

RESTOCKING, STOCK ENHANCEMENT AND SEA RANCHING: ARENAS OF PROGRESS

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Tremendous progress has been made in farming aquatic species. Aquaculture of marine, brackish and freshwater species has grown steadily at ~9% per year during recent decades, resulting in global aquaculture production exceeding 45 million tonnes, worth more than US\$ 63 billion, in 2004 (FAO 2006). In the case of marine and brackish water species, the number of taxa farmed increased from 150 in 1984 to >260 in 2004. The increase was due to improvements in breeding and larval rearing, and advances in offshore aquaculture.

Increased aquaculture production is predicted to result in 50% of fish consumed being farmed, and to increase global per capita fish consumption to 16 kg/yr by 2020 (Delgado et al. 2003). However, recent trends in exploitation of capture fisheries, which have seen catches increase from 63.4 million tonnes in 1974 to 96.5 million tonnes in 2004, raise concerns about the capacity of wild fisheries to meet the remaining demand for fish. Current catch levels may not be sustainable without interventions to improve production and management. Of particular concern is the fact that although the percentage of fully exploited stocks remained at ~50% between 1974 and 2003, the percentage of over-exploited, depleted or recovering stocks increased from ~10% to 28%, and under- to moderately- exploited stocks decreased from ~40% to 24% (FAO 2004). Restoration of over-exploited and depleted stocks, and increased resilience of fully exploited stocks, will help secure production from capture fisheries.

The application of aquaculture technology through responsible restocking, stock enhancement and sea ranching programs (Blankenship and Leber 1995) are among the measures with potential to increase production for some capture fisheries (Bell et al. 2005, 2006). However, these relatively new fields of fisheries science and management have yet to overcome all the challenges involved. These challenges include: identifying when and where to use restocking, stock enhancement, and sea ranching to add value to other forms of management; integrating these initiatives with institutional and fisheries management regimes; monitoring the success of the interventions; producing cultured juveniles cost-effectively; and releasing them in the wild so that they survive in high proportions (Blankenship and Leber 1995, Bell et al. 2005, 2006). There is increased awareness that simply releasing large numbers of fish without addressing these challenges is unlikely to have the desired result. However, development and research agencies need to ensure that this message continues to be disseminated widely.

We outline the lessons learned from restocking, stock enhancement, and sea ranching initiatives over the past 30 years and summarise the main arenas of progress (Table 1). We describe initiatives that promise to improve the application of restocking, stock enhancement and sea ranching. These include: programs in China; identification of the species/situations best suited to release of hatchery-reared juveniles; interventions to increase fish production in addition to releasing juveniles, e.g., relocation of wild juveniles and adults from areas of poor survival or slow growth to more productive areas, and addition of nutrients to coastal waters; improvements to the management of broodstock; efficiencies in rearing juveniles in hatcheries; new ways to collect and rear wild juveniles to bypass survival bottlenecks at settlement; and advances in tagging methods to assess the effectiveness of these activities.

Table 1. Arenas of progress and actions underway to meet the challenges of restocking, stock enhancement and sea ranching.

Arena of progress	Action (Examples of species/countries)
Decision making and fishery management	Stock delineation and genetic population structure (Pacific salmon/North America, crabs/Japan)
	Modelling to predict benefits of releases, e.g., Enhancefish
	Base releases on carrying capacity (flounder/Japan, mulloway/Australia)
	Promote restoration of critical nursery habitat (shrimp, sea bream/Japan)
	Integrate stocking, restocking and sea ranching into comprehensive biological and social management system (Sweden)
	Involve local fishers/community and establish co-management (seabass and sea bream/Italy; giant clams/Philippines; Freshwater species/Asia;)
	Promote natural recruitment using rotational fishing and no-take zones (Scallops Japan/New Zealand, sea cucumber/Pacific)
	Limit access and promote ownership and incentives for stock enhancement (Invertebrates/Japan, scallops/New Zealand)
	Eco-system approach (Oysters/ USA; carps/Asia)
Monitoring and evaluation	Improved tagging (Pacific salmon/North America)
	Genetic marking (flounder, black sea bream/Japan)
Reducing the cost of juveniles	Development of methods for collecting wild postlarvae (spat) and juveniles (Scallops/Japan and New Zealand; spiny lobsters/Australia, Caribbean)
	Combined culture of juveniles for aquaculture and stock enhancement (Shrimp/Japan, China)
Improving survival of juveniles released in the wild	Reduced predation through predator removal, customised release habitats and increased size at release (Scallops/Japan; abalone/Australia; giant clams, sea cucumbers/Pacific, finfish/USA)
	Improved husbandry (Sea cucumbers and giant clams/Asia and Pacific; red sea bream/Japan)
	Identification of critical nursery habitat (Shrimp/Japan, Australia, sea cucumbers/Pacific)
	Improve disease diagnosis and fish health (Atlantic salmon/Baltic Sea)

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