tic importing country or international food standards authorities. The onus of responsibility to prove that an export consignment is safe for human consumption rests entirely with the exporter.

The use of unapproved chemicals in the live fish trade can be considered hazardous due to the potential consumption of fish before the allowable 'withholding period' is complete. If exporters fail to comply with NRA approval protocol, 'Control of Use' legislation at the State/Territory level and AQIS regulations, they can jeopardise the overall viability of Australia's seafood export trade.

The question of unregistered chemical use in the live fish export trade surfaced in Australia on 11 May 1998 following the release of a public notice by AQIS to exporters of live fish. The notice issued a warning about the inappropriate use of Sodium Nifurstryrenate, an antibiotic, on live fish during containment. The Chemical Residues Section of the Victorian department of Natural Resources and Environment generated a report following analyses of the chemical. The report stated that Sodium Nifurstryrenate might cause cancer, birth defects, and liver disease in humans particularly if consumed before the recommended withholding period.

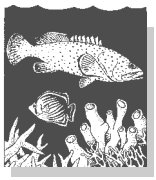
Interestingly, a few years prior, this chemical was classified as 'not permitted for aquacultural use' by the Registration liaison Committee (RLC) of the NRA due to its deleterious side effects.

A National Task Force on Aquaculture Drugs and Chemicals was established in 1995 to address the registration of drugs and chemicals for use in aquaculture and live fish export. A joint industry and government project funded by Fisheries Research and Development Corporation (FRDC) titled *Registration of Aquaculture Chemicals* was initiated in 1996, aimed at gaining registration or permits for 12 or more drugs or chemicals. The relatively small demand for these products compared to the cost of registration has resulted in a general lack of interest by drug and chemical companies.

When dealing with the use of chemicals in the live fish export trade, the task force states that this industry currently has not drugs or chemicals registered or with permits for the use pattern required.

The task force is due to meet again in mid-February 1999 to address this issue. If there is any appearance of chemical residues in the flesh of exported live fish it will potentially damage a developing and lucrative export and lucrative export industry.

Source: *The Queensland Fisherman*, March l999, page 32.



The capture and culture of postlarval coral reef fish: Potential for new artisanal fisheries

by Johann Bell[1], *Peter Doherty*[2] *& Cathy Hair*[3]

Introduction

There has been much debate about the merits of harvesting and growing wild juvenile coral reef fish to supply the aquarium market and live fish trade. Arguments centre on whether the harvesting of juveniles will affect natural replenishment of coral reefs, and the effects of removing juveniles of different ages (Sadovy & Pet, l998; Johannes & Ogburn, this issue). The age of the juveniles is pivotal to the debate; harvesting of postlarvae from the water column is considered to have a much lower (negligible) impact on rates of replenishment than the removal of the larger juveniles from benthic habitats because the postlarvae have yet to undergo severe mortality.

The effects of harvest levels and times are not the only factors to be considered in assessing the scope for capturing and culturing wild juvenile coral reef fish, however. The acceptance and success of such ventures will also depend on cost-effective methods for rearing the juveniles to market size. Postlarval groupers are removed from artificial habitats designed to attract them and then sold to growers (Johannes & Ogburn, this issue) but there is little documentation of culture methods. We need to know more concerning whether postlarvae can be collected in a way that does not damage them, whether they can be weaned easily onto simple diets, and whether they can be grown at low cost to create new artisanal enterprises.

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In this article, we summarise the reasons why the removal of postlarval coral reef fish should be sustainable and identify those conditions that may require restrictions to fishing for postlarvae. We also outline why the capture of wild postlarvae complements initiatives underway to sustain the production of coral reef fish through the cultivation of juveniles reared in hatcheries. We conclude by describing research underway in Solomon Islands to develop methods for the grow-out of postlarval coral reef fish.

The rationale for harvesting postlarval coral reef fish

It is now widely accepted that coral reef fish have two periods during their lives when they are subject to high levels of mortality. The first is during the pelagic larval development phase, which lasts weeks to months (Leis, 1991). Fewer than 1% of larvae survive this process to be potential colonists of coral reefs (Doherty, 1991).

The second is the settlement and establishment on coral reefs at the end of the pelagic phase, when the juveniles suffer intense predation by larger fish associated with reefs. Mortality rates are highest during and immediately after settlement, but can be substantial for much of the first year (Doherty & Sale, 1986; Hixon, 1991). Caribbean grunts, for example, have been shown to lose at least 95% of the juveniles that settle (Shulman & Ogden, 1987).

Clearly, one way of increasing the productivity of high-value coral reef fishes would be to 'quarantine' a proportion of the settling juveniles from predation. Although it was once considered feasible to boost production by providing additional refuges for newly-settled fishes in the form of artificial reefs, such structures have not proved to be cost-effective (Bohnsack 1989, Pickering & Whitmarsh 1997). Instead, the most practical way is to harvest a portion of a year-class and rear it in some form of aquaculture until the fish are either marketed or returned to the sea (Maroz & Fishelson, 1997; Munro & Bell, 1997; Doherty, 1999).

The basic concept of catching a proportion of the juvenile year-class and rearing them in captivity is already being applied in several other fisheries. The milkfish industry, a crucial source of protein, employment and income in the Philippines, is largely dependent on the harvest of wild 'bangus' fry using push nets in shallow subtidal embayments (Rabanal & Delmendo, 1993). The shrimp aquaculture industry in South America is also based mainly on the collection of wild postlarvae (e.g. Larsson *et al.*, 1994).

The development of sustainable methods for the capture and culture of coral reef fishes depends on finding efficient ways to catch the juveniles before they suffer high levels of mortality, and the development of cost-effective methods for rearing them to useful sizes. Although the early larval stages of coral reef fish can be collected easily with towed nets (Choat *et al.*, 1993), the retained larvae are too fragile to be cultured. On the other hand, the postlarvae that settle onto reefs are relatively robust—they are similar in size and development to marine fish weaned from a diet of live plankton to a formulated diet in aquaculture (Barnabe, 1988; Foscarini, 1988).

Two methods developed initially as research tools, appear to be suitable for catching live pelagic juvenile fishes. Doherty (1987) designed submersible light-traps which attract the animals from the water column. Light-traps can collect large numbers of young reef fish from relatively small volumes of water (Milicich, 1988), but are effective only for species that are photo-positive, and relatively strong swimmers (Carleton & Doherty, 1997). Dufour and Galzin (1993) used stationary 'crest' nets behind the surf zone of fringing barrier reefs in French Polynesia to catch postlarvae crossing over to back-reef lagoons. Crest nets capture large numbers of fish, including valuable species like groupers, and some small taxa not sampled well by light-traps (Dufour *et al.*, 1996). The use of crest nets is, however, limited to shallow reef crests with unidirectional wave action. Both light-traps and crest nets can be modified easily to ensure that their catches remain alive. At this stage, the relative costs and benefits of the two techniques for catching fish for subsequent grow-out, and the overlap in species composition of the catches, is not well known.

Concerns about overfishing of postlarval coral reef fish

Although the high mortality of juvenile fish settling on coral reefs provides a strong incentive to use the postlarvae in more productive ways, harvesting should not be allowed to jeopardise natural rates of replenishment. Research is needed to provide information on the distribution and mean abundance of postlarvae arriving on reefs, and the proportion of these juveniles surviving to adulthood. Such information will then enable managers to calculate the area of reef required to provide regular replenishment of wild stocks. Studies of this nature are currently being done by the Australian Institute of Marine Science (AIMS) and other research groups elsewhere in the Pacific. Until the appropriate experiments are complete, conservative levels of harvest will be required.

The easiest way to impose conservative levels of harvest is to restrict the amount of reef used for catching postlarvae. Such management dovetails well with the methods for catching postlarval fish because only small areas of reef are needed to supply large numbers of juveniles. For example, Dufour et *al.* (1996) obtained a mean of > 200 large postlarvae per night from crest nets with a mouth gape of 1.125 m^2 deployed around Moorea, French Polynesia. However, limits to the amount of reef that can be fished alone may not prevent overharvesting of postlarvae. Several studies of the spatial distribution of recently settled fish show that a subset of sites consistently receive a high proportion of the postlarvae. Thus, over-exploitation of postlarvae may occur within a country if relatively few sites contribute the bulk of recruits to wild stocks, and these sites are identified and fished excessively. In such circumstances, overfishing can be prevented by introducing seasonal closures, rotational fishing of areas, limits on the number of fishermen (or nets per fisherman) and/or regulations regarding the distance between nets. Such measures are commonplace in other fisheries worldwide and should not be difficult to implement in the Pacific.

Another concern is that the removal of a proportion of juveniles could destabilise coral reef food webs, which are usually nutrient-limited. However, controls on the catch of juveniles, and the very small size of the fish involved, should mitigate any such effects.

Why not produce juveniles in hatcheries?

Is it necessary to investigate the capture and culture of wild postlarvae when aquaculture is working on the production of juveniles in hatcheries? The answer lies in the fact that there are two main steps in the aquaculture of marine fish—the propagation (or collection) of juveniles and the grow-out of the fish to market size. Propagation of most species of groupers in hatcheries is proving difficult (e.g. The World Bank, 1999) so it is important to verify that a species is amenable to growth in captivity before investing in methods for larval rearing. This is done most easily by capturing and growing wild juveniles. Thus, experimentation on the capture and culture of postlarvae should identify a wide range of valuable coral reef fishes that are amenable to culture without having to incur the high costs of propagating them in hatcheries.

There are also other reasons to investigate the scope for culturing wild postlarvae. First, it may be possible to obtain juveniles of some species more economically by catching postlarvae than by hatchery production. This applies particularly to species in demand by the aquarium trade that have an extended pelagic larval phase. Second, benefits to small-scale fish farmers in developing countries are likely to be increased if they can catch postlarvae using rudimentary materials rather than buying juveniles from hatcheries. Third, the use of wild fry reduces the risks of alterations to gene pools and the transfer of diseases that are often associated with the use of juveniles from hatcheries (Munro & Bell, 1997).

Research on the capture and culture of postlarval coral reef fish in Solomon Islands

The International Centre for Living Aquatic Resources Management (ICLARM), AIMS and the Ministry of Agriculture and Fisheries in Solomon Islands are currently investigating the potential for capturing and culturing postlarval coral reef fish. The three-year project is funded by the Australian Centre for International Agricultural Research (ACIAR) and is based at ICLARM's field station at Gizo in the Western Province of Solomon Islands. The project has three main aims:

1. To document variation in abundance and diversity of fish settling to coral reefs in the vicinity of Gizo for a period of 2.5 years.
2. To compare collections of postlarvae from light-traps and crest nets to determine differences in the types of species, and the proportion of live fish in good condition, caught by each type of gear.
3. To develop methods to culture postlarvae of species known to be of high value to the aquarium market and live fish trade.

The specific goals of the third aim are to determine which species are: robust in handling, amenable to grow-out at low cost by coastal villagers, able to reach minimum marketable size rapidly at good rates of survival, and compatible with other species during grow-out.

The project is designed to benefit coastal villagers in the Pacific. By capturing a sustainable proportion of the postlarvae as they settle from the plankton, and then rearing them to the minimum marketable size, villagers could have up to three new options to derive income. They could sell species of high value to the aquarium market to local dealers, export juvenile groupers to growers of live reef fish in Asia, or sell juvenile groupers to local growers who have access to a supply of fishmeal or trash fish. Another potential benefit of capturing and culturing postlarvae is that juvenile fish which have been reared to a size where they escape most predation could be released onto protected reefs to enhance natural spawning stocks, or for subsequent harvest.

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