

Issue 18 – November 2008

# LIVE REEF FISH

## information bulletin

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### Editor's note

This issue of the *Live Reef Fish Information Bulletin* features three articles about a single species, the Banggai cardinalfish (*Pterapogon kauderni*), a species whose geographic range is limited to a very small area in Indonesia but the market for which, as a popular ornamental fish, is global.

The first article, by Ron Lilley, describes the situation on the ground and in the water in the Banggai Archipelago: the species, the fishery, and the communities involved. He also outlines efforts being made to improve local management of the Banggai cardinalfish and other marine resources in the area. The second article, by Mochamad Indrawan and Suseno, gives us a close look at some of Indonesia's internal deliberations in 2007 in preparation for the global community's decision as to whether the species should be afforded protection under CITES, the Convention on International Trade in Endangered Species of Wild Fauna and Flora. Finally, Alejandro Vagelli provides a thorough description of the status of the Banggai cardinalfish and a revealing account of the deliberations of the parties to CITES and the factors that influenced their decision. (Sorry, but I am not giving away the decision here; you will need to read the articles.)

The Banggai cardinalfish makes an interesting case study of a marine ornamental species, not least because of its peculiar biological attributes. It is also instructive as an example of the relationship between local and international management of a natural resource. CITES can be seen as a management tool of last resort, to be applied only when local management has failed. Similarly, CITES can be viewed as a "protected species" management tool, as opposed to a "fisheries" management tool, again, to be applied only when the latter has failed. The tension between these management approaches — international versus local and protection versus regulation — is evident in the three articles in this Bulletin. Perhaps it is a healthy tension. For example, the looming "threat" of a species being listed under CITES might serve as an impetus for stronger local efforts to manage the resource effectively, even if the species is not actually listed. In fact, the first level of protection under CITES, listing under its Appendix II, does not prohibit trade, but merely requires that a nation, before allowing an export of a listed species, determine that the product was taken legally and that its export would not be detrimental to the survival of the species. In other words, it must ensure that the local management system is doing its job satisfactorily.

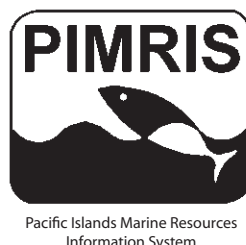
For previous articles about the application of CITES to marine species, see Bulletin #13 about seahorses (*Hippocampus* spp.) and the humphead wrasse (*Cheilinus undulatus*).

The final article in this Bulletin, by Emmanuel Malpot, René Galzin and Georges Remoissenet, reviews the efforts in French Polynesia during the last 15 years to research and develop techniques to harvest and rear post-larval reef fish. The authors conclude their article with comments on the potential for the development of “reef aquaculture” in the Pacific Islands. For other information and perspectives on this topic, see the article by Gilles Lecaillon and Sven Michel Lourié in Bulletin #17. Also note that the Australian Centre for International Agricultural Research has published a practical manual on these techniques, focusing on production for the aquarium trade. See the Noteworthy Publications section for details.

**Tom Graham**

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PIMRIS is a joint project of five international organisations concerned with fisheries and marine resource development in the Pacific Islands region. The project is executed by the Secretariat of the Pacific Community (SPC), the Pacific Islands Forum Fisheries Agency (FFA), the University of the South Pacific (USP), the Pacific Islands Applied Geoscience Commission (SOPAC), and the Pacific Regional Environment Programme (SPREP). This bulletin is produced by SPC as part of its commitment to PIMRIS. The aim of PIMRIS is to improve the



availability of information on marine resources to users in the region, so as to support their rational development and management. PIMRIS activities include: the active collection, cataloguing and archiving of technical documents, especially ephemera (“grey literature”); evaluation, repackaging and dissemination of information; provision of literature searches, question-and-answer services and bibliographic support; and assistance with the development of in-country reference collections and databases on marine resources.



## The Banggai cardinalfish: An overview of conservation challenges

Ron Lilley<sup>1</sup>

### Introduction

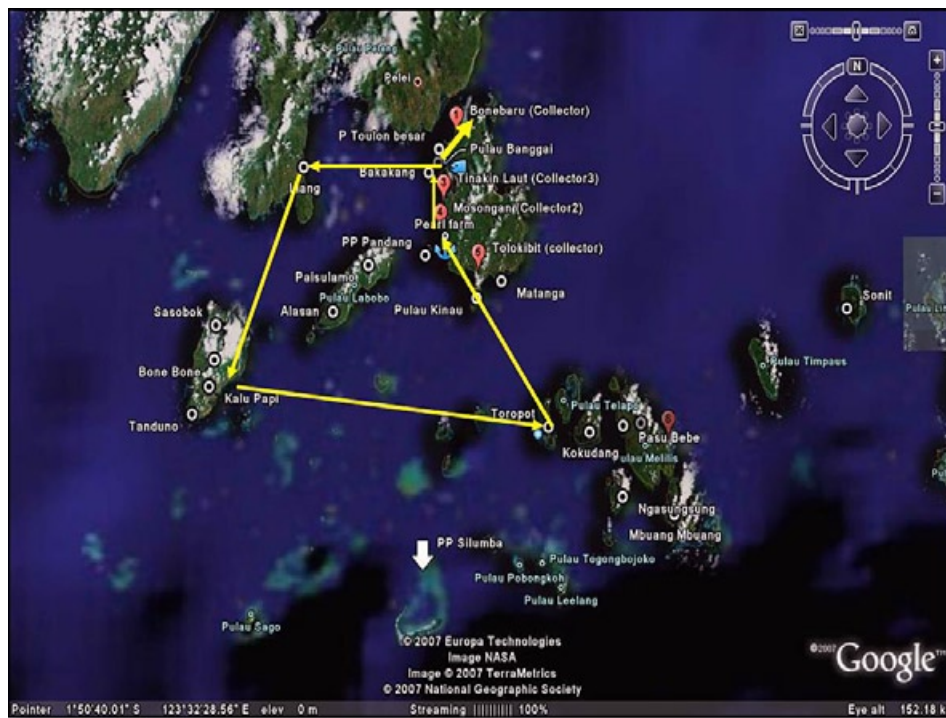
The Banggai cardinalfish (*Pterapogon kauderni*) (BCF) is a popular marine aquarium fish that has been collected in the Banggai Islands of Indonesia for at least the last 15 years, according to fish collectors there. This account attempts to identify some of the issues surrounding the conservation and trade in this species, and the area in which it is found. It also proposes a number of suggestions for actions, without which the management of this species and its wild habitats is likely to fail. The case of BCF to some extent reflects the wider issues and problems of wild species conservation throughout Indonesia. The way in which this species and its habitat are managed will determine how other internationally traded species are handled in the future. The work on this aquarium trade species — which is being done as part of the government's Banggai Marine Conservation Area Management Plan — will, if successful, potentially act as a model for conservation of marine species and habitats elsewhere in the archipelago.

BCF is only found in a small group of islands, the Banggai Archipelago, in central Indonesia, which lies at 1°35'S and 123°30'E. It is the first marine ornamental fish to have become an international issue under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). In 2007 it was proposed that the species should be listed on Appendix II of CITES, a move that would hopefully go some way towards controlling and restricting the wild trade of this species. This proposal came about partly because of concerns from some quarters that over-collection might lead to its extinction in the wild. Several BCF population studies point to this possibility (Kolm and Berglund 2003; Vagelli and Erdmann 2002; author's observations) but accurate current wild population estimates are still unavailable. Kolm and Berglund (2003:911) wrote, "It is unknown to what extent the aquarium fishery trade may affect the wild populations of any reef fish" and for BCF, this is clearly still the case.

The level of awareness of the importance of BCF among people in the supply area is still very low. Furthermore, those who are keen to instigate positive changes in the management and conservation of the Banggai area suffer from a lack of manpower, coordination, skills and funding. Although there has been some research on this species, more needs to be done to translate the findings into helpful guidelines for the local authorities and other decision-makers. It is vital that they first gain an understanding of the issues, and then make policy decisions and allocate funds so that practical conservation and management actions can happen at the field level. Without full stakeholder support, efforts to protect the area are likely to fail.

The Marine Aquarium Council (MAC), an international non-governmental organisation (NGO) based in Hawaii, developed a certification system to improve the management of the marine aquarium trade. MAC has helped to develop collection area management plans, and has trained collectors, middlemen and exporters in supply countries, including Indonesia, in "best practices". Successful implementation of these practices has led to the possibility of the traders applying for MAC certification, which means adhering to an internationally recognised standard. The objectives of certification include an improvement in product quality and reduction in mortality rates of the organisms collected and sold, safer practices for collectors, and fairer prices being paid to collectors. Since 2008, MAC International has continued to develop the certification guidelines, while the training for fish collectors, local trainers and government officials in Indonesia has been taken over by Yayasan Alam Indonesia Lestari (LINI, or The Indonesian Nature Foundation). LINI is a new local NGO staffed by former MAC staff. It focuses on surveys, capacity building and training for local suppliers of the marine ornamentals trade, and reef restoration. LINI was asked by the local government's Department of Marine Affairs and Fisheries to help with the development of a species management plan for BCF, which would

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**Figure 1.** Islands visited in the Banggai Archipelago. Arrows indicate the route taken during the MAC Indonesia team's site visit in November 2007 (adapted from: Google Earth 2007).

become part of the Banggai Marine Conservation Area Management Plan, under development by the local government.

### Site assessment in Banggai

In November 2007, at the request of the local Department of Marine Affairs and Fisheries, a MAC Indonesia team visited the Banggai area for 10 days to conduct a site assessment. The areas visited included Luwuk, P. Banggai, Bone Baru, Bone Bone, Liang, and P. Teropot (Fig. 1). The Banggai Archipelago is located in east-central Sulawesi, and is separated from the Togeian islands and Tomini Bay to the north by a narrow peninsula. Several BCF collection sites were visited, and people from various stakeholder groups (e.g. collectors, villagers, village heads, middlemen, government officials) were informally interviewed. A number of stakeholders who were interviewed requested that their names not be divulged.

The islanders are mainly a mixture of Bajo and indigenous Banggai. Many of them live in houses on stilts over the reef flat (Fig. 2). BCF collectors explained that, according to official statistics, they do not even exist, being identified as "farmers" in the local censuses, although there is virtually no farmland on these

islands. Some of these villagers do farm very small plots of land, but access to fresh water is a problem, and soil productivity is low. Most of their income is derived from the local sale of marine products, including food fish, octopus, squid, groupers and sea cucumbers. They also sometimes catch BCF and other marine fish species for the aquarium trade. More recently, villagers have begun to supplement their incomes by farming seaweed. These people are very poor, and the sales of BCF do have a significant positive impact on the livelihoods of at least several hundred families.



**Figure 2.** Typical Bajo house in Liang with *Diadema* urchins and Banggai cardinalfish underneath (photo by Ron Lilley, LINI).

Recently, the “Banggai Cardinal Fish Centre” was opened in the offices of the Department of Marine Affairs and Fisheries in Banggai town, with the full support of the local District Head (*bupati*). The purpose of the centre is to have a “one-stop” information source about BCF. The trade of BCF and other marine aquarium species in the area remains largely unmonitored and undocumented. Accurate figures and other information concerning any aspect of the trade are lacking; this basic groundwork needs to be done as a crucial first step in the development of a credible species management plan for BCF.

Some short transects were surveyed by snorkelling to provide a rough estimate of BCF abundance. In those areas visited where there has been recent collection, BCF numbers were relatively low — only a few tens of fish were seen during a one-hour swim, and these were sometimes in small groups of two or three fish. In contrast, at sites where there had not been recent collection, BCF stocks appeared to be healthy and locally abundant, usually occurring in groups of at least several tens of fish. These groups were large enough to be seen by looking down from the boat into the water. According to the collectors, BCF populations occur around many of the 123 islands in the Banggai Archipelago, but there was general agreement among collectors interviewed that these populations may be suffering from overexploitation. Once a collection area has been stripped of BCF, it is abandoned until stocks recover. It was not clear as to how long this recovery period might be, although one collector said that collection at one site had stopped “about a year ago”. In some cases, collectors venture to neighbouring islands to collect BCF, but this is costly because of the extra fuel requirements and rising fuel costs. These collectors are also regarded as “poachers” of other peoples’ resources, and run the risk of being forcefully driven away by villagers.

Some key issues were identified during the visit, and these are discussed in the sections that follow. Much of the information presented here is anecdotal in nature. Except where specific sources are cited, the source of this information is the author’s observations, most of which were made in the course of the November 2007 site visit by the MAC Indonesia team and the interviews conducted during that visit.

### Lack of no-take zones

Poaching of marine resources by people from neighbouring islands and farther away is a widespread problem. Government patrols of the area are infrequent and insufficient to act as a credible deterrent to would-be poachers or traders from elsewhere.

In the past, villagers on some islands tried to develop nearshore no-take zones, with their own initiative and money, and using simple marker buoys and signs. They said that “visible” no-take zones were necessary to deter people from other islands from coming to fish there, using bombs or other methods (the use of homemade bottle bombs for fishing is far more common than the use of dynamite). However, because these no-take zones were not part of a coordinated regional plan, the buoys and ropes were stolen within a few days of being installed. There was no “scientific” rationale for the location of the no-take zones, and no guarding systems were put in place. Villagers are generally reluctant to have to guard areas that are far away from their villages, especially if they have to stay there overnight. Proximity of the collection area to the village is an important consideration when setting up community-based guarding and patrolling schedules. According to villagers, a physical human presence near the collection area can act as an effective deterrent, with a few shouts often being enough to drive poachers away.

### Fuel shortages

The price of fuel (petrol, diesel and kerosene), used for transportation and cooking, has recently more than doubled. Problems of irregular supplies (from Java) and distribution delays have further increased economic hardship. High prices and problems of fuel availability conspire to make the movement of boats between the islands costly and sometimes prohibitive, particularly for villagers living on the outer islands. These constraints are having a significant negative impact on local trade, not only of aquarium fish but also of food fish, water, food and all other products and materials that are traded by boat between the islands. Harsh economic pressures



**Figure 3.** A group of Bajo women on their way to market in a dugout canoe in Bone Bone Village, Pulau Bangkulu, Banggai Islands (photo by Ron Lilley, LINI).

such as these oblige people to take more desperate measures when seeking incomes, including the use of destructive fishing techniques. It also encourages the clearance of wooded slopes and mangroves through the chopping of trees for firewood.

### Threats to collection areas

All collection areas visited appeared to be threatened by poachers and activities that have destructive impacts on the reefs. These include fish bombing, cyanide use and careless boat handling and anchorage. Over-collection of trade species — including BCF — could deplete these resources to a point where recovery is unlikely, even if non-destructive collection techniques are used. There is no evidence that explosives are being used to catch aquarium trade species — this practice is only used for food fish collection.

Sedimentation from inland activities such as logging and construction threatens corals, and increased nitrate runoff from the use of fertilizers and human waste encourage algal growth on the reefs. There are plans for mining on the main island of Peleng, which could also negatively affect the surrounding reefs. The lack of coordinated regional planning means that information about proposed developments for the area is difficult to access.

Significant amounts of plastic, netting, Styrofoam and other rubbish were seen floating in the sea and draped over the reefs. In fact, given the relatively low human population numbers, it was surprising to see the high levels of solid waste in the sea, especially around harbours and areas of human habitation. There is currently no waste management or garbage disposal system in place for the islands, although piles of accumulated rubbish, as a result of an increasing human population, coupled with the replacement of traditional, biodegradable banana leaf packaging with plastic bags and Styrofoam, are evident everywhere .

### Banggai cardinalfish habits

BCF are easily observed in shallow waters throughout the area, including around piers in harbours. Significantly, one of the best places to observe relatively large numbers of BCF was in one of the pearl farms, where public access is strictly prohibited.

BCF live in groups in and among coral heads, anemones, seagrass, jellyfish, and sea urchins (Fig. 4). If the reef is badly degraded or there are high levels of nitrates in the water (i.e. near dwellings, piers and raw sewage outlets), algal growth is encouraged, which in turn promotes the proliferation of black long-spined sea urchins, *Diadema setosum*. In areas where the coral cover has been destroyed and the



**Figure 4.** A group of Banggai cardinalfish swimming over anemones, Pulau Teropot, Banggai Islands (photo by Yunalidi Yahya, LINI).

reef flat is covered in algae, numerous groups of *Diadema* sea urchins become the main refuges for BCF.

Kolm and Berglund (2003) say that villagers also collect *Diadema* as a food source, and that currently used collection techniques for BCF cause physical damage to the sea urchins' spines. The collection of sea urchins and the means by which BCF are driven out of the urchins into nets both deprive BCF of hiding places (Kolm and Berglund 2003). Indeed, the sea urchin is a favored hiding place for BCF, and the black and white striped patterns of this fish make it difficult to see when it retreats among urchins' spines (N. Kolm, Uppsala University, pers. comm. 2008).

In areas with little or no corals, seagrass or urchins, BCF were observed to cluster and shelter around any large object, including pieces of wood and other rubbish. The fish were also observed swimming very close to the walls of piers. In other words, it seems likely that, once the reef has been degraded and there are no more corals or seagrass in which BCF can hide, they will "make do" with hiding in the sea urchins, which proliferate when the area becomes covered in algae.

Although not observed firsthand, the team was told that BCF could occur in significant numbers in association with a certain (unidentified) species of jellyfish. Because BCF have a very low capacity for dispersal, as they do not have a pelagic larval stage, it might be that the jellyfish provide a means of dispersal for BCF by passive drifting on ocean currents. It is important to understand this and other dispersal mechanisms for species management purposes. DNA studies (Hoffman et al. 2005) indicate significant genetic differences within BCF sub-populations, which need to be preserved for the continued well-being of the species.



**Figure 5.** Collectors demonstrating how they use the *cang* net, with a long-handled scoop net, to catch Banggai cardinalfish (photo by Ron Lilley, LINI).



**Figure 6.** *Cang* net with *Diadema* urchins (photo by Ron Lilley, LINI).



**Figure 7.** Free-diver using a *cang* net to capture Banggai cardinalfish, Pulau Teropot, Banggai Islands (photo by Yunaldi Yahya, LINI).

When approached, BCF do not swim rapidly away, but try to make themselves inconspicuous, turning away so that their narrow profile is presented to the potential predator. In spite of their black and white cryptic coloration and long spines, the fish would seem to be easy prey. Sea snakes (*Laticauda colubrina*) were seen in a number of places where BCF also live, and these might be predators of BCF.

### Capture and handling techniques

Almost all the BCF collectors said they were free-divers; that is, they held their breath while diving for fish, and did not use dive tanks or compressors. They often dove using only simple masks (which can be homemade from wood, glass, sealer and strips of tire rubber), and without fins. Where fins were used, these were either homemade from plastic or wood and fastened with string to the collector's feet, or store-bought fins that were in poor condition (most of these had been donated by visiting tourist divers). Most of collectors we interviewed said they used masks only, and had no experience of using a snorkel. Regular long trousers, long-sleeved shirts and woollen *balaclavas* (hoods that completely cover the head and neck, except for holes for eyes and mouth) were used to retain body heat. Becoming cold was cited as one of the main factors limiting collection time. There were reports of compressors and air lines (hookah gear) being used to collect other aquarium species at greater depths.

Access by collectors to a supply of cheap masks, fins, snorkels and wetsuits would increase efficiency and safety, as would some basic dive safety training. In some areas of Indonesia, for example in Komodo National Park, the use of compressors for catching fish has been banned, but the ban is hard to enforce, given the lack of marine patrols. Compressor use greatly facilitates the use of cyanide for fish catching, but poor maintenance and a disregard for safety (e.g. no watches or depth gauges are used) has led to many accidents, including cases of paralysis and death. There is no decompression chamber in the Banggai area, the nearest one being in Manado, about 40 km away (by sea). This is too far away from Banggai for emergency evacuation to be an option for collectors. A lack of health services in the area means that injured collectors receive only "traditional" treatment in their villages. MAC does not support the use of compressors for diving.

It is very easy to catch large numbers of BCF at one time, by simply driving them out of the sea urchins with a stick into a waiting funnel net, called a *cang*, which is hand-woven of coarse material (Figs. 5–7). When the net is lifted to the surface, hundreds of variously sized BCF are concentrated in the bottom of the net, resulting in damage to scales, fins and eyes. Although large numbers can quickly be

caught using this technique, the high mortality and rejection rates make this method inefficient. In the minds of collectors, rejected and dead fish are not considered as lost potential earnings. Based on the author's experience in other areas, a short session with collectors on the economics of what they do, and how much money is being thrown away each time they go collecting, would be a very useful addition to any training programme.

After collection, BCF are transferred to Styrofoam boxes in canoes, where an initial sorting takes place. Collectors said that a significant number — between one-quarter and one-half — of fish collected in this way become damaged and are thrown back. The fish are then transferred to floating holding pens in shallow water, where several thousand fish may be kept together for up to three days. The buyer then selects only the healthy fish of medium size. Those that are sick, damaged, too big or too small are thrown back into the sea. Collectors estimate that about half the fish held in the floating pens die, and as few as one-fifth to one quarter of the fish they catch are finally bought by the buyer, although, as no records are kept, these figures are anecdotal.

### Prices paid for fish

In Banggai, collectors are generally paid about 250 rupiah (IDR) (0.02 US dollars, or USD) per fish. Local middleman can sell each fish for up to IDR 1500 (USD 0.16). Exporters sell the fish for roughly USD 2–5. One exporter said the reason for this dramatic increase in price was that, unlike fish collectors, exporters had huge overheads to pay for running their facilities, transportation costs, and a higher standard of living. An importer sells the fish for about IDR 90,000 (USD 9.55). The retailers in the buying countries can sell each fish for about IDR 189,000 (USD 20).

At the end of the 1980s, collectors received IDR 10 per fish, which in real terms was greater than the current price. The same is true for middlemen and exporters, who are now paid less in real terms per fish than they were 20 years ago. As a result of having to accept low prices for their fish, coupled with rapidly escalating fuel and food costs, collectors are faced with increasing debt. This economic pressure provides an incentive for collectors to join food fishermen in their use of cyanide and other destructive techniques, in order to try to make ends meet financially. By being taught some basic economics and negotiation skills, and becoming part of a Banggai-wide collectors' organization, collectors would be in a much stronger bargaining position when dealing with middlemen. As long as the market still needs wild-caught fish, collectors are still in a position to recognize and take better advantage of their power as important players in the aquarium trade.

### The middlemen

Many middlemen arrive by boat at the villages, negotiate directly with collectors, select the fish, and then return to their places of origin (mainly Manado, Tumbak and Kendari, but also Bali) to sell the stock to exporters. They use larger boats than collectors, and/or trucks for overland transport to Manado (although these trucks are sometimes owned by exporters). Sickness and mortalities of the stock during this stage of transport, which may take several days from source to facility, are common because of "gang packing" (i.e. packing 30–50 fish in one bag), and infrequency of water changes.

Other aquarium fish species, including angel-fish (Pomacanthidae), and notably the palette surgeonfish, known locally as "letter six" (*Paracanthurus hepatus*), which is one of the most sought-after fish for aquaria, are caught in the Banggai area. Among these, the species that are faster-swimming, or that live in deeper water, are caught using compressors (hookah). Middlemen are known to be one of the main sources of the cyanide used to catch these species.

### Exporters

Some Indonesian exporters are experimenting with captive breeding of BCF, but so far, the fish have only been bred in very small numbers. Exporters report that the captive fish are apt to suffer from stress-related disorders, including internal parasite infestations, because of overcrowding. Some exporters prefer to buy from suppliers located nearer to them (e.g. in Bali), and are willing to pay higher prices for locally supplied fish, knowing that they have not been gang-packed and transported for many days by boat from Banggai.

### Tourism

An influx of tourists in the future would significantly improve the economic outlook of the area. However, Banggai currently has almost no infrastructure in place to accommodate visitors. The potential for tourism development is also hampered by the current security warnings to potential travellers to central Sulawesi. Now that the BCF is becoming better known locally, it has been suggested that this fish become the provincial mascot, and that its image be used to promote tourism in posters, brochures and television advertisements. Simple awareness and "socialization" programmes for schools, government departments and the local people would do much to raise their awareness of the economic possibilities associated with tourism. The presence of growing numbers of tourists could also act as an incentive to manage the area more effectively, such as reducing pollution and poaching.



It was suggested by a person from the Banggai tourism department that a community-based tourism programme be included as part of the government's Banggai Area Development Plan<sup>2</sup>, as none currently exists for the area. Standards for visitor transportation and accommodations, including hygiene, and the provision of information to tourists will need to be significantly improved if tourism is to become a viable industry in Banggai.

Tomini Bay and the Togean Islands are geographically not far from Banggai (due north across a narrow peninsula), and have had experience in developing community-based tourism, although this has recently fallen apart because of security risks and other factors. This is an ideal source of information and lessons learned, especially given its proximity and cultural similarities with the Banggai area.

### The issue of land-based aquaculture versus community-based mariculture

At present, the numbers of BCF being captive-bred are too small to support or supplant the trade in wild-caught fish. Individuals produce only 30–40 eggs at a time, a factor that somewhat limits the potential for captive breeding. Some people, including those in the local fisheries department, have argued that the development of land-based aquaculture for BCF in Banggai should be the main thrust of the species management plan for BCF. Although this might eventually help to provide fish ready “on the shelf” for the market, and perhaps even provide a few local villagers with alternative income, land-based aquaculture requires expensive investment and, in isolation, has little to do with conserving the species in the wild, or keeping collectors above the poverty line. So far, there is little evidence to support the idea that captive breeding can develop to the point where it could help to maintain wild populations. Moreover, land-based (aquaculture) facilities require expertise and investment that might be better spent on development of community-based mariculture efforts in the sea near villages, which would provide incentives for islanders to protect the surrounding reefs. Well-managed wild collection that is slowly augmented by community-based mariculture would arguably provide a better means of conserving wild stocks than *ex-situ* captive breeding can achieve on its own.

### Feral BCF populations of BCF elsewhere in Indonesia

Over the years, middlemen and exporters have released rejected BCF in various parts of the Indonesian Archipelago. Introduced populations of BCF can be found in north Sulawesi, including

Manado, Palu Bay and the Lembah Strait (Vagelli and Erdmann 2002) and in north Bali. A few adult BCF have also been seen swimming in the harbor at Luwuk (see Fig. 1), where the ferries from Banggai Islands arrive, and from where aquarium fish are sent for export to towns with international airports. Recently, the author made a visit to a site in north Bali where significant numbers of BCF are collected by Balinese collectors, who are paid up to IDR 4000–6000 (USD 0.40–0.60) per fish. One exporter said he preferred to buy “Bali BCF” because the extra price was offset by lower mortalities. He was selling these fish overseas for IDR 12,000 (USD 1.20). Middlemen requested that the locations of these collection sites remain secret (Fig. 8).



Figure 8. Collector with Banggai cardinalfish in north Bali (photo by Ron Lilley, LINI).

Although these other sites may be more convenient for buyers because they are nearer to points of export, they do highlight the problem of alien species introductions and the potentially negative ecological effects of such releases, which are still poorly understood. It will be interesting to see whether these *ex-situ* sites are eventually given some measure of legal protection.

### Research, management and conservation efforts in Banggai

There is a growing body of information about BCF, including a number of scientific papers, which detail, among other things, various aspects of BCF ecology, behavior and genetics (e.g. Allen 2000; Hoffman et al. 2005). These are for the most part in

2. This is a broad plan within which the Banggai Marine Conservation Area Management Plan will be a component.

English, and in need of translation into Indonesian, because very few Indonesians can read English. There have been efforts by local NGOs to work on various aspects of community development in the Banggai area, including the establishment of no-take zones. However, these efforts appear to have been done on a piecemeal basis, and have not been integrated into the Banggai Marine Conservation Area Management Plan. Recent meetings involving national and local stakeholders, including government, NGOs and the traders, have helped to create a more coordinated approach to the management of the area (Reksodihardjo and Lilley 2007).

The local politics of the Banggai area are very complex, not least because of current disputes about administrative boundaries. Efforts by outsiders and local NGOs to work there have, in the past, been beset by bureaucratic and administrative hurdles. In addition, there is a culture of secrecy, especially among middlemen and exporters, so they are reluctant to divulge details of their businesses to outsiders. In addition, gathering information is difficult because there is a tendency for people to give the replies that they perceive are expected of them rather than the objective responses that are being sought. It is therefore small wonder that information-gathering in this area is so difficult and time-consuming, and that previous assertions about the situation have differed so markedly.

It is hoped that the recently established Banggai Cardinal Fish Centre in Banggai town will help to create a central point from which management decisions and efforts can be coordinated and shared with the wider community.

### The future

From the foregoing account, it should be apparent that a great many changes would need to take place in the Banggai area if it is to survive and develop economically. One component of this development is the aquarium trade. This will need to be addressed in terms of legal, financial, and technical support from government, the aquarium industry, local businesses, NGOs, and scientists. However, to realize these changes, local island residents will first need to be helped in understanding what these changes are and how they might benefit from them financially or otherwise. Securing residents' agreement and support means giving them the opportunity for active involvement in the development and implementation of the Banggai Area Development Plan and the species management plan for BCF. Therefore, other, more powerful, stakeholders will first need to acknowledge and respect the needs of the villagers, and then involve them in the process and provide them with some incentives to do so.

Development of the Marine Conservation Area Management Plan will involve all of the key stakeholders. If successfully implemented, it will afford the reefs greater protection and promote more sustainable marine fisheries. To achieve such outcomes, several local partners will need to cooperate to provide training and capacity building to local stakeholders in such areas as marine surveys, mapping and monitoring, mariculture, community savings schemes, and no-take zone development.

LINI will use MAC tools and expertise to conduct interviews with local stakeholders to identify and document current issues. This will include gathering information on BCF trade issues, the distribution of BCF populations, and the socioeconomic condition and prospects of BCF collectors. LINI will also provide training to collectors and suppliers, and conduct in-water surveys for the purpose of BCF stock assessment. Other local NGOs with a history of working with local communities in the area will also be involved in the development of the Banggai Marine Conservation Area Management Plan.

The formation of a collectors' association has been proposed so that all of the collectors throughout the Banggai area can have one voice when it comes to negotiating the price of fish with buyers. Participation in the association could be made contingent on the collectors being adequately trained and having permits from the government that give them exclusive collecting rights in the area. The number of permits to be made available could be determined once more accurate data are available concerning the status of fish stocks and their productivity. Such data could also be used to establish total allowable catches.

There is an urgent need to set up a long-term monitoring programme for BCF throughout the Banggai Archipelago. The programme would gather information on catch, sales, collection effort, and BCF population characteristics. Using this information, critical areas and fish populations can be identified, fish population trends can be monitored, and catch quotas can be established and enforced. In addition, studies are needed to determine how long it takes BCF populations to recover in "over-collected" areas. Instead of relying on foreign researchers to undertake this kind of work, as is currently the case, it would be more cost-effective to support the development of a long-term research programme that involves the training of local Department of Marine Affairs and Fisheries staff, students and local researchers in various survey methodologies.

Previous and current catch and sales data for other traded marine species would also be very useful for developing the management plan, as they would help to identify historical and present trends at

collection sites and in the trade. However, written records have so far not been kept by collectors, so at best there may only be anecdotal information available from them on the history of the trade. Traders are generally reluctant to share their purchase and sales data, but if they could be encouraged to do so in the future, they would be providing essential information to support a continued trade from the Banggai area. Simple record keeping for collectors and middlemen is a possibility, but would require agreement on their part, as well as training and long-term supervision.

The cost of establishing no-take zones is relatively small, especially if they are developed and maintained by the villagers. They have requested financial help for this from local government, but the initial development phase (including reef and resource surveys, community mapping and basic materials with which to demarcate the no-take zones) will need further support from outside donors. In addition, local communities will need further legal support from government to empower them to serve as effective custodians of their own resources.

The development of a waste disposal system for the whole Banggai area, coupled with an education programme for schools, would be timely at this stage and would anticipate the problem of having to dispose of much higher levels of rubbish in the not too distant future. Local human populations are growing, and plastics (particularly plastic bags) are replacing the traditional biodegradable banana leaf wrappings. Plans for mining and logging on some of the larger islands threaten to increase the amounts of sedimentation on surrounding reefs. The Banggai Marine Conservation Area Management Plan will need to take future developments into account, and credible environmental impact analyses will be needed to inform the planning process.

The estimates of fish mortalities and eyewitness accounts indicate that the processes of capture, post-harvest handling and holding are all extremely stressful and damaging to the fish. There is a need to employ experienced trainers to review and improve the capture, post-harvest handling and holding methods, and to train collectors in their use. Encouraging collectors to catch individual fish using hand (scoop) nets, using softer netting material, and redesigning holding pens would all help to reduce fish mortalities significantly. Only existing fish collectors will be targeted for training, because MAC does not advocate more people becoming ornamental fish collectors.

Given the very restricted geographical range of BCF, collectors should be in a strong position to set a more reasonable price than what they currently receive. As an example, a doubling of the price paid

to collectors, from IDR 250–500, would be equivalent to an increase of only USD 0.02–0.03 per fish. It seems reasonable to expect that hobbyists would be willing to pay, say, an extra 2–5 dollars for a 20-dollar fish (i.e. a 10–25% increase) that is known to come from a well-managed collection area. Then it only remains for that increase to be passed down the trade chain to collectors, for whom a doubling of the price would make a significant difference. MAC teaches collectors to adopt the “catch only to order” rule (i.e. catch only enough fish to respond to buyers’ requests), rather than opportunistically catching all of the fish they come across, and then hoping to sell them all to middlemen. This needs to be accompanied by the implementation of a total allowable catch system, which is also promoted by MAC/LINI. Total allowable catches would be based on the analysis of fish surveys in particular collection areas (a process that has already been successfully applied in some collection areas in north Bali). Community-based patrolling, monitoring, and data recording all need to be included as part of skills training. Given training and support, the island communities could do much of this work themselves.

Providing training in post-harvest handling and the use of better quality nets with soft netting, as well as snorkels, masks and fins, would be relatively cheap and would immediately reduce the rate of stock mortalities. These items and other basic equipment would be provided to the collectors’ group organizing committee, to sell to its members at cost (rather than encouraging dependence through the provision of free handouts). Sales of these items to members would provide funds for the next round of equipment purchases. Savings schemes of any kind are a new idea for these communities.

LINI has committed to act as facilitator of the development process for the species management plan for BCF and other needed work, but accomplishing these tasks will depend on others to come forward to help. LINI proposes that, where possible, all actions (both short- and long-term) should be firmly in the hands of local stakeholders. LINI could provide further support by enlisting the help of overseas organizations and expertise (e.g. the wildlife trade monitoring network, TRAFFIC, the Ornamental Aquatic Trade Association, and Ornamental Fish International) to look more closely at trade routes and practices beyond Indonesia, and how these might be better monitored and improved.

If implementation of the species management plan for BCF is successful, it would become a model for fisheries management throughout the Indonesian archipelago, and consequently bring economic benefits to a very large number of people for whom alternative income generation is not an option.

As wild natural resources become scarcer, captive breeding of species that have historically been collected from the wild becomes an increasingly economically attractive alternative for the industry. In their paper on *ex-situ* captive breeding of BCF, Hopkins et al. (2005:25) stated, “hobbyists will eventually learn that captive-bred Banggai make much better aquarium fish”; and further, “...raising Banggai can be profitable at the US\$7 farm gate price”. Arguably, the financial incentives that captive breeding provides should not be the only consideration for businesses in developed countries, when there are opportunities for them to also support the conservation of the species in the wild. Well managed community-based *in-situ* mariculture efforts, stimulated by fairer prices, can provide real incentives for people at the supply end to protect and conserve habitats. It is hoped that hobbyists in buyer countries can be encouraged to consider this factor when deciding which suppliers to make their purchases from. The successful development and implementation of a species management plan for the BCF will not only increase the chances of protecting this species in the wild, but hopefully also serve as a model for combining trade and conservation, in which all people along the trade chain can feel they have a stake.

Anyone requiring further information about LINI or interested in providing donations or funds towards our work in the Banggai Islands may contact LINI:

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**Figure 9.** Banggai cardinalfish with clownfish in anemone, Pulau Teropot, Banggai Islands (photo by Yunaldi Yahya, LINI).

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## The complications of CITES inclusion of endemic species in Indonesia: Lessons learned from an in-country deliberation on protecting the Banggai cardinalfish, *Pterapogon kauderni*

Mochamad Indrawan<sup>1</sup> and Suseno<sup>2</sup>

The Banggai cardinalfish, *Pterapogon kauderni* (hereafter, BCF), was first brought to the attention of science in 1920 by Walter Kaudern. After not having been reported for about 75 years, BCF was “rediscovered” in 1994 by Allen and Steene (1995). BCF has now become an internationally well-known (and sought after) aquarium fish in Europe and the United States of America (USA). This reef-dependent apogonid was initially believed to be naturally distributed only in the Banggai Islands, which administratively comprise an entire district (region) in the province of Central Sulawesi, Indonesia. However, recent observations indicate that BCF also occur in Luwuk Harbor, on the mainland eastern peninsula, Lembah Strait in North Sulawesi, and Palu Bay in Central Sulawesi (Vagelli 2002). The fish observed in Lembah, and possibly Palu, are feral populations<sup>3</sup> (Vagelli and Erdmann 2002). Collecting pressure has been high: between 2000 and 2001, close to 700,000 BCF were traded in the Banggai Islands. An assessment made just after this period estimated a total population of about 1.7 million surviving individuals (Vagelli 2002). According to a more recent estimate, there are about 1.8–2.2 million fishes, and the harvest rate is at least 900,000 fishes per year (Vagelli 2007). However, these estimates have yet to be adequately peer-reviewed, and the harvest rate, having been estimated by extrapolating from short-term export figures, might be inflated if there were substantial between-year variations in exports (IUCN/TRAFFIC 2007).

This high harvest rate, combined with certain biological and ecological attributes of BCF that constrain rates of colonisation of vacant habitats (e.g. its association with benthic substrate, its lack of planktonic larval dispersal, the fact that its habi-

tat is fragmented due to the geomorphology of the reef substrate, and the fact that currents preventing colonization between reefs; Vagelli 1999, 2007), give rise to concerns about the species’ conservation status. It is seriously doubted whether recruitment and recolonisation rates can keep up with ongoing harvesting rates (Vagelli 2002, 2007; Vagelli and Erdmann 2002). BCF has not received national or international protection status, but in September 2007 it was classified as “endangered” by the World Conservation Union (IUCN).

In early 2007, in anticipation of the 3–15 June 2007 Fourteenth Meeting of the Conference of the Parties (CoP 14) to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), deliberations within Indonesia were held to discuss and determine whether or not to support the proposal by the USA to list BCF under Appendix II of CITES<sup>4</sup>, as well as proposals for other species. The authors participated in some of those deliberations, specifically a preparatory meeting (in Jakarta, 24 May 2007)<sup>5</sup> that included representatives from the central government (scientific and management authorities), conservation non-governmental organizations (NGOs), sub-national governments (province and region), and scientists (regional, national and international). Considerable differences of opinion regarding the proposed inclusion of BCF under CITES arose, which highlighted the complexity of listing an endemic species. It is hoped that the lessons learned from that process can be used to inform the policy formulation process in the future.

This article focuses on consensus-building and decision-making processes, not on the decision

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3. Over the years, middlemen and exporters have released rejected BCF in various parts of the Indonesian Archipelago.

4. Appendix I includes species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances. Appendix II includes species not necessarily threatened with extinction, but the trade of which trade must be controlled in order to avoid utilization incompatible with their survival (<http://www.cites.org/eng/disc/how.shtml>; accessed 15 March 2008). Under Appendix II, an exporting country should set a quota, and the quota should be based on good evidence showing that the harvest rate is not detrimental to the population(s).

5. Suseno also served as a member of the Indonesian delegation to the CoP 14, in Den Haag, the Netherlands.

itself or its basis (the decision at CoP 14 was not to list BCF).<sup>6</sup>

In the course of the preparatory meeting, different interest groups made proposals on various grounds. Representatives of the central government, represented by personnel from the Ministry of Fisheries and Marine Affairs, as well as the Indonesian Institute of Sciences, reasoned that inclusion of BCF under CITES would only increase the already substantial CITES paperwork burden (for already listed species) without improving BCF's conservation prospects. But the central government left the final decision (of whether or not to support the listing of BCF) to the provincial and regional governments. Representatives of the provincial government of Central Sulawesi reasoned that inclusion in CITES would disrupt local livelihoods. Days after this preparatory meeting, the head of the provincial fisheries agency (Dinas Perikanan Propinsi Sulawesi Tengah) raised concerns through a statement in a national newspaper that CITES protection would hamper local captive breeding efforts should they become feasible in the future (Anon. 2007a). The regional government of Banggai Islands (represented by a senior official from the district fisheries agency), which had had no previous exposure to CITES, hesitantly supported the proposal, arguing that the inclusion of BCF under CITES would enhance recognition of the biodiversity importance of the Banggai Islands. Notably, local fisheries stakeholders — fishers, collectors and traders — were not present at the meeting, yet they are important beneficiaries of the BCF resource. All meeting participants agreed that more time was needed to make a final decision.

The variety of opinions on the issue highlighted the need for a closer look at the pros and cons of listing under CITES. It is conceivable that one positive impact of listing would be increased awareness among regional stakeholders of the value of their own natural resources, which in an era of strong regional autonomy within Indonesia, could be valuable for conservation.

The other side of the coin is that in some of the more remote archipelagic regions of Indonesia (of which Banggai Islands is one), enforcement is difficult and the imposition of new regulations might bring socio-political resistance on the part of the people

involved in the trade of BCF (some of which have considerable political clout). Also, the central Indonesian government might not favour the additional bureaucratic layer that would be necessitated by the inclusion of another species under CITES. Under Indonesia's regional autonomy laws (Laws 22/1999 and 25/1999, Government Regulations 25/2000, and Law 32/2004), governance of the natural resources "sector" (as opposed to "function") is devolved to regional governments, with the exception of "strategic" issues (see USAID DRSP 2006). However, decentralization of management of marine space and resources is yet to be effectively implemented, as governmental regulations are still needed to form the necessary legal framework (Satria 2003). Consequently, the roles of various governing authorities need to be clarified.<sup>7</sup>

CITES, by its international nature, primarily involves central governments, a characteristic that in Indonesia has yet to be effectively reconciled with regional autonomy principles. In the remote and scattered Banggai Archipelago, it is difficult enough to convince people of the need for conservation on ethical grounds alone. It is almost impossible to introduce into the public mainstream the concept of, and need for, multilateral environmental agreements. Regional governments that have had experience with CITES are likely to oppose the inclusion under CITES of species that are present locally because it is likely to lead to stacks of additional *berita acara* (paperwork). The central government is experienced with CITES, and if it tries to discourage the inclusion of a species, it is often because it is simply trying to spare the regions from additional paperwork.

One positive outcome of CITES inclusion of an endemic species is that it might be accompanied by technical assistance to the regional and central governments and stakeholders, which would provide capacity building opportunities.

During the meeting, one participant (and only one) proposed that the significance to the local economy of the current (unsustainable) level of harvest of *Pterapogon kauderni* was very modest, and that less than 0.1% of the local people were involved in the BCF trade (which began only about 12 years ago). It was consequently argued that BCF should be listed in CITES Appendix I, which would effectively prohibit international trade. It was

6. Considering the geopolitics of Indonesia, in order to be effective, decisions for including species under CITES should be supported by the sub-national governments as well as the national government. Naturally, challenges remain in attaining such agreement, especially in how to improve communications with, and the knowledge base of, local governments, especially in more remote islands such as those in the Banggai archipelago.

7. Although decentralization is a time-consuming process and has yet to be fully achieved, evidence remains that it can bring positive outcomes, including increased public services, institutional resilience, and improved capacity for governance reform (USAID DRSP 2006; Suseno 2007).

countered, however, that further socio-economic information was needed to weigh the importance of the fact that less than 0.1% of the population, or about 160 people, were involved in the trade. It was recognized that even when fish collecting is considered to be artisanal, and the number of people involved is small, the impacts can be substantial. The fishers are members of closely knit family groups and clans whose deep social coherence means that the benefits of the fishery carry well beyond the fishers themselves.

The difficulties in introducing conservation measures were also recognized. If carelessly introduced to local communities, even basic conservation ideas may not be perceived by the communities in the same way that they are by the government bodies introducing them, resulting in both misunderstanding and animosity towards the government and conservation interest groups (including researchers and activists). Empirical evidence abounds showing that “cultures of nature” such as the fishing communities of the Banggai Islands have very different perspectives on the politics of local conservation, and that working closely with members of such communities may be the only way to understand them (e.g. Lowe 2006). Also important is the need to understand and take into account the combined political influence of the traders who drive the collection of BCF, particularly since the structure of the trade has for many years been an oligopoly (Indrawan pers. obs.).

Multiple conclusions may be drawn. Firstly, CITES inclusion faces the political reality of the decentralized nature of governance in Indonesia, where the respective governing roles for natural resources have yet to be clarified among the three levels of government: national, provincial and regional. Sorting out those roles would be particularly challenging for a species with such a highly restricted range as BCF, which is distributed in a single region.

Secondly, for a species or resource such as BCF with local economic importance, the decision of whether to list under CITES should be based on adequate analysis of the impacts of listing, including consideration of socio-political dimensions. Undertaking such an analysis calls for the direct involvement of the trade stakeholders themselves. Archipelagic-wide consultations should be undertaken. Considerable effort should be spent to disseminate the principles of CITES to the regions (especially those with higher levels of endemism), and to help the regions prepare any necessary rules and regula-

tions. Effective participation of artisanal fishers must be ensured so that they do not feel victimized by government policies to which they otherwise would have little input. In order to realize policies that side with the poor and the marginalized, it is important to appreciate the aspirations of, and preserve the dignity of, local communities. One risk of not doing so is that stakeholders would be confused by the regulations at multiple governance levels. Given the need for such consultations, ample time should be provided before a decision is made to list a species under CITES.<sup>8</sup>

Thirdly, consideration should be given to the trade-offs between the timing of listing, and the threat to BCF imposed by trade. For instance, the (then-upcoming) CoP 14 could be viewed as an opportunity to list BCF and consequently stem the threat, but that opportunity has to be weighed against the advantages of deferring the decision about whether to list in order to gain time to further deliberate and gain support for such a decision.

Fourthly, properly conducted research is, of course, crucial to effective decision-making. Cooperation between local and international scientists in such research should be fostered and encouraged. Naturally, each country has its own sets of norms, ethics and rules that need to be respected. The process for obtaining the necessary research permits — for both national and international scientists alike — can require considerable time. However, it would be a pity if excellent and useful research were to be viewed in an unfavorable light only because of concerns over the legal status of the research. Complying with legal requirements would also bring the benefits of cooperative research between local and international scientists: local researchers and their international counterparts can learn and develop more holistic analytical approaches, including more socially and culturally sensitive approaches.

In conclusion, the basic tenet emerges that every interest group has something valid to contribute to the decision-making process. In order to harmonize the different perspectives of those groups and produce a shared understanding of the issues and a common conservation goal, more extensive and careful outreach effort with all interest groups, as well as making the appropriate linkages with research, would be worthwhile.

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8. As an example of such outreach, following the CoP 14, between June and September, 2007, the Ministry of Marine Affairs and Fisheries of the central government, in collaboration with the regional government, organized multiple dialogues for protecting and managing BCF, as reported in local newspapers (e.g. Anon. 2007b).

ing their expert knowledge of the CITES. For direct and indirect inputs to this article, we would like to thank Dr Alejandro Vagelli, Mr Eko Rudianto, Ms Gayatri Lilley, Mr Liliiek Soeprijadi, Ms Ratna Dynni, Mr Samliok Ndobe, Ms Suryani Mille and Mr Syamsul Bahri Lubis. Mr Thomas Graham kindly reviewed the manuscript and offered constructive improvements.

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## The unfortunate journey of *Pterapogon kauderni*: A remarkable apogonid endangered by the international ornamental fish trade, and its case in CITES

Alejandro A. Vagelli<sup>1</sup>

### General introduction to *Pterapogon kauderni* (the Banggai cardinalfish)

#### *A species with a unique combination of traits*

*Pterapogon kauderni* (Koumans 1933) is a popular aquarium fish that is endemic to the Banggai Archipelago in eastern Indonesia. It is generally found in calm zones on the leeward side of larger islands, commonly in sheltered bays. It inhabits a variety of shallow habitats, including coral reefs, sea-grass beds and less commonly, open areas of low branching coral and rubble. Its depth distribution ranges between 0.5 m and 6 m, but is most common between 1.5 m and 2.5 m. It is a sedentary species associated with a variety of marine organisms, principally sea urchins, anemones and branching corals, and forms small groups frequently composed of a few dozen individuals of mixed age classes.

*Pterapogon kauderni* possesses a number of biological characteristics that make it an exceptional species, and of great interest in comparative studies on ecology and evolution of coral reef fishes. For instance, it is a rare example of a marine fish with an extremely limited geographic range. It has a very unusual mode of reproduction among coral reef teleosts, including advanced parental care of post-hatch embryos and an absence of a pelagic dispersal phase during its entire ontogeny. It is an atypical diurnal apogonid with a puzzling ontogenetic shift in its habitat and microhabitat preferences. It presents the highest population structure ever documented in a marine fish. It has special commensal relationships with several organisms to which it remains associated, and it plays an important role in its environment by preying on the larval stages of coral reef fishes' parasites.

Unfortunately, the human impact on *Pterapogon kauderni* is very significant. Overfishing for the international ornamental fish trade and rampant habitat destruction (primarily due to dynamite fishing) have led it to an endangered status in little

more than 10 years since the beginning of its commercial trade.

#### *A brief chronology of the scientific interest in Pterapogon kauderni*

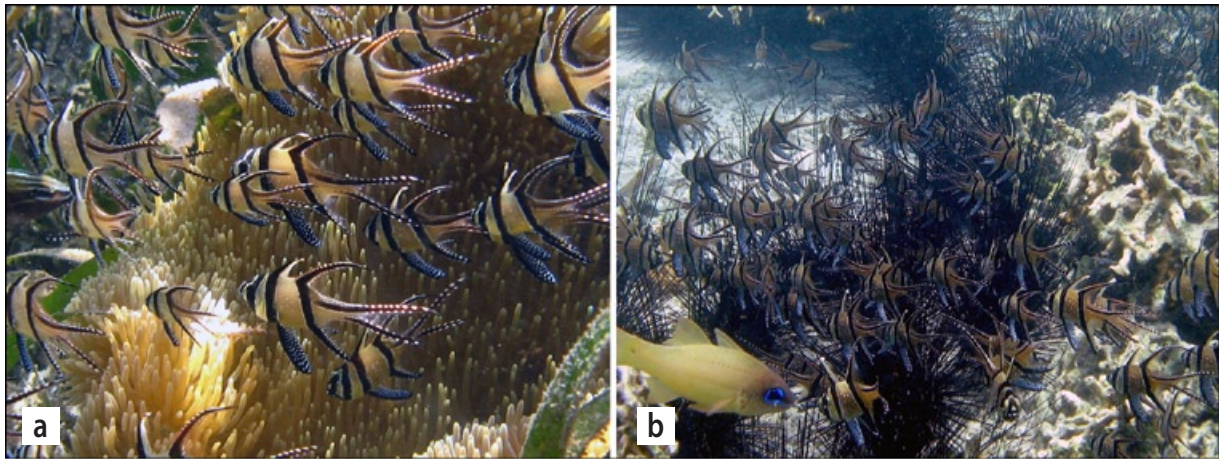
*Pterapogon kauderni* was first discovered by science in 1920 when Kaudern collected two specimens, most likely off Banggai Island, and sent them to the Leiden Museum of Natural History (Netherlands).

In 1933, Koumans found the specimens at the museum and described them, creating the genus *Pterapogon* (Koumans 1933). About 40 years later, Fraser (1972) studied the osteology of those preserved specimens. Then, in November 1994, Gerald Allen went to southwest Banggai Island to search for what he thought was an undescribed cardinalfish. He published his observations on general ecological aspects and the first photographs of live specimens in their natural environment (Allen and Steen 1995). In 2000 and 2002, Kolm visited the Banggai Archipelago and conducted studies on (reproductive) territorial behaviour, group and homing behaviour, and the effect of collecting on group size and density (Kolm and Berglund 2003, 2004; Kolm et al. 2005).

In 2001, Lunn and Moreau conducted a detailed study on the collecting effort and trade of *Pterapogon kauderni* in the Banggai Archipelago and north Sulawesi. Also, they conducted observations on group structure, density and microhabitat associations at the only site within the Banggai region in which all fishing, including the capture of *P. kauderni*, has not been allowed since before the beginning of its trade (Lunn and Moreau 2002, 2004).

In 1996, the author began a comprehensive research project on the natural history and conservation of *P. kauderni*. All aspects of its reproductive biology were studied, and a captive breeding programme was developed, which included studies on nutritional requirements of juveniles raised in captivity (Vagelli 1999, 2004b). In addition, most ecological

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**Figure 1.** The capture of *P. kauderni* does not require expensive equipment and it is facilitated by its sedentary and social behaviours. This species remains attached to shallow substrates such as anemones (a) and sea urchins (b), forming groups that are easily collected (photos by A.A. Vagelli).

aspects, geographic distribution, and the conservation status of *P. kauderni* were clarified for the first time as a result of expeditions to the Banggai Archipelago and north and central Sulawesi in 2001, 2002, 2004 and 2007 (Erdmann and Vagelli 2001; Vagelli 2002, 2004a, 2005a; Vagelli and Erdmann 2002; Vagelli and Volpedo 2004).

In September 2007, *Pterapogon kauderni* was included in the IUCN Red List of Threatened Species. It was assessed as “endangered,” a category meant for species “considered to be facing a very high risk of extinction in the wild.”

#### **The particular susceptibility of *Pterapogon kauderni* to overfishing**

*Pterapogon kauderni* is a small (maximum ~ 65 mm standard length, SL) fish especially vulnerable to indiscriminate collecting due to its highly restricted geographic distribution, low productivity, and the ease of its capture (which is greatly facilitated by its attachment to shallow microhabitats, sedentary nature and group formation) (Figs. 1a,b). In addition, given its biological and ecological characteristics, *P. kauderni* is not capable of naturally recolonising areas from which it has been eliminated.

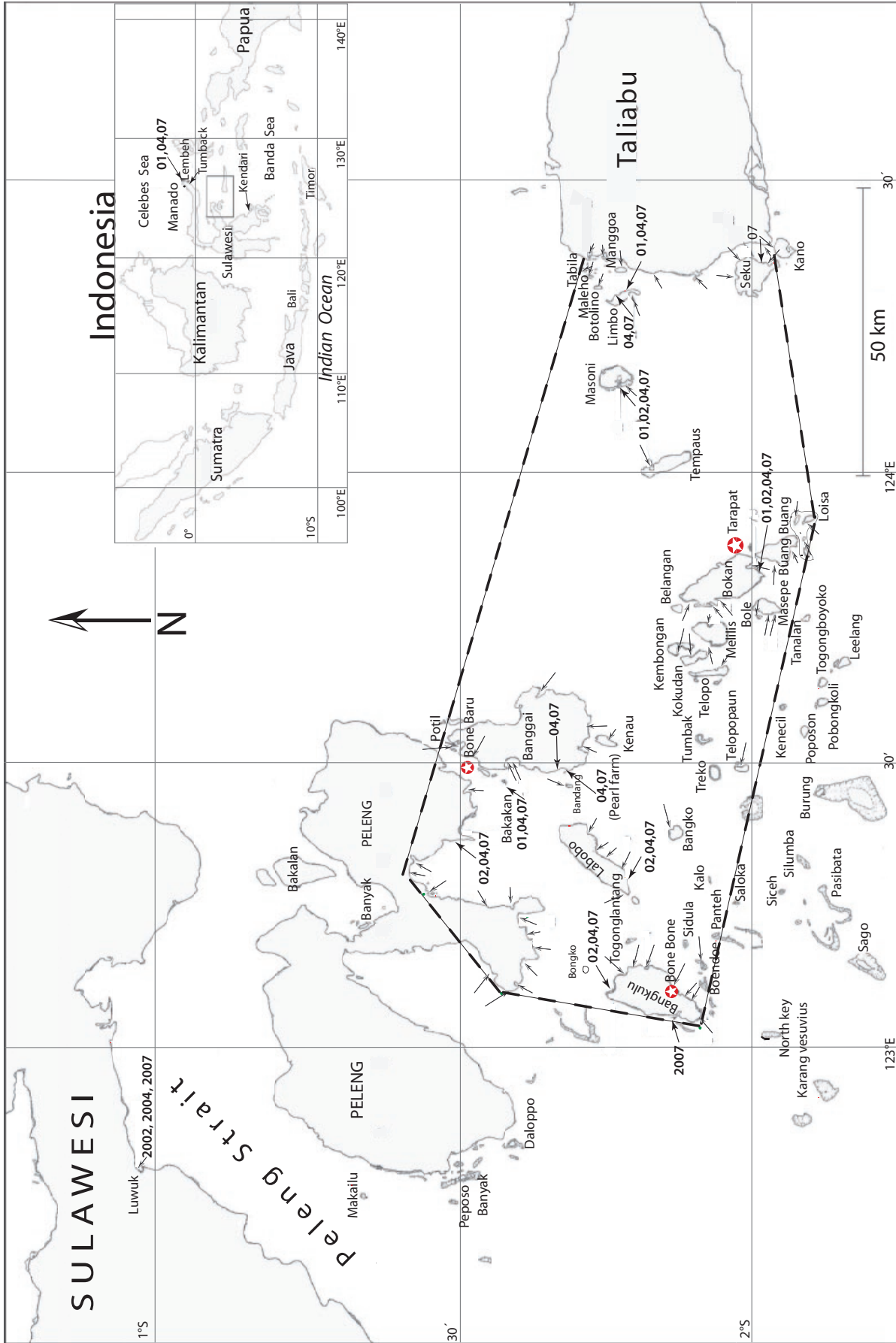
The natural range of *Pterapogon kauderni* covers an area of approximately 5,500 km<sup>2</sup>. However, its available habitat is limited to only about 300 km of coastline of 32 islands, confined within a maximum area of about 30 km<sup>2</sup> (<http://www.cites.org/eng/cop/14/prop/E14-P19.pdf> 2008)<sup>2</sup> (Fig. 2).

Unlike most coral reef teleosts, including other apogonids, *Pterapogon kauderni* has very low fecundity. Females produce small egg clutches of up to 60–70 large eggs (the mean clutch size found in wild incubating males was 41 eggs). Females can reproduce at about 8–9 months of age and at 35 mm SL. The smallest female with signs of advanced gonad maturation found in the wild was 41 mm SL. Females require about one month between spawns. Mated pairs isolate themselves for up to a few days, and display a variety of behavioural patterns easily interrupted by the presence of other individuals. Spawning and recruitment appears to follow a lunar cycle. Males mouthbrood the egg clutch for about 20 days, and after hatching, the embryos remain within the male’s oral cavity for about a week until their release as juveniles. Males do not feed while incubating and are limited to just a few brooding cycles per year.

The fertility rate is not more than about 70%, and it is frequently less due to loss of eggs during the clutch transfer. Contrary to the expectation for a species with high parental energy investment per offspring and with parental care of an advanced degree, *P. kauderni* suffers high early mortality, most likely due to predation, shortly after recruitment (Vagelli 1999, 2005a; Vagelli and Volpedo 2004).

*Pterapogon kauderni* exhibits the highest degree of genetic structure reported for a marine fish. Some populations occurring on reefs of the same islands are genetically distinct from one another (Bernardi and Vagelli 2004; Hoffman et al. 2005).

2. A very small population is restricted to inside Luwuk Harbor (central Sulawesi). It is likely a product of human introduction. The nearest population is found ~100 km southeast, across the 900 m deep Peleng Strait in the Banggai Archipelago. Another population was introduced 400 km north of the species’ natural range by trade activities in north Sulawesi. It was first detected in 2000 in the Lembeh Strait. In 2002, specimens were introduced by local resort operators on Lembeh Island. Also, in Tumbak (a main purchase centre on north Sulawesi) another small population was established through the routine discharge of specimens by sellers and buyers.



**Figure 2.** Geographic distribution, census sites, and main collecting centres. The natural range of *P. kauderni* covers about 5,500 km<sup>2</sup> (area delimited by dashes). However, it is restricted to a few sites (small arrows) on 32 islands with a maximum potential available habitat of only about 30 km<sup>2</sup>. The census sites are indicated by larger arrows and the years in which the censuses were completed. Stars indicate the location of the three collecting centres.

Habitat loss due to destructive fishing practices (dynamite and cyanide fishing) and coral diseases greatly affects *P. kauderni*. As its reef habitat is diminished, fewer shallow areas with sufficient living substrates remain for this species, forcing it in some areas to inhabit deeper waters. However, at deeper depths the microhabitats used by *P. kauderni* are much scarcer, reducing the capacity of these areas to sustain sizable populations (Vagelli 2005a).

### Conservation situation of *Pterapogon kauderni* and its path to “endangered” status

#### *The beginning of the trade*

The aquarium hobbyist community first learned about *Pterapogon kauderni* in 1995 when Allen introduced it at the Marine Aquarium Conference of North America (MACNA) VII, and through his publication describing the re-discovery of this species in a popular aquarium magazine (Allen 1996). By the late 1990s, *P. kauderni* became very popular in the aquarium hobbyist community and the demand for it grew enormously. Soon, however, the first concerns for its conservation were expressed when Allen, during his survey of the Banggai Islands with Conservation International in 1998, found holding nets with thousands of specimens waiting to be sold, leading him to recommend the inclusion of *P. kauderni* in the IUCN Red List (Allen 2000, 2001). In addition, Kolm and Berglund (2003) showed that (in 2000) collecting activities could have a significant detrimental impact on its populations.

In 2001, the first ecological and geographic distribution survey of *Pterapogon kauderni* was completed, as well as the first census and assessment of its fishery and trade. The results showed that *P. kauderni* was absent in most of the small and southern islands of the Banggai Archipelago, and that at least 700,000 specimens per year, and probably many more, were reaching a north Sulawesi export centre, and several thousands more were being sent to Bali each year (Lunn and Moreau 2004; Vagelli 2002; Vagelli and Erdmann 2002).

#### *Present conservation situation*

##### *Collecting pressure and population declines*

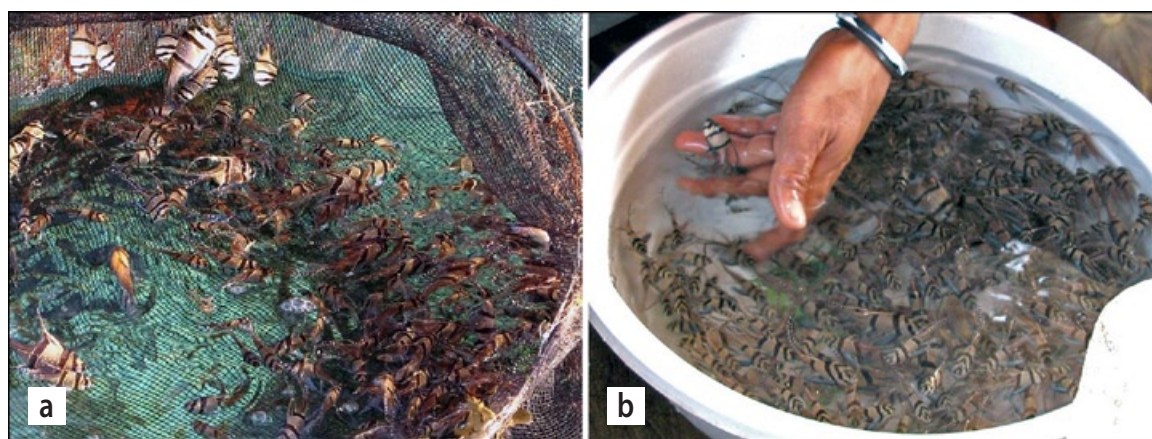
Three main collecting centres dominate the capture-trade operations in the Banggai region (Fig. 2). One is located in northwest Banggai Island, where about 20 fishers collect *Pterapogon kauderni* (and one of them is a buyer). They collect around Banggai, Labobo, Bakakan, and Peleng Islands. The

local buyer purchases 6,000 specimens per month. In addition, another four buyers come to this centre to purchase about 30,000 specimens per month. All five buyers go to Tumbak (north Sulawesi) to sell specimens with a reported 25% mortality during this 24-hour trip, and 15% rejection by the buyers due to poor specimen condition (Figs. 3a,b). The second centre is located in southeast Bangkuru Island, where about 15 fishers collect an average of 15,000 fish per month, mostly around Bangkuru Island. Buyers come two to three times per month and take the fish to Kendary (south Sulawesi) (Figs. 4a,b). The third centre is located in southeast Bokan Island, where the village chief is the main buyer of the region and organizes collection around Bokan, Buang Buang, Loisa, Masepe and Kokudan Islands. He purchases approximately 15,000–20,000 specimens per month and transports them directly to Bali (4–5 day trip) with a 30% mortality and rejection rate. In addition, three to four buyers come to Bokan from Manado (north Sulawesi) to purchase 35,000 specimens monthly (Fig. 5).

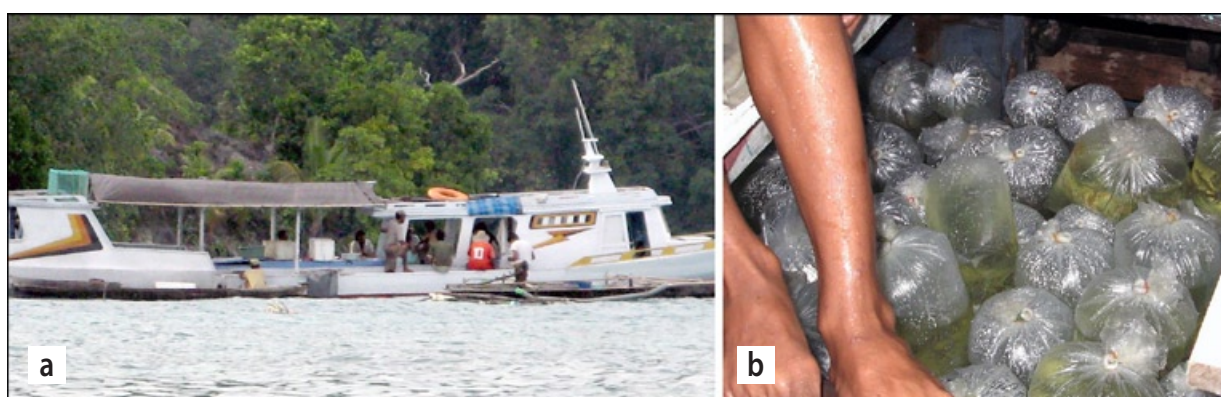
In addition to collection by local fishers, boats come directly from Bali to collect in the Banggai region. This outside (illegal) collection was detected as long ago as 2001 (Lunn and Moreau 2004). Boats bringing about 10 fishers generally collect for a week before returning to Bali. Although the present magnitude of this outside capture is unknown, a reasonable figure may be several thousand fish per month.<sup>3</sup>

In conclusion, assuming that weather and/or logistical problems may cause some interruptions in both harvesting and shipping, a conservative estimate of the present total rate of capture of *Pterapogon kauderni* within the Banggai Archipelago is about 1,000,000 specimens per year. When this figure is compared with the estimated total number of individuals inhabiting the entire Banggai region (i.e. 2,200,000), it reveals the bleak conservation situation of *P. kauderni*. Several populations monitored since 2001 clearly show the impact of overexploitation. For instance, the population on Masoni Island, monitored since 2001, has been dramatically reduced. In 2007 only 37 individuals were found in the census site (4,800 m<sup>2</sup>), and a search of the entire island uncovered no more than about 150 individuals. The population in southeast Peleng Island, followed since 2002, has been practically exterminated, with only 27 individuals found at the census site. The population in Bakakan Islands did not recover from the dramatic decline suffered between 2002 and 2004. Approximately 350 individuals remain at both islands, compared with the 6,000 estimated to have been present in 2001. The small popula-

3. In the past, it was common for these outside boats to hire local collectors to capture *P. kauderni*. For instance, in 2003–2004 local fishers in Kokudan and Banggai sold about 3,000 and 20,000 specimens per month, respectively, to boats from Bali.



**Figure 3.** At Bone Baru, Banggai Island, *P. kauderni* are moved from a holding pen (a) and then transported to a buyer's boat, where they are sorted by size and are counted (b) (photos by A.A. Vagelli).



**Figure 4.** Local collectors at Bone Bone, Bangkuru Island, taking their catch to a buyer's boat (a), which can transport more than 12,000 specimens (b). Mortality during transport is usually about 25%, but can reach 50% or more (photos by A.A. Vagelli).



**Figure 5.** Mr Rahman, Chief of Panapat Village, Bokan Island, in his home providing the author with a detailed description of how the collection and trade of *P. kauderni* is organized under his supervision, as well as of places of collection and capture volumes (photo by Junico Seba).

tion inhabiting the census site in southeast Limbo Island, which had a low density of 0.02 individuals  $m^{-2}$  in 2001, and was determined to be virtually eradicated in 2004, has not recovered. A total of only four specimens were found. Thus, it did not come as a surprise that by 2007, population surveys had documented a reduction of close to 90% in the species' abundance, with a reduction in mean density to 0.08 individuals  $m^{-2}$ . This can be compared with the estimated historical baseline density of *P. kauderni* within its natural range of about 0.6 individuals  $m^{-2}$  (Vagelli 2002, 2005a, 2007).

#### **Habitat degradation affecting *Pterapogon kauderni***

In addition to the unsustainable collection of *Pterapogon kauderni* for the aquarium trade, populations of this species are threatened by habitat loss due to destructive fishing, which was already affecting this region for years prior to the beginning of the *P. kauderni* trade (Indrawan 1999). Today, dynamite fishing for food fish remains widespread, and the narrow reefs and limited available habitats for *P. kauderni* are being destroyed throughout its natural range (Figs. 6, 7).

In 2007, an undetermined disease affecting hard corals was detected in several islands. It particularly affected the top sections of long-branched *Acropora* species as well as species of *Porites*. In some areas, *Millepora* formations were covered by green algae and some have lost more than 50% of their structure. These corals form substrates where *Pterapogon kauderni* is commonly found. In addition, a new viral disease has been documented in wild-harvested *P. kauderni* individuals imported into the United States. The origin of this iridovirus (genus *Megalocytivirus*), as well as its prevalence in and impacts on wild populations, are currently under investigation. However, it is known to occur in ornamental fishes exported from Southeast Asia (Weber et al. in press).

#### **The Banggai cardinalfish and CITES: A biologist's disappointing experience**

##### ***The proposal to include P. kauderni in CITES Appendix II***

The need for protecting this species became evident earlier in this decade as a result of the author's and other researchers' fieldwork (Allen



**Figure 6.** A recently bombed reef patch in Labobo Island. Dynamite fishing is widespread throughout the Banggai Archipelago and includes areas inhabited by *P. kauderni* (photo by A.A. Vagelli).

2000; Lunn and Moreau 2002; Vagelli 2002; Kolm and Berglund 2003).

After evaluating his field data gathered in 2004, which showed no indications of a reduction in collecting effort and a significant decline of some populations (including the extinction of one), the author decided to recommend that *Pterapogon kauderni* be included under an appropriate CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) Appendix at the next CoP (Conference of the Parties) meeting.

In March 2006, the recommendation was submitted by the author to CITES United States, which evaluated it favourably. CITES United States invited its Indonesian counterpart to co-sponsor a proposal to include *P. kauderni* under Appendix II<sup>4</sup> of CITES at CoP 14. After several requests by CITES United States, CITES Indonesia finally answered, declining to co-sponsor it. In its response, CITES Indonesia did not oppose the proposal, but stated that it was "not able to provide strong support", and that it was expecting "positive impacts from the current management program being undertaken at the area, such as the establishing of District Marine Protected Areas and a fishermen certification system in collaboration with the Marine Aquarium Council (MAC)" (Susmianto 2007). CITES United States did, however, receive supporting letters from Yayasan Pemerhati Lingkungan (YPL), the only local non-governmental organisation (NGO)

4. CITES' objective is to ensure that international trade in specimens of wild organisms does not threaten the survival of the species. Species are placed into three appendices depending on the threat of trade to their survival, current or future. Appendix I includes the most endangered among CITES-listed species. They are threatened with extinction and CITES prohibits their international trade except for non-commercial purposes (e.g. scientific research). Appendix II lists species that are not necessarily threatened with extinction, but may become so unless trade is regulated. International trade of such species may be authorized by granting permits, but only if the relevant authorities are satisfied that international trade will not be detrimental to the survival of the species in the wild. Appendix III includes species that are not globally threatened, and they are listed at the request of a Party that already regulates trade in the species and that needs the cooperation of other countries to prevent unsustainable or illegal exploitation.



**Figure 7.** Typical “bomb” used in the region: It is made with a beer bottle filled with fertilizer and phosphorus scraped from matches (photo by A.A. Vagelli).

that has been working on educational and conservation issues in the Banggai Archipelago (Lunn and Moreau 2004; Vagelli 2005b), and from the head of the Banggai Fisheries and Marine Affairs Department. In the end, CITES United States submitted the proposal to the CITES Secretariat.

### **The opposition**

By June 2007, the CITES Secretariat, IUCN, the European Community, and several international conservation organizations supported the proposal. Furthermore, YPL was adamant in its support of the proposal and expressed it to local, regional and federal fisheries department authorities as well as to CITES Indonesia.

At CoP 14, after the proposal was introduced on the floor, CITES Indonesia voiced opposition. It argued that the regulation of trade of *Pterapogon kauderni* would have severe negative impact on the livelihoods of the people of the Banggai region. It also stated that conservation efforts were underway by Indonesia’s central and local governments, including in situ aquaculture programs and the development of sustainable collecting practices.

Indonesia did not refute the data contained in the proposal, which clearly indicated the appropriateness of including *Pterapogon kauderni* under Appendix II, if not Appendix I. The only instance in which CITES Indonesia referred to any survey data, they grossly misrepresented them. The CITES Indonesia representative, in a statement made in opposition to the listing proposal at the CoP 14, said that in the “most recent assessment done in the Banggai region

[referring to the author’s survey in 2007] only six out of 77 sites surveyed were found with a significant decline in population.” What the representative did not mention was that out of the 77 sites surveyed, *P. kauderni* was found in only 35, and that the 2007 censuses were conducted in only 11 of the sites that had been followed since 2001.<sup>5</sup> Therefore, the more relevant finding was that 6 out of the 11 long-term monitoring sites showed significant reductions in population sizes relative to 2004 (including 3 sites with only 38, 27 and 4 individuals remaining) (<http://www.cites.org/common/cop/14/inf/E14i-37.pdf>). The conservation implications of this finding were, of course, quite different than those portrayed by CITES Indonesia in its opposition to the proposal.

The United Nations Food and Agriculture Organization (FAO) expressed its opposition to the proposal and incorrectly stated that *P. kauderni* was a high-productivity species. Subsequently, several countries adopted CITES Indonesia’s position. Most cited the hardship that the inclusion of the species under CITES would bring to the local people, and mentioned the alleged conservation efforts already put in place by Indonesia. Some criticized the CITES United States’ lack of consultation with CITES Indonesia in preparing the proposal. As a result of this opposition, the US delegation to the CoP 14 withdrew the proposal before a vote could be called.

### **Misinformation on the Banggai cardinalfish CITES proposal**

The author’s personal discussions at The Hague with several Latin American CITES representatives, which took place previous to the proposal’s introduction, highlighted the lack of familiarity of those delegations with the Banggai cardinalfish proposal. Yet they were prepared to follow CITES Indonesia’s portrayal of the situation; that is, a region highly dependant on an allegedly well-managed natural resource, the livelihoods in the entire region being disregarded by a powerful country (i.e. the US, the proponent), and a proposal prepared without consultation with the host nation.

It was disappointing to know that these Latin American delegations were prepared to vote against the proposal as a block without considering additional information that was provided by the US to all CITES parties (<http://www.cites.org/common/cop/14/inf/E14i-.pdf>). This additional information described in detail the impact of the *Pterapogon kauderni* trade in the Banggai region and refuted the faulty assessment by FAO. This regrettable position seemed far from

5. The information on the number of sites surveyed and the presence/absence of *P. kauderni* in 2007 that was cited (and misused) by CITES Indonesia is part of a detailed report presented by the author to the Indonesian CITES authorities in Jakarta in May 2007.

the mission of CITES; that is, “to ensure that international trade in specimens of wild animals and plants does not threaten their survival.” Although unfortunate, this position might have been the product of lack of interest rather than part of a tactical approach regarding their relationship with Indonesia, as was most likely the case with the Asian block of countries that opposed the proposal.

Economically driven interests were likely behind the positions of several organizations representing the ornamental aquarium industry. They exerted strong efforts, both financial and logistical, to oppose the proposal and cloud its interpretation. They even produced a propagandistic brochure in association with CITES Indonesia that was given to all CoP participants (<http://www.zza-online.de/aktuelles/88.html> 2008). For instance, as published in *Aquarama Magazine*, “... seven representatives from the ornamental aquatic industry, three of whom were from the European Pet Organisation (EPO), and one from each of the following: Ornamental Fish International (OFI), Pet Industry Joint Advisory Council (PIJAC), Ornamental Aquatic Trade Association (OATA) and Pet Care Trust (PCT) ... and after much cooperative lobbying before and during CoP, they were able to influence the final decision not to list the Banggai cardinalfish in CITES Appendix II ...” (September 2007, Issue 9, News Section). Another interest group, World Conservation Trust, also congratulated the failure of CITES in protecting *P. kauderni*, exemplifying how misinformation about the Banggai cardinalfish proposal has been disseminated. In this case it accepted both the false notion that CITES United States did not consult with CITES Indonesia before submitting the proposal, and that the proposal did not meet listing requirements. The editorial page of the July-August 2007 Sustainable e-News/ IWMC World Conservation Trust argued that “the success factor [at CITES] for some officials and delegations now clearly has more to do with securing a listing. Why else... would the US (Banggai cardinalfish) make proposals without first consulting with range states as they are required to under CITES rules?”

After pointing out that CITES rejected the listing of four species (spiny dogfish, porbeagle, Banggai cardinalfish and red/pink coral), as well as the creation of a position for a CITES fisheries officer, the editorial thanked “all the colleagues for their hard work in achieving this outcome.” In the same issue, it states that “IWMC advocated the rejection of the proposals because, in each case, they clearly failed to meet requirements of a listing” (<http://www.iwmc.org/newsletter/2007/A2007-08.pdf>).

### The reality

Despite the above-mentioned arguments put forward by CITES Indonesia for declining the US’s request for co-sponsorship and for opposing the proposal at CoP 14, and the false notion that CITES United States did not consult with CITES Indonesia (e.g. Moore and Ndobe 2007), the reality is quite different and is described in the following paragraphs.

First, no conservation programme involving *Pterapogon kauderni* was ever attempted in the Banggai region. Neither the author’s first three expeditions spanning the entire archipelago (2001, 2002, 2004), nor regular visits by YPL to the Banggai region ever uncovered evidence of a conservation or aquaculture programme being implemented or planned by any federal, regional, or local institution or NGO.<sup>6</sup>

During the field survey of March–April 2007, the author made a special effort to determine if a conservation project was being developed, because the main reason put forward by CITES Indonesia in declining the invitation by CITES United States in submitting a joint proposal to include *P. kauderni* in CITES, was that “it will hamper current conservation projects underway in the region.” As suspected, there were no areas being established to protect *P. kauderni*, no local aquaculture project being developed, and no village in the Banggai Archipelago was approached by the government to implement any conservation or management plan directed toward *P. kauderni*. In addition, in late March 2007 while in the Banggai region, the author was contacted by MAC Indonesia, which had been asked to advise on the *P. kauderni* CITES proposal. In the course of several conversations, the author clarified several aspects of the biology of this species and its present conservation situation. MAC Indonesia representatives acknowledged their unfamiliarity with both the species’ conservation status and the Banggai region, and stated that they were not planning a certification system directed towards *P. kauderni*. Furthermore, they suggested that the author request a meeting with CITES Indonesia in order to inform them about the real situation involving *P. kauderni*, since apparently they were being misinformed by other parties.

Second, CITES United States invited Indonesia to co-sponsor the proposal. In addition, it requested from Indonesia available information on the conservation status of *Pterapogon kauderni*, including data on its collection, captive breeding efforts, existing legislation, trade regulations and management plans. Furthermore, CITES United States shared with CITES Indonesia the full recommendation for *P. kauderni* to be included in an appropriate CITES

6. That is, other than the programme jointly proposed by the YPL and the author to the local fisheries authorities in Banggai Island (Vagelli 2005b).



Appendix as well as reprints of published papers on the biology and conservation status of *P. kauderni* that the author submitted to CITES United States (Gabel 2006).

In May 2007, the author, following the advice given by MAC Indonesia, travelled twice to Jakarta to meet with the scientific and the management authorities of CITES Indonesia, with high officials at the Ministry of Marine Affairs and Fisheries, and with the head of the regional government and local fisheries department (Fig. 8). They were presented with a detailed report on the current conservation situation of *P. kauderni*, including the latest data on each population's status, trade volumes, habitat degradation, and significance of its trade to the local economy. During those meetings, it became evident that neither CITES Indonesia nor the local government authorities were familiar with the species' conservation situation, nor with any regulation aimed to protect it, nor with the implementation of any marine protected area in the region.

It is known now that it was not until August 2007 that the first step was taken to develop a Banggai cardinalfish management plan (specifically, a meeting among stakeholders was conducted) (Moore and Ndobe 2007).



**Figure 8.** The author speaks with Dr Nurdjana, Indonesia's Director of Directorate General for Aquaculture, prior to the author's presentation on the conservation status of *P. kauderni* at the Indonesia Ministry of Marine Affairs and Fisheries (Jakarta) (photo by Suryani Mile).

### ***The real impact of the Pterapogon kauderni trade in the Banggai Archipelago***

The main opposition to regulating the capture and international trade of *Pterapogon kauderni* was based on the alleged significant economic impact that its inclusion under Appendix II would have brought to the entire Banggai region. However, the real economic importance of the capture and trade of this species within this region is virtually nil. The

reality is that the overwhelming majority (> 99%) of the approximately 160,000 local residents (Head of Regional Government, pers. comm. 2007) do not depend on *P. kauderni* for their livelihood. The vast majority of the Banggai people make their living with more profitable and traditional economic activities such as agriculture, seaweed culture, and fisheries (Fig. 9a,b,c). About 55% of the region's GDP is due to agricultural and traditional fisheries activities (<http://www.banggai-kepulauan.go.id> 2008). The rest comes from mining, industry, public service, and trade activities.



**Figure 9.** The economic activity due to the collection and trade of *P. kauderni* within the Banggai region is negligible. The overwhelming majority of people dedicated to sea-based activities focus their efforts on traditional fisheries, including production of salted-dried fish (a), squid (b), and seaweed culture (c) (photos by A.A. Vagelli).

The production of salted and dried fish, squid, octopuses, shark fin and sea cucumber is by and large the main fishing activity in the region.<sup>7</sup> In addition, a small number of fishers are involved in the live fish trade for both food and ornamental species. Among them are no more than 60–80 fishers actively engaged in the capture and local trade of *P. kauderni*. The low price obtained per fish (~USD 0.03), which is 10–100 times lower than that obtained for other ornamental species, is the reason why so few people are dedicated to the capture of *P. kauderni*. Moreover, these collectors do not rely solely on this activity as a source of income, but as a complement to their other, more traditional sources of livelihood. Thus, the capture and trade of *P. kauderni* is negligible in terms of both economic impact and employment within the Banggai Archipelago.

### The benefits of regulating the collection and trade of *P. kauderni* through CITES

The inclusion of *Pterapogon kauderni* in the IUCN Red List as “endangered” underscores its bleak conservation status. However, this designation does not restrict international trade or collection. If it is not regulated, the current unsustainable capture of *P. kauderni* will deplete many sub-populations and, given their genetic distinctiveness, entire genetic lines will be lost.

The inclusion of *Pterapogon kauderni* under CITES is the best practical way to ensure the protection of both the species and the ability of local people to sustainably harvest it over the long term. The regulation of trade will likely facilitate the restoration of its populations, increase protection of its habitats, and create an incentive to develop comprehensive management plans for the species. In addition, a CITES listing might provide more opportunities to seek international funding to conduct additional surveys, to expedite the implementation of management plans<sup>8</sup>, and to establish captive breeding operations managed by local people.

The inclusion of *Pterapogon kauderni* in CITES Appendix II would require CITES Indonesia to issue export permits and to demonstrate that harvest and trade levels are not detrimental to the species. Moreover, the European Community, one of the largest markets, would impose additional (although not

required under CITES) controls and require import permits. Thus, the inclusion of *P. kauderni* in CITES II would significantly reduce the present export (harvest) volume.

However, it is the author’s opinion that given the current dire conservation situation of this species (confirmed by its recent listing as “endangered” in the IUCN Red List), a more appropriate measure to protect it would be its inclusion under CITES Appendix I. This listing would impose a ban on international trade and since there is no local market for *P. kauderni*, it would mean the cessation of its capture.

### Restriction on collecting and development of in-situ aquaculture

The current challenges and potential benefits of sustainable trade in Indonesian marine aquarium organisms are known (Reksodihardjo-Lilley and Lilley 2007). The various benefits of community-based aquaculture of marine ornamental fishes have been pointed out, and its important role as a complement to restrictions on trade and collection of threatened species has been recognized (e.g. Job 2005). The combination of commercial aquaculture of *P. kauderni* to reduce the need to capture wild specimens and a trade monitoring system established in collaboration with fish exporters has been strongly recommended (Wabnitz et al. 2003). Furthermore, CITES allows the international trade of specimens bred in captivity, even of species listed under Appendix I, as long as particular guidelines are followed (CITES, Article VII, paragraph 4, available at: <http://www.cites.org/eng/disc/text.shtml#VII>).<sup>9</sup>

The development of in-situ aquaculture of *Pterapogon kauderni* is feasible. The reproductive biology, husbandry, and captive breeding techniques to produce this species are well known (Marini and Vagelli 2007; Vagelli 1999, 2004a). These techniques can be applied to develop an extensive system of culture customized to local conditions, taking advantage of unlimited supplies of natural seawater and food.

The aquaculture of *P. kauderni* would facilitate the implementation of a product certification method such as the one administered by MAC, and it would reduce the number of intermediaries, giving local

7. Data from the first six months of 2004 show that on Banggai Island 16.5 metric tonnes (t) of seaweed, 1.2 t of demersal fish, 3.9 t of shark fin, 0.8 t dried fish, 1.1 t lobster, and 0.2 t sea cucumber were produced. For the same period on Bokon Island, 211 t of dried salt fish, 10 t of sea cucumber, and 4 t of shark fin were produced (EC-PREP 2005). Banggai and Bokon are two of the three islands where the main *P. kauderni* collection and trade centres are located (no data from Bangkuru Island were included).

8. Had CITES approved the listing of *P. kauderni*, CITES United States would have made funding available to implement the management programme dictated by CITES as well as to help develop an in-situ aquaculture project.

9. For example, “Ranching and trade in ranched specimens of species transferred from Appendix I to Appendix II” (CITES resolution Conf.11.16, available at: <http://www.cites.org/eng/res/11/11-16R14.shtml> 2008), and “Guidelines for a procedure to register and monitor operations that breed Appendix-I animal species for commercial purposes” (CITES Resolution Conf.12.10, available at: <http://www.cites.org/eng/res/12/12-10R14.shtml> 2008).

culturists more direct access to export activities. The restriction in trade of wild specimens (as would be imposed by Appendix I) would restrict the market to exclusively captive-bred specimens, which would provide to local producers a much better price than the current price paid to collectors, and the higher price per fish would more than offset the production costs. However, without restricting the trade of wild-caught specimens, it is difficult to see how in-situ aquaculture projects could succeed. Locals willing to invest several months of work and resources could not compete with the low price accepted by those that only require a hand net, a floating cage, and few hours of work.

At CoP 14, the conservation status of *Pterapogon kauderni* was disregarded. The parties chose to give more value to political and economic interests than to the survival of a species endangered by international trade, which is what the parties should be focusing on. It is hoped that personal interests and political susceptibilities will be put aside and that local, regional and national stakeholders can work together to develop a sustainable local aquaculture program. The author has offered technical assistance to develop such aquaculture projects to both federal (Director of Aquaculture, Ministry of Marine Affairs and Fisheries, Director of CITES) and regional authorities (Bupati Banggai Kepulauan District and head of Banggai Fisheries) during meetings held in Jakarta and Banggai in 2007, and he is still willing to provide such assistance if requested.

It is also hoped that non-local economic and political interests stop dictating the future survival of this species, which is a unique part of the special identity of the Banggai region.

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## Using coral reef fish larvae: Synopsis of work conducted in French Polynesia

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### Introduction

For more than 15 years, the École Pratique des Hautes Études (EPHE – French Applied Higher Studies Institute), in collaboration with French Polynesia's Fisheries Department (SPE), has been studying the reef colonisation phase of fish larvae, and has been working on the sustainable exploitation of post-larvae through an integrated aquaculture approach.

The goal of this paper is to assemble and share the basic knowledge of coral reef fish post-larval harvesting and rearing techniques used in French Polynesia. This overview is not a comprehensive compilation of all data, but rather a presentation of key points identified in the French Polynesian context. We hope, in this way, to present practical and useful information for the development of, on an island scale, sustainable reef aquaculture that is specifically oriented towards the production of live fish for the ornamental fish trade. After reviewing the principles acquired from basic research, we present the issues dealt with by applied research in French Polynesia and explain in detail how the French Polynesian expertise could be promoted.

### Knowledge acquired through basic research

#### *The crest net*

In the 1980s, in order to describe the zooplankton in reef and lagoon environments in French Polynesia, Jean-Pierre Renon (EPHE) anchored fine-mesh nets on the reef crests or in the shallow channels that connect the ocean and lagoon (locally called *hoa*) of islands such as Takapoto, Hao, Mataiva and Moorea (Renon 1989). The purpose of those nets was to filter the flow of plankton entering the lagoon, which is how the passage of fish larvae and juveniles over the reef are now studied. The study on ichthyoplankton in the reef complex of Moorea<sup>5</sup> was then continued by EPHE. As part of his DEA (upper tertiary studies) and later his doctoral thesis presented in 1992, Vincent Dufour took up Renon's technique of fixed nets, which he called "crest nets" (Dufour 1991, 1994; Dufour and Galzin 1992, 1993).

These nets, which for the first time offered the possibility of expressing catch results in terms of larval flow (i.e. the number of specimens caught per meter of barrier reef and per unit of time), proved to be both vital for the dynamics of CRIOBE research on larval reef fish colonisation and the forerunners of the nets used today for aquaculture purposes.

#### *Temporal variations in larval colonisation*

Studies on temporal variations in larval colonisation by Dufour (1991), Planes et al. (1993) and Dufour et al. (1996) on Moorea, and Lo-Yat (2002a) on Rangiroa show they are highly cyclical (Fig. 1). Descriptions of these temporal variations are given below.

**Nycthemeral cycles.** The vast majority of larval colonisation takes place at night. The most credible theory to explain this phenomenon is that nighttime is better for the survival of fish larvae in terms of reef predators.

**Lunar cycles.** Larval colonisation is higher on moonless nights, and the most productive period for collection is around the new moon. The explanation for this phenomenon is also associated with predation, as dark nights promote the survival of larvae during colonisation.

**Annual cycles.** Lo-Yat (2002a) demonstrated on Rangiroa that most fish species (72%) have seasonal colonisation cycles lasting a few months a year, whereas 27% of species caught are so-called "mixed" species that colonise throughout the year. Among seasonal species, 58% prefer colonisation during the warm season, from October to May, and only 14% are specific to the cold season. An increase of a few degrees in ocean temperature changes biotic factors (e.g. a plankton bloom = more prey for larvae) and abiotic factors (e.g. an increase in larval metabolic activity = better growth rates), which promote better survival of larval cohorts. These arguments may make it possible to explain the evolutionary trend in most fish species towards reproducing during the warm season.

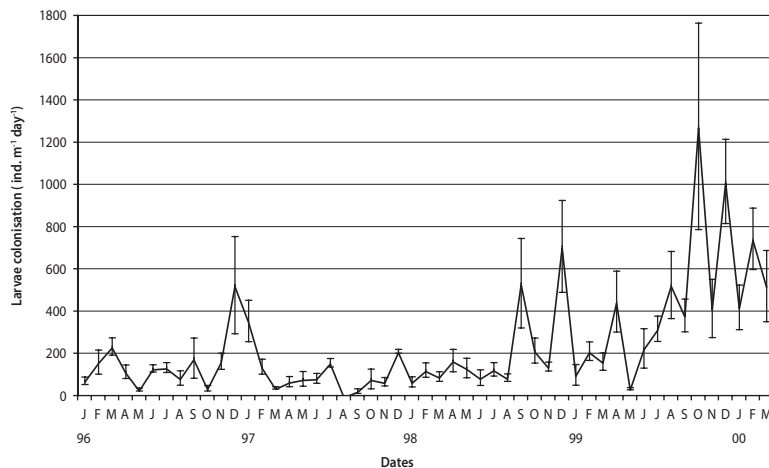
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**Figure 1.** Temporal evolution of larvae colonisation at Rangiroa from 1996 to 2000 (Excerpt from Lo-Yat A. 2002a).

**Inter-annual cycles.** Colonisation varies widely from one year to another (Fig. 1) and at present, there is no model to predict such variations. The survival of larval cohorts in the ocean is very arbitrary and linked to unforeseeable biotic and abiotic phenomena.

#### **Spatial variations in larval colonisation**

A study of variations in larval colonisation was carried out on several different scales on Moorea. Dufour et al. (1996) conducted an experiment using five crest nets that were 8–12 kilometres (km) apart and distributed around the island. This made it possible to show that colonisation was homogenous over all reef crests in Moorea. For certain species, simultaneous peaks in colonisation were observed in sites located 10–30 km apart. In addition, as part of the COVARE (colonisation larvaire et variabilité des stocks de poissons récifaux) mission, six crest nets placed 200 m apart on the northern coast of Moorea (Lecchini et al. 2004) made it possible to validate the homogeneous nature of larval colonisation on a smaller scale by demonstrating the absence of any significant differences in abundance and species richness between traps. Comparable results were obtained by Dufour (1992a,b) with two nets located 10 m apart.

It would appear that larval colonisation, at the level of reef crests on high islands such as Moorea, is homogeneous no matter what the spatial scale is.

In order to compare larval colonisation on reef crests with that in other habitats, Malpot (2005) conducted a study using light-traps on Rangiroa. Three sites (outer slope, pass and lagoon), located 2 km apart, were each equipped with three independent light-traps. The results showed that colonisation was significantly higher in island passes than on the outer reef slope, which seems to indicate that current-related phenomena in the pass favour larval concentration. The lagoon site recorded very low catches, due to the prior settlement of larvae from the ocean. The use of three independent light-traps

at each sampling site allowed confirmation of the absence of spatial variation in colonisation on a small scale.

The notion of spatial variation in larval colonisation does not appear, in principle, to be determined by quantitative parameters (e.g. distances between sites) but rather by qualitative criteria (e.g. hydrodynamics and habitat). It has only been recently that the notion of auto-recruitment and connectivity between islands has been studied in greater detail (Planes et al. 2002; Irisson et al. 2004; Almany et al. 2007).

#### **Structure of larval cohorts**

Analysis of fish larval catches in French Polynesia, using nets and light-traps repeatedly, shows very low catch diversity. Even when total species richness of catches is high (i.e. a very large number of species), most species are poorly represented and only a few taxa are very abundant (Fig. 2). Annual catches are generally dominated by Pomacentridae (45–55%), Apogonidae (15–20%), Acanthuridae (6–8%) and Holocentridae (4–5%).

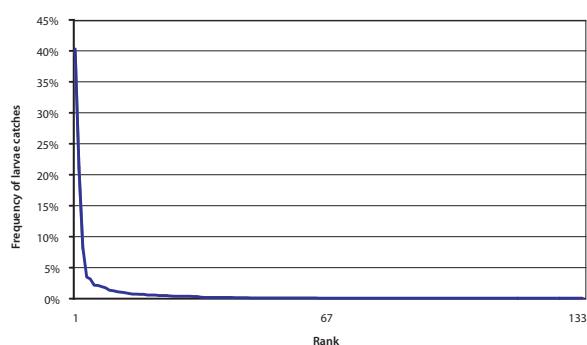
#### **Larvae after colonisation**

A study by Dufour et al. (1996) made it possible to show, through density estimates (larval abundance at colonisation vs settled adult fish), that out of every 100 larvae that arrive alive on the reef, only 1 to 10 survive to become adults.

In 1998, as part of the COVARE programme, 20 French, American and Australian researchers monitored both the colonisation and mortality of *Naso unicornis* post-larvae during settlement on the lagoon floor on Moorea. This study showed that 61% of the larvae that colonised the lagoon during this period had disappeared by the morning following their arrival, regardless of the size of the cohorts (mortality density-independent). Over the following days, daily cohort mortality was assessed at between 9% and 20%, depending on their size (mortality density-dependant). This vital scientific result (Doherty et al. 2004) demonstrates that harvesting part of the stock of larvae colonising a reef only has a minor impact on the dynamics of the fish population. In this way, the merits of exploiting larvae, instead of adults, as suggested by Yan (2001), Hair et al. (2002) and De Villers (2003), was scientifically validated.

#### **Overview of knowledge acquired through basic research**

The basic research carried out in French Polynesia by CRIOBE, with the support of the French and



**Figure 2.** Rank/frequency diagram showing the heterogeneous structure of larval catches on Rangiroa from January 2006 to February 2007. The ranks correspond, in descending order, to the abundance classes of species caught.

French Polynesian governments, has made it possible to summarise the processes (Lecchini and Galzin 2003) and respond to three vital questions regarding the use of larvae for fisheries purposes.

*How should larvae be collected?* A well-designed crest net is key to properly carrying out research on larval colonisation. It is also a tool that has raised the interest of development agencies such the Etablissement pour la Valorisation des Activités Aquacoles et Maritimes (Aquaculture and Maritime Activities Development Agency – EVAAM), and has allowed applied research to begin, for the first time, the development of a net for the channels through the reef that connect the ocean and lagoon, *hoa*.

*Where and when should larvae be collected?* The work carried out by CRIOBE and EVAAM made it possible to determine the most favourable time periods for collecting fish larvae in French Polynesia, both overall and also specifically, by analysing the qualitative structure of catches and changes over time. This also allowed the best collection sites to be identified.

*Why collect larvae?* Crest and *hoa* nets mainly catch specimens in the colonisation phase, just before they are subjected to high rates of mortality from predators. So, catching them to rear in aquaculture facili-

ties has only a very small impact on populations at the site, which ensures the sustainable ecological nature of this activity (Hair et al. 2002).

The French Institute of Research for Development (IRD), in collaboration with EPHE, SPE and the Pearl Farming Department (PRL), is now directing research towards determining the factors that influence larval colonisation on the reef (Lecchini 2004, 2005).

### Development of applied research

The various basic research studies mentioned above focused solely on the colonisation phase. This work allowed a theoretical base to be laid with a view to exploiting a new resource (i.e. reef fish larvae). Fish larval stock use and aquaculture development were the natural outcome of this work and have been the subject of several developmental research programmes.

### Optimising larval harvesting techniques

The crest net that Dufour used on Moorea to describe changes in larval flow was poorly adapted to production purposes. Its opening was quite small (1.5 m x 0.75 m), it was built out of flimsy materials, and the initial design did not promote the survival of collected samples. A trap designed to supply larvae for aquaculture facilities needs to meet different specifications; for example, it must be robust, as productive as possible, and limit stress on larvae as much as possible. It was at EVAAM on Rangiroa — from 1996 to 2000 — that improvements to the crest net began.

The first modification involved the site where the trap was set up. A reef crest is a particularly exposed area, and its strong hydrodynamics limit the useful life of equipment, and complicate deployment, collection and maintenance of traps. The shallow channels through the reef (*hoa*) through which ocean water enters the lagoon, provides an interesting alternative for setting up nets. Located several hundred meters from the wave impact zone, *hoa* are sites that are easy to use and, more importantly, they concentrate larval flow. This was demonstrated by Malpot (2005) at Rangiroa by comparing catches using a *hoa* net and a crest net (Fig. 3) located upstream. The



**Figure 3.** Crest and *hoa* nets on Rangiroa (From Malpot 2005).

*hoa* net had a larval flow that was 250 times more concentrated than the flow at the crest, while the volume of water filtered was only 26 times greater. These results demonstrate the tendency of certain taxa to swim along the atoll's outer reef flat looking for a passage into the lagoon, and suggest that an isolated *hoa* crossing a long strip of reef acts as a bottleneck for the passage of larvae.

In addition, Yan (2001) and Lo-Yat (2002a) worked on improving the trap itself. Its opening was widened to 2 m x 1 m and its filtering capacity was increased by adding current deflectors. The collectors that the larvae are held in at night were also modified to increase their volume.

Additional improvements have been made by a few private sector companies, covering, in particular, the overall design of the trap to make it easier to handle, especially during the removal of harvested larvae.

While collection techniques in French Polynesia are exclusively based on crest and *hoa* nets, in the 1990s Australian researchers developed collection devices based on light (i.e. light-traps; see Fig. 4). In order to test their efficiency in French Polynesia, and possibly to use them in addition to net techniques, vertical-slot traps were tested by Polti (2001) on Moorea and compared with crest nets. The author showed that nets were significantly more productive than light-traps in terms of total catch abundance and species richness. On Rangiroa, the performances of *hoa* nets, crest nets and nine CARE systems (Lecaillon 2004) were tested by SPE, CRIOBE and Tropical Fish Tahiti (Malpot 2005) over 101 consecutive nights. Results show that *hoa* nets are much more productive than light-traps in terms of total catch abundance and species richness, and that there is no significant difference in terms of larval survival rates between the various traps (Table 1). However,

light-traps have the advantage of collecting species that are confined to outer reef slopes, which nets do not catch (i.e. 13.5% of the species caught in the CAREs had never before been collected at Rangiroa) (Malpot 2005). This advantage is limited by the very low number of specimens of these additional species (0.76% of the total number of larvae collected by Malpot using CARE systems in 2005), their low commercial interest, and the often prohibitive operating costs of traps used on outer reef slopes. The low level of effectiveness noted in light-traps and CARE systems on reefs in French Polynesia — where fish populations are abundant, tides are shallow or non-existent and larval colonisation is very dynamic — leaves us perplexed as to the usefulness of this kind of trap for aquaculture projects, in contrast to what has been suggested by Lecaillon and Lourié (2007).

#### **Development research on the rearing phase**

The fact that reef fish larvae can be caught alive, using crest nets, led public agencies in French Polynesia to become interested in finding out if the larvae could be farmed. Several studies have been carried out in this area since 1995, by both EVAAM and the public agencies that took over from it, currently SPE, and its private and public partners (i.e. Ifremer, Aquanesia, BoraEcoFish, Tropical Fish Tahiti, and Vai Consulting). Producing small fish for the aquarium market, which is the primary objective of the private sector, and the priority SPE has given to reseedling have, in large part, oriented zootechnical work towards the first two months of rearing. For that reason, most of these studies have covered acclimation of post-larvae to rearing conditions, weaning onto inert feed, and nursery rearing to the point that they are ready to be transferred to cages, released into the lagoon or shipped overseas, depending on the planned outcome.

**Table 1.** Comparison of performances of *hoa* nets, crest nets and CARE systems at Rangiroa over 101 consecutive nights from 16 May to 24 August 2004 (taken from Malpot 2005).

Comparison criteria	Hoia net <sup>(a)</sup>	Crest net <sup>(b)</sup>	CARE system <sup>(c)</sup>	Observations
Abundance (mean daily catch ± s.d.)	11,476.7 (±44,622.9)	41.8 (±146.8)	2.7 (±3.7) to 51.4 (±17.6)	<i>Hoia</i> net performed better. (F=57.61; p<0.001; df=2,277)
Species richness (mean daily species richness ± s.d.)	13.2 (±11.5)	5.5 (±4.3)	1.4 (±1.4) to 3.72 (±4.7)	<i>Hoia</i> net performed better. (F=41.03; p<0.001; df=2,277)
Larval survival	76.9%	75.8%	77.8% to 87.3%	No significant difference (K=2.49; p=0.64; df=4)

<sup>(a)</sup> An extraordinarily large peak of *Epinephelus polyphkadion* was recorded in the *hoa* net. Even when this peak is excluded from analysis, the *hoa* net retains its significant advantages.

<sup>(b)</sup> The crest net, originally designed for barrier reefs on high islands, was set up at Rangiroa on the crest of an external reef flat at that island. The specific hydrodynamics of this spot may have disturbed how it functioned, which would explain the lack of any significant differences between the performance of the crest net and the best CARE system.

<sup>(c)</sup> Nine CARE systems were set up at three sites (lagoon, ocean and *hoa*); shown here are the minimum and maximum values among the nine systems.





**Figure 4.** Aquafish Technology light-trap in Moorea lagoon (taken from Polti 2001.) and Ecocean light-trap (CARE system) in sub-surface waters at Rangiroa (taken from Malpot 2005).

The results indicate species-related variations in the parameters for success. Herbivores have no problem acclimating, and Esnault and Tetuanui (2005) demonstrated, with two Acanthuridae genera (*Acanthurus* and *Naso*), very good survival rates during rearing (> 98% after 60 days). At the same time, three species of Holocentridae, nocturnal zooplankton-eaters in the wild, proved to be very difficult to wean, and repeatedly had daily mortality rates of about 0.5%. Additional work carried out at Tropical Fish Tahiti (de Boishebert 2005) made it possible to confirm the very good survival rates during rearing for *Naso brevirostris* (98% after 63 days) and study how well that species — as well as *Zebrasoma veliferum*, *Chromis viridis* and *Chaetodon auriga* — can be farmed using a protocol described by Durville et al. (2003). The results, which were very encouraging for *Naso brevirostris* and *Zebrasoma veliferum*, were more modest for *Chromis viridis*, which, after a few weeks, developed high heterogeneity in size, perhaps due to overcrowding during rearing or the appearance of dominance phenomena, characteristic of a community with a harem structure. For *Chaetodon auriga*, the early appearance of territorial conflicts limited the zootechnical performances of that species.

In August 2004, the collection of more than 30,000 larvae of the grouper *Epinephelus polyphekadion*, allowed SPE (at the Ifremer station in Vair) to test several environmental factors affecting their survival during rearing (Tamata 2004). It appears that light and the type of settlement substratum (artificial reefs in the tanks) are determining factors, but this study more importantly confirmed the exceptional adaptability of wild grouper post-larvae (particularly cannibal) to farming conditions with a survival rate — quite good for Serranidae weaned

on inert feed — ranging from 20–52% after 21 days, while the mean weight went from 0.3–1.5 g.

It is important to point out that the haphazard nature of larval colonisation limits the structured development of zootechnical research programmes. It is, in fact, impossible to anticipate the abundance and taxonomic composition of future catches. Rather than designing experiments in advance, a particular hypothesis is formulated and tested spontaneously when the harvest on a given day yields a statistically useful number of specimens of a species of interest. So, most of the technical progress in rearing has been made empirically, as part of the daily operations of private pioneer farms in this sector. It appears that the success of a production cycle is linked to mastering

conventional fish farming factors such as density; homogeneous batches; diet and feeding scheme; environmental conditions such as water turnover, aeration and luminosity; type of habitat; intra- and inter-species relations (although multi-species batches are generally inadvisable); and maintaining strict prophylaxis. Managing these parameters for the 100 or so species farmed on a regular basis constitutes the expertise of French Polynesian farms.

There are few results on the grow-out phase leading to the production of fish for food purposes. Only the study carried out by Martin in 1997 and continued by Yan (2001) at EVAAM on Rangiroa made it possible to record growth performances in tanks for a limited number of lagoon fish and then model them (Table 2). However, rearing conditions during this work were not optimal and the results obtained could probably be improved.

**Table 2.** Weight gains for eight food species (according to Martin 1997 and Yan 2001). Gains are expressed as changes in the square root of mean weights over time.

Species	$\sqrt{W} = f(t)$	R <sup>2</sup>
<i>Acanthurus xanopterus</i>	$y = 0.0506x + 1.521$	0.99
<i>Caranx melampygus</i>	$y = 0.0441x + 5.2816$	0.99
<i>Cephalopholis argus</i>	$y = 0.0142x + 0.9182$	0.99
<i>Crenimugil crenilabis</i>	$y = 0.0205x + 0.6069$	0.98
<i>Epinephelus polyphekadion</i>	$y = 0.0328x + 2.1778$	0.99
<i>Naso annulatus</i>	$y = 0.0697x + 1.6804$	0.99
<i>Naso brevirostris</i>	$y = 0.0222x + 2.5995$	0.98
<i>Naso unicornis</i>	$y = 0.0279x + 3.5369$	0.99

Figure 5 shows interesting weight–growth increases for two Acanthuridae (*Naso annulatus* and *Acanthurus xanthopterus*), which unfortunately are poorly represented, from a statistical viewpoint, in the larval harvest in French Polynesia. As for Serranidae, *Cephalopholis argus* seems to have a slow growth rate and so is only of moderate interest for aquaculture.

For certain species whose post-larvae are several centimetres long at colonisation, and which can therefore be rapidly acclimated and weaned (Bigot 2006), rearing in cages placed in the lagoon (Kerneur 2003) may be an option for reducing production costs and improving zootechnical performances. An initial approach to this technique was taken on Bora Bora by CRIOBE and SPE (Planes et al. 2004) and continued by SPE in partnership with BoraEcoFish (Bigot 2006). The latter study made it possible to compare performances of batches of *Naso unicornis* reared in tanks to batches reared in sea cages. The results showed that there were no significant differences in terms of the batches' survival or conversion indexes, but there was significantly more rapid growth in those batches reared in cages starting from the second week of rearing. An initial comparison of small-scale production costs showed that tank farming costs twice as much as cage farming for a three-month cycle.

### Reseeding

Reseeding consists of releasing cohorts of farmed fish on an appropriate part of a reef so that they mix with the existing population. This technique makes it possible to add fish stock to a given fisheries to guarantee adequate resources for all, or else to recreate an adequate stock of genitors so that an

overexploited population can once again regenerate and develop. Through SPE, French Polynesia has funded and led all work carried out in this area since 2004, with the goal of this work leading to viable protocols in terms of reseeded for ecotourism or fisheries purposes.

Initial reseeded work, using juveniles from post-larval catches, took place simultaneously on the islands of Moorea and Bora Bora from March to August 2004 (Planes et al. 2004). The main objective was to assess the feasibility of this technique (collection, rearing, release), and determine the constraints and yields. The post-larvae collected using crest nets (Moorea) and *hoa* nets (Bora Bora) were sorted and then sent for rearing in tanks or floating cages for 3–12 weeks. Only those fish species to be used for food or ecotourism purposes were selected for this work. Rearing juveniles were then marked with coloured elastomers and released into coral gardens at hotel sites or near traditional fishing areas. Assessment of the effectiveness of reseeded was then done by visual census surveys over a two-week period after their release. The overall project allowed release, at each island, of 1500 specimens for ecotourism purposes and 1000 specimens for fisheries purposes. Of these, 30 species were for ecotourism and 20 species for fisheries. Survival rates showed large differences by species, more than 20 of which were not observed at all, suggesting total elimination of the species through predation and/or emigration, or the inability of researchers to effectively detect these species. In contrast, 19 fish species had encouraging survival rates (> 5%). Among those, four Acanthuridae species had survival rates of 15–50% (i.e. up to 10 times greater than during natural recruitment;

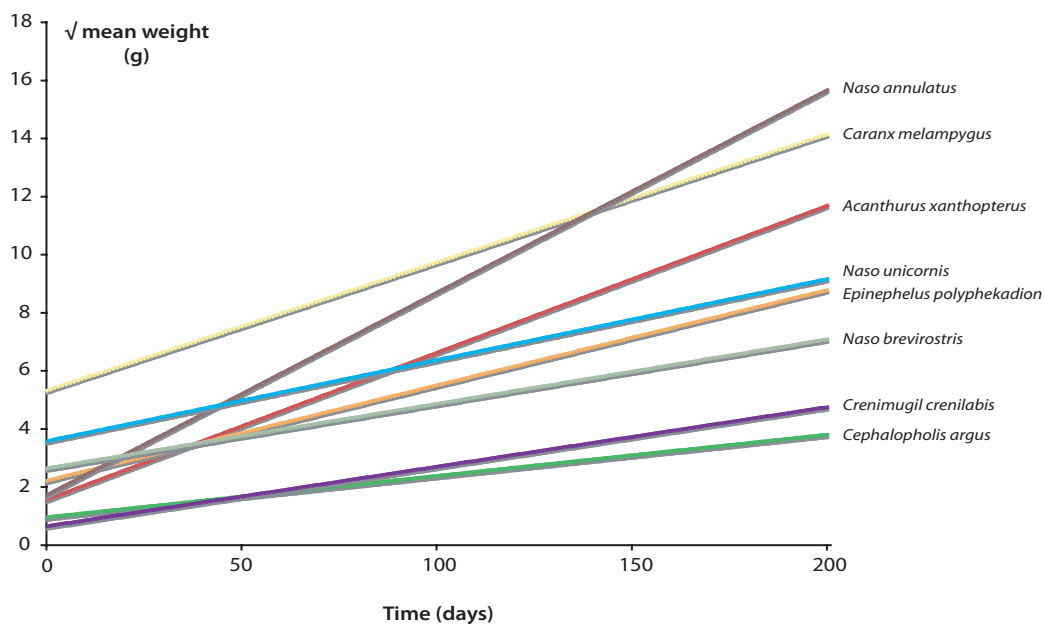


Figure 5. Larval weight development in relation to time:  $\sqrt{W} = f(t)$  for eight reef fish species (according to Yan 2001).

Doherty et al. 2004). These results were confirmed on Bora Bora with *Naso unicornis* during a study carried out by SPE in 2006 at the BoraEcoFish farm (Bigot 2006). After a month of rearing, survival rates after release were 14%, demonstrating the influence of the release site on the results.

Identification of constraints during this preliminary study revealed a need to optimise the methodology so as to improve survival. The influence of rearing and release conditions had previously been studied on Rangiroa by SPE and CRIOBE through logistical support to the company Tropical Fish Tahiti (Maamaatuaiahutapu 2005). Factors such as length of rearing time before release, the lunar cycle (time and phase of the moon), the release technique or the length and method of acclimation to the lagoon environment were tested. These experiments were limited to six species from three families. Given the large stocks required for this type of experiment, it was only possible to study a few species: *Chromis viridis* (Pomacentridae), *Acanthurus triostegus* and *Naso brevirostris* (Acanthuridae), *Sargocentron microstoma*, *S. spiniferum* and *Neoniphon sammara* (Holocentridae). During each experiment, specimen survival was assessed through visual census surveys over a period of three days. Only *Acanthurus triostegus* could support marking with elastomers. The results with *Chromis viridis* and *Acanthurus triostegus* revealed optimal survival rates for a rearing period of at least 30 days, transport of the fish in plastic bags to the release site, release at dusk on a natural reef protected by an anti-predator cage, and finally, an acclimation period of three days before cage removal. These very interesting results demonstrate that rearing and release conditions have a significant influence on fish survival and offer new perspectives for study. Observation of *Naso brevirostris* and three Holocentridae species was a failure in all these experiments, undoubtedly because the release sites were not appropriate for these species.

In general, the initial reseeding studies using juveniles from post-larval collection revealed the technique's potential, and offered some interesting prospects in terms of projects to restore damaged sites, given the good results obtained with territorial benthic species such as *Chromis viridis*, a species used for ecotourism that had survival rates of 70% under experimental conditions three days after release. Already, French Polynesian companies offer ecotourism site development services with reseeding species of similar behaviour (i.e. very substrate-specific). The results of these studies also give a glimpse of success over the medium term with reseeding projects for food (fisheries) and ecological purposes through the release of herbivore species caught locally (e.g. *Naso unicornis* or *Naso lituratu*), which could contribute to the elimination of invading seaweeds from the genus *Sargassum*, for example.

### **Ornamental reef fish sector**

About 99% of the worldwide commerce in fish for the reef aquarium trade is based on the collection of wild fish, which has led to often critical levels of fishing pressure on the stocks of exporting countries (Wabnitz et al. 2003). Sustainable use of this resource through the harvest of post-larvae offers an alternative to the traditional harvest of adult fish, which encouraged French Polynesian authorities to study how French Polynesia could become an exporting country. Dufour (1997) conducted the first aquarium trade market study and provided some strategic proposals for French Polynesia. Recognition by the International Coral Reef Initiative in 2001 of larval collection as a "good practice for the protection and management of coral reefs", heightened general interest in the technique and when several "ecological aquarium trade" projects became known, two studies (Biodax 2003; de Villers 2003) were designed to propose a model structure for the future French Polynesian aquarium fish trade sector, with support of the Marine Aquarium Council (Holthus 2003).

On a more technical level, Scourzic's work (1999) was designed to summarise the administrative procedures for shipping live fish from French Polynesia to the European Community, and to set up tests to determine the best transport conditions for fish survival. These results served as a working basis for private sector companies, which then improved their transport protocols in line with feedback from their customers in the United States and Europe. To date, nearly 150,000 fish from post-larval harvests have been exported, with survival rates or more than 95%.

### **Promoting French Polynesian expertise**

#### ***In French Polynesia***

The experience acquired in French Polynesia over the past 15 years on the scientific, technical and, now, economic aspects of reef fish larval collection, rearing, and market outlets for such larvae has allowed French Polynesian stakeholders, both public and private, to have enough information on hand to define a joint strategy designed to develop a sustainable economic sector. The basic objectives are, obviously, to allow companies to make profits while at the same time protecting fisheries resources and guaranteeing the health of the marketed product.

In 2007, a study carried out jointly by SPE, aquaculture specialists and economists analysed the current situation in two French Polynesian companies, identifying their strong and weak points, and then proposing an update of the development strategy for the "reef aquaculture" sector in French Polynesia. The results showed that production costs at French Polynesian farms do not constitute a primary limiting factor and that affordable improvements to

production would allow gains in productivity that would bring production costs below market prices. In fact, it seems that the main factor limiting the development of the two farms analysed was linked to the efficiency of larval collection methods, as *hoa* nets, and even more so, light-traps, generally do not catch enough marketable specimens, particularly in terms of high added value species. The random nature of larval colonisation further complicates rationalisation of a production plan and generates operating overruns.

Research and development should continue with reseedling techniques and techniques for harvesting larvae from target species. Designing a new generation of traps seems to be a decisive step in the development of ornamental or food fish aquaculture projects. Food fish projects currently appear to be limited by the inadequate efficiency of the post-larval capture and culture (PCC) traps available (Pickering et al. in progress).

At the same time, French Polynesian authorities are working on creating a legal framework for this sector. Draft legislation is being studied by SPE's legal specialists and is based on Lo-Yat's (2002b) proposal for setting out the rules of conduct for sustainable harvest and production traceability.

In addition, the Fisheries Department, in partnership with IFREMER (French Institute of Research for Ocean Development), is continuing its research and development work in aquaculture zootechnics on *Platax orbicularis* and in terms of animal health monitoring for farms. Finally, the SPE also has the intention and mission of assisting French Polynesian companies gain better control over these two aspects of production, through the creation of a specialised team in this area.

### **Elsewhere in the South Pacific**

As part of the Coral Reef Initiative for the South Pacific (CRISP) programme, which was initiated by the Agence Française de Développement ([www.crisponline.net](http://www.crisponline.net) 2007), Component 2A-1 covers reef fish post-larval harvest and development at a regional level. Its missions are to further basic research, transfer knowledge and train technical staff.

The publication of a guide identifying reef fish larvae in French Polynesia (Maamaatuaiahutapu et al. 2006) is a first step towards sharing French Polynesia's experience (SPE, EPHE and private work) with students, researchers and those conducting projects in the South Pacific. In addition, under EPHE's scientific responsibility, the University of the South Pacific is hosting French students to do basic research work in Suva, Fiji. The topic "Larvae rearing and identification" has been raised, and a PhD student is looking into optimising reseedling methods in natural settings, using juveniles from

post-larval collection (Clua 2007). In this context, the expertise that CRILOBE acquired on Moorea has been promoted, and may make it possible to develop sustainable activity in the Pacific region. French Polynesia, a pioneer and leader in reef post-larval harvesting and rearing, could benefit from this technology transfer by accompanying the development of South Pacific island countries, in the form of partnerships between private French Polynesian farms and foreign projects.

Since November 2007, the Aquaculture Section of the Secretariat of the Pacific Community (SPC) has been developing, with support of the French Ministry of Foreign Affairs, an experimental project to harvest and rear reef larvae in Aitutaki, Cook Islands. Coordinated by SPC, this project is being developed as a partnership between the Cook Islands' Fisheries Department and French Polynesia's SPE, and involves the participation of private stakeholders in French Polynesia (Aquanesia and BoraEcoFish).

Because it is based on techniques that have been recognised as ecofriendly, the reef fish larval harvesting and rearing sector, known as "reef aquaculture" in French Polynesia, opens — under certain environmental, technical, socioeconomic and cultural conditions — some interesting possibilities in terms of sustainable development based on:

- exports of high-added value products to the aquarium trade markets,
- lagoon development for eco-tourism, and
- additional farms for food purposes using certain post-larval species that can colonise *en masse*.

Many international agencies such as the WorldFish Center or SPC have seen the value of this. However, in addition to mastering larval harvesting and identification techniques, several conditions must be met in order to allow such sustainable development in Pacific Island countries.

- In terms of the environment, at least a minimum level of information is required regarding spatial and temporal changes, both qualitative and quantitative, in fish larval colonisation at each operating site.
- In terms of the aquarium trade market, recognition must be sought from all stakeholders of the sustainable aspect ("ecofriendly") of this type of harvest and the "farm" quality of the products (and so, their prices) resulting from these techniques.
- In terms of the food market ("food-fish"), well-adapted traps and production protocols must be designed for herbivore species that are *a priori* competitive, such as *Siganus* spp.
- We should continue research and development in order to master the sustainable harvest of other reef species (in the same way as what SPE did with the collection of giant clam spat) by first

targeting those sites that have specific assets that could be promoted.

- Finally, we feel that research and development efforts should focus on fish farming and preventive care, techniques that now are relatively well understood for certain species in French Polynesia.

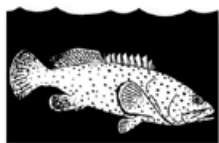
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As part of this basic research and development work, a large number of students conducted their first field experiments with us. We would like to take this opportunity to acknowledge those individuals whose names are not mentioned in the bibliography: Cécile Fauvelot, Karine Georges, Matthieu Junker, Olivier Martin, Julien Million, Isabelle Mollaret, Denis Poinonec, Thibault Rauby, Caroline Vieux, Raymond Vueilleumier, Rarahu David, Sylvain Dupieux, Pascal Romans, Pierre-Yves Brachelet, Mathieu Trottet, Julien Grignon, Mateata Peirsegaele, along with the VAT (French Technical Assistance Volunteers) and the agents of EVAAM, the Fisheries Department and CRIOBE, who contributed in large part to the development of this field work on Rangiroa and Moorea, and the existing French Polynesian companies (Tropical Fish Tahiti And BoraEcoFish), without whom this sector would no longer exist and could not continue to progress. This research has enjoyed the financial support of the French Polynesian ministries for the ocean, the environment and research; French national ministries for research, the environment and Overseas Departments and Territories; and IFRECOR. This paper is a contribution by Component 2A (Status of Coral Reef and Exploitation of their Resources) of the Coral Reef Initiative for the Pacific (CRISP) programme.

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## News and events

### Palau prohibits export of live reef food fish

After many years of off-and-on engagement in the live reef food fish trade, Palau has decided to prohibit the export of live food fish. Some of the events leading up to the new law are recounted in these news items:

- <http://www.pacificmagazine.net/news/2007/11/30/blog-site-claims-live-catch-operations-threatening-reef-fish-stock> (Pacific Magazine, 30 November 2007)
- <http://www.pacificmagazine.net/news/2008/01/03/chiefs-impose-10000-fine-for-violating-fishing-ban> (Pacific Magazine, 3 January 2008)
- [http://www.mvariety.com/?module=displaystory&story\\_id=9123&format=html](http://www.mvariety.com/?module=displaystory&story_id=9123&format=html) (Marianas Variety, 1 April 2008)
- [http://www.mvariety.com/?module=displaystory&story\\_id=11177&format=html](http://www.mvariety.com/?module=displaystory&story_id=11177&format=html) (Marianas Variety, 13 May 2008)

### Spawning closures relaxed on Australia's Great Barrier Reef

The government of Queensland has found that its fishery closures have been overly cautious, and will remove the nine-day closure in December, leaving the October and November spawning-focused closures intact. See this story by ABC Rural (12 November 2008): <http://www.abc.net.au/rural/news/content/200811/s2417568.htm>

### Live fish shipment intercepted at Palawan airport

According to Inquirer.net (31 December 2007), an illegal shipment involving 71 live red groupers was intercepted by enforcement authorities at Puerto Princesa International Airport. The Mayor of Puerto Princesa City suspended three of the city's enforcement personnel on the suspicion that they conspired with the shipper of the fish, and ordered that the fish be released immediately into Puerto Princesa Bay. See the story at: [http://newsinfo.inquirer.net/breakingnews/regions/view\\_article.php?article\\_id=109676](http://newsinfo.inquirer.net/breakingnews/regions/view_article.php?article_id=109676)

### Cargo of live whale sharks intercepted

A story in Inquirer.net (7 April 2008) relates how a task force of provincial fishery officials and environmentalists intercepted a cargo that included whale sharks among the live groupers and ornamental fishes that were likely headed for export via Manila. See the story at: <http://newsinfo.inquirer.net/breaking-news/regions/view/20080407-128932/Quezon-task-force-seizes-cargo-of-alleged-young-whale-sharks>

### Catch of humphead wrasse in Northern Mariana Islands triggers controversy

According to a 5 February 2008 story in the Saipan Tribune, an employee of the Division of Fish and Wildlife in the Commonwealth of the Northern Mariana Islands found himself having to defend his catch of two humphead wrasse, in spite of not being accused of any legal wrongdoing. See the story at: <http://www.saipantribune.com/newsstory.aspx?newsID=76728&cat=1>

### Live reef food fish trade in the news in Malaysia

It appears from several news stories that the live reef food fish trade, particularly the humphead wrasse, is gaining public and government attention in Malaysia. For example, see:

- <http://www.dailyexpress.com.my/news.cfm?NewsID=55698> (Daily Express, 4 February 2008)
- <http://thestar.com.my/news/story.asp?file=/2008/4/8/lifefocus/20080407202246&sec=lifefocus> (the star online, 8 April 2008)
- <http://thestar.com.my/news/story.asp?file=/2008/4/8/lifefocus/20843352&sec=lifefocus> (the star online, 8 April 2008)

### Fate of marine ornamental species of concern in Thailand

The Phuket Marine Biological Research Institute is breeding harlequin shrimp and other marine ornamental species because of concerns that they might become extinct, according to this story from the Thai News Agency (26 June 2008): <http://enews.mcot.net/view.php?id=4935>

### Clownfish in trouble?

Five years after its release, the hit movie "Finding Nemo" is being blamed for dramatic declines in clownfish populations, according to the Times Online (26 June 2008): <http://www.timesonline.co.uk/tol/news/environment/article4220496.ece>



## Noteworthy publications

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