

## Direct payment system to promote the appropriate management of aquaculture grounds

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**Abstract:** Aquaculture occupies an important role in Japanese fisheries; it also plays various social, cultural and economic roles and functions other than food supply, but is becoming a problem in that leftover feed and excrement causes coastal environmental pollution. A subsidy system is already in place in the EU and USA to compensate for the decreased revenue and increased costs incurred by reducing environmental damage by agriculture. In this study, I consider a plan to apply a similar subsidy system to Japanese aquaculture.

**Key words:** direct payment system, aquaculture, multifunctionality

### Materials and methods

Aquaculture is one of Japan's key industries: it provides a steady supply of various types of fish all nationwide. Aquaculture also has various social and cultural roles and functions. The financial state of aquaculture businesses, however, has been worsening for a number of reasons, including falling prices. The number of businesses is shrinking and their operators are aging. In this paper, I describe the current state of the Japanese aquaculture business through analysis of statistical data and case studies. Another point I discuss in the paper is pollution problems, including the damage caused to wild fishing grounds by uneaten fish food used in aquaculture and excrement of fish. I focus on the direct payment method applied in the agricultural field in some other countries and analyze it for its applicability to the Japanese aquaculture industry.

### Results

#### (1) The current state of Japanese aquaculture

In 2002, Japanese marine aquaculture yielded 1,333,000 tons, worth 478.3 billion yen, and freshwater culture yielded 51,000 tons worth 43.8 billion yen. These account for 23% and 23%,

respectively, of marine fisheries output and 45% and 42%, respectively, of freshwater fisheries output (Fig. 1). According to the national census of fisheries, the number of marine aquaculture businesses in 2003 was 23,068, 17% of the total number of fishing businesses. The number of freshwater aquaculturists was 4,495 in 2003.

For the production of major fish species in 2002 in marine aquaculture, the output of marine aquaculture was 162,000 tons for yellowtail and 72,000 tons for red sea bream; that of shellfish aquaculture was 272,000 tons for the common scallop and 221,000 tons for oysters; and that of seaweed aquaculture was 436,000 tons for laver, 54,000 tons for *Undaria* and 51,000 tons for *Laminaria* (Fig. 2). The output of laver and *Undaria* has been decreasing in the last few years. In inland water aquaculture, major fish species cultured include eel with an output of 21,000 tons, trout with 14,000 tons, carp with 9,000 tons, and sweetfish (ayu) with 7,000 tons (Fig. 3). The production of each of these is decreasing, with that of eels showing the steepest decline.

Concerning the financial condition of aquaculturists, the annual average fishery profits in 2002 was 7,745,000 yen for oysters, 7,654,000 yen for laver, 6,873,000 yen for common scallops, 4,725,000 yen for pearls, and 3,840,000 yen for *Undaria*. These

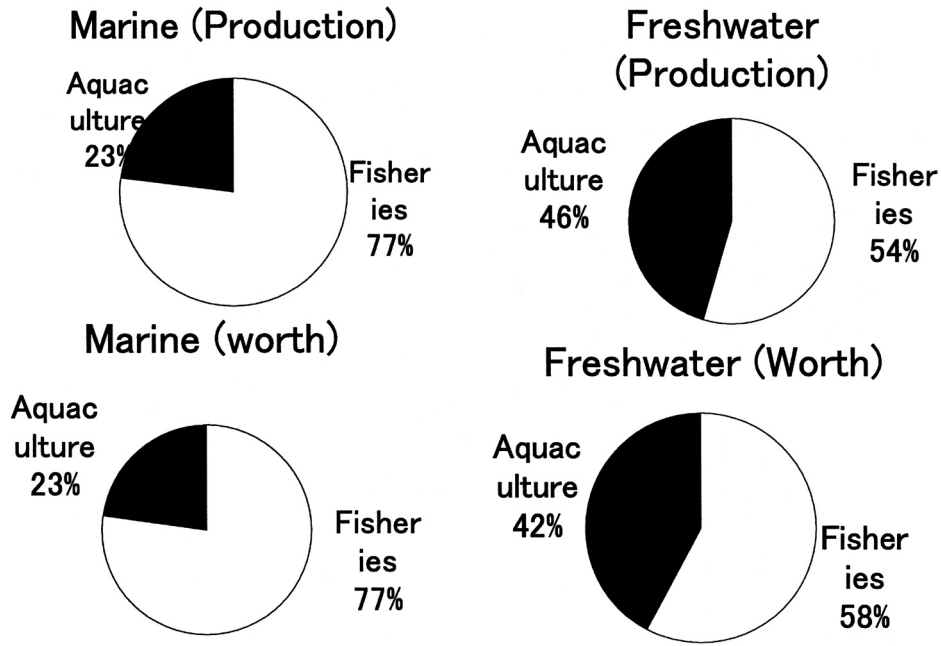


Fig. 1. Aquaculture proportion of the whole fisheries

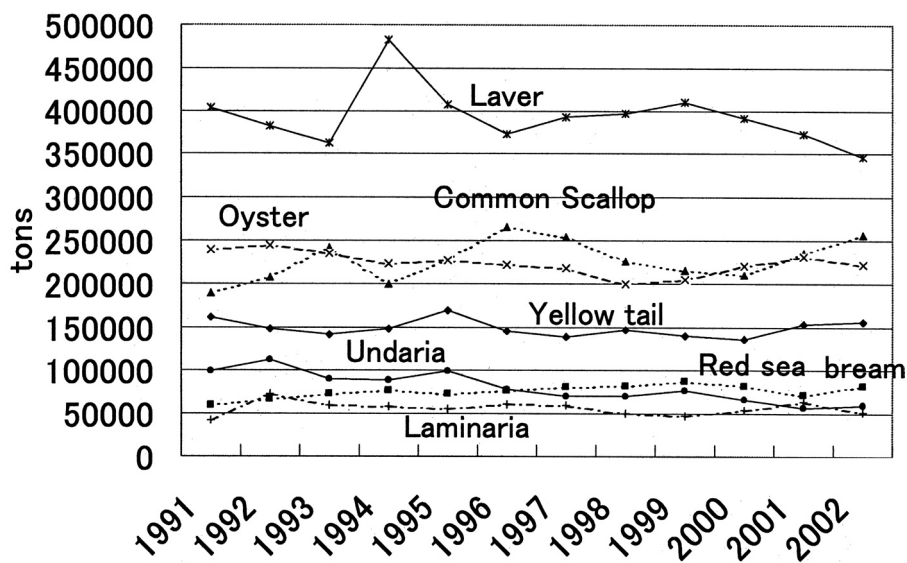


Fig. 2. Change of Marine Aquaculture Productuin

culturists earn more than the average profits for all fishing businesses. However, culturists of yellowtail (2,799,000 yen), sea bream (1,770,000 yen), and pearl oyster (792,000 yen), earn below the average of 2,871,000, evidence of their poor financial state

(Fig. 4). Of 21,129 individual marine aquaculturists, 27%, or a little more than one-fourth, know who will take over the business when they retire. Of 3,457 individual freshwater aquaculturists, only 15% have successors (Fig. 5). Inland water aquaculturists

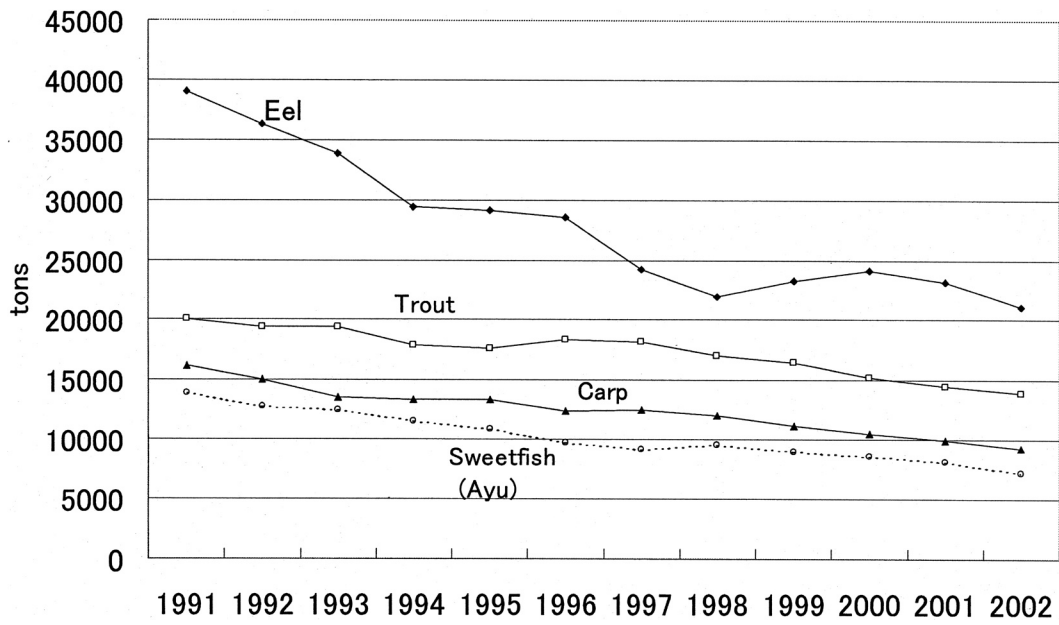


Fig. 3. Annual variation of Freshwater Aquaculture Production

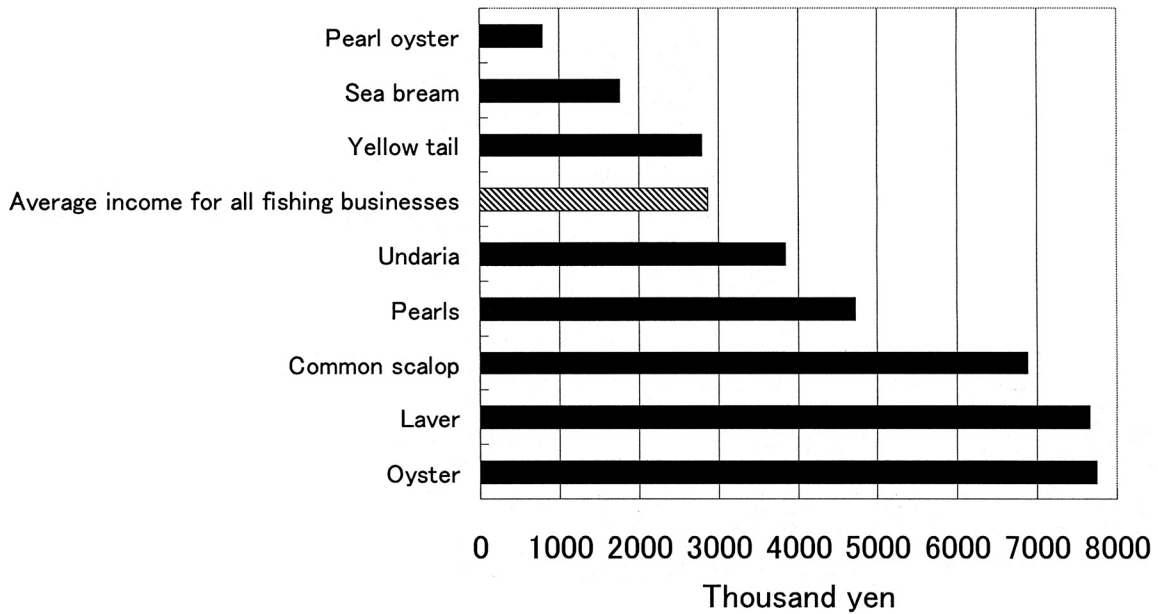


Fig. 4. Annual Average Profits of Aquaculture in 2002

are aging: 43% of male operators of inland water aquaculture are aged over 60. The majority of Japanese aquaculturists are small-scale operators dependent on family labor. The major cause of their financial deterioration is a drop in fish prices

due to growing imports and the stagnant domestic economy. However hard each aquaculturist tries to improve their financial condition, it is not enough to bring about any significant improvement.

A comparison of the age constitution of male

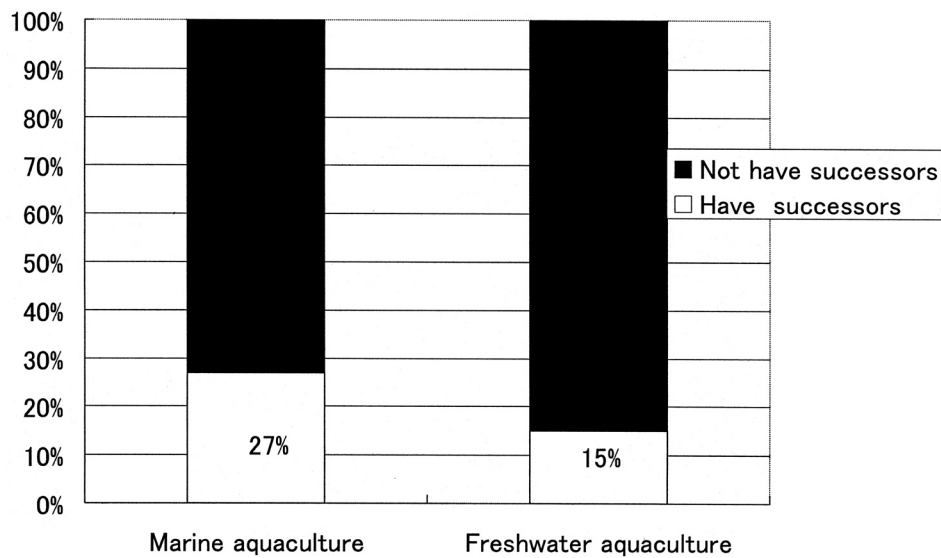


Fig. 5. Successors of Aquaculturist in 2003

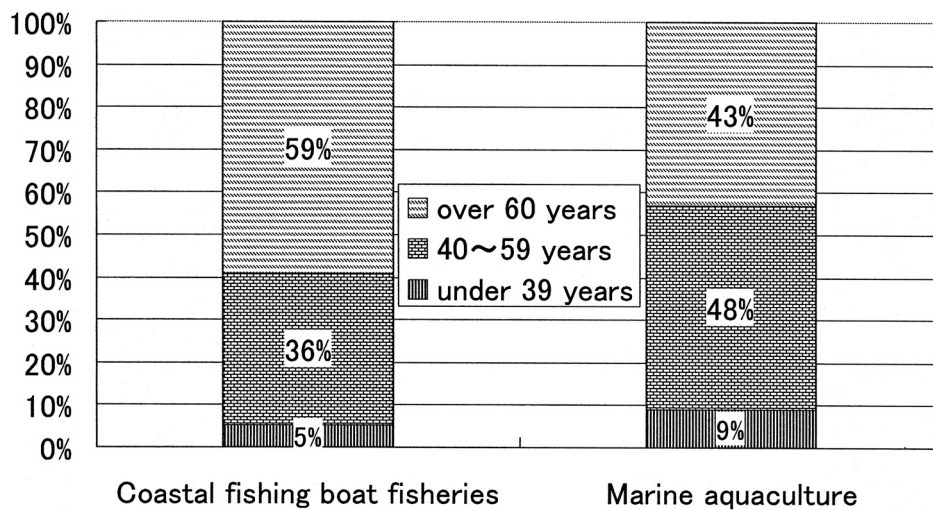


Fig. 6. A comparison of age construction of male fishery workers in 1998

fishery workers in 1998 between coastal fishing boat fisheries and aquaculture businesses, according to the census, shows 59% in fishing boat fisheries to be over 60 years of age, whereas fewer aquaculturists (43%) are over 60 (Fig. 6).

**(2) The various roles and functions of aquaculture**

Aquaculture has multifaceted functions in addition to the supply of fish. Each such function is explained

below.

1) Food security

Unlike ordinary fishing, where fish are caught as a natural resource, aquaculture can reliably supply selected fish species with the help of appropriate technology. Some aquaculture seeds, such as yellowtail, oyster, or common scallop, may have to be taken from natural resources, but others, such as red sea beam, prawn, or laver, can be artificially

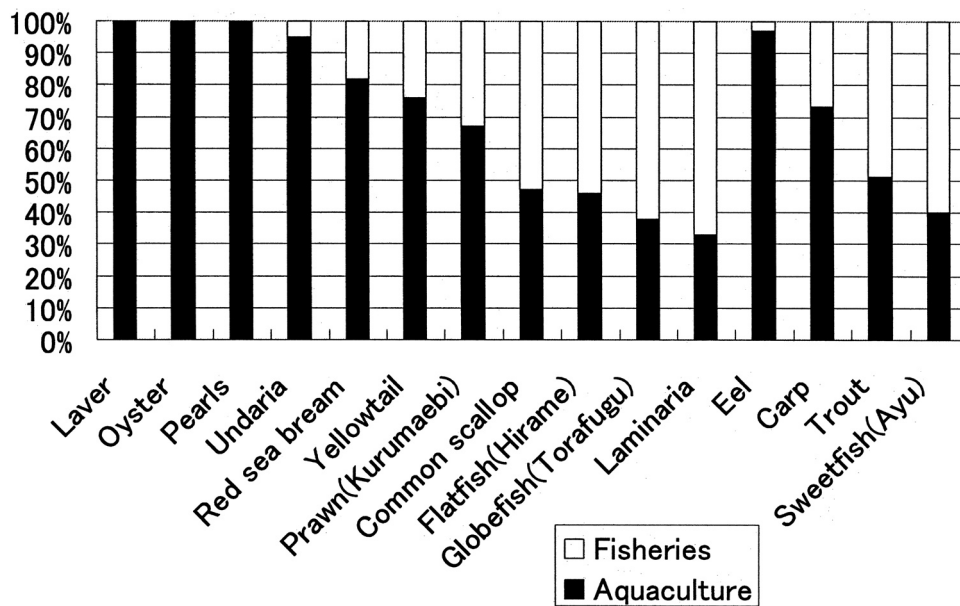


Fig. 7. Production Ratio of Aquaculture in 2003

produced. Even when culturing natural seeds, taking special care of life stages at which fish seeds have a higher natural mortality rate can reduce the death ratio and minimize loss of resources.

In addition, aquaculture produces the types of fish that are particularly in demand. In fact, certain fish species are characterized by high production ratios, such as 100% for laver, oysters, and pearls; 95% for *Undaria*, 82% for red sea beam, 76% for yellowtail, 67% for prawn, 47% for common scallop, 46% for flatfish, 38% for globefish, and 33% for *Laminaria* as well as, in freshwater culture, 97% for eel, 73% for carp, 51% for trout, and 40% for sweetfish (ayu) (2003). There are many fish species that would disappear from the market or be in very short supply if it were not for aquaculture (Fig. 7). Given these circumstances, it is logical to conclude that aquaculture plays a major role in food security.

## 2) Environmental improvement (Table 1)

Seaweeds convert carbon dioxide in the seawater into oxygen through photosynthesis. They also prevent eutrophication of the seawater by immobilizing dissolved nitrogen and phosphorus. In cultured seaweed grounds, unlike natural seaweed grounds, we can recover most of the immobilized nitrogen and phosphorus before these elements

are eluted into the water. Seaweed also provides shelter to young fish and the larvae of many other creatures, contributing to biodiversity. In addition to the benefits obtained from seaweeds themselves, there are cases where the bamboo poles used in aquaculture for attachment of laver in the water can serve as substrates for the larvae of short-necked clams, promoting favorable growth of shellfish grounds. In waters where aquaculture facilities are set up, rafts and net pens used to aquaculture can also provide shelter for wild fish. It is impossible to carry out seine fishing or trawl netting in the same waters, thus promoting the preservation of marine resources. When filter-feeding marine species, such as bivalves and sea squirts, are cultured, they filter seawater and simultaneously reduce the organics in the water. Silver carp and white crucian carp produced in freshwater culture grow on phytoplankton and do not need to be fed, therefore reducing the pollution load on lakes. One kilogram of silver carp filter a cubic meter of water and eat 20 grams of phytoplankton daily (Ibaraki Prefecture, 1996).

## 3) Exchange between urban and fishing communities

Aquaculture promotes exchange between urban

**Table 1.** Environmental improvements by aquaculture

Aquaculture species	Example
Seaweeds	Convert carbon dioxide in the seawater into oxygen
	Immobilizing nitrogen and phosphor
	Provide shelter to young creatures
Bivalves and Sea squirts	Filter sea water and reduce organics in the water
Silver carp and White crucian carp	Filter sea water and reduce organics in the water
Aquaculture facilities (rafts and net pens)	Provide shelter for natural fish
	Stop the fisheries operation of natural resources and provide nursery ground

and fishing communities. For instance, a fisheries cooperative in Kagawa Prefecture has a cultured oyster ownership system in which consumers buy oysters at the seeding stage. Later, they are entitled to experience the harvesting of the grown oysters or have them directly delivered by delivery service. In this system, an aquaculture rope with some 70 oysters attached is sold at 2,200 yen. Orders for some 1000 ropes are received per year. They even come from outside the prefecture, such as from Okayama or Tokyo. This cooperative has also discovered that many consumers prefer to come to get the oysters themselves to having them delivered. Another fisheries cooperative is advertising for purchasers of oyster culture ropes, at 2,500 yen each, but only accept orders from consumers within the same prefecture. In 2000, they received some 500 orders. In Kagawa Prefecture, some culturists, including the said cooperative, have their own small restaurants that serve grilled oysters during the winter. A different cooperative offers “all the oysters you can eat” at 2500 yen per person and, in 1999, achieved sales of 10 million yen. In Kanagawa Prefecture, a “hands-on experience” program that offers a course in *Undaria* culture was provided for 100 groups at a fee of 3000 yen per group. Visitors took part in seeding of *Undaria* and studied the details of seaweed aquaculture and its environmental advantages, including how it purifies water. In November, they learned how to culture seaweed and in February experienced harvesting of the seaweed, took classes on the nutrients in *Undaria*,

and learned how to use it in cooking. There are also exchange promotion programs in which elementary and junior high school students visit a fishing village as one of their school excursion destinations and take part in various events alongside the people of the village to gain a closer and more personal understanding of how they live. Since the culture grounds are close to the port and located in calmer waters than in the case of offshore fishing, programs that feature actual experience of aquaculture are very popular with city people as safe and accessible opportunities to experience this type of fishery. It is a valuable experience for young people to actually feed cultured fish species and see how shellfish species and seaweeds are cultured. They can actually see for themselves what the sea has to give them. Another example is “fishing ponds” using the sea surface in Mie and Hyogo Prefectures, or fresh water in other prefectures. These “fishing ponds” are very popular among angling fans, not to mention beginners and children who tend to be seasick in open waters, because they can experience fishing in a safe and unthreatening environment. Many of the fish caught from these ponds are cultured species. Aquaculturists facilitate exchanges between cities and fishing villages by stocking these ponds with fish and opening them to the public. Aquaculturists can also obtain a profit by selling fish for stocking the ponds. Oyster culture rafts are ideal nests for black sea bream, a popular fish with anglers, for their shade and the plants and animals that cling to them. In Ishikawa Prefecture, these rafts are



**Table 2.** Example of exchange between urban and fishing communities

Area	Example
Kagawa Prefecture	Cultured oyster ownership system
Kagawa Prefecture	Small restaurants that serve grilled cultured oyster
Kanagawa Prefecture	Experience of <i>Undaria</i> culture
Mie Prefecture and Hyougo Prefecture	Provide cultured fishes to "Fish ponds"
Ishikawa Prefecture	Oyster culture rafts are provided for sport fishing
Shimane Prefecture	Takes anglers aboard recreational fishing boats to the water near their aquaculture grounds
Freshwater	Fisherman's cooperative release cultured seeds for sport fishing
Fishing Village	School excursion

**Table 3.** Maintenance of traditions

Culture	Example
Maintain Japanese culinary traditions	Enjoy eel on specific days in summer
	Laver for Rice ball (Onigiri) and Rice roll (Norimaki)
	Sushi
Japanese garden	Fancy carp
Local festivals	Goldfish scooping

provided by some culturists for sport fishing. A fisheries cooperative in the Oki Islands, Shimane Pref., who know that large wild fish are attracted to their fish culture grounds to eat the fodder that leaks out, take anglers aboard recreational fishing boats to the waters near their aquaculture grounds. These anglers pay 10,000 yen per person for this experience and are allowed to take home up to three red sea bream. The cooperative had some 250 customers in five months in 2002. Freshwater fisherman's cooperative often release cultured seeds for sport fishing. According to the census, the total number of sport fishers in fresh water in 2003 was 7,770,000 (excluding those for bass). Thus, aquaculture plays numerous roles, including exchange between urban and fishing communities and provision of recreational opportunities to urban dwellers (Table 2).

#### 4) Maintenance of traditions (Table 3)

I have already pointed out as one of the features

of aquaculture that it provides types of fish that would run short if we relied exclusively on natural resources. Providing these fish also helps to keep alive Japanese culinary traditions. For example, it is a custom to eat eel on certain days in summer. Without aquaculture, however, the lack of eels would lead to this custom's disappearance. Red sea bream is very popular to the Japanese style wedding reception. Laver, indispensable for rice ball and sushi, is 100% supplied by aquaculture. Yellowtail, red sea bream, and common scallop are also essential materials for sushi and are supplied by aquaculture. Fancy carp (nishiki-go) are an invaluable part of many Japanese gardens. Without aquaculture, "goldfish scooping," an essential and entertaining part of local festivals and a traditional festive pastime for children, would disappear. These aquarium fish species are also the products of aquaculture.

#### 5) Formation and maintenance of local communities

Aquaculture needs calm waters and clear fresh water and is thus often conducted in places far from major cities. The economy of many such places relies entirely on fisheries and related industries. Aquaculture helps dilute the otherwise concentrated population in cities and settle people in remote areas by providing economic security. At the same time, it plays other associated roles, such as monitoring of national borders, preservation of national land and protection of the landscape.

### (3) Pollution of fishing grounds by aquaculture

So far I have dealt with the bright side of aquaculture by discussing the originally intended and various roles and functions of aquaculture. However, it is also true that aquaculture causes problems. In aquaculture which involves feeding, residual fodder and feces are swept out of the grounds and cause pollution of neighboring waters and the sea floor. Even with shellfish culture, which requires no

feeding, it is reported that feces and pseudofeces (rejected food particles embedded in mucus) tend to accumulate on the sea floor. Katsuhiko Ito (1994) compared the sediment in the water at the mouths of bays not used for aquaculture with those employed for shellfish (pearl) culture grounds and those with fish (red sea bream and yellowtail). The sediments were analyzed for total amount of sulfides, oxidation-reduction potential, total amount of organic carbon, total amount of nitrogen, and the content of pheo-pigment. The results showed sediments to be worst near fish culture grounds, followed by shellfish culture grounds and then non-cultured bays (Table 4). Red tides often occur in the waters with the most serious pollution, with the negative impact of such pollution affecting both cultured products and natural resources. Ito reported that toxic red tides, such as those comprising *Gymnodinium* or *Chattonella*, occur over wider areas in waters where fish culture is more common and extensive.

**Table 4.** Comparison of Bottom environment with Aquaculture grounds to non aquaculture grounds in Gokasyo-bay (average 1984-1985)

	Aquaculture		Non aquaculture ground
	Pearl	Fish	Bay-entrance
Total amount of sulfides(mg/g dried mud)	0.16	1.96	0.004
Eh(mV)	+172	-11	+323
Content of pheopigment( $\mu$ g/g dried mud)	45.3	98.2	4.9
Total amount of organic carbon(mg/g dried mud)	20.4	23.4	2.1
Total amount of Nitrogen(mg/g dried mud)	2.51	3.53	0.37
Katsuhiko Ito(1994)			

**Table 5.** The Environmental Benefit Index of The Conservation Reserve Program (CRP) of USA

- Water quality (maximum 20 points)
- Wildlife (20)
- Land erosion (20)
- Reforestation (10)
- Desired rent

Eiichiro Nishizawa (2001)



#### (4) Direct payment methods used to support agriculture in some countries

Schemes based on the direct payment method assume that existing modes of agriculture impose loads on the environment, and are designed to compensate for the increased costs or loss of income that result from efforts to make agriculture more kind to the environment.

##### 1) Agriculture in the USA

The Conservation Reserve Program (CRP) is a scheme created as part of the Food Security Act of 1985 to remove fragile and easily eroded farmland from production for 10 to 15 years. Instead, the United States Department of Agriculture (USDA) pays rent on the retired land and 50% of the cost incurred in maintaining the land's vegetation cover. As of October 2000, 13 million hectares of farmland, 8% of total farmland, was retired, with more than 80% of this retired land turned into grassland. A total of 290,000 farmers participated in the program. Rental payments made per year are \$111.5 per hectare, and \$4,800 per farm on average. Annual spending by the USDA on the CRP totaled \$1.7 billion, accounting for half of environmental preservation spending. The rental payment and cost-share payment to be made by the USDA are determined based on an environmental benefit index calculated from the total sum of points for water quality (maximum 20 points), wildlife (20), land erosion (20), reforestation (10) and desired rent (Table 5) (Eiichirou Nishizawa, 2001).

##### 2) Agriculture in the EU

EU agricultural environment programs provide subsidies to programs to limit the input amount of fertilizers and agricultural chemicals, maintenance of already reduced input, introduction and maintenance of organic farming, introduction of extensive production of plants, conversion of cultivated land to extensive grassland, reduction of rearing density of cows and sheep, introduction of farming methods necessary for preservation of the environment and preservation of the rural atmosphere and landscape, protection of rare or threatened breeds, maintenance and management of abandoned farmland or forests, retiring of farmland for over 20 years for protection of the biotope and water quality, and management of farmland for easier access by the general public

and for recreational use (Table 6) (Keiichi Ishii, 2001). One example is the system of environment payments introduced in France. The overall programs in this system generally include reduction of input, conversion of farmland to grassland, long-term suspension of production, and reduction of rearing density, and, as local projects, preservation of biotopes and prevention of farmland decay. Grassland promotion grants are provided nationwide in France. The highest grant per contract is for reduction in rearing density, at about 27,000 francs (about 565,000 yen) (Table 7). In 1997, 1.9 billion francs were spent on the agricultural environment program. Of this amount, 1.63 billion francs were spent on the promotion of conversion to grassland. By type of operation, 69% of operators covered by the program were sheep and goat farmers and 55% were for beef farmers (Keiichi Ishii, 2001).

#### Discussion -Application of the direct payment method to Japanese aquaculture

Assuming that control of aquacultural activity based on a system using the direct payment method, as practiced outside Japan, would be effective in improving the fishing environment, I reviewed a potential form of direct payment system applicable to the Japanese case. If this method were introduced, it would run the risk of sending a clear message officially stating that aquaculture without control is an environmental threat. It is also important to set a certain standard that does not violate the polluter's responsibility principle and to make payments to aquaculturists who satisfy the standard.

Actions or efforts to reduce environmental loads include, for fish culture by feeding, reduction in rearing density, amount of fodder, and amount of chemicals; for shellfish culture without feeding, reduction in rearing density; and for aquaculture operated inland, installation of wastewater treatment facilities. Changing to fish species that have less environmental load is also a strategy for reducing environmental load. Reduction in CO<sub>2</sub> of vessels and processing machine such as laver molder. Changing floats of plastics and foam polystyrene to aluminum floats. Direct payment for doing this may be logically equivalent to the direct payment method used for

**Table 6.** EU Agricultural Environment Program

- ①Limit the input amount of fertilizers and agricultural chemicals, maintenance of already reduced input, introduction and maintenance of organic farming
- ②Introduction of extensive production of plants, conversion of cultivated land to extensive grassland
- ③Reduction of rearing density of cows and sheep
- ④Introduction of farming methods necessary for preservation of the environment and preservation of the rural atmosphere and landscape, protection of rare or threatened breeds
- ⑤Maintenance and management of abandoned farmland or forests
- ⑥Retiring of farmland for over 20 years for protection of the biotope and water quality
- ⑦Management of farmland for easier access by the general public and for recreational use

**Table 7.** The system of environment payments introduced in France

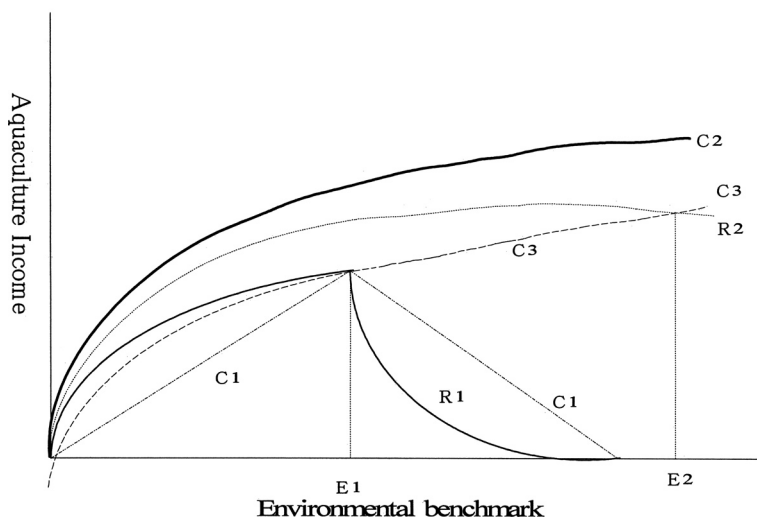
- ①Overall programs
  - Reduction of input (422)
  - Conversion of farmland to grassland (236)
  - Long-term suspension of production (Biotopes (302), Water maintenance (247))
  - Reduction of rearing density (565)
  - Protection of rare or threatened breeds (52)
  - Switch to organic farming (485)
- ②Local projects
  - Preservation of biotopes (242)
  - Prevention of farmland decay (226)
  - Prevent a risk of a fire (427)
  - Water maintenance (349)
- ③Provided nationwide in France
  - Grassland promotion grants (283)

( ) means average grant per one contract (Thousand yen)

Keiichi Ishi (2001)

**Table 8.** Actions or efforts to reduce environmental loads

Type	Example
Fish aquaculture by feeding	Reduction in rearing density, amount of fodder, amount of chemicals
	Change to seaweed aquaculture
Shellfish aquaculture without feeding	Reduction in rearing density
	Change to seaweed aquaculture
Inland water aquaculture	Installation of wastewater treatment facilities
Aquaculture	Reduction in CO <sub>2</sub> of vessels and processing machine
	Changing floats of plastics and foam polystyrene to aluminum



**Fig. 8.** The Schematic Diagram Showing the Relationship between the Environmental benchmark and Aquaculture Income

agriculture in some other countries. For example, it is considered worthwhile to plan coordination with fishing ground improvement plans in the Law to Ensure Sustainable Aquacultural Production (Table 8).

According to the schematic diagram showing the relationship between the environmental benchmark and aquaculture income shown here, for R1, the production curve of ordinary aquaculture, production increases with the rise of the environmental benchmark until reaching a certain point E1. But after E1, it is necessary to reduce production to maintain the environmental benchmark. For C1, the cost curve of ordinary aquaculture, past E1, costs are reduced due to production control, but the balance turns negative due to a large reduction in income. R2 is production curve of environmentally friendly aquaculturists, increase of production does not give big influence to environmental benchmark. C2 is the cost curve of environmentally friendly aquaculturists, who have a minus balance, since the cost is greater than for ordinary aquaculturists. On the other hand, C3 is the cost curve of an environmentally friendly aquaculturist who received a grant for cost reduction efforts. They make a profit until the break-even point at E2. E2 is a higher environmental benchmark than E1 (Fig. 8).

## References

- Ibaraki Prefecture Inland Water Fisheries Experiment Station, 1996: *Biology of the Fish of Lakes Kitaura and Kasumigaura*, Ibaraki, p 10 (in Japanese)
- Ito Katsuhiko, 1994: *Environmentally Friendly Propagation and Aquaculture*, in "Fisheries and the Environment" (ed. by Shimizu Makoto), Koseisha-Koseikaku Publishing Co., Tokyo, pp. 20-21 (in Japanese)
- Ishii Keiichi, 2001: *Development of Environmental Payments in France*, in "Direct Payments to and Environmental Preservation in Mountainous Areas" (ed. by Goda Yasuyuki), Ie-no-Hikari Association, Tokyo, p. 117 (in Japanese)
- Ishii Keiichi, 2001: *Development of Environmental Payments in France*, in "Direct Payments to and Environmental Preservation in Mountainous Areas" (ed. by Goda Yasuyuki), Ie-no-Hikari Association, Tokyo, pp 120-121, 125 (in Japanese)
- Nishizawa Eiichirou, 2001: *US Preservation Retiring Program*, in "Direct Payments to and Environmental Preservation in Mountainous Areas" (ed. by Goda Yasuyuki), Ie-no-Hikari Association, Tokyo, pp 154, 167-168 (in Japanese)