in sea area is

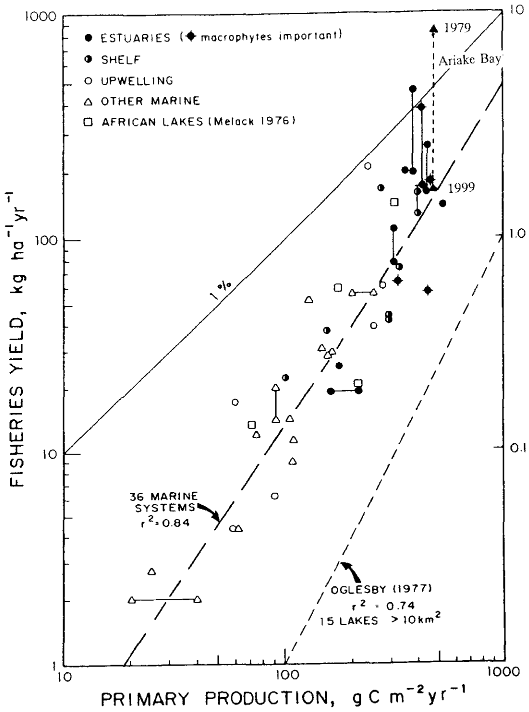

Fig.3 Relation between the primary production and the fish catch in coastal seas. (modifyed from Nixon, 1988)

10%[14]. Possible fish catch in tidal flat of the Seto Inland Sea and Ariake Bay are 785,000 ton/year and 1,555,000 ton/year, respectively, when we assume that the carbon content of clam in tidal flat is 2%[14]. Total possible fish catches in the whole area are 3,440,000 ton/year in the Seto Inland Sea and 1,750,000 ton/year in Ariake Bay and those per unit area are 148 ton/km^2/year in the Seto Inland Sea and 1,030 ton/km^2/year in Ariake Bay (Table 1). The ratio of last numbers, 7.0, is nearly the same as the ratio of 3.9 in Fig.1, that of largest fish catches in the Seto Inland Sea and in Ariake Bay.

4. Primary production and fish catch

The relation between the primary production and fish catch in the coastal seas is already examined as shown in Fig.3[15]. We superpose the result in Ariake Bay on Fig.3. The result of Ariake Bay in 1979 is very high compared to other coastal seas. This suggests that the fisheries productivity in tidal flat is very high compared to that in sea area. However, the number of fish catch per unit area in Ariake Bay is "diluted" because the total fish catch is divided by the total area including sea area. The clam catch in 1979 in Ariake Bay was 110,000 ton/year and this number corresponds to 474 ton/km^2/year= 4740 kg/ha/year. Such value is out of Fig.3 and suggests that the fisheries productivity in tidal flat is very high.

5. Rice field and tidal flat

Tidal flat has been converted to rice field in Japan in order to increase the food production because it is very shallow and suitable for the reclamation. The rice (starch) productivity in Japanese puddy field is about 5000 kg/ha/year[16]. This number is nearly the same as the clam (protein) productivity in tidal flat of 4740 kg/ha/year. Such fact suggests that it is waste of money and labor to convert the tidal flat to rice field.

6. Conclusion

Tidal flat has been said to be important because it decomposes inflowed organic matter, that is, tidal flat is very efficient sewage treatment facilities[17]. Of course it is one of important functions of tidal flat. Moreover we have to emphasis that tidal flat is a very good ground of food production which will become more important in the middle 21st century because the food will be lack due to the rapid increase of human population in the world. Therefore it is very important to preserve the environment of tidal flat.

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