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"Sato-Umi"—A New Concept for Sustainable Fisheries

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A new concept for sustainable fisheries called "Sato-Umi", is defined as "High productivity and biodiversity in the coastal sea area with human interaction". To establish Sato-Umi, it is necessary to realize comprehensive material cycling in coastal sea area. In order to achieve high aquatic biodiversity, we have to keep nutrients concentrations moderate within coastal sea area to provide good habitats for marine biota. Proper management of aquatic resources is important to obtain high fish productivity in Sato-Umi.

KEYWORDS sustainable fisheries; material cycling; environmental conservation

1. Introduction

Some people say that "Nature takes its best state without mankind." Would it be true that no environmental problems would exist if mankind was not present on Earth? However, there would be no meaning to a discussion regarding environmental problems without the presence of mankind.

Nature does exist that takes its best state under mankind's interaction. In Japan, an example of such nature is called "Sato-Yama". In Japanese, "Sato" means the area where people live and "Yama" means the forest. Sato-Yama is thus the forest near where people live, which will be explained in the next section. The area of Sato-Yama in Japan is about 4,500,000 ha making up about 20% of total area of forest of 25,000,000 ha, which occupies 67% of the total area of Japan.

In this paper we discuss a new concept for sustainable fisheries based on the ideas of Sato-Yama.

2. Sato-Yama

Sato-Yama forests are dominated by deciduous trees such as oak and these trees are cut every 20–30 years for use in mushroom cultivation or for making charcoal. Fallen leaves are used as fertilizer in rice fields near Sato-Yama forests. Insects such as butterflies and

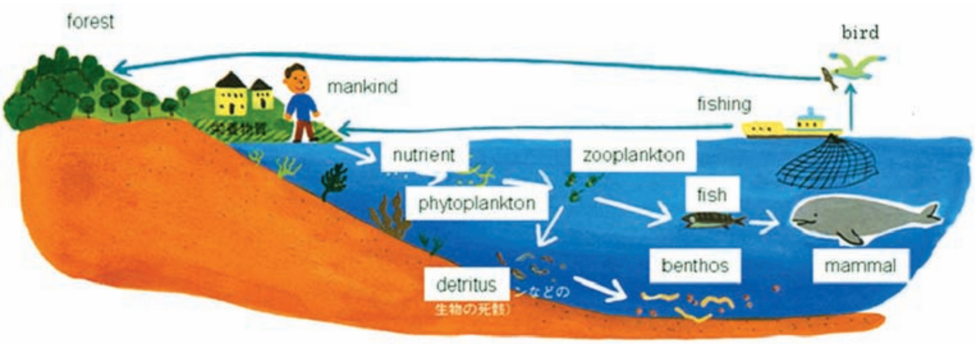

Fig. 1. Comprehensive material cycling in the coastal sea area.

beetles come to Sato-Yama for honey from flowers and trees honey, respectively, and small animals such as squirrels come for acorns. Many flowers bloom in the spring because there have been no leaves.

The Sato-Yama forests are managed through periodical cutting of plants and trees. Periodic harvest of plants and trees are actually good for the maintaining high biodiversity within Sato-Yama. A beautiful and successful relation between nature and mankind has thus been maintained in Sato-Yama. We may call such relationship a kind of symbiosis between nature and mankind, and can conclude that sustainable forest practices are realized in Sato-Yama.

Parts of Sato-Yama have decayed in recent years because many people have abandoned the life near Sato-Yama in the countryside and have moved to the city. The periodic disturbances have been lost in much of Sato-Yama and so the high productivity and biodiversity have also disappeared.

However, some city residents have recently started to go to Sato-Yama to work part-time to re-establish the nature of Sato-Yama (Takeuchi *et al*. 2003).

3. Sato-Umi

Would it be possible to create a "Sato-Umi" similar to Sato-Yama? In Japanese, "Umi" means the sea, so "Sato-Umi" we define as "High productivity and biodiversity in the coastal sea area with human interaction" (Yanagi 1998).

To establish Sato-Umi, we first need to understand quantitatively the material cycling in the coastal sea area. We need to know the quantity of nutrients that are discharged from the coast, and the primary, secondary and tertiary productions in the Sato-Umi area. Understanding the comprehensive material cycling in Sato-Umi area is a necessary first step (Fig. 1).

Successful establishment of Sato-Umi will also need to identify permissible coast, shoreline and coastal sea area manipulations to increase fish production (human's benefit from the coastal sea area) and biodiversity (many kinds of biota in the coastal sea area).

For example, a red tide (abnormal increase of phytoplankton biomass) which has a large material flow is not comprehensive material cycling because the large biomass of dead phytoplankton sinks to the bottom creating an oxygen-deficient water mass (hypoxia or anoxia). Therefore, elements such as nitrogen and phosphorus are not transferred up to zooplankton. Successful implementation of Sato-Umi will prevent the occurrence of red tides and oxygen-deficient water masses in coastal sea area.

Successful implementation of Sato-Umi in eutrophic coastal sea area must reduce

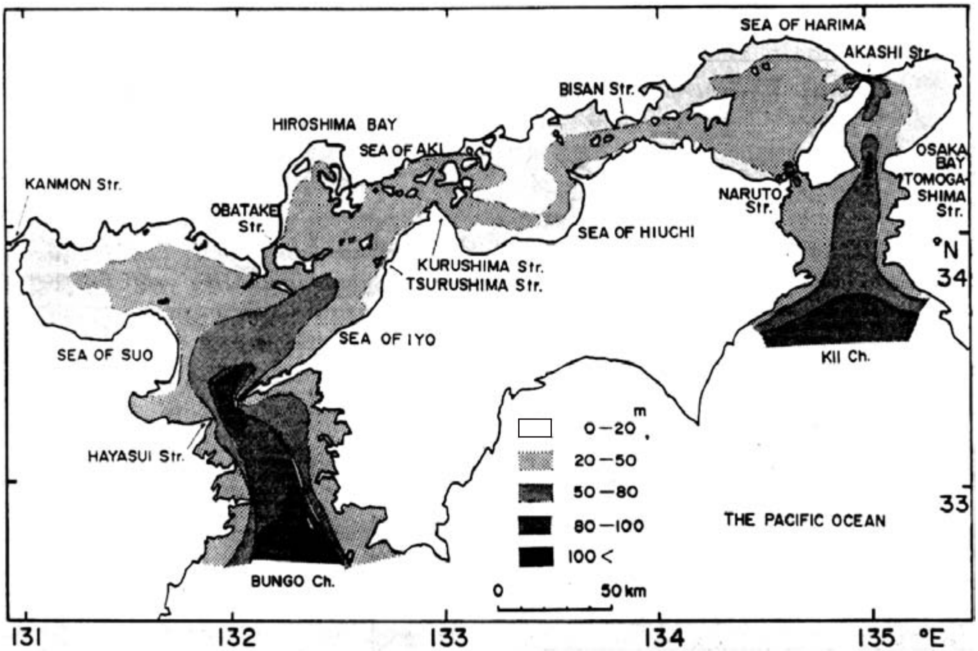

Fig. 2. Seto Inland Sea, Japan

nutrient loads from the land to prevent red tides. For example, in the Seto Inland Sea, Japan (Fig. 2), not only COD (Chemical Oxygen Demand) load but also TN (Total Nitrogen) and TP (Total Phosphorus) loads have been reduced since 1972, as shown in Fig. 3(a). The number of red tides has been reduced since 1978, six years after the reducing of COD load, as shown in Fig. 3(b).

In oligotrophic coastal sea area, we need to increase nutrient concentrations in the euphotic layer, through creation of a man-made upwelling structure. A field experiment using a man-made upwelling structure, made of concrete, was conducted in the Bungo Channel (water depth of 50 m), the western part of the Seto Inland Sea, Japan in 1987. A strong tidal current comes across a short wall of type-S structure and generates two eddies with a horizontal axis (Fig. 4(a)). Eddies, created from these structures, flow down, come across a long wall of type-L structure, change their axes from horizontal to vertical and upwell into an euphotic layer with a thickness of about 30 m. Two walls of type-S and two walls of type-L structures were arranged as shown in Fig. 4(a). We expect generation of two upwelling eddies during flood and ebb tidal currents from the placement of these two types of structures. After these structures were installed, the chlorophyll-*a* concentration has increased 1.5 times compared to that before the setting of the structures (Fig. 4(b)). The local fishermen say that the fish catch has also increased there after 1989 (Yanagi and Nakajima 1991).

Material cycling in coastal sea area is governed by physical processes such as current and diffusion and also by chemical-biological processes such as primary production and predation (Fig. 5; Hayashi and Yanagi 2002). We know that within coastal sea area biochemical processes have a greater effect than physical processes, because the

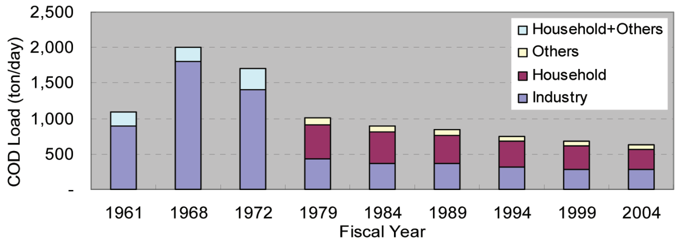

Fig. 3(a). Year-to-year variation in the COD load to the Seto Inland Sea, Japan.

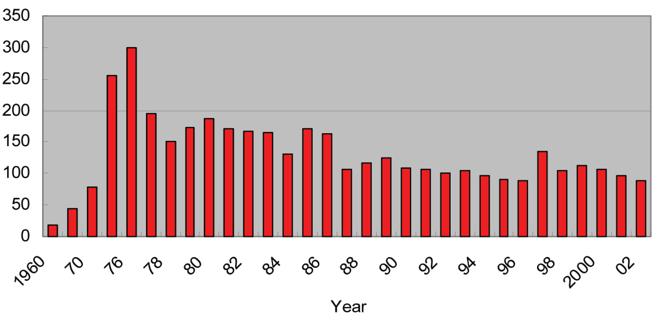

Fig. 3(b). Year-to-year variation in the occurrences of red tides in the Seto Inland Sea, Japan.

biochemical flux from nutrient to phytoplankton is larger than the physical flux from rivers (Fig. 5).

Therefore it is important to assure a living environment for many kinds of life from phytoplankton to dolphin (shown in Fig. 1) in Sato-Umi. For example, a gentle sloped coast is much better than a straight uplifted coast for the coastal environment because many kinds of biota can live along a gentle sloped coast where the environmental gradient is small (Fig. 6).

4. Discussion

The process of establishing Sato-Umi has just started in the Seto Inland Sea, the largest semi-enclosed coastal sea in Japan. We need to accumulate many experiences of the processes and occurrences related to comprehensive material cycling in the coastal sea area, in order to establish Sato-Umi (Okaichi and Yanagi 1997; Research Institute for the Seto Inland Sea 2006).

Establishment of Sato-Umi will require a correct regulation of the nutrients loading from the land to prevent red tide occurrence and to prevent oxygen-deficient water masses in order to increase primary production. Regulations could follow the special law for the preservation of marine environment of the Seto Inland Sea which was enacted in 1973. The second method to preserve and rehabilitate the shallow sea area with a water depth less than 20 m is important to assure the sustainable recruitment of fish in the coastal sea area. Large shallow sea areas have been lost to reclamation in recent years due to the expansion of mankind's activities in the Seto Inland Sea (Fig. 7). Further, tidal flats and sea grass beds, which are also very important for primary production and as a nursery ground for fish, have been lost due to the reclamation and the

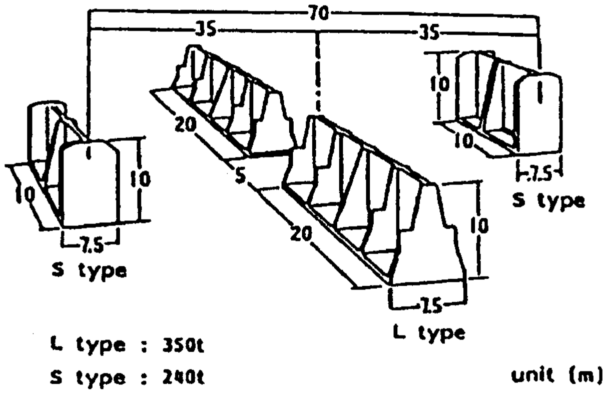

Fig. 4(a). Man-made structure for upwelling.

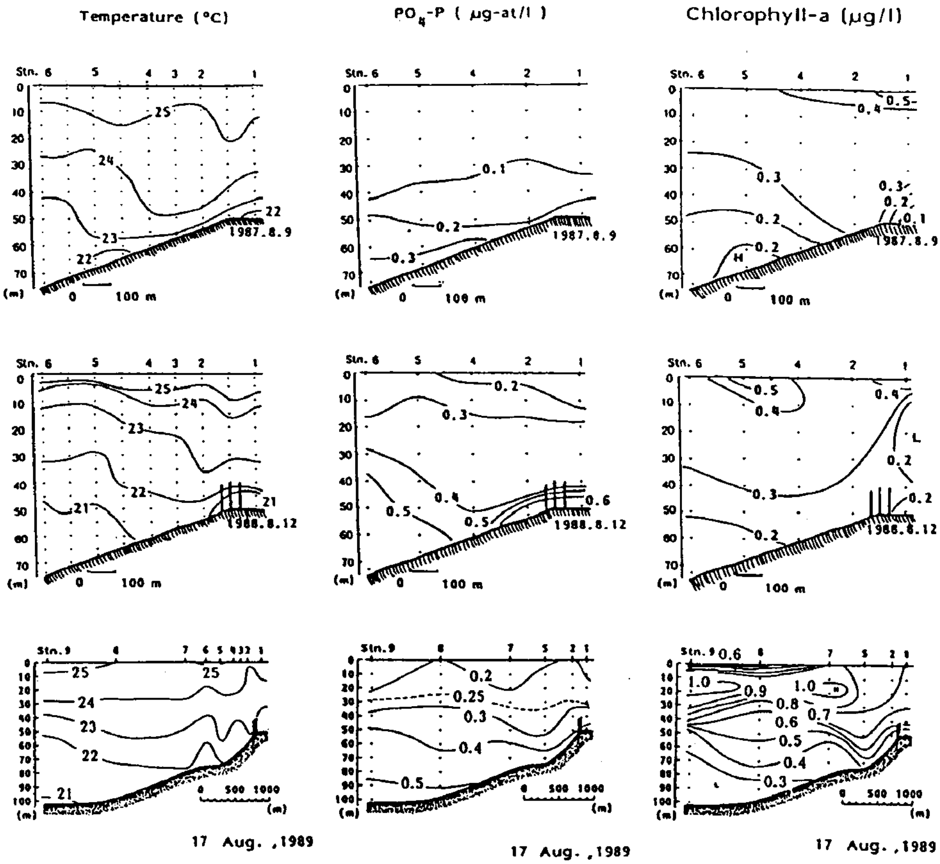

Fig. 4(b). Change in vertical distributions of water temperature, phosphate and chl.*a* from 1987 (upper; before construction) to 1988 and 1989 (middle and lower; after construction of the man-made structure). Three bars in the central panels show the positions of the structures (Yanagi and Nakajima 1991).

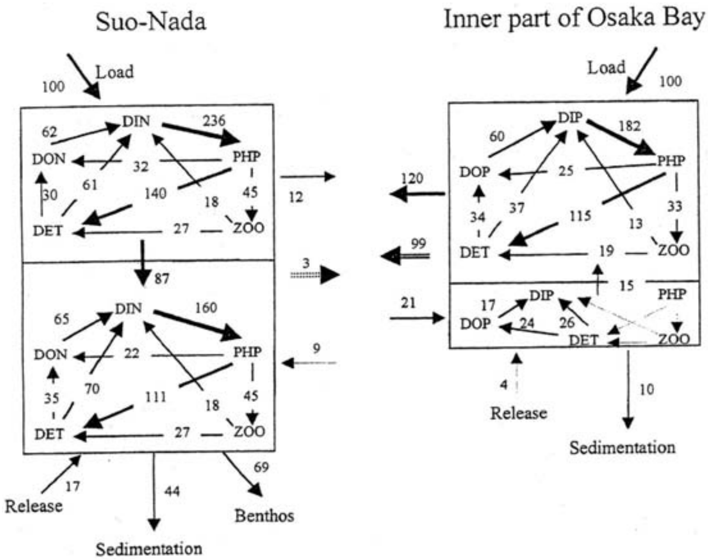

Fig. 5. Biochemical element flux in Suo Nada (left), where DIN a limiting nutrient for primary production, and Osaka Bay (right), where DIP is a limiting nutrient, in the Seto Inland Sea, calculated by box ecosystem models in which the flux is normalized by the river load as 100. Primary production flux in Suo Nada is 236 and that in Osaka Bay is 182, which are larger than river flux of 100. PHP: phytoplankton, ZOO: zooplankton, DET: detritus. (Hayashi and Yanagi 2002).

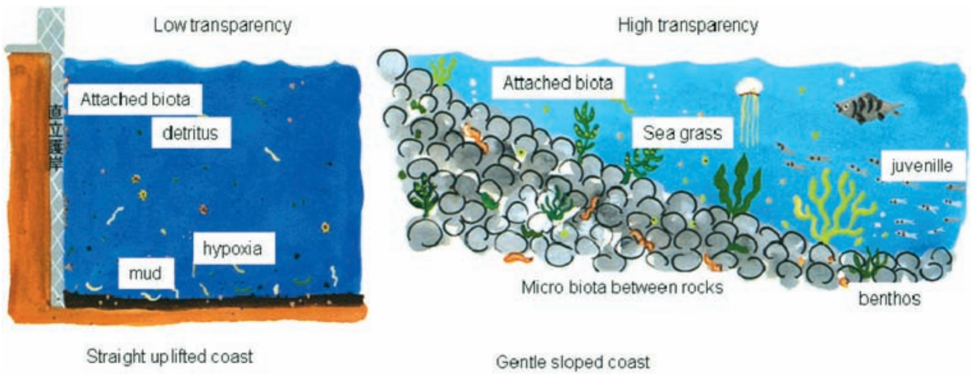

Fig. 6. Straight and uplifted coast (left) and gentle sloped coast (right).

decrease in water clarity (Fig. 8). Devastated coastal sea environments have to be recovered by proper management applying Sato-Umi concept.

Appropriate management of fishing effort is important for the preservation of fish resources, though this can be very difficult. We can turn to some successful examples of fish resource management by Fishermen's Unions in the Seto Inland Sea, Japan such as Himeshima (Yanagi 2004) and Misaki (Yanagi 2005) to guide implementation of Sato-Umi. Fish management in these fishermen unions is community-based and all

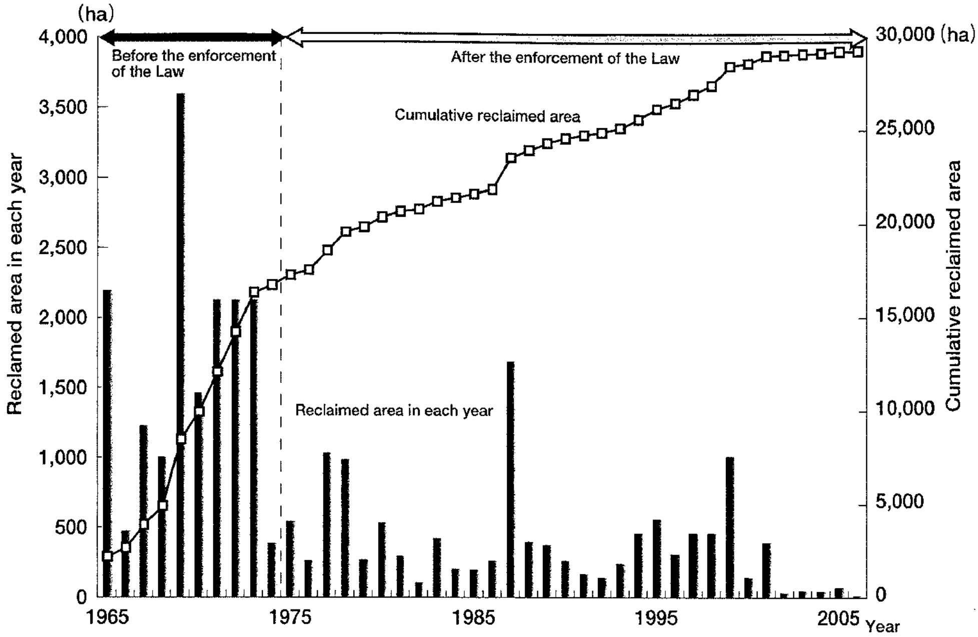

Fig. 7. Trends in reclaimed areas in the Seto Inland Sea, Japan.

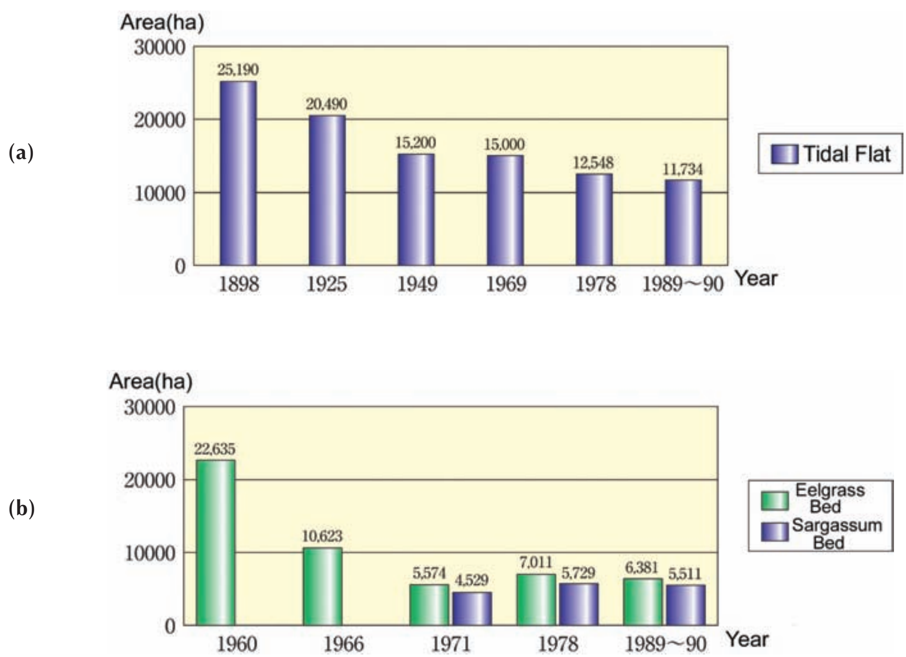

Fig. 8. Trends in areas of tidal flats (**a**) and sea grass beds (**b**) in the Seto Inland Sea, Japan.

fishermen in the Union cooperate to sustain the fish resources in their fishing ground. We will have to expand such successful examples of sustainable fish management to the whole coastal sea area in order to establish Sato-Umi. Finally, the sales strategy of harvested fish for the consumers in the city area is important to ensure a successful fishing economy (Yanagi 2007a).

The details of the Sato-Umi concept and trials for its realization are introduced in Yanagi (2007b).

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