Potentials and Limitations of Stock Enhancement Programs in Japan

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Abstract

In Japan, a lot of stock enhancement programs have been carried out in the last fifty years. Such programs have been successful in terms of cost-effectiveness as well as stocking efficiency. Seeds of 85 species of fishes, mollusks, crustaceans, and other aquatic organisms have been released for stock enhancement, including those of chum salmon *Oncorhynchus keta* and barfin flounder *Verasper moseri* in northern Japan, red sea bream *Pagrus major* in central and western Japan, and sawara *Scomberomorus niphonius* in Seto Inland Sea. To be successful, assessments of the natural stocks and investigations on the environment of their nursery grounds are necessary prior to seed release. However, if the natural stock is abundant compared with the capacity of hatcheries there would be no need for seed release. Healthy marine environment in the nursery ground is a prerequisite for effective seed release. Though overfishing sometimes results in high "recapture rate" of released fish, most of these cases are neither economically effective nor sustainable. A suitable fisheries management is needed. The carrying capacity of the nursery ground restricts the allowed number of released seed. In the case of hirame *Paralichthys olivaceus*, it tends to higher in northern Japan than in the southwestern areas. To evaluate both stocking efficiency and cost-effectiveness, YPR (Yield per Release = weight of landed "recaptured fish" divided by number of released seeds) is recommended. YPR for successful cases is estimated to be more than 50 metric tons per 1 million seeds. Furthermore, since increased production often results in decline of price, socio-economic studies are also important.

Keywords: seed release, stock assessment, carrying capacity, YPR (Yield per Release), socio-economic studies

Introduction

In Japan, a lot of near-shore nursery grounds had been reclaimed leading to the degradation of the environment of coastal waters mainly because of the development of industries. Degradation of the environment and overfishing resulted in the exhaustion fishing resources. Stock enhancement programs were therefore started to recover natural resources by releasing artificial seeds. A total of more than 80 species of fish, mollusk, crustacean, and other aquatic organism seeds have been released in the last 50 years. Although these programs could be successful in terms of cost-effectiveness as well as stocking efficiency, some of them were evaluated and found to be failures.

Activities and Results

Successful Cases

The red sea bream *Pagrus major* is very popular and one of the most important fishes for the coastal fisheries in Japan and was selected as first target species for stock enhancement. The seed production technology of red sea bream was developed in 1960s and 1970s, and the ecology of this species was studied in 1970s and 1980s, and mass-release of artificial seeds was started in 1980s. In the central area of the southern coast of Japan, the amount of landings increased after the mass-release started and maintained around 1,500 metric tons in these 20 years (**Fig. 1)**. Between 10% and 50% of newly recruited fish were occupied by the released fish (**Fig. 2**). Released fish seem to play an important role when the recruitment of natural fish is not abundant. In this region, fishers have positively carried out the resource management and environmental remediation. It is considered that seed release lifts up the motivation of these activities.

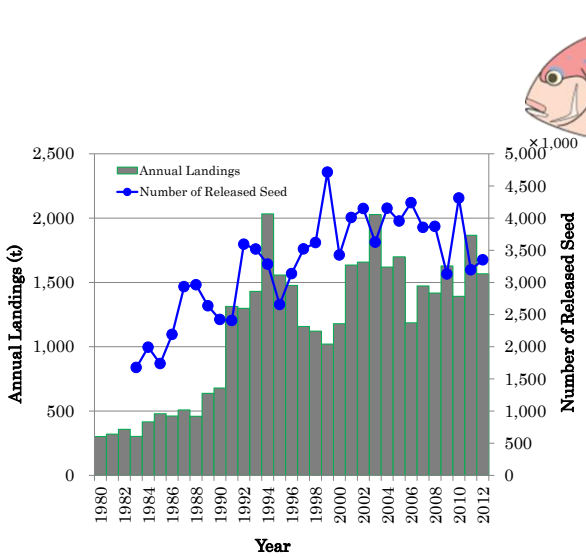

Fig. 1. Annual landings and number of released seeds of red sea bream in the central area of southern coast of Japan

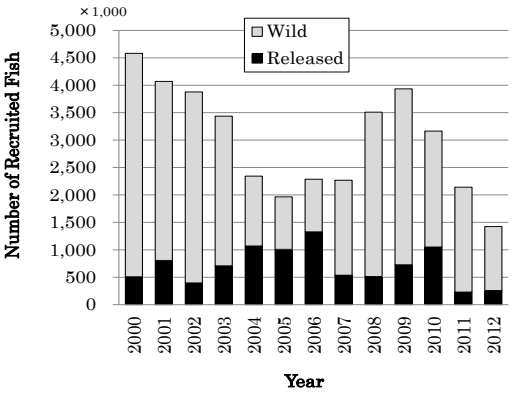

Fig. 2. Number of newly recruited red sea bream

The stock enhancement program for sawara *Scomberomorus niphonius* in Seto Inland Sea is also considered to be successful. Annual landings of sawara had reduced rapidly in the latter half of 1980s and 1990s mainly because of over fishing. Fishers started self-regulations in 1998. In 2002, governmental regulation, which consists of mesh size limitation of the gill net and closed season, and upper limit of catch by purse seine, was imposed, and mass release of artificial seeds started. After these activities, the stock size of sawara recovered (**Fig. 3**). Although the impact of releasing seeds is estimated to be small compared with that of the red sea bream, seed release have changed the attitude of fishers to be positive about fisheries management.

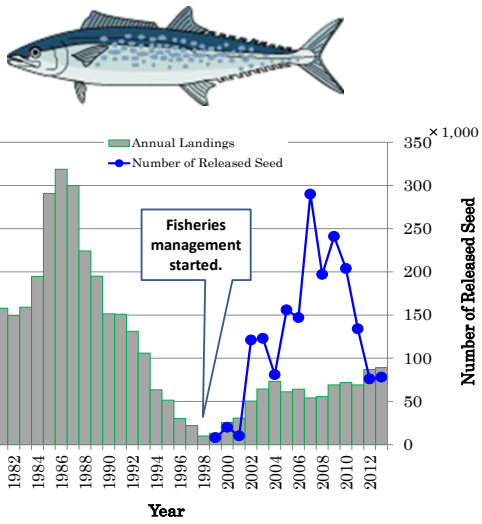

Fig. 3. Annual landings and number of released seeds of sawara in the central area of southern coast of Japan

Limitation of Carrying Capacity

In the case of hirame *Paralichthys olivaceus*, the stocking efficiency tends to be higher in northern Japan than in the southwestern areas (**Fig. 4**). It is considered that nursery ground in northern Japan have higher surplus productivity for stocking of hirame. Yamashita *et al.* (2004) suggested that lower density of wild hirame and higher productivity of prey organisms were the main factor for the difference in the carrying capacity.

Break-Even Point of Stocking

The Break-Even Point of Stocking is calculated from cost of releasing seeds and benefit of recaptured released fish. The benefit per cost should be greater than 1. Break-Even Points under different costs of seeds and YPR (amount of recaptured released fish (metric tons) / number of released seed / 1,000,000) are shown in **Fig. 5**.

For example, when the cost of seeds is 100 JP yen, the price of recaptured fish should be more than 1,000 JP Yen when YPR = 100, and more than 2,000 JP Yen when YPR = 50.

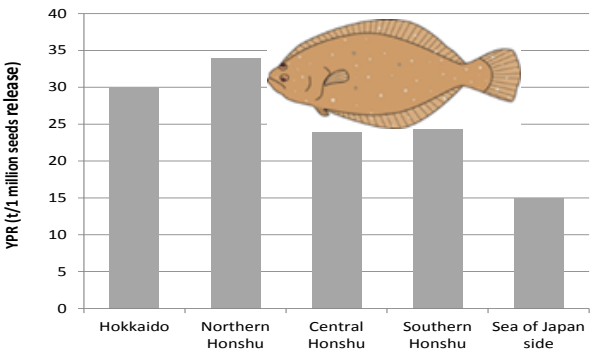

Fig. 4. Difference in stocking efficiency of hirame among the areas studied

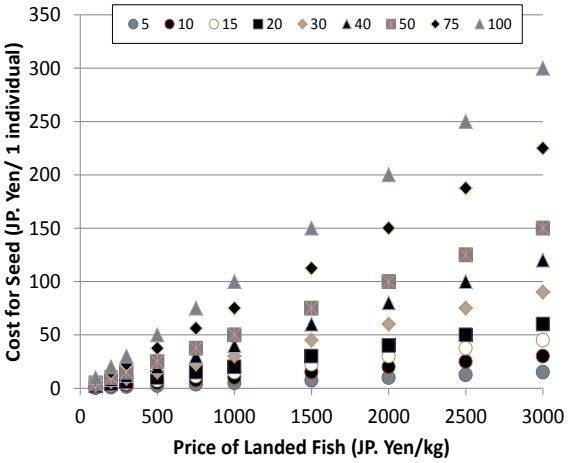

Fig. 5. Break-Even Points under different costs of seeds and YPR

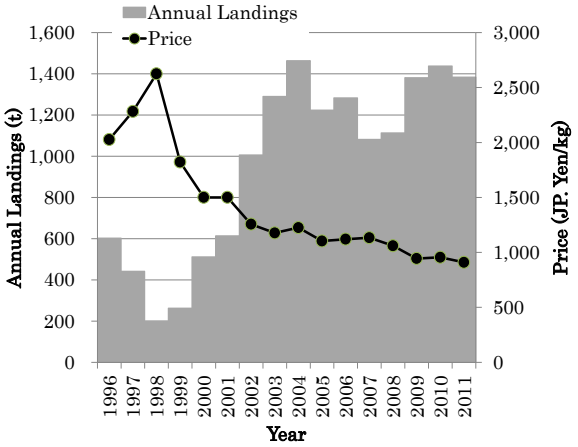

Fig. 6. Annual landings and price of sawara in Seto Inland Sea

Socio-economic Issues

Although the stock size of sawara in Seto Inland Sea recovered in recent years, its price declined as the amount of landing increased (**Fig. 6**). On the other hand, the price of cultured red sea bream declined in 1980s as its production from aquaculture increased. In 1990s, production of aquaculture surpassed the quantity of captured fish, thus, the price of captured fish declined (**Fig.7**). Sawara and red sea bream had been very precious fish for the Japanese, but these fish species seem to lose their status at present.

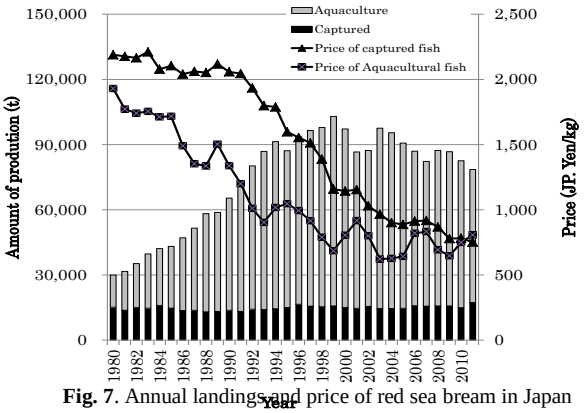

Fig. 7. Annual landings and price of red sea bream in Japan

Lessons Learned

For successful seed release, assessments of the natural stocks and investigations on the environment of their nursery grounds are necessary at first. There is no need of seed release if the natural stock is abundant compared with the capacity of hatcheries. Healthy marine environment in the nursery ground is a prerequisite of the effective seed release. Although overfishing could sometimes result in high "recapture rate" of released fish, most of these cases are neither economically effective nor sustainable. A suitable fisheries management is needed. Carrying capacity of the nursery ground restricts the allowed number of released seeds. To evaluate both stocking efficiency and cost-effectiveness, YPR (Yield per Release; weight of landed "recaptured fish" divided by number of released seeds) is recommended. YPR of successful cases is estimated to be more than 50 metric tons per 1 million seeds released. Furthermore, increased production often results in decline of price, therefore, socio-economic studies are also important.

Recommendations and Way Forward

First of all, **diagnosis** (stock assessments, investigations on the ecology of target species, and investigations on the environment), followed by the so-called **PDCA Cycle,** *i.e.* **Plan** (releasing strategy (when, where, how, how many) and seed quality (size, shape, activity etc.), **Do** (cooperation with fisheries management, and habitat improvement, rehabilitation, and conservation), **Check** (monitoring by market survey, evaluation of stocking efficiency and cost- effectiveness), impact on environment including genetic impact), **Act** (improve, expand, spread, or decide to discontinue), is recommended.

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