SUSTAINABLE DEVELOPMENT IN THE SETO INLAND SEA, JAPAN– FROM THE VIEW POINT OF FISHERIES

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General feature of the Seto Inland Sea and the problems occurred

The Seto Inland Sea is situated in the western part of Japan and is famous for its beautiful landscape including as much as 700 islands. It length is about 500km and its width 5km to 50km. At the same time the lands surrounding the Seto Inland Sea have developed to be one of the most industrialized area in Japan, with the population of about 38million in 13 Prefectures concerned, accounting about 28% of Japan's total population of 120million. The population density is about 500 people per square kilometer.

The surface water area is about 22,000km ^{2} with mean water depth of 37m. The sea has three mouths ; the Kanmon Strait, the Bungo Channel and the Kii Channel. The tidal current is dominant in the Seto Inland Sea. The maximum tidal current speed is about 500cm/sec at Naruto Strait in eastern part and the maximum tidal range about 400cm in the central part of the Seto Inland Sea.

Before the industrialization of the area, coastal fisheries have developed and supplied considerable amount of marine foods around the regions. Now Japan is experiencing a smaller fishery output from deep–sea and offshore fishing owing to the restriction of the Marine Law and other problems. The total catch is 7million tons in 1996, decresed to about 60% in 1996 of the fish catch in 1990. Under such circumstances, the Seto Inland Sea plays a important role in coastal fishing and aquaculture. The fish catch in the Seto Inland Ssa accounts for a quarter of the total coastal production. In 1993 the fish catch in the Seto Inland Sea was 281,000tons and the aquacultural products was 349,000tons.

Along with the activities of fishery and aquaculture, industrial production of the area extremely reached to ¥94,500billion in 1991, so there is potential for serious artificial contamination of the Seto Inland Sea. Since 1965, red tides, phenomena caused by the abnormal blooming of harmful phytoplanktons, have occurred on a lange scale almost all over the Seto Inland Sea and brought a loss of over ¥25billion in 25 years, especially in aquaculture.

Measures to the eutrophication and the outbreaks of red tides

Generally speaking, red tide occurs as a result of the eutrophication of water.

The measures to control chemical oxygen demand(COD) and to prevent nitrogen and phosphorus from flowing into the sea were terribly inadequate around 1970 and water of

the Seto Inland Sea was heavily polluted. To cope with this situation, the Law Concerning Special Measures for Conservation of the Environment of the Seto Inland Sea was enacted in 1973, and number of administrative steps were taken, such as cutting COD loading from the land in half, reduction in phosphorus and nitrogen loads and restrictions on reclamation of coastal area. In the meantime, industrial plants and local governments made effort to improve their water treatment facilities. Residents living in the coastal area also became more aware of the need for environmental conservation. Due to the efforts of both the government and the private sector, the pollution of the Seto Inland Sea has gradually been reduced, and the environment is being improved to some extent. Red tides ocuured 299 times in 1976, but this figure decresed to less than 100 in recent years. Aquaculture technology has also been progressed including the improvement of fish diet. Thus the damage to fishery is being curtailed.

The Interdisciplinary Study on tha Sustainable Prodution of Variable Fishes and Preservation of Environment in the Seto Inland Sea, Japan (1992–1995)

The aim of this interdisciplinary study is to clarify the basic natural and economic social and legal conditions for preservation of both the fisheries inudustry and a desirable natural marine environment in the Seto Inland Sea.

The head of this study team was Dr. Tomotoshi Okaichi, the present author, and carried out under the sponsorship by the Nippon Life Insurance Foundation (a total funding of 70 million yen)

The study team is composed of six core projects as follows.

1) Quantitative clarification of the rate of primary prodution in the whole area (P. I. Prof. O. Matsuda, 6 members)

2) Quantitative clarification of the temporal variations in fish cathes (P. I. Drs. Y. Aizawa (1992–93), S. Hayashi(1993–94) and Y. Masaki(1994–95), 7 members)

3) Preservation of fishery grounds and creation new ones (P. I. Prof. T. Yanagi, 4 members)

4) Methods for reducing the nutrient load from the land and an assessment of its effect (P. I. Prof. H. Nakanishi, 6 members)

5) Local economic development and policy decisions (P. I. Prof. S. Komori 5 members)

6) Regal problems related to fisheries and the marine environment (P. I. Prof. T. Tuchida, 3 menbers)

The results and proposal by the Study

1) The averaged primary production in the Seto Inland Sea is estimated to be 730mgC/m^2 /day and secondary production is cstimated to be 210mgC/m^2/day, though they vary significantly both seasonally and spatially. The transfer efficiency to secondary is 26%.

The tertiary production rate is estimated be 58mgC/㎥/day resulting in transfer efficiency from secondary to tertiary production of 28%. As far as the transfer efficiency from primary production to planktivorous fish production is concerned, we cannot detect any deleterious effect due to excessive eutrophication.

2) However, deteriorated conditions at the sea bottom in stegnant areas such as Osaka Bay, Harima Nada and Hiroshima Bay cause benthic hypoxia or anoxia during summer. The summer destruction of bottom environmental condition lead to a large reduction rate of benthic animals. Proper environmental measures to reduce nitrogen and phosphorus loads from the land should be taken to recover the bottom condition. We propose that the environmental standards for the each region should be adopted for the sustainability of the fisheries. We have to reduce the nitrogen and phosphorus loads from land to 10–80% and 30–65% of the respective loads in the eastern part of the Seto Inland Sea.

3) The current fish catch in the Seto Inland Sea is 23tons/km ^{2}. The present rate of fishing activity is assessed to be three times than the optiimum rate to keep the stocks of some commecially important fishes. Suitable fisheries management such as a gear with coarse mesh size, regulation of fishing period and areas must be adopted.

4) In 1993 the production by aquaculture exceede the fishery production as mentioned above. However, the aquaculture grounds are heavily polluted by the continuous load of uncomsumed diet and fecal pellets. Development of scientific management methodologies for aquaculture to keep the aquaculture ground clean are required.

5) The man–made structure for inducing upwelling is a very promising technology for increasing primary production in nutrient poor fisheries grounds even in the Seto Inland Sea.

6) The Seto Inland Sea has value not only as a ground for fisheries but also as an industrial area, a recreational area, and a region with historical meaning. Harmony is needed between the various kinds of human activities conducted there. In order to sustain these activities, we have to develop some kind of environmental assessment system that evaluates the total environmental values of the Seto Inland Sea including not only economic use but also recreation use, historical heritage and symbolic meaning of the scenary in Japan.

7) The examination of Japan's legal system concerning environmental preservtion and fisheries industry do indeed provide us with benificial guidance relating to the governance of coastal management. Assessment of new legal system in which water use by land–based industries and the public who want to use the Seto Inland Sea for various porpusese including water sports and others is cordinated with the fisheries, on the recognition of fisheries operators as major players in the protection of the coastal environment.