# Sea Farming of Red Sea Bream *Pagrus major* (Temmick et Schlegel) In waters off Kanagawa Prefecture , Japan with Special Reference to Stock Enhancement Effect

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ABSTRACT

Technical activities are reviewed in a regional stock enhancement project for red sea bream off Kanagawa Prefecture. The project is aimed at recovering from the decline of catches, which fell from 136 ton in the late 1960s to the 30-ton level in the late 1970s. Current major activities aim:(ⅰ) to select a marking technique ; (ⅱ) to estimate annual catches, both commercial and sport;(ⅲ)to evaluate the effects of stock enhancement on catch, both artificial and wild as well as on achievement of economic efficiency.
Further problems suggested here are in relation to the benefit principle on the seed restocking concerned from the legal viewpoint.

## INTRODUCTION

The red sea bream is one of the most important commercial fish in Japan.
Japanese people have given special meaning to this fish a folk pun on the words "red sea bream" and " congratulation" in Japanese emphasizes its importance.

This fish symbolizes happiness and is used for celebrations such as weddings or winning a championship. Official statistics indicate that 1953-1980 catches of this fish have declined at 20,000-ton level that is nearly 25,000- ton with the catch from 1960 to 1970.

Sea farming promotion in Japan, arose from a considerable decrease of catches in coastal shallow waters and nursery area for fish larvae and juveniles. This decrease apparently resulted from reclamation of the foreshore for industrial or urban use during the rapid economic growth of the 1970s.
Then water pollution caused by factories and cities is also serious cause of diminished catch. The red sea bream fishery was no exception.

Its catches in the 1970s were about half those of the 1960s. Due to such circumstances, resource recovery projects dependent on culture started.

The prefectural authorities of Kanagawa began stock enhancement of red sea bream in 1978. They released on average 930,000 juveniles a year into the littoral shallow waters of Tokyo and Sagami Bays by 2004. The stock enhancement effect was estimated by tag marking for the first 12 years (1978-1989).

Evidence indicated that the reexamination of marking technique should take precedence over every other problem, and a trial technique applied on 1990 gave effective results. The technique uses differences between natural fish and artificially produced fish in an external character (cutaneous bridge of the nostrils) .

Another interesting aspect of this investigation is the role that stock enhancement plays in sport fishing for the fish concerned. Located near by a big urban area, the coastal waters off is a very popular fishing ground for the sport fishermen, and the red sea bream is naturally their favorite subject. The ninth fishery census (Stat. Inf. Dep., MAFF, 1996)[12] revealed 1992 sport fishing population of 1,120,000, who enjoyed line fishing from party fishing boats off the Kanagawa coast. A questionnaire also indicates that about 140,000 amateurs fished for red sea bream by line in 1990.

This report covers estimate of the release of red sea bream. This estimate comes from being based on data on catches of released fish in the catch by commercial and sport fishing at the coastal waters off Kanagawa Prefecture.

### 1 Fishing condition in Kanagawa Prefecture(1953-1980)

The main methods used to catch red sea bream in the Kanagawa Prefecture area are angling and long line, set nets, gill nets, round haul nets, shore

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seines and small trawler are also used. In the 1960s, the yield was usually 70-90tons (40–136 tons range); catches fell to the 40–ton level in 1970 and rose to the 50–ton level in the early half of the1970s. During the period from 1977 to 1980, catches diminished to "the lowest level" 30 tons. Thus 1977 to 1980 catches constitute only about 0.1% of the domestic total red sea bream harvest (Fig. 1). Being such a

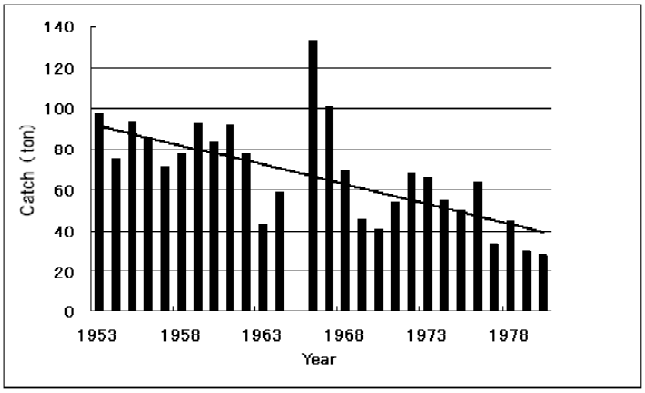



**Fig. 1**. Annual catch by weight ( Catch ;ton) for red sea bream in kanagawa Prefecture from 1953 to 1980

minority, Kanagawa fishermen shipped the fish live, because of the geographical advantage of nearness to cities like the Tokyo metropolis, as well as high market prices of ¥ 4,000–15,000 per kilogram for live fish. Nevertheless poor yield were seriously decreasing their incomes.

## 2 Stock enhancement and marking

Red sea bream in Kanagawa are currently restocked data of 800,000–1,200,000 fish by year up from initial production of 370,000 seeds in 1978.

The general method of red sea bream farming in this region is that spawning is induced in reared parents during the period from late May to early June; fry are cared for in ponds on land until they grow to 12-14 mm in body length and then in cages in the sea up to 6–8 cm. Between late August and early September, they are released to move toward the open sea. Stock enhancement locations are 10–14 stations (Fig. 2, triangle) at 10–20 m depth in Tokyo and Sagami Bays. The number of released fish varies between 50,000 and 100,000 per station.

At the time of stock enhancement, a research boat takes in cages in its hold tank to each station

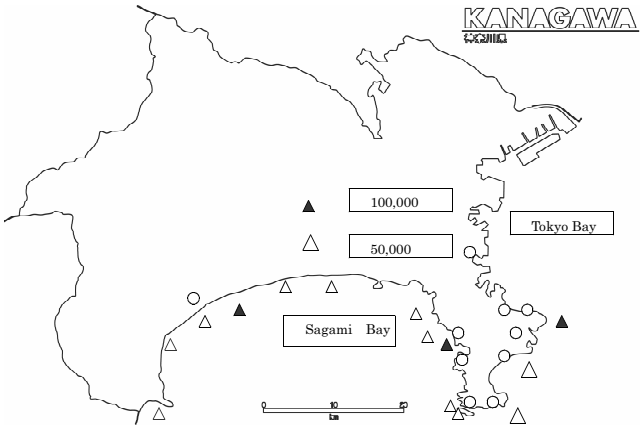



**Fig. 2**. Fourteen stations (triangle) for red sea bream seed restocking and 10 fish markets for sampling survey off the coast of Tokyo and Sagami Bays, figure attached to circle mark

where they are freed with a dip net. For the 12 years mentioned above 5-10% of released seeds were marked with an anchor tag on the dorsal fin base. The aim is to collect information on growth, movement, and recovery by age, as well as on fishing gear through questionnaires to fishermen who recover tagged fish.

These data should provide us with further information on the amount or rate of recapture fish ( Takama, 1986)[13].

The tag-type marking plan was found inappropriate (Kitada, Suda, 1988)[9] for the purpose concerned, because a considerable number of tags dropped off of the sampled fish. Moreover, the questionnaire because less effective, as the recovery reports from fishermen decreased through the years.

Countermeasures since 1990 have included: (1) a new marking technique; and (2) research officers surveying recovery in sampled markets of the landing port, instead of the questionnaires mentioned above. Further details on the newly applied marking technique are given in the next section.

## 3 Follow –up survey for tagged fish

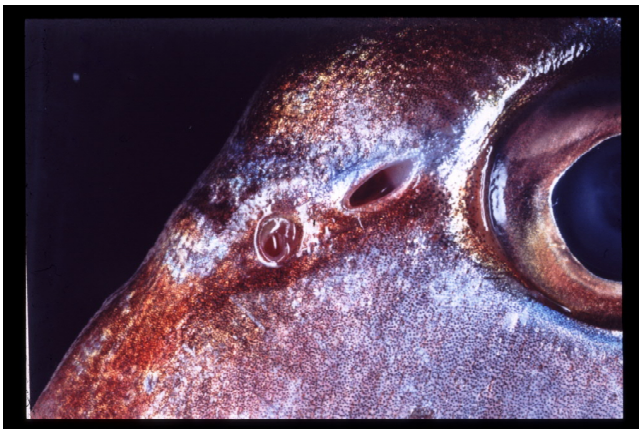
The follow-up survey has progressed in two phases particularly us regards marking.

The first phase was of tag marking, discussed above. The second phase from 1990, depends upon another marking method and on research staff of the experimental station in charge sampling and measuring fish at 10 markets (Fig. 2, circle)

dealing in red sea bream on the Kanagawa coast. The surveyed was conducted twice a week as a rule.

Total numbers sampled were 2, 307, 5, 089, 4, 863, 5, 278 and 6, 592 in the respective years from 1990 to 1994.

The new marking method is based on Goto's (1986) [1] findings on the formation ( Fig. 3 Type B) of the cutaneous bridge of the nostril. The bridge divides the nostril usually into anterior and posterior parts.



Type A

Type B

**Fig. 3.** Formation types (A) found in cutaneous bridge of the nostril in the red sea bream. Type A, normal condition in wild fish. Type B, abnormal condition in cultured fish. (Unpublished after A. Yamazaki and Goto, 1986;modified)

This external character apparently develops under normal conditions in wild fish (Fig. 3 type A). These differences allow us in most cases to distinguish between those two groups. Precisely speaking, the composition of the two fish group in question is not necessarily in proportion to the abnormality in the nostril bridge formation. The interrelationship was adjusted by the examination (Imai, 1996) [4] of the external character on recoveries of fish released before 1990. Catch were 46-74 % released fish in number and 39-65% in weight (Fig. 4) in the 5 survey years 1990-1994.

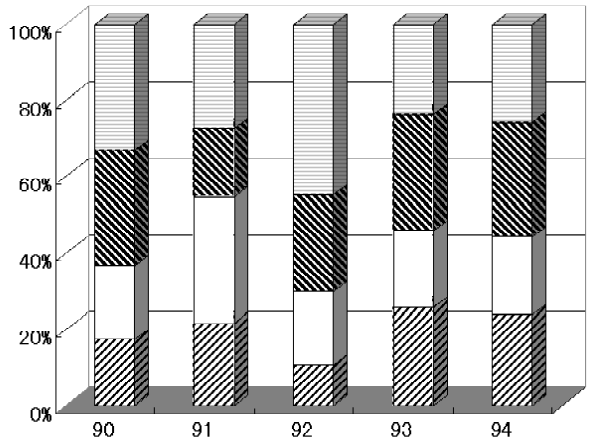



**Fig. 4.** Proportional composition (%) of naturally grown (slash and closed bars) and artificially produced (open bar and open) catches for the years from 1990 to 1994.

## 4 Analysis of commercial and sport catches

Catches are analyzed as follows. The first aim is to determine the catch size of released fish by age. For commercial catches, prefectural catches (in weight) are available by fishing method and for every local fishery cooperative from official statistics issued every year by the regional statistics and information office, MAFF. Data are convertible to catches in number as the quotient of average body weight given by each fishing method. Previous fish market survey provide this weight. Measurement of landed fish makes it possible to estimate size (in length) by age-length key obtained previously from a growth curve of the fish population.

Finally, the recovery catch (in number) by age is calculated from product of gross catch and recovery rate by age.

Sport catches 160 party boats registered for sport fishing in Kanagawa for 1989 were used as the subject to random sampling of daily angling records including fish type, body size, and fishing ground. These data tell us the regional total size and the catch per unit of fishing effort (CPUE), or per capita, by day and by boat. In addition, for the 15 years from 1982 to 1996, 20-40 party boats specialized for red sea bream fishing by amateurs recorded at official request their fishing conditions, that is, fish body size and fishing ground, as well as the number of marked fish and sport fishermen on board.

The CPUE those 15 years was standardized by that in 1989, based on 160 boats' catches. This information used to estimate catch size, particularly in number (Imai et al., 1994)[6] by year as well as by age with the aid of age analysis of the data.

The investigation makes possible the following estimates; (1) catch size by fishing type (Table 1)

**Table 1.** Catch of red sea bream (in number; × 1000) in commercial and sport fishing in watersoff Kanagawa Prefecture for the years 1990 to 1994.

| Year | 90 | 91 | 92 | 93 | 94 |
|---|---|---|---|---|---|
| Commercial | 58 | 81 | 48 | 77 | 64 |
| Sport | 100 | 67 | 90 | 65 | 81 |

for the years of 1990-1994 in Kanagawa Prefecture range between 48,000 and 77,000 for commercial fishing, between 65,000 and 100,000 by sport fishing, and between 145,000 and 167,000 in total; (2) catch weight varied from 103 tons (for 1991) to 124 tons (for 1994), averaging 114 tons; (3) the ratio by weight of the commercial fishery to sport fishing ranges from 75:25 (for 1992) to 57:43 (for 1991) during the 5 years mentioned above, averaging 63:37.

### 5 Effect of the stock enhancement on catches

Recent surveys indicate that sport fishing, rather than the commercial fishery is benefiting from effects of stock enhancement. Before the mass stock enhancement of the fish concerned, the sport catches were estimated at 3.8 tons in 1977 (Kanagawa Agric. Dep. Fish. Sect., 1978).[8] This increased to 82.5 tons in 1989, 12 years after the beginning of the stock enhancement. The commercial catch, however, was of 53.5 tons in 1989 (Fig. 1). As for the sport fishing population in Kanagawa, 930,000 amateurs in 1978 swelled to 1,310,000 in 1987 (Stat. Inf. Dep., MAFF, 1991)[11].

By contrast, the commercial catch indicated no such increase. The average catch (Table 2) was

**Table 2.** Catches (ton) on average and range, and their coefficient of variation (V) in commercial and sport fishing for red sea bream during the 10 years before (1967-1976) and after (1982-1991) the start of stock enhancement.

| | | Before | After |
|---|---|---|---|
| Commercial | Average | 49.9 | 49.2 |
| | Range | 29.1-69.4 | 37.7-64.7 |
| | Variation | 0.207 | 0.157 |
| Sport | Average | 3.8 | 67.4 |
| | Range | | 22.5-103.2 |
| | Variation | | 0.39 |

49.2 tons respectively for the 10 years before and after the starting period of stock enhancement, while the number of fishery management units (Kanagawa Assoc. Agric. For. Stat. 1957-1991)[7] changed from 1,305 to 1,023 between the two decades mentioned above. The sport catches was 3.8 tons in 1977, as indicated above no further information is given for the former decade. It reached 67.4 tons on average for the latter decade. The total catch, then, was 116.5tons.

As already stated, the stock enhancement apparently effected a remarkable increase in the sport catches, while commercial ones have shown little change.

The former catches increased to 21.6 times the quantity before stock enhancement, and 1.8-2.3 times the commercial ones. Strictly speaking, the commercial fishery concerned has not necessarily decreased and may have even augmented its

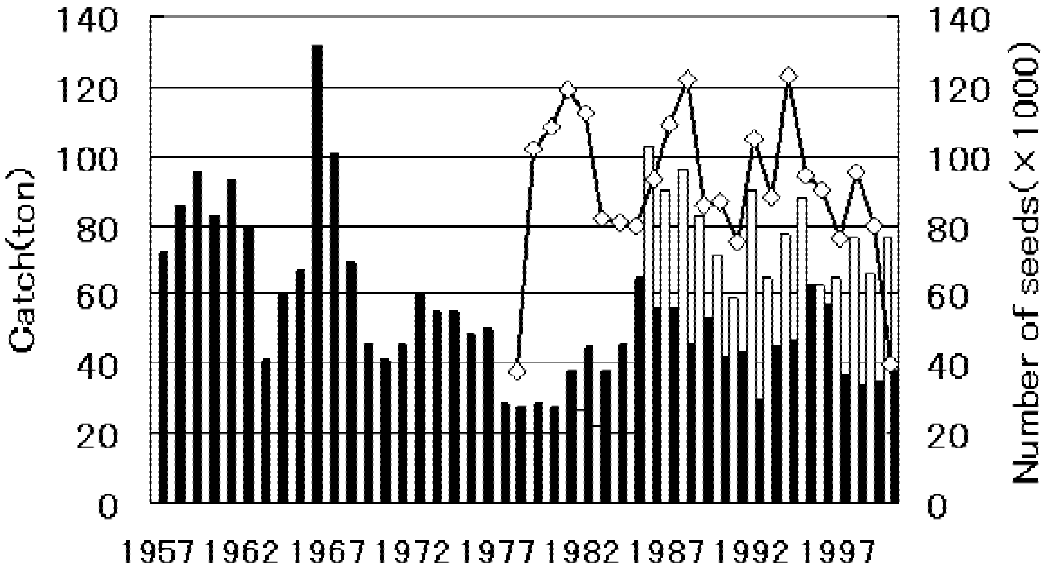


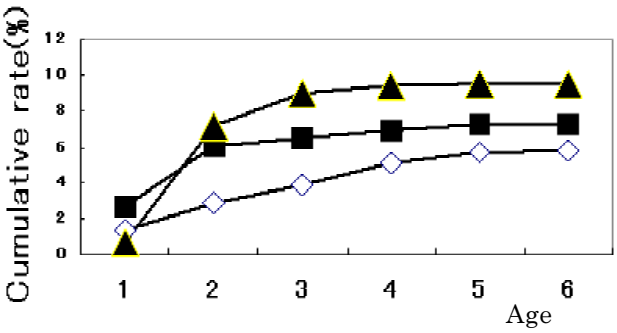

**Fig. 5**. Red sea bream catches in weight (Catches in ton on left scale; bar) and number (Number ×1,000 on the right scale; diamond) of released fish during the period from 1957 to 2000. Bars: closed, commercial catches; open, sport catches

efficiency. As shown above, the catch per a boat unit increased by 1.25 times, and the coefficient of variation went down though a boat units have decreased by 78% at the same time. Finally, the total catches (Fig. 5), which had been decreasing, apparently recovered to the level of preceding the period of rapid economic growth.

### 6 Quantitative effect of the restocking

Recovery records of the stock enhancement for the 5 years are 83,000 (47.1 tons) for 1990, 89,000 (29.8 tons) for 1991, 103,000 (78.1 tons) for 1992, 73,000 (48.0 tons) for 1993 and 67,000 (52.0 tons) for 1994. Fish of ages 2 and 3 were usually dominant.

Cumulative recoveries for a lifetime may be given as for the group released for 1990, which consisted of 886,700 fish. Recoveries were 78,574 (44.5 tons)



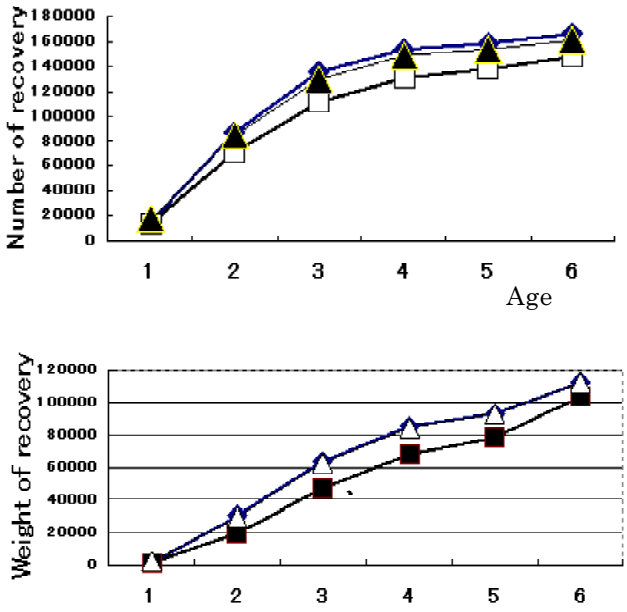




**Fig. 6**. Cumulative rate (% left), number (upper) and weight (kg; bottom) of recovered fish by age (1-6) in groups released for year 1989 (diamond), 1990 (square), and 1991 (triangle). (Imai, 1996;modified)

for the 5 years. When standardized on 100,000 released fish the equivalent (Imai, 1996)[4] is 8,858 (5 tons) (Fig. 6.). This is comparable to estimates given in the Shizuoka ( Hataya & Atsumi, 1987)[2] and Kagoshima ( Shiihara et al., 1980)[10] Prefectures stock enhancement programs.

### 7 Accounting aspects of restocking

Gross expenses for production and stock enhancement of red sea bream comprise operating expenses such as for fish feed, fuel, production implements, rearing cages, labor expenses, and depreciation for equipment. It is estimated totaling as about 40 million yen in rearing 1 million red sea bream seeds.

Net incomes are derived from direct and indirect sources. The release for 1990, mentioned above, should bring a gross income of about 300 million yen, calculated from the product of an average market price (¥ 4,400 /kg) and accumulated recoveries (68 tons), the sum of 26 tons of commercial catches and 42 tons of sport ones, cumulative figures for years since 1995.

Sport fishing in Kanagawa produces an estimated annual income of about 1,050 million yen, assuming that 140,000 users of party fishing boats pay boarding charges of ¥7,500 per person. In the commercial fishery, the fish would produce a gross income of 110 million yen. The red sea bream for stock enhancement, then apparently profit the sport fishing much more than the commercial fishery.

### 8 Problems previewed

Expenses of the stock enhancement project for red sea bream in Kanagawa Prefecture until 1996 were among the national and prefectural governments (75 %) as grantor in aid of the project, fishery operators (12%), keepers (12%) of party boats for sport fishing, and others (1%). The government agencies recently have been considering cutting their subsides and instead emphasize application of the benefit principle. However, this poses complex problems, because the national fishery law defines fish in the sea as completely independent of any proprietorship, and there are disagreements over the allocation of resources between fishery operators and sport fishermen. These problems seem to have arrested the development of sea farming. Countermeasures ( Imai, 1995)[3] may be necessary to laws that invest inland fishery operators with proper rights, and adjusting share to reflect realities by agreement among beneficiaries concerned.

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