

New approach for the integrated aquaculture management from the view point of multi-functional role of fisheries and aquacultures

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Abstract: Supply of food, in particular of protein has long been widely accepted as major role of fisheries and aquaculture for human society. However, recent growing concern on the global environmental issue and sustainable development is now making clear that fisheries and aquaculture also play important roles on material cycling between land and sea, monitoring of fishing environment and living resources, purification of pollutant through biological activities and food chain, environmental watching by fisherman, environmental education, eco-tourism and etc. In this context, Science Council of Japan submitted a special report to the Minister of Agriculture, Forestry and Fisheries recently (Aug. 2004) on multiple roles and functions of fisheries and fishing communities, in which role on environmental conservation, role on formation of regional community, role on maintaining personal security, role on providing fields of education and many kinds of amenity were highlighted as well as the role of food supply. Responsible and sustainable aquaculture also can play important functional roles. As an example of possible new approach for the integrated aquaculture management from the view point of multi-functional role of aquaculture, present status and possible future direction of large scale oyster culture in Hiroshima Bay, Japan are discussed. For the future direction, integrated oyster culture management responsible for regional economy and community are proposed with particular reference to safe and clean oyster meat supply, benthic living resource enhancement by raft oyster culture system, recovery of discharged N and P from land, environmental and red tide monitoring system, many varieties of recreation, seascape, eco-tourism and environmental education for especially younger generation. This proposed management should be involved in the more holistic environmental and ecosystem management by wide variety of stakeholders as a part of integrated coastal management of Hiroshima Bay including land use management of Ohta River watershed which has strong influence on the biological productivity and diversity of Hiroshima Bay.

Key words: multi-functional role, integrated aquaculture management, oyster, Hiroshima Bay

Introduction

A major role of fisheries and aquaculture which has long been widely accepted and is still primarily important is supply of food, in particular of protein, for human society. However, new ideas on the concept of multi-functional roles of fisheries and aquaculture are now growing public concerns in the environmental conscious society under the

global environmental crisis. In the symposium on "Role of Fisheries in Environmental Management and Remediation" held in 2001, Matsuda (2002) pointed out another six possible functional roles described below in addition to food supply, which are closely related to environmental conservation, purification of polluted environment and prevention of eutrophication: 1) Conservation of habitat environment, 2) Monitoring of environment and

living resources, 3) Recovery of inflowing nutrients (nitrogen and phosphorus) through fish catch and harvesting, 4) Reduction of COD (chemical oxygen demand) value through biological activities, 5) Environmental watching by fisherman, and 6) Environmental education, eco-tourism.

In this context, fisheries and aquaculture which is to be discussed in the present paper indicate primarily responsible fisheries and aquaculture, and hence, do not include such destructive fisheries or aquaculture as had ever given strong negative impact on the fisheries environment and living resources.

Fundamental Law on Fisheries was enacted in Japan in 2001, in which the term "multiple functions of fisheries and fishing community" officially appeared and the necessity of future investigation on these functions was clearly stated.

In February, 2003, "International Symposium on Multiple Roles and Functions of Fisheries and Fisheries Communities" was held in Aomori, Japan, where Hiro Yoshi (2003) made a key note lecture, in which he stated "There has not been awareness among people regarding multiple functions of fisheries communities. There is a need to renew our recognition in this respect from the view point of structural changes in fisheries as well as the earth's environment".

The Ministry of Agriculture, Forestry and Fisheries of Japan made an announcement on the new policy from 2004, main concept of which is more environmental conservation concerned agriculture, forestry and fisheries through healthy water circulation, healthy atmospheric circulation, healthy material circulation and conservation of healthy local communities.

In August, 2004 the Science Council of Japan submitted a special report to the Ministry of Agriculture, Forestry and Fisheries of Japan on the multiple roles and functions of fisheries and fishing communities with particular reference to role on food supply, environmental conservation, formation of regional community, people's security and providing fields of education and many kinds of amenity.

Thus, public awareness and interest on the multi-functional roles of fisheries is rapidly increasing

during recent few years. In the present paper, under these circumstances, five selected multi-functional roles of fisheries and aquaculture below are highlighted and reviewed in order to clarify those functional roles with particular reference to environmental conservation, purification of polluted environment and prevention of eutrophication: 1) Material cycling between land and sea, 2) Monitoring of environment and living resources, 3) Purification of polluted environment through biological activities and process of food chain, 4) Environmental watching by fisherman, and 5) Environmental education.

Therefore, main objective of the present paper is not to show experimental data but to propose new concept and approach for the integrated aquaculture management from the view point of multi-functional role of fisheries and aquacultures.

Exemplified multi-functional roles of fisheries and aquaculture

1. Material cycling between land and sea

Landing of fish catch by capture fisheries is a valuable and rare process by which inflowing nutrients to the sea such as nitrogen and phosphorus are recycled to the land. Non-feeding aquaculture such as bivalve culture and algal culture also contributes to the same type of processes. Since anadromas fishes such as salmon play a same role on the material cycling between land and sea, conservation of normal behavior of anadromas fish can contribute to this function.

The magnitude of the recovery of inflowing nitrogen and phosphorus by fisheries is sometimes not so small and that in the Seto Inland Sea is estimated as 5 to 8% for nitrogen and 15 to 22% for phosphorus.

2. Monitoring of environment and living resources

Fishing boats encounter many kinds of oceanographic and meteorological evidence or phenomena and can collect huge amount of data which has high possibility to build up valuable data base. Fisheries statistics in particular of fish catch data in terms of weight according to species are valuable information of living resources particularly in Japan. Although fish catch data do not directly

indicate fish resource data, no other similar biological data base are available covering such a long term and wide area of the sea as to many species. By the careful analysis of fish catch data, evaluation of living resource and estimation of the change in ecosystem structure is possible.

3. Purification of polluted environment through biological activities

During a process of food chain, filter feeders such as bivalves purify water through filtration of particulate matter and detritus feeders purify sediment through decomposition of organic matter. Not only detritus feeders but also aquatic animals generally decompose organic matter through heterotrophic nutrition resulting in the reduction of BOD, COD values of water and sediment. Another purification process regarding biological activities is removal of pollutant. When any kind of organic matter in the area is carried out by some migration or behavior of animals, this kind of removal of organic matter from the area in question is also evaluated as a kind of purification of the area in the broad sense. Filtering activities by bivalves estimated by some authors depends on conditions but generally very significant. With use of those effects of filtering activities of bivalves as well as the removal of N and P through catch of the bivalves, environmental restoration of tidal flats is made in some coastal area of Japan, for example, in Mikawa Bay, to enhance the production of clam shells as Manila clam.

4. Environmental watching by fisherman

Fisherman is a careful watch on marine environment, who can find out any kind of abnormal conditions such as red tide, oil spill or accident. Therefore, when the legal right of fishing of some area became null and void due to some reason, environmental conditions of the area often deteriorated historically because of the lack of watching and objection against deterioration. Original information on abnormal conditions, occurrence of red tide for example, often comes from fisherman. Therefore, networking of the information collected by fisherman potentially can play an important role on environmental conservation.

Fisherman on the boat also sometimes rescues and saves people in crisis.

5. Environmental education

Fisheries and aquaculture provide us with valuable opportunity for environmental education and recreation. Excellent fishing ground and fisheries community are attractive site for eco-tourism. Not only that fish landing market is a part of informative eco-museum on living resources but also cooking fish at home can help the understandings of children for introductory anatomy and zoology. In Japan, access to natural seashore has been historically restricted by new land reclamation or port development, combined activities of recreation, seascape, eco-tourism and environmental education such as shellfish gathering is recommended for better understanding of marine environment and living resources, especially for younger generation.

New approach for possible integrated oyster culture in Hiroshima Bay

Among a number of multi-functional roles of fisheries and aquaculture which has already been exemplified in the previous section, oyster culture has many positive aspects of functional roles of aquaculture. Matsuda *et al.* (1999) already reported on the new perspectives for oyster culture as a biofilter and biohabitat. According to Songsangjinda *et al.* (1999, 2000), role of oyster culture in Hiroshima Bay on material cycling is valuable. However, production of oyster from Hiroshima Bay has been decreased due to multiple reasons. Main objective of the present proposal is to maximize any kind of positive effect of oyster culture and to minimize negative effect at the same time. As positive effects, in addition to supply of high quality oyster meat which is primarily important, purification of seawater by filtering activity of oyster, enhancement of material circulation through harvesting, providing variety of habitat for living organisms by culture gear, effect of oyster raft as floating algal bed, effects on recreation, amenity and education are pointed out. Oyster culture of Hiroshima Bay has valuable experience of monitoring and management of paralytic shellfish poisoning (PSP) in which monitoring of causative phytoplankton and toxicity

of shellfish were made. While, as negative effects, deterioration of sediment quality by deposition of feces and pseudofeces due to excessive culture, inhibition to tidal movement by more than 10,000 floating culture rafts, occurrence of PSP, effect of waste from oyster culture industries can be listed up. Not a small amount of waste from culture system such as foam polystyrene from float and PVC pipe from oyster hanging wire system have been ever reported in and around culture ground.

Under these circumstances, future integrated oyster culture management in Hiroshima Bay should be responsible for regional environment, economy and community. Hirata and Akashige (2004) analyzed the present situation and problem of oyster culture in Hiroshima Bay and pointed out, as one of the problems, dense cultivation which prolonged the culture period due to low phytoplankton level. They also showed with use of model that the reduction in oyster biomass in the culture ground is needed to solve the problem and that shortening of the culture period was the most effective method without reducing harvest magnitude.

In addition to safe and clean oyster meat supply, benthic resource enhancement with particular reference to sea cucumber resource enhancement under oyster raft is recommended partly because oyster culture system is an excellent collector of sea cucumber larva. In addition to the recovery of discharged N and P from land, improvement of environmental and red tide monitoring system are also proposed. This proposed integrated oyster culture management should be involved in the more holistic environmental and ecosystem management by wide variety of stakeholders as a part of integrated coastal management of Hiroshima Bay including watershed and land use management of Ohta River watershed which has strong influence on the biological productivity and diversity of the ecosystem in Hiroshima Bay. Interdisciplinary investigation on the restoration of deteriorated Hiroshima Bay environment also started in April, 2004 by the prefecture government.

Closing remarks

Although primary objectives of the integrated aquaculture will be to supply safe and high quality

food, future direction for integrated aquaculture management should be sustainable in its manner, responsible for human society and playing as much multi-functional roles of aquaculture. Integrated aquaculture management to enhance regional economy and employment should also contribute to build up healthy material circulation and healthy ecosystem. In order to maximize multi-functional roles of fisheries and aquaculture, collaboration is recommended with holistic regional environmental management as a part of integrated coastal zone management which includes watershed area management. It is also proposed for integrated aquaculture management from the view point of multi-functional role of aquaculture to minimize waste material, to reuse waste material, to reduce energy consumption, to reduce new resource consumption, to restore deteriorated environment and to collaborate with variety of stakeholders.

References

- Hirata Y. and Akashige S, 2004: The present situation of oyster culture in Hiroshima Bay, *Bull. Fish. Res. Agen. Supplement No. 1*, 5-12.
- Hiroyoshi K., 2003: Keynote speeches in "Proceedings on the International Symposium on Multiple Roles and Functions of Fisheries and Fishing Communities" (ed. National Federation of Fisheries Cooperative Associations), p. 5.
- Matsuda O., Songsangjinda P., Yamamoto T., Rajendran N., 1999: New perspectives for oyster culture as a biofilter and biohabitat. *Proceedings MEDCOAST99-EMECS99 Joint Conference*, pp. 294-299.
- Matsuda O., 2002: Holistic approach to fisheries management from the view point of environmental conservation (in Japanese), in "Role of Fisheries in Environmental Management and Remediation" (ed. by Matsuda O., Furuya K., Taniguchi K. and Hino A.), *Kouseisha-Kouseikaku*, pp. 32-43.
- Songsangjinda P., Matsuda O., Yamamoto T., Rajendran N., and Maeda H., 1999: Application of water quality data to estimate the cultured oyster biomass in Hiroshima Bay: Estimation of the culture oyster biomass. *Fisheries Science*,

65(5), 673-678.

Songsangjinda P., Matsuda O., Yamamoto T.,
Rajendran N., and Maeda H., 2000: The role of
suspended oyster culture on nitrogen cycle in
Hiroshima Bay. *Journal of Oceanography*, **56**,
223-231.