# The Japanese Restocking Program

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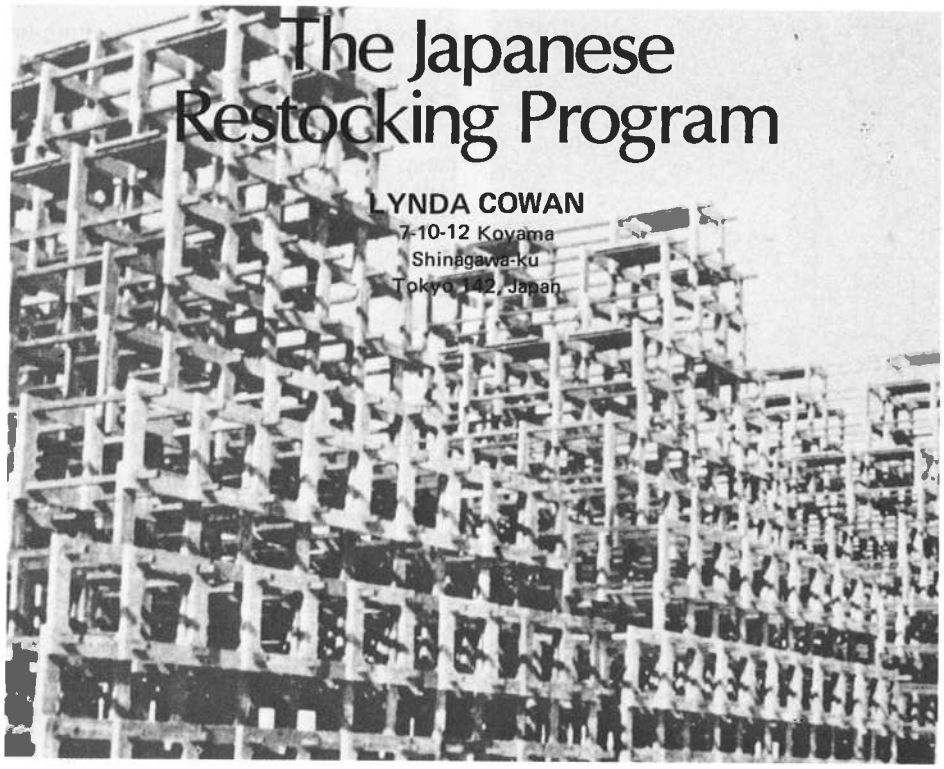


In scale of operations, variety of species produced, amount of financial backing, and degree of popular and official support, the Japanese fisheries restocking program (saibai gyogyo) is unique. From its birth in 1962 when the government established two hatcheries on the Seto Inland Sea, it has undergone continuous expansion. By 1982, some 37 coastal prefectures are scheduled to have sea farming centers operating. Seven national centers have been opened and five more are under construction. There are also 11 other semi-government or private hatcheries.

Although salmon ranching has been practiced in northern Japan for over 80 years, the present program began with kuruma prawn restocking in the Seto Inland Sea, where overfishing, extensive foreshore reclamation and pollution had led to severe declines in catches of several luxury species. The first project aimed at stocking 100 million prawns in the five years to 1970. Just eight years later, Japanese hatcheries were producing 12 million fish seedings (15 species excluding salmon), 470 million crustaceans (five species), 13 million molluscs (ten species) and 800,000 echinoderms (two species), annually, mostly for restocking purposes.

The establishment of a network of hatcheries for fishery restocking is complemented by a ¥200 billion program for development of the coastal environment, including construction of artificial tidelands and reefs, breakwaters and fish-ladders, cleaning of the sea floor, removal of predators and propagation of seaweed beds. Each hatchery complex has cost between ¥300 and 1,600 billion to construct. In 1981, the budget allocation for saibai gyogyo is ¥4.6 billion.

Despite considerable differences in capacity and sophistication of rearing facilities in the various centers, hatchery procedures for most species are standardized. Spawning of broodstock may be natural, e.g., prawns (shrimp), crab and bream, or artificial, e.g., abalone and salmon. Larval feeding regimes for carnivorous species begin with rotifers (preceded by diatoms for kuruma prawn), supplemented later with *Artemia* nauplii, and followed by minced flesh of trash fish, clam and krill, or artificial feed at the early juvenile stages. Water quality is maintained by filtration, aeration and/or mechanical stirring, water exchange, and the action of microorganisms grown in the rearing water, such as marine bacteria and the alga *Chlorella*. Typical survival rates from hatching to harvest of juveniles are 15-30% for prawns, 5-15% for bream, and 10-50% for crabs. After harvest, seedlings are either transferred to an intermediate rearing facility or are stocked directly into the sea.

### Kuruma prawn *(Penaeus japonicus)* restocking

In early restocking trials, prawn fry were released directly into the sea or into shallow pools on the beaches at low tide. Twenty-four hour mortality was found to be almost 50%, with most losses attributable to predation by gobies and flatfish. Intermediate rearing methods were introduced to protect the vulnerable hatchery-bred seedlings from immediate post-release predation while they adopted behavior appropriate to the natural environment, e.g., nocturnalism, food search and capture and burrowing.

In intermediate rearing, the prawn fry are usually stocked at a size of 13-15 mm into net enclosures or artificial ponds in the beach zone, and are released after about two weeks when 30 mm long. Enclosures are first treated with fish poisons to remove predators. Stocking densities are 400-2,000 per square meter. Survival after two weeks ranges from 30% to 80%. Artificial feed is provided daily. Stocking density on the artificial tideland is much lower, about 100 per square meter. Feed is not provided and the fry gradually move out to deeper water as they grow.

Estimation of the contribution of restocking to commercial catches is still fraught with difficulties. Because only larger (5 cm and over) prawns can be tagged, mark-recapture studies give only an approximate recovery rate, in addition to information about dispersal. Hatchery recruits in inshore gill net catches can often be distinguished from wild recruits by size-frequency distribution analyses. For offshore trawl fisheries which catch recruits from many different nursery

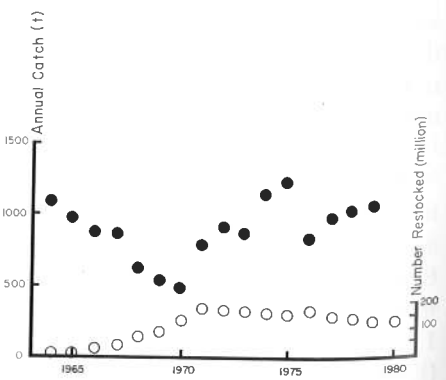



Fig. 1. Apparent correlation between prawn catch and seedlings stocked in the Seto Inland Sea.

grounds, the only method is to examine catch statistics before and after liberation.

Tag-recapture investigations have produced recovery rates of 1-6% for prawns of 5-8 cm size, and 35-41% for large prawns (16 cm and over). Combined data from gill netters and trawlers indicate recovery rates of 0.7% to 5.7%.

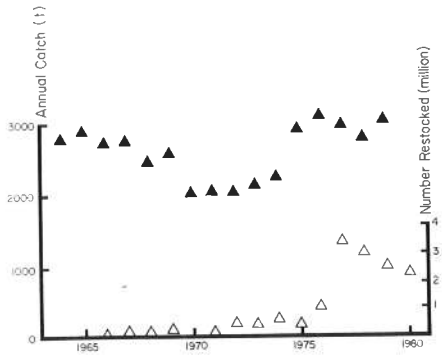



Fig. 2. Increases in catch of red sea bream, attributed largely to restocking.

In Niigata Prefecture, since the start of a restocking program in which the number of seedlings released increased from 90,000 in 1977 to 1.1 million in 1980, the annual catch has steadily risen from 21,000 to 50,000 t, and catch/boat per day is 3.8 times higher. However, as previous catches have fluctuated in the range of 14,000 to 56,000 t, this trend will have to be manifested for several more years before it can be regarded confidently.

Fifteen years of restocking prawns in the Seto Inland Sea has produced the apparent correlation shown in Figure 1.

### Red sea bream *(Pagrus major)* restocking

The restocking program for *P. major* is comparatively small-scale: 1978 seedling production for restocking was 4.3 million, about 1% of prawn seed production. This difference is partly due to the protracted period of intermediate rearing needed for bream. After hatchery rearing to 10-15 mm size, the fish fry are maintained for 3-4 weeks in floating net cages in the sea until they reach 2-3 cm, the minimum restocking size. Some are reared for further 3-6 months and are tagged at a size of 8-10 cm before release. Pelleted food is given throughout the intermediate rearing period. Survival of up to 63% has been reported. Intermediate rearing of fry has also been done in converted salt fields and in a fenced-off bay. In the latter case, acoustic conditioning was used to lure the fish out of the bay to over-winter in deeper water.

A 4-year mark-recapture investigation by five Inland Sea prefectures recovered 8% of 206,000 released fish or their tags. Other recoveries based on size-frequency data ranged from 20% for second-year fish, to 16% for third- and 5% for fourth-year fish.

The sea bream population in the Inland Sea has been estimated at 1.6 to 2.3 million fish. From 1970 to 1974, annual catches were at their lowest level ever, about 2,000 tons. In 1975, restocking was intensified and annual catches soon exceeded the pre-1970 levels, as shown in Figure 2. This rapid rise was not observed in other areas of Japan and is attributed largely to the restocking program. However, even with the use of the most optimistic recovery rates, the maximum contribution of hatchery output to annual catches is only 1.4% in terms of tonnage.

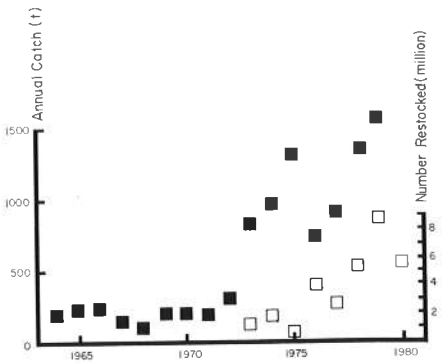



Fig. 3. Blue crab catch shows a relationship with seven years of restocking the Inland Sea.

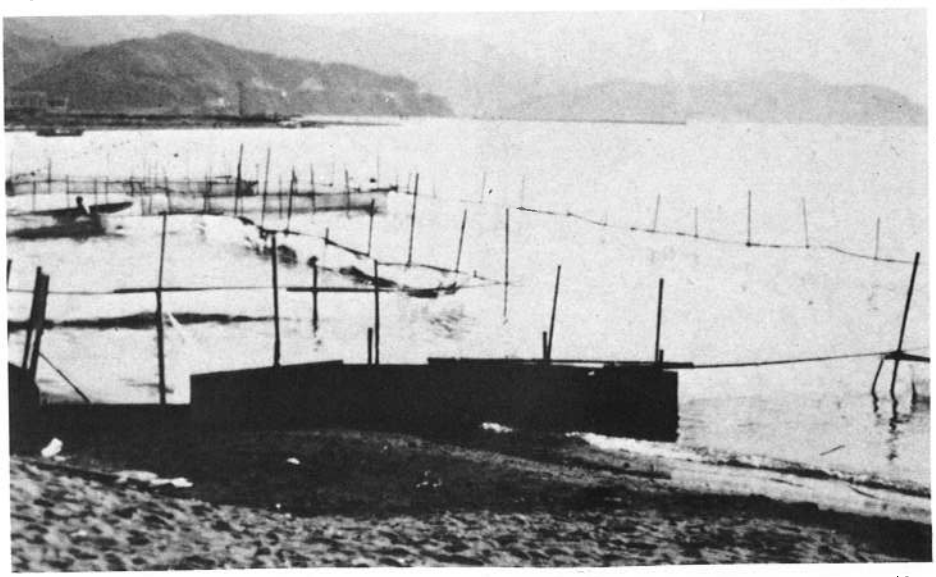
## The restocking program shows every sign of becoming a permanent integral part of Japanese fisheries.

To produce an increase distinguished from natural fluctuations, 5 to 10 million seedlings would have to be restocked annually in the Inland Sea alone.

### Blue crab *(Portunus trituberculatus)* restocking

Intermediate rearing of blue crab seedlings is complicated by the aggressive nature of this species. Even at moderate densities and high food levels in hatchery rearing, cannibalism can eliminate 50% of juvenile crabs during molt periods. To reduce mortality during transportation and intermediate rearing of the seedlings, lengths of 'kinran'—nylon rope interwoven with thousands of shorter strands—are provided as refuge.

Intermediate rearing facilities include artificial tidelands, ponds and canvas tanks on land, intertidal net-fence enclosures and net baskets, and rafts with suspended kinran ropes. The early, juvenile-stage crabs are usually held for 2 weeks before release. Survival in the ponds, tanks, net



Simple net enclosure for intermediate rearing.

baskets and enclosures ranges from about 30% to 56% while survival and movement of crabs in the open raft and tideland systems are still not clear.

A 2-year tagging study on large (9-17 cm) crabs produced recapture rates of up to 22%. But such studies are hampered by the lack of a suitable tag that will last through more than one molt. Reasonably distinctive size-frequency patterns for restocked crabs in the western end of the Seto Inland Sea permitted researchers there to calculate 1979 recovery rates, which were 4-13%, and to infer restocked proportions of the annual catch in the region, at 49% to 87%. Figure 3 shows an apparent relationship to annual catch during the seven years in which crab restocking has been carried out in the Inland Sea.

**Value of the restocking program**

Considering the billions of yen that have been committed to this scheme, the as-yet inconclusive nature of the returns for the first 10 to 15 years of restocking may seem surprising. However, the general consensus within the organization is that it is still early in the era of the saibai gyogyo; in the meantime, all efforts are directed at overcoming immediate problems. These efforts include the development of techniques of mass production for new species such as spanish mackerel, squid, tuna and king crab; improvement of intermediate rearing methods; the search for effective tags for the juvenile stages, and cooperative multi-prefecture follow-up surveys of migratory species.

Using available recovery rates, some tentative cost-benefit studies have been attempted. The net profit per individual prawn restocked at Aijo, Shikoku, is estimated at ¥5 for gill netters and ¥20 for offshore trawlers. Profit per-fish for bream in Oita Prefecture is ¥214. For crabs in the western Seto Inland Sea, a model has been developed relating rearing costs, market price, recovery rates and break-even points, which shows that a recovery rate of only 1.2% would be sufficient to break even.

Photos by Lynda Cowan.

*From top:* Direct stocking at Okayama. 'Kinran' and polytank for transporting seedlings. Production of *Artemia* nauplii for food during larval rearing at Fukui. Modern prefectural hatchery at Aichi. Indoor abalone rearing tanks. *Above photo* shows the intermediate rearing pen with framed nets at Fukui. All signs point to the Japanese restocking program becoming an integral part of the country's fisheries.

Although recent catch increases may have been partially due to other factors such as environmental improvement, the Japanese fishing industry in general is convinced of the potential benefits of restocking. Not surprisingly in a nation dependent on the sea for 50% of its protein, the impressive new hatcheries have come to acquire considerable political value. Thus, the saibai gyogyo program shows every sign of becoming a permanent integral part of Japanese fisheries. ○