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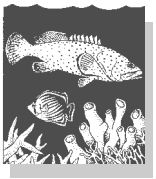

Wild collection of juveniles for grouper mariculture: just another capture fishery?

by Yvonne Sadovy[1] *& Jos Pet*[2]

Heavy fishing pressure in Southeast Asia has led to declines in fish catches and overexploitation of many demersal fish stocks, yet demand for fish is projected to grow rapidly, especially in certain sectors such as the high-value live reef-fish trade (LRFT) (e.g.- Johannes & Riepen, 1995; Sadovy, in press). Mariculture is viewed as one possible way of relieving pressure on fish stocks, as well as a means of filling the increasing demand–supply gap for marine fishes (Williams, 1996). In discussing the contribution of aquatic resources to global food security, however, Williams (1996) cautions that 'There is potential for aquaculture to make a large contribution to world food supply, but only if it is environmentally sustainable'.

Most fish culture in Southeast Asia is based on the collection of juveniles (fry or fingerlings) from the wild and their grow-out in captivity to marketable size. Fish production based on grow-out is generally considered, for statistical and management purposes, to represent 'mariculture', rather than 'capture fishery', production, even though juveniles are taken from the wild, because there is intervention (feeding) in the rearing process to enhance production (e.g. the Food and Agriculture Organization). The possible impacts on stocks of the removal of juveniles from the wild for mariculture, and whether or not production is actually enhanced through this kind of mariculture practice, are rarely considered. This is despite general concerns that 'For too long fisheries and aquaculture have been treated as sectors in isolation, a practice that has ignored important linkages and externalities' (Williams, 1996). We need to examine some of these linkages.

A critical question is whether mariculture practices based on the capture of juveniles from the wild are sustainable, or could be modified to become so. We examine these questions using groupers as an example, because groupers are widely cultured in the region, and are highly desired and valued in the LRFT. They are also among the most vulnerable of the reef fishes to exploitation (e.g. Huntsman et al., 1993; Sadovy, 1996).

In pelagic spawning (in which eggs are released and then drift away) fishes, such as the groupers, early natural mortality rates must be extremely high between egg production and settlement (when young fish change from their planktonic to their benthic phase). This follows from the fact that, in her lifetime, each female is capable of producing millions of eggs but will, on average, only produce two young that survive to adulthood under stable population conditions. What is not known is where the bulk of this early natural mor-

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tality occurs. If natural mortality remains high for some time after settlement, then the removal of young juveniles for mariculture grow-out may have little impact on adult stocks, because most juveniles taken would otherwise perish due to natural causes. If, on the other hand, early natural mortality rates have dropped to low levels *prior* to juvenile capture, then fishing mortality will represent an important source of total mortality (which is fishing mortality plus natural mortality). If this is the case, such capture may not be sustainable and should be managed as a capture fishery. What do the existing data indicate about early natural mortality rates in reef fishes?

Natural mortality drops rapidly during the early post-settlement period in tropical reef fish, i.e. several weeks or months following settlement. In juvenile gag grouper (*Mycteroperca microlepis*), for example, which settle into seagrass beds in the Gulf of Mexico, survivorship in the first three months following settlement is highly variable, but can reach 100 per cent (Koenig & Colin, in press). In non-grouper reef species, mortality rates vary markedly but, overall, they drop quickly; of 17 species examined for the first 45 days after settlement, the highest levels of mortality occurred in the first one to two weeks with substantial drops in mortality after the first month (Sale & Ferrell, 1988; S. Holbrook, pers. comm).

In New Zealand's lobster fishery the relationship between the number of puerulus (i.e. settlement) stage lobster and adult stock size is acknowledged through recently enacted legislation, which imposes a quota system for puerulus collections because of their presumed impact on adult stock size (Michael Riepen, personal communication). In sum, these examples strongly suggest that post-settlement mortality drops within a few weeks or months of settlement on a reef across a wide range of species and, moreover, that harvest after this early period can negatively influence subsequent stock size.

The sizes of grouper juveniles taken for mariculture range from 20 to 120 mm total length (TL), depending on location, species, time of year, and capture method used, among other factors (Sadovy, unpubl. data). Juvenile grouper settle at about 20–25 mm TL and data on their early growth rates indicate these to be about 10 mm/month (e.g. Beets & Hixon, 1994; Sadovy et al., 1992; Light & Jones, 1997).This means that fishes taken for culture may be anything up to a year old at capture and, therefore, that many are probably taken well beyond the early weeks or months post-settlement. If this is the case, then fishing mortality represents a substantial proportion of total mortality and the fishery should be managed to avoid overfishing.

It could reasonably be argued that, if current juvenile collection methods are unsustainable, juveniles could be caught at an earlier stage, for example as they settle out from the plankton. It may indeed be possible to develop such techniques for groupers (e.g. Vincent Dufour, pers. comm.). However, some species of grouper evidently settle out of the plankton over very limited time periods each year, often into quite specific habitats (Shenker et al. 1993; Doherty et al., 1994). It is possible, therefore, that heavy targeting at such times or places may threaten local stocks, because annual recruitment pulses are so spatially and temporally concentrated that a substantial proportion of the annual recruitment into a particular area could be removed. In sum, we need to understand much more of the biology and population dynamics of target species before advocating the introduction of techniques that are potentially harmful.

It has also been proposed that artificial habitats might enhance the survivorship of settling juveniles by providing supplementary shelter, thereby increasing net survivorship through protection from predation. The critical question here is whether natural mortality is reduced by artificial habitats such that the 'excess' survivors, i.e. the juveniles that would otherwise have perished, can be harvested, or, alternatively, whether artificial habitats attract significant numbers of juveniles that would otherwise settle successfully in natural habitats thereby increasing total mortality.

To understand the basis for fishery production and to evaluate possible ways of improving it, two key questions must be resolved: (1) are fish stocks recruitment (or habitat) limited, i.e. limited mainly by the number of fish settling out of the plankton (e.g. Doherty & Williams, 1988; Lewin, 1986), or, alternatively, by sufficient shelter (habitat) to allow recruits (settling fish) to survive after settlement (e.g. Smith & Tyler, 1972), and (2) *if* populations are habitat-limited, do artificial habitats increase survival or simply concentrate recruits making them easier to catch. These are difficult but important questions that must be addressed rigorously before promotion of large-scale implementation of artificial habitats is advocated as a possible means of enhancing fishery production. Evidence for increased survival conferred by artificial habitats is limited, and their possible role in fisheries enhancement, in general, remains controversial (Bohnsack, 1989).

One harvest method which may enhance survivorship of settling juveniles (i.e. allow more juveniles to survive than would do so naturally) is the fish nest or 'gango' that has been developed in the Philippines (Ogburn & Ogburn, 1994; Johannes, 1997). The gango is essentially an artificial habitat

of rock sand branches into which fish settle or migrate. What is needed is an Environmental Impact Assessment (EIA) of gangos based on appropriate monitoring and experimental protocols to assess their capacity for enhancing the net survivorship of settling groupers. Such a study is being proposed under the auspices of The Nature Conservancy and The University of Hong Kong.

If wild capture of juveniles is not a sustainable basis for grouper mariculture and threatens to increase the risk of overfishing local stocks; if, in answer to the title to this article, it is just another capture fishery, then what are the possible options to supply mariculture? The most promising alternative is hatchery-rearing. While still in its early stages for the groupers, it could be pursued aggressively so that hatchery-reared juveniles could increasingly replace those taken from the wild. The reliable and stable hatchery production of juvenile grouper on a commercial scale is an excellent basis for the large-scale development of mariculture. Hatchery-based mariculture operations are already commercially viable for several *Epinephelus* species in Taiwan (e.g. Liao, 1993; Johannes & Riepen, 1995) and *E. coioides* has been successfully cultured in Bahrain (Uwate & Shams, 1997). The potential exists; what is needed is the economic commitment to proceed.

To evaluate the sustainability of using wild-caught grouper juveniles for mariculture, we concur fully with Johannes (1997) that we need to learn a lot more about the biology of, and fisheries for, juveniles caught for grow-out. We also agree that such research is only really possible if funded by governments, regional agencies or large NGOs. We would go further to suggest that funding from such sources also be sought to seriously explore ways of promoting and developing a hatchery-based mariculture industry and to plan on a more long-term basis for mariculture to contribute increasingly to world food security.

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Grouper and snapper aquaculture in Taiwan

by Mike Rimmer

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A previous article outlined the status of marine finfish aquaculture in Taiwan (see Austasia Aquaculture *11(5)). Some of the highest value finfish species being cultured, or developed for culture, in Taiwan are groupers (Family Serranidae) and snappers (Family Lutjanidae). Groupers and snappers are in demand not only in Taiwan but also in other parts of Asia, for example, in the live markets of Hong Kong and southern China, where they bring up to $A 87/kg (Dragon Search, 1996). This article deals with the technical aspects of production of groupers and snappers in Taiwan.*

Broodstock

A particular feature of marine finfish aquaculture in Taiwan is that broodstock of most, if not all, species cultured are maintained in outdoor ponds. These ponds are up to 0.3 ha in area and 2–4 m deep. Stocking density is usually around 300 fish in a single 0.2–0.3 ha pond, which for king grouper (*Epinephelus lanceolatus*) represents a biomass of up to 10 tonnes (t) in a 0.3 ha pond. Some other fish species—e.g. milkfish—may be held at lower density (100 fish per pond) due to their greater space requirement. Broodstock ponds have one or two paddlewheels to aerate and circulate the water, but only low rates of water exchange. The fish are fed every three days with trash fish, and every two or three weeks with squid stuffed with a vitamin supplement.

Generally, the fish breed naturally in the ponds. At the height of the breeding season up to 20 kg of eggs (c. 30 million eggs) are produced per day by the 300 broodfish in a single 0.2 ha grouper broodstock pond. Eggs are sold by weight. Hormone induction appears to be rarely carried out, although I did observe king grouper and sea bass (*Lates calcarifer*) on two farms being injected with HGG as they were transferred between ponds. According to the farmers, hormonal induction is usually carried out to encourage the fish to breed earlier in the season than would occur without this intervention. Fingerlings produced early in the season, when demand is great and supply is small, attract higher prices than those supplied later in the season, so there is an economic rationale for inducing broodstock to spawn early. Researchers from the Taiwan Fisheries Research Institute (TFRI) have developed techniques for cryo-preservation of grouper sperm, and this technique has reportedly been used in at least one Taiwanese hatchery (Chao et al., 1992), but it appears not to be in widespread use.

Larviculture

Larviculture is undertaken using either the 'indoor method' or 'outdoor method'—i.e. in concrete tanks indoors or in outside ponds. The compara-