

Bahrain fish stock enhancement: lessons learned and prospects for the future

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Introduction

Stock enhancement

The concept of increasing or re-establishing fish and invertebrate populations through ocean ranching has been considered for many years (Kafuku, 1986; Yamaguchi, 1988).

Results from stock enhancement programmes have varied. In Japan, 8 per cent of 206,000 tagged red seabream were recovered (Cowan, 1981). For blue crab, the recapture rate was 22 per cent. By the early 1980s, Japan had been involved in stock enhancement for about 15 years with annual expenditure reaching about US\$ 40 million (Preston & Tanaka, 1990). However, results were still inconclusive. In many cases, there was no demonstrable effect on harvest, despite years of restocking efforts.

In Norway, cod stock enhancement studies resulted in survival rates from 13 to 32 per cent (Svaasand & Kristiansen, 1990b). Released cod represented between 21 and 61 per cent of the entire cod population of a fjord (Svaasand & Kristiansen, 1990a).

There are several key issues when a stock release programme is being considered (see Preston & Tanaka, 1990; SPC Secretariat and the FAO South Pacific Aquaculture Development Project, 1990; Naevda & Joerstad, 1983; and Thorpe, 1986):

1. Stock enhancement is not a substitute for fisheries management;
2. Knowledge of the biology and culture technology of a species is critical to the success of stock enhancement;
3. The impacts of stock enhancement programmes may be insignificant or can be extremely difficult to assess;

4. Stock enhancement programmes can affect the gene pool of wild stocks;
5. There can be complications when exotic species are introduced as part of any stock enhancement programme;
6. Stock enhancement programmes can be very costly and absorb major resources.

Bahrain fisheries situation

Overall fish landings have fluctuated over the years, but the situation appears to be rather stable (Fisheries Statistical Service, 1996). However, landings and catch-per-effort estimates for certain preferred species suggest that these resources are being overfished. This is especially evident with species such as grouper, shrimp and Spanish mackerel.

The major difficulty in Bahrain's fishery is the level of illegal fishing (Directorate of Fisheries, 1993). Regulations are in place, but enforcement of regulations and compliance have been negligible.

National Mariculture Center (NaMaC)

Hatchery technologies are currently being developed and refined at the National Mariculture Center (NaMaC) at Ras Hayan (Shams & Uwate, 1996). Species undergoing hatchery and grow-out trials include: grouper (hamoor), *Epinephelus coioides*; two species of seabream (shaem), *Acanthopagrus latus* and (sobaity) *Sparidentex hasta*; and rabbitfish (saffee), *Siganus canaliculatus*. NaMaC fish fry production between 1994 and 1996 is presented in Table 1.

Grow-out capacity of NaMaC is limited. Starting in 1994, hatchery production exceeded grow-out requirements. This provided the resources necessary to initiate trial fish releases.

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Table 1: Number of fingerlings released in Bahrain, 1994–1996

Year	Fry produced		
	Grouper <i>Epinephelus coioides</i>	Rabbitfish <i>Siganus canaliculatus</i>	Seabream <i>Acanthopagrus latus</i>
1994	31,400	4,000	17,000
1995	11,000	59,000	0
1996	12,000	59,000	120,000
Total	54,400	122,000	137,000

Table 2: Number of fish released in Bahrain, 1994–1996

Year	Nos of fingerlings released		
	Grouper <i>Epinephelus coioides</i>	Rabbitfish <i>Siganus canaliculatus</i>	Seabream <i>Acanthopagrus latus</i>
1994	10,000		7,000
1995	10,000	300	3,000 *
1996	8,250		116,000
Total	28,250	300	126,000

* fish produced in 1994 and kept over winter prior to release

Bahrain fish releases

1994

The objective of the 1994 fish-release efforts was to develop and refine procedures for future large-scale fingerling releases (see Uwate & Al-Ansari, 1994). Youth volunteers completed pelvic fin clips on 7,000 seabream (shaem) and 8,000 grouper (hamoor). In 1994, fish were transported by towed barge in 1 tonne fibreglass tanks with oxygen aeration. About 17,000 fish were released in 1994 (Table 2).

Several key issues became apparent during 1994 fish-release trials (Uwate & Al-Ansari, 1994): (1) fish releases should be completed when water temperature is not extreme (not above 35°C); (2) outboard engines broke often when speedboats were used to tow the barge; (3) transport of 1,000 fingerlings with a 1 tonne aerated fibreglass tank resulted in almost 100 per cent survival; and (4) public cooperation was critical to the success of this project.

Interestingly, in 1994 the Directorate of Fisheries received informal reports that some fishermen were actually catching and selling large quantities of grouper fingerlings to the consumer market. This was done despite a media campaign during fish releases.

1995

The 1995 fish-release objective was to demonstrate that fish releases can be routinely accomplished by the Directorate of Fisheries (Uwate et al., 1996). Observations of 1994 fin-clipped fish indicated that fins grew back in four to six months. In 1995 youth volunteers tagged 3,000 shaem with plastic anchor tags. Since grouper prefer caves and rocky areas (where tags could catch), groupers were not tagged. A total of 13,300 fish were released in 1995 (Table 2).

Lessons learned in 1995 (Uwate et al., 1996) included: (1) truck transport and release was quick, but bucketing fish from the truck to the sea was dif-

ficult and hazardous; (2) boat and barge transport was more reliable when lower boat speeds were used; and (3) public cooperation was again very helpful in the success of 1995 releases.

1996

In 1996, the objective of fish-release activities was to refine technology and demonstrate that large-scale fish releases could be completed by the Directorate of Fisheries (Al-Hendi et al., 1996). The quantity of fish released in 1996 was almost 10 times that moved in previous years (Table 2). Fish were not marked in 1996 because: (1) there was no budget for fish release; (2) time available for release was very short; and (3) facilities and resources (feed, water, manpower) for fish grow-out were extremely limited.

As in the past, public cooperation was very helpful in completing this project (Al-Hendi et al., 1996). For two of the grouper releases, a private boat was used (at no government expense). Most of the fish releases were done using a six-wheel truck. The problems of releasing fish by bucket were overcome by attaching one or two 6 in diameter PVC pipes to the flex hose on the truck tanks. Fish could then be flushed directly into the sea.

Effects on landings

One key question about any fish-release programme is: does it increase fish stocks and fish-landings? Since there has never been any project budget for fish releases, modern fish tagging technology could not be applied. The Directorate of Fisheries routinely sends staff to record fish landings (for its annual statistics report). Some anecdotal reports have been received of large quantities of small grouper and shaem entering the market just after fish releases.

More recently, a model for grouper landings was proposed and constructed (Radhi, draft). Linear and quadratic time-series analyses were completed applying the multiplicative decomposition model (including seasonal, trend, cyclical, irregular components). The quadratic time-series model generated closely resembled grouper landings from 1980 to 1994. Thus it was considered a good model.

Since fish releases started in mid-1994, a six-month delay was assumed prior to impact of released fish (Radhi, draft). Using the above model, landings for January 1995 to June 1996 were projected and were compared with actual landings (from the Fisheries Statistical Services database). For this post-release period, actual grouper landings were always higher than those projected by the model. This sug-

gests that for grouper release, there has been a positive impact on the fishery, especially, on landings.

Costs and benefits

Another critical issue for any fish-release programme is: how do the costs of the programme compare with the benefits? It is not appropriate if it costs \$ 10 to grow and release a fish, which is harvested and sold for \$ 5.

Prior to initiating a fish-release project, it is possible to estimate costs and benefits. Production and fish-release costs can be reasonably estimated based on hatchery experiences and appropriate budgets for transporting fish.

However, estimating the benefits of fish releases is very difficult. Even with sophisticated fish marking and landing surveillance, it is difficult to detect effects of increased landings, let alone quantify benefits. What is the value of the additional fish? Is it based on the landed or retail market price? the value of a recreationally caught fish? the value to the local economy? or a societal value? As noted above ('Stock enhancement'), even some large stock-enhancement programmes have yet to show any impact or benefits.

In Bahrain, there has never been any additional or supplemental funding for the fish-release programme. In addition, until 1995, there were no additional funds available to operate the National Mariculture Center. NaMaC and fish-release costs were all supported by the internal annual budget of the Directorate of Fisheries. This budget has been stable for the last few years. The only way these major activities have been supported has been by reallocation of resources within the Directorate of Fisheries and by more efficient utilisation of existing resources.

As additional large-scale fish releases are completed in Bahrain and effects to the fishery are measured and documented (as in Radhi, draft), it will be possible to quantify and value the economic benefits of the Bahrain fish release programme.

Discussion

Over the last few years, NaMaC has demonstrated that it can mass-culture key fish species. In addition, the Directorate of Fisheries has demonstrated that it can transport and release fish anywhere in Bahrain and its adjacent waters. Fish mortality during transport is very low, in most cases zero. Public support, in the form of volunteers, has been extremely valuable in achieving success with this project.

Like artificial reefs, stock-enhancement programmes should be considered within the broader issue of fisheries management (Shams & Uwate, 1996). Stock enhancement is just one tool available to fisheries managers. In isolation, it will not cure an overfished fishery, or compensate for structural problems within a fishery.

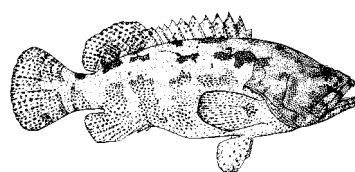
In Bahrain, a major marine resource issues is illegal fishing (Directorate of Fisheries, 1993). Given the magnitude of illegal fishing activities, the benefits of even large-scale fish-release programmes may be compromised. Efforts continue to address this problem.

Finally, as large-scale fish releases continue and more information becomes available, it would be appropriate to assess the costs and benefits of the fish stock enhancement project in Bahrain.

References

- AL HENDI, H., M.H. MANSOOR, J-Y. LU, K.R. UWATE, AND E.A. AKBARI. (1996). Bahrain Directorate of Fisheries' fish release activities in 1996. National Mariculture Centre, Directorate of Fisheries, Ministry of Works and Agriculture, State of Bahrain. 6 p.
- COWAN, L. (1981). The Japanese restocking program. ICLARM Newsletter, October 1981, 14–16 (cited in Preston & Tanaka, 1990).
- Directorate of Fisheries. (1993). Survey of fishermen in Bahrain. Ministry of Commerce and Agriculture, Bahrain. 27 p.
- Fisheries Statistical Service. (1996). Annual Statistics Report 1995. Directorate of Fisheries, Ministry of Works and Agriculture, State of Bahrain. Technical Circular No. 64.
- KAFUKU, T. (1986). How to carry forward aquaculture projects in the Pacific: a proposal. Fifth Expert Conference for Economic Development in Asia and the Pacific. Asian-Pacific Development Center, Tokyo.
- NAEVDA, G. & K.E. JOERSTAD. (1983). Importance of genetics in the propagation of cod. In: Dahl, E., D.S. Danielssen, E. Moksness, and P. Solemdal (Eds.). The propagation of cod *Gadus morhua* L. An international Symposium, Arendal, Norway. 14–17 June 1983 (cited in ASFA). 733–743.
- PRESTON, G.L. & H. TANAKA. (1990). A review of the potential of aquaculture as a tool for inshore marine invertebrate resource enhancement and management in the Pacific Islands. Paper presented to the South Pacific Commission's 22nd Regional Technical Meeting on Fisheries, Noumea, New Caledonia, 6–10 August 1990. SPC/Fisheries 22/IP.5. 22 p.
- RADHI, A-K. (draft). An assessment of orange spotted grouper, *Epinephelus coioides*, landings before and after trial fish releases in Bahrain. Fisheries Statistics Section, Directorate of Fisheries, Ministry of Works and Agriculture, State of Bahrain. 22 ms p.
- SHAMS, A.J. & K.R. UWATE. (1996). Bahrain fish release activities: 1994 to present. Directorate of Fisheries, Ministry of Works and Agriculture, State of Bahrain. 10 p.
- SPC Secretariat & the FAO South Pacific Aquaculture Development Project. (1990). Enhancement of Pacific Island invertebrate fisheries by restocking. Paper presented at the South Pacific Commission's 22nd Regional Technical Meeting on Fisheries. Noumea, New Caledonia, 6–10 August 1990. SPC/Fisheries 22/WP.25. 5 p.
- SVAASAND, T. & T.S. KRISTIANSEN. (1990a). Enhancement studies of coastal cod in western Norway. Part 3. Interrelationships between reared and indigenous cod in a nearly landlocked fjord. J. Cons. Ciém. 47(1): 23–29. (cited in AFSA)
- SVAASAND, T. & T.S. KRISTIANSEN. (1990b). Enhancement studies of coastal cod in western Norway. Part 4. Mortality of reared cod after release. J. Cons. Ciém. 47(1): 30–39. (in ASFA).
- THORPE, J.E. (1986). Salmon enhancement: stock discreteness and choice of materials for stocking. In: D. Mills and D. Piggins (eds). Atlantic salmon: planning for the future. Proceedings of the Third International Atlantic Salmon Symposium. Biarritz, France, 21–23 October 1986. (cited in ASFA). 373–388
- UWATE, K.R. & A. AL-ANSARI. (1994). Trial release of hatchery reared grouper, *Epinephelus coioides*, & yellow-finned black seabream, *Acanthopagrus latus*, in Bahrain's waters: 1994. Directorate of Fisheries, Ministry of Commerce and Agriculture, State of Bahrain. 9 p.
- UWATE, K.R., H. MAGHANI & E. AKBARI. (1996). Bahrain Directorate of Fisheries' fish release activities for 1995. Directorate of Fisheries, Ministry of Works and Agriculture, State of Bahrain. 9 p.

YAMAGUCHI, M. (1988). Transplantation and marine ranching/farming of inshore resources on coral reefs. SPC Fisheries Newsletter No. 46. South Pacific Commission, Noumea, New Caledonia.



Grouper spawning aggregations need protection

by R.E. Johannes

Many coral reef food fishes aggregate in large numbers at specific locations, seasons and moon phases in order to spawn. Such fishes include groupers, the main objects of the live reef food fish trade.

These aggregations are prime targets for fishers, who often take large catches from them. Groupers have been virtually eliminated by overfishing in at least five Pacific Island locations within Palau, the Cook Islands, the Society Islands, the Tuamotus, and on the Great Barrier Reef. Fishing over spawning aggregations at three of these locations has been specifically implicated in their demise. It may also have been a factor in the other two cases.

One aggregation fished by Palauans for centuries was eliminated by a live reef fishing operation in just three years. It is very likely that a great many other aggregations of groupers have been eliminated without written record because the slowness with which Indo-Pacific marine biologists have recognised and acted upon the need to locate, characterise and protect them, even although descriptions of their importance and vulnerability have been in the scientific literature for almost 20 years.

Although details are hard to come by in many areas, it is clear that grouper spawning aggregations are under increasing pressure because of the live reef food fish trade and because of the ease today with which aggregation sites can be pinpointed and relocated with global positioning systems. In the Solomon Islands one Hong Kong company was even described by an ex-employee as using spotter planes and expert Chinese fishermen to locate likely grouper spawning sites using reef topography.

Accounts obtained from fishers in the Philippines and Indonesia reveal that they, also, are discovering increasing numbers of grouper spawning aggregations as the depletion of shallow-water resources forces them to dive deeper and further from shore.

One group of Indonesian fishers said they got such high catches from spawning aggregations they recently discovered that they no longer bother to fish for the trade during the non-spawning season. Such fisheries are not sustainable.

Marine resource managers should consider banning fishing on grouper spawning aggregations for a second reason. Gravid females are reportedly subject to significantly higher mortalities during shipment. (Most shipped groupers are females because they are the ones in the size range preferred by restaurants.)

The fish are treated with the anaesthetic MS222 prior to air shipment. This often causes gravid females to release eggs into the water of the shipping containers. The eggs clog their gills and probably also remove oxygen from the water. This appears to be one of the reasons for the higher mortalities, according to shippers, even among fish that are in prime condition.

Reducing transport mortality is in everyone's interests; every fish that dies means another must be caught to supply consumer demand for live fish. Some Australian live reef fish companies operating on the Great Barrier Reef have recognised that targeting of spawning aggregations is not in their own long-term best interests and actively support closing the fishery during spawning months.

The most widely discussed marine conservation measure in shallow tropical waters is the marine reserve. Proponents often assert that the most important function of marine reserves is to protect spawning stock biomass and ensure recruitment to fished areas by means of larval dispersal.

Clearly, for that reason, the boundaries of such reserves should, wherever practical, encompass spawning aggregation sites. There is little evidence in the literature, however, that spawning