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LIVE REEF FISH

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Inside this issue

Current status of marine post-larval collection: Existing tools, initial results, market opportunities and prospects
G. Lecaillon and S.M. Lourié p. 3

Towards a sustainable marine aquarium trade: An Indonesian perspective
G. Reksodihardjo-Lilley and R. Lilley p. 11

Consumer perspectives on the “web of causality” within the marine aquarium fish trade
B.A. McCollum p. 20

Applying the triangle taste test to wild and cultured humpback grouper (*Cromileptes altivelis*) in the Hong Kong market
N.W.W. Chan and B. Johnston p. 31

Monitoring the live reef food fish trade: Lessons learned from local and global perspectives
H. Scales et al. p. 36

The live reef fish trade in the Pacific: A look at recent trends and developments
B.M. Yeeting p. 43

News & events p. 48

Noteworthy publications p. 56

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Editor's note

Three articles in this bulletin focus on the marine ornamentals trade. Together, they give an absorbing around-the-world tour of the trade, from the day-to-day lives of collectors in small fishing villages in the Indo-Pacific to the buying habits of aquarium hobbyists in the United States.

First, Gilles Lecaillon and Sven Michel Lourié report on recent developments in collecting and using post-larval reef fish – that is, young fish collected just before they settle on reefs. They describe the latest post-larval collection and grow-out methods and how they are being applied in the Indo-Pacific. They are optimistic that these methods can be used to produce fish for the aquarium trade and other purposes, but they cite further research and outreach that will be needed to make that happen.

Next, Gayatri Reksodihardjo-Lilley and Ron Lilley take a close look at the supply side of the ornamentals trade through a case study of fishing communities in north Bali. They describe the fishing patterns and working conditions of collectors, as well as the very interesting business dynamics among collectors and the series of buyers up to the point of export. They conclude that reform of Indonesia's aquarium fish industry is needed, and that a fundamental step would be to get players near the demand side of the trade, including importers and exporters, to work more closely with collectors to improve working conditions, the quality of the product and reef management.

Shifting to the demand side of the marine ornamentals trade, Breck McCollum examines the perspectives and preferences of marine aquarium hobbyists in the United States. Like Reksodihardjo-Lilley and Lilley, she takes it as a given that reform of the trade is needed to safeguard the resource and to improve the lot of collectors. She finds that the information available to hobbyists and the general public pays little attention to the negative environmental and health impacts of the trade, and that improving the public discourse about those issues is fundamental to shifting consumers' preferences and consequently forcing needed changes at the supply end of the trade.

This bulletin includes two articles devoted to the trade in live reef food fish.

Noel Chan and Brian Johnston describe the results of a “blind” taste test in Hong Kong in which participants tried to discern between wild-caught and cultured forms of the popular live food fish species, humpback grouper (*Cromileptes altivelis*). There was a general preference

for the colour, taste and texture of the wild product, but the cultured product was found to be highly acceptable, and the authors find this to bode well for the widespread commercial acceptance of cultured products in the future.

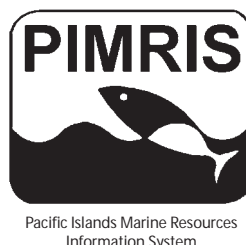
Helen Scales and co-authors examine the trade in live reef food fish from two different perspectives. First, they analyse a long time series of Hong Kong import data and find disturbing patterns in the geographical expansion of the trade, boom-bust patterns of fishery development among supply countries, and “fishing down the price list”. Second, with the help of detailed records maintained by fish traders, they take a close-up look at the fishery for live reef food fish in northern Borneo and find evidence of marked and fairly rapid declines in the target fish stocks.

Writing about both ornamentals and food fish, Being Yeeting provides a history of live fish fisheries in the Pacific Islands region and an update of the activities of SPC’s Regional Live Reef Fish Trade Initiative, which is aimed at improving the management of both types of fisheries.

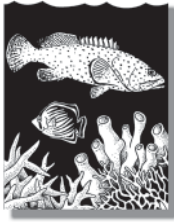
The publications section at the end of the bulletin includes a reference to the proceedings of a workshop last year on the economic and marketing aspects of the live reef food fish trade. An overview of the workshop, by Brian Johnston, is reprinted here in full. It gives an overview of the three-year ACIAR-funded research project (which the workshop was a part of) and summarizes the many papers presented at the workshop.

Tom Graham

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.



Current status of marine post-larval collection: Existing tools, initial results, market opportunities and prospects

Gilles Lecaillon¹ and Sven Michel Lourié¹

Introduction

All marine fisheries — no matter the scale at which they occur — involve removing a portion of the targeted stocks, which are often limited and finite. This is a serious problem because stocks of certain species are becoming increasingly depleted and in some cases even exhausted. This overexploitation of resources is evident not only for food species but also for reef species that are popular for the aquarium fish market.

In general, most fishing techniques take adults, often breeders, thereby diminishing not only current stocks but also future stocks. Open-ocean fishing techniques, whose destructiveness varies depending on the technique used (e.g. gillnets) and the amount of fish caught, do, however, spare habitat. This is not the case for coral reef fisheries, which, depending on the technique, can have a direct effect on habitat conditions (e.g. cyanide, explosives). Russ and Alcalá (2004) found that 75% of the coral reefs in the Philippines have been damaged. In other words, not only is there overfishing but the fishes' habitats have been destroyed, leaving nature with no way to recover from such disturbances.

Recent studies have shown that most marine reef fish species have a pelagic larval stage in their life cycles that concludes with oceanic post-larvae returning to their "original" reef habitat. Yet, during settlement, more than 95% of post-larvae disappear due to natural causes. Collecting a small percentage of these post-larvae before they are lost to this high level of natural predation offers a new exploitable marine resource while helping ensure the sustainability of coral reef ecosystems.

Post-larval collection is certainly not the only solution to overexploitation of demersal species², but it is, nevertheless, a path worth exploring, not only for developing an innovative and sustainable type of aquaculture but also for repopulation efforts, which are just beginning (Delbeek 2006).

Overview of the life cycle and non-impact of post-larval collection

Most coastal fish (coral reef fish and also demersal fish in temperate zones) have oceanic larval phases at the beginning of their life cycles (Sale 1980; Leis 1991; Leis and Carson-Ewart 2000). This phase allows them to colonize new habitats, thereby facilitating the species' broad distribution and, consequently, their persistence (Choat and Robertson 1975; Lobel 1978; Victor 1986a).

Depending on the species, larvae spend from 20 days (Pomacentridae) to more than 100 days (Aulostomidae) in the open ocean (Brothers et al. 1983; Victor 1986b; Wellington and Victor 1989; Victor and Wellington 2000). Fairly passive during most of this phase, they finally become active — entering their competence phase (Doherty and Williams 1988; Cowen et al. 2000; Fauvelot et al. 2003) — in order to look for their new habitat. This settlement phase takes place at night, if possible when there is no moonlight. Still, most of those post-larvae (more than 95%) disappear during the week that follows settlement, mainly due to predation (Planes and Lecaillon 2001; Planes et al. 2002; Doherty et al. 2004).

Post-larval collection techniques make it possible to recover these animals before this phase of high natural mortality. Given the very large number of post-larvae arriving from the ocean, collecting a small percentage of them has almost no impact and one that is limited in time (Bell et al. 1999). These techniques provide access to a previously unexploited marine resource, without impacting stocks or damaging the environment (Lecaillon 2004).

Today, thanks to a range of existing collection tools and the know-how developed by certain private and public agencies, these post-larval fish can be kept alive, weaned and grown out to become a new marine resource, while respecting the spirit of sustainable development and biodiversity conservation.

1. Founders of the company Ecocean, holders of a patent on the CARE technique, and founders of the association Moana Initiative for development of post-larvae collection. 1 rue St Sauveur; 34 980 St Clément de Rivière; France. Email: ecocean_label@yahoo.com

2. Demersal species are bottom-dwelling species (as opposed to "oceanic/pelagic" species such as tuna).

Post-larval fishing techniques

Currently four main systems of post-larval fishing are used.

Crest nets on barrier reefs

This technique consists of setting a net on the barrier reef (with the open end towards the ocean) in order to catch the post-larvae surfing over the reef crest to enter the lagoon (Fig. 1).

This technique was developed by both a French laboratory (École Pratique des Hautes Études – EPHE – of Perpignan) (Dufour 1991) and an Australian one (Australian Institute of Marine Science – AIMS) in collaboration with the WorldFish Center (Hair and Doherty 2003). The technique was used by a private firm based in Moorea, French Polynesia, which is no longer in business.

A number of people are needed to set up the poles that support the nets on the reef crest. The equipment wears out quickly because it is constantly hit by waves. These nets can only be used near amphidromic points (where tidal ranges are very small) and, by definition, only in those areas where there are crests/ridges. Thus, this considerably reduces the number of countries where the technique can be used (these nets cannot be used in temperate settings). Finally, *Sargasso* and *Turbinaria*-type seaweed can get caught in the net's collector and can abrade the post-larvae and damage them.

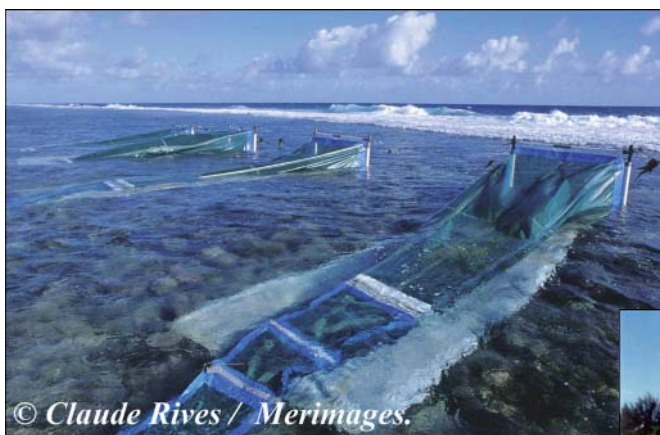


Figure 1.
Crest nets in Moorea, French Polynesia.

Hoa nets between small islands and on reef ridges

Certain islands, particularly coral atolls, have very shallow (2 m) channels on their reef ridges surrounded by dry land, called *motu* in Polynesian. The channels, or *hoa* (meaning “marine rivers”), allow the ocean to fill the lagoon. This technique consists of setting a net across these *hoa* to catch the post-larvae concentrated in the water masses passing between the *motu* and entering the lagoon (Fig. 2).

The technique was mainly developed by the EPHE of Perpignan and the SPE (Fisheries Service) of French Polynesia. It is currently used by a private company based in Rangiroa, French Polynesia.

If a site has a *hoa*, setting up the net is simpler than for a crest net. There is less wave force on the gear so it is easier to set the net up and take it down. This device traps everything going through the *hoa* and so is very effective. It is sometimes the victim of its own high level of effectiveness because when the post-larvae of a given species are particularly abundant, millions of post-larvae can be caught. But because there are too many of them in the collector, most die from a lack of oxygen. This is not profitable for either the fisher or the environment.

This technique arose from efforts to optimize the use of crest nets and so has appeared more recently. Of course, a *hoa* must be present in order to use this method. Unfortunately, these geomorphologic structures are even rarer than reef ridges, so use of this technique is also limited geographically.



Figure 2.
Hoa net. Rangiroa, French Polynesia

Light-trap

Many different models of light-traps exist because this method has been used by scientists for many years. First developed by the Australians (Doherty 1987), then optimized by the French, the light-trap consists of a casing surrounding an autonomous underwater lamp. Post-larval fish, attracted by the light, are trapped when they go through the slots into the trap (see arrows on Figs. 3 and 4).



Figure 3. Light-trap, French model.



Figure 4. Light-trap, Australian model.

This technique is widely used for scientific studies because it can be set up rapidly (Watson et al. 2002). Because it does not depend on reef ridges or *hoa*, it can be used anywhere. But light-traps have their limits because the post-larvae have to find the slots (which are vertical in the French model, and horizontal in the Australian one; Figs. 3 and 4) in order to be trapped, and this reduces the trap's effectiveness. In addition, certain small pelagic fish (e.g. sardines) are also attracted to the light, and because of their horizontal swimming style, they become trapped, and then panic and die.

CARE (Collect by Artificial Reef Eco-friendly)

This new technique was recently developed by a French company (patented by Ecocean in 2002). It uses a lighted artificial reef that takes advantage of the behaviour of new recruits to trap them: their attraction to light (phototropism), their desire to come into contact with a solid object (thigmotropism) and their desire to find shelter from predators (Fig. 5). These sensory elements are important for post-larval fish, which have very acute senses during recruitment (Sweetman 1988; Lecchini 2003).

This technique has the advantages of light-trap fishing, while being more efficient and free of the problem of also attracting pelagic species. It attracts the post-larvae of reef or demersal species that are in the settlement phase. The post-larvae choose to take shelter in the artificial reef, while unwanted small pelagic fish just swim over the reef.

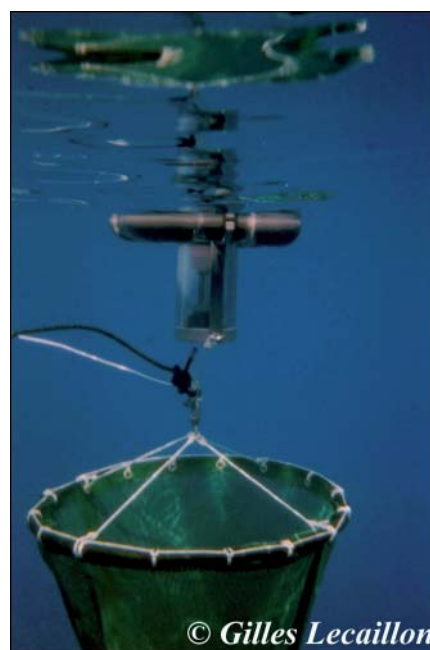


Figure 5. CARE, underwater view.

Other techniques

There are also other, less frequently used, post-larval collection techniques, not described in detail here, such as Bongo nets, SMURFs (Ammann 2004) and plankton nets pulled behind a vessel. These techniques are used by researchers to collect eggs, larvae and post-larvae, but few of them survive.

Table 1 provides a comparative summary of the four most commonly used techniques.

Notes on fishing results

Since the authors began collecting larvae, almost all the fish families (except for very rare, extremely deepwater families and large pelagic fish) have been collected at least once.

In Mayotte, *in situ* comparative trials were carried out with two types of light gear, light-traps and CAREs. The devices were set up 200 m apart so as not to interfere with each other. This experiment was carried out over a 12-night period around the new moon in June 2002. The results of this study found that the CARE trap was 78% more effective than the light-trap, with an average of 35.8 post-larvae caught per night per device, as compared with 20 post-larvae for the light-trap.

This difference can be explained by the fact that with the light-traps, post-larvae are attracted by the light but must find their way through the slots in order to be trapped and “saved” from predators; with CAREs, they take shelter in the collection net themselves after being attracted by the light. So, the CARE trap’s scope of action seems to be wider. In addition, we saw post-larvae coming back out of the slots in the light-trap due to micro-currents inside the device created by the swell.

In late 2004 (from 19–24 November), the authors were able to compare the effectiveness of CAREs and *hoa* nets: 8184 post-larvae were collected in one week using three CAREs (65 species collected), compared with 537 with one *hoa* net (only 35 species collected). Some of the species from the CAREs had never been collected in nets before. *Hoa* nets did, however, prove to be more effective over the long run in terms of both catches and the diversity of species collected. Unfortunately, these data are confidential and we could not go any further with our comparisons.

The species composition of the catches made with CAREs at several sites were (ignoring catches of Apogonidae, cardinalfish):

- 10–15% ornamental fish (excluding Pomacentridae, damselfish),

- 50–60% damselfish (low-value ornamental fish),
- 20–30% food fish (in descending order in terms of abundance: Siganidae, Lutjanidae, Lethrinidae, Carangidae, Serranidae), and
- 10–20% invertebrates (shrimp, squid) and non-targeted fish (e.g. Synodontidae)

We did not take into account the large numbers of Apogonidae collected with light collection techniques. However, these species can be used for scientific studies or even, in some areas such as in the Philippines, be promoted as food fish.

Given the large variability in the abundance and diversity of species collected and in the collection sites and periods (e.g. new moon, full moon, dry season, wet season), statistically comparing collection data between projects and devices is difficult. Also, collection data are often misinterpreted. Reports of certain projects include the small pelagic species in their catch results even though they are not post-larvae. Others include the catches from extremely rare events (e.g. on the order of a million fish in one night) in their reported mean daily catches.

Market opportunities and ongoing trials

The technique used to collect this new marine resource and rear it is called post-larval capture and culture, or PCC.

The Reef Check Foundation, directed for the past 10 years by Dr Gregor Hodgson, is using larval collection techniques to find marine resource management solutions in the Philippine Islands through two of its projects.

Through know-how mainly developed by the French, post-larval fish, collected with whatever method, can now be farmed so as to produce large quantities of marketable product. The entire procedure, from collection to grow-out, is explained in a brochure produced by the Moana Initiative that can be downloaded at www.moanainitiative.org. This guide, which was funded by UNESCO through its Man and the Biosphere Programme, describes potential market opportunities for this new resource (Lourié and Lecaillon 2005).

According to numerous specialists, post-larval collection is a socioeconomic solution that can contribute concretely and rapidly to the creation of new jobs in several areas listed below.

Alternative aquarium fish farming

Here, opportunities exist mainly in developing countries such as the Philippines and Indonesia (whose current exports account for 80% of the world market). Aquarium fish farming generates foreign

exchange income through exports to markets such as the USA and Europe.

The steps for post-larval collection, grow-out and shipping are very well known and several trials have been successfully carried out in the Comoros, Hawaii, French Polynesia and the Philippines. On average, about three months of grow-out are needed to get fish of a “small” marketable size (less than two months for Pomacentridae but more than four months for Labridae and Chaetodontidae).

This new procedure makes it possible to produce immunized and disease-resistant specimens, thereby bringing a certain level of quality to a declining market for wild product, for which the mortality rates range up to 90% between the points of collection and final purchase (Schmidt and Kunzmann 2005).

Currently, one private enterprise exists in French Polynesia and others will be created soon in Asia. A project also began in Hawaii in late 2006 with funding from the US National Oceanic and Atmospheric Administration.

Supplementary multi-species aquaculture

Here again, opportunities exist mainly in developing countries. This activity can provide ciguatera-free protein for local consumers, as well as product that could be destined for the Asian live fish market.

It should be noted that most food fish families have “large” (>2 cm) post-larvae, which makes it possible to produce meal portion-sized specimens after about six to eight months of in-cage grow-out. Currently, trials are underway in the Philippines, in collaboration with Reef Check and the Municipality of Tubigon (island of Bohol), as part of the Marine Aquarium Market Transformation Initiative (MAMTI). Initial results for in-cage grow-out of Siganidae and Lethrinidae indicate growth coefficients that were 1.8 times greater than those in land-based tanks.

Another project underway (September 2006–September 2007) in the Philippines, with funding from the US-based National Fish and Wildlife Foundation, is attempting to transfer knowledge about larval harvesting techniques to local communities. This project has the unanimous support of various fishers, farmers and decision-makers. The farm belongs to a local non-governmental organisation (NGO), Feed the Children, and the operational project is part of a Coastal Resource Management Plan set up by the Municipality of Tubigon. This project also has the goal of repopulating a local marine reserve with some 10,000 juvenile fish.

Some developed countries may also be interested in collecting post-larvae, particularly in order to study the growth rates of certain target species before attempting to improve particular reproduction phases (e.g. increasing gamete production rates, limiting stress, etc.) Finally, biotechnical companies could be interested in the bio-molecules contained in oceanic post-larvae, which have low parasite levels.

Managed repopulation with native species

There is increasing interest in repopulating native stocks. Several repopulation programmes — including a programme underway in Fiji (CRISP, Coral Reef Initiative South Pacific; www.crisponline.net), one being tested in marine protected areas (MPA) in the Philippines, and another that has been completed in French Polynesia — demonstrate the enthusiasm for this procedure. It offers the possibility of repopulating degraded or overexploited zones with native fish that have not been genetically modified.

Some MPAs, such as in the Philippines (Russ and Alcala 2004), have taken a long time to recover their initial marine populations. Repopulation is designed to accelerate the natural process of growth in populations after a halt in exploitation and to select, as best as possible, those species to be reintroduced so as to fill the various ecosystem niches, such as detritivorous species and herbivores. The results at this time are encouraging but very few studies have been completed. The projects underway in Fiji and the Philippines will lead to more concrete results.

It should be noted that species that are not appropriate for repopulation (e.g. predators such as trevallies and groupers) can, nevertheless, be of interest to local fish farmers, so PCC can still be useful for those species.

A pilot project similar to those undertaken in tropical settings was completed in the Mediterranean in September 2006 (Moana Initiative 2006). This project, funded by the Hérault (France) General Council, was designed to test, in a temperate setting, the technical feasibility of reintroducing grown-out larvae on artificial reefs. Given its success, a wider project is anticipated for 2008.

Many questions have been raised and will continue to be raised about marine repopulation. These are just the first, very promising, steps for this activity.

Bio-monitoring

A recent survey showed that estimates of species biodiversity through genetic identification of marine animal larvae are more precise than those from visual census surveys of adult specimens in the wild, particularly for species with dispersive oce-

anic larval phases (Barber and Boyce 2006). In this study, 50–150% additional manta shrimp species were found through analysis of the larvae's genetic "bar codes".

Since areas of high diversity are major conservation targets, collecting post-larvae and examining them genetically should make it possible to identify new species.

In addition, multi-year recruitment studies using collected post-larvae of demersal species could contribute knowledge about the population dynamics of such species and make it possible to predict variations in stocks. Such predictions could be made well before those based on traditional methods of assessment that rely on counting landed fish. Today, fishery management decisions are largely based on the annual catch statistics maintained since 1950 by the Food and Agriculture Organization of the United Nations. When catches from year to year are stable, it is supposed that an equilibrium between stock renewal and the effects of fishing has been reached. But according to Loury (2005) of l'Institut de Recherche et Développement (IRD) in Noumea, New Caledonia, this assessment method has come under strong criticism because, in a great number of cases, the collapse of a stock has been preceded by a period of stable production.

Finally, fishing for post-larvae around a "model" MPA should make it possible to compare the effectiveness of MPAs versus non-protected areas or one MPA versus another.

Comparative table to assist in selecting collecting gear

It is difficult to obtain precise comparative statistics on the effectiveness of the various post-larval collection devices. For example, as mentioned, most collection data for crest and *hoa* nets are confidential.

Nevertheless, all the techniques work. Each has its own advantages and disadvantages, which are summarized in Table 1. It should be noted that there are different versions and add-ons for each type of device, which could affect the relative advantages of each device and alter the scores given in the table.

These comparisons have been made on the basis of the authors' work in the field and their personal data as well as published and unpublished data. The authors have worked at least once with every one of the techniques described in this table and have more than eight years of experience in larvae collection. The authors have assessed each of the four devices on a scale of 1 (excellent) to 4 (poor) for each of the following attributes and uses:

- Flow studies of larvae entering the lagoon, which yield scientifically valuable data.
- Ease of installation; that is, the time and number of people needed to set up the device, etc.
- Diversity of species and families caught.
- Collection of unwanted species (plant and/or animal).
- Source of stress and/or physical damage to larvae, mainly because of agitation in the environment and/or the presence of predators or algae in the collection containers.
- Abundance of larvae collected (excluding any non-reef species such as sardines and other small pelagic species that are occasionally collected in large numbers but are not post-larvae).
- Cost of fishing gear.
- Universality of the device; that is, the different types of places (ocean, lagoons, tidal pools, outer reef slopes, mangroves, etc.) where it can be set up.
- Ergonomics of the device, which is important for fishers who use it on a daily basis (e.g. accessibility, fatigue caused by fishing, whether the collection time depends on sea conditions, need for diving, transport, etc.).

Table 1. Summary evaluation of post-larval collection device attributes.

	Flow studies	Ease of installation	Diversity	Un-wanted species	Source of stress	Abundance	Cost	Univer-sality	Ergo-nomics
Crest net	1	4	3	4	4	3	2	3	4
Hoa net	2	2	1	3	3	1	1	4	2
Light trap	4	2	3	3	1	3	3	1	3
CARE	4	1	2	2	1	2	2	1	1

1 = excellent; 2 = good; 3 = acceptable; 4 = poor

This table, the scores in which are solely attributable to the authors, makes it possible to choose which post-larval collection device to use, depending on the situation in the field and the desired results.

The CARE technique was developed by the authors after they had used the other techniques. The main reasons for this were to develop a tool that could be used anywhere in the world, in both tropical and temperate settings whatever the tide levels, and in areas where nets cannot be used (outer slopes); and to make it possible to collect and grow out post-larvae under the best possible conditions; that is, to minimize stress on them so as to obtain a high-quality live product.

Conclusions and prospects

Use of post-larval collection and grow-out techniques is growing. Nevertheless, apart from aquaculture, some of its applications, such as repopulation, still require years of research and more data collected over longer periods of time in order to better understand the complex recruitment processes on a worldwide scale. As is often the case with innovative techniques, the main limiting factor is the lack of trials carried out with this tool. For this reason, the authors believe that it would be useful for NGOs and research laboratories to integrate this new technology into their research and monitoring programmes. This is already the case for the EPHE laboratory in Perpignan, France (under the direction of Mr Galzin), the American NGO Reef Check Foundation, and IRD (COREUS group).

It is important to note that certain techniques that have been mastered for reproducing marine aquaculture species or for massively repopulating a single species, as in Japan, required decades of research and huge investment.

Efforts will also have to continue so as to inform all those involved with the sea — local authorities, fishers, fishing cooperatives, public aquariums — of the existence of this tool. This will require greater international collaboration. The research laboratories and private agencies involved in this concept have to unite in order to better understand the recruitment periods of families of interest so as to optimize the use of PCC.

Finally, it is vital to continue work on optimising the design of collection gear so as make it useable by all, including those in developing countries. In particular, integrating sound or pheromones so as to increase effectiveness (i.e. catch per unit of effort) are paths to be explored.

A UNESCO-funded publication, which presents the various “eco-jobs” that are possible from

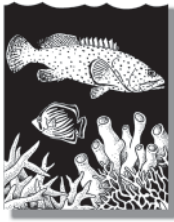
the collection of marine post-larvae (Lourié and Lecaillon 2005), has been sent to all the “Man and Biosphere” reserves in the inter-tropical belt. Preparation of a new publication funded by the Total Corporate Foundation for biodiversity and the sea is underway and is planned for release in the summer of 2007.

The use of post-larval collection techniques can be an alternative to certain types of over-exploitative activities in marine settings, particularly in developing countries, where, for the most part, such activities are managed as though resources were unlimited.

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Towards a sustainable marine aquarium trade: An Indonesian perspective

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Introduction

With all the benefits and information that modern communications have to offer the end buyers of tropical marine ornamental organisms, it is disappointing to see just how little factual information is available to them concerning the sources of the organisms they buy, and the circumstances by which they are caught. This article seeks to provide a view of the aquarium trade from the perspective of one of the supply countries, Indonesia, and to identify the actions needed to bring about reform. One of the greatest stumbling blocks facing those who are trying to reform the trade is the acute lack of data from scientific surveys to support their arguments for change. A visit to collectors in this part of the world will illuminate far more than the written word can describe. For those not able to visit, constructive dialogue with those working in the supply countries will also help to enlighten them, and hopefully provide some solutions to the many problems experienced by the suppliers.

The context of the trade

Indonesia is the world's largest exporter of marine ornamentals for the aquarium industry, and has relied overwhelmingly on the harvest of wild organisms to supply the trade. Because it is situated along the equator, this developing country has been in a good position to supply both quantity and diversity of marine species to Europe, North America and Asia over the past 25 years. Many thousands of people living in coastal communities depend economically on the collection of fish, corals and other marine invertebrates for the aquarium trade. These communities are among the poorest in the country, and suffer from lack of education, health care and land. Therefore, their choices for income generation are very limited. Prior to being approached by buyers from the trade, most existing collectors will have been living at the subsistence level, fishing for food fish to either sell or

consume on the same day, or preserve using salt, as there are almost no refrigeration facilities available in their villages. Ironically, although they lack education and business skills, many of these collectors are highly skilled in the identification and capture of various marine organisms.

The sheer diversity of both terrestrial and marine biota in Indonesia has been both a blessing and a curse for the country. Like tropical forests, coral reefs have been overexploited to the point that although this vast archipelago rivals anywhere else on the planet in terms of natural living resources, it also has more endangered or threatened species – many of which are endemic – than virtually any other country. With an urgent need to develop and generate much-needed revenue, it was logical for the government to encourage – or at least not obstruct – high levels of exploitation. Official data on resource distribution and exploitation rates have always been lacking, and resource monitoring has been poor. Therefore, the true extent and impacts of years of largely uncontrolled exploitation of natural marine resources have only recently started to be recognized.

The Indonesian collectors and the trade

The marine ornamentals trade has taken full advantage of these circumstances in Indonesia. Unfortunately, all too many people in the marine ornamentals industry and elsewhere still seem to assume that the supply of wild marine organisms is unlimited. This industry has encouraged thousands of coastal fishermen to make a little extra money by becoming collectors for the aquarium trade. Being largely uneducated and unable to find other work, the collectors have been obliged to endure low prices, poor working conditions, disability and even death as a result of their collection efforts, in order to satisfy an expanding overseas market. Critically, they have thus far had little representation by national or local governments, although this situation is now slowly changing.

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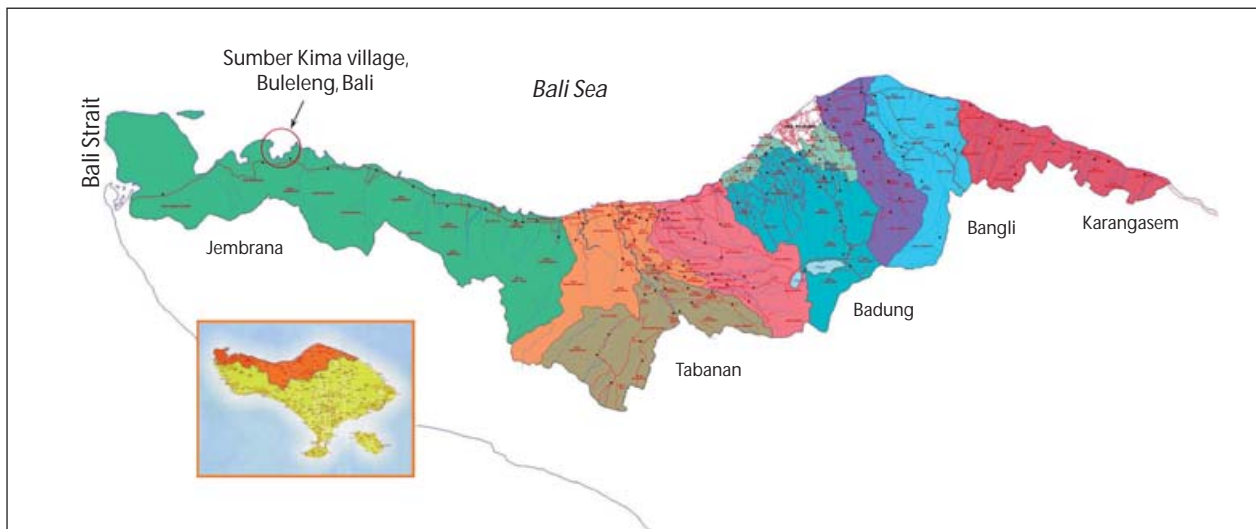


Figure 1. Buleleng district, Bali, Indonesia.

As many as three generations of collectors can be found among the poor families of a coastal village. The first generation used to be able to fish on the reefs in front of their houses. The older collectors tell of times when their reefs were intact, fish were plentiful, and many species that are now rare were easily caught within minutes of the village.

Since those early days, these nearby reefs have become progressively damaged or reduced to rubble by coral mining for building materials, the use of explosives and poisons for catching fish, land-based pollution, and sedimentation. The increasing frequency of crown-of-thorns starfish (*Acanthaster planci*) invasions and coral bleaching have also contributed to reef degradation. Finally, with a current national population of more than 220 million people, overexploitation of natural resources has in many places led to their total destruction, including the local disappearance of many species. As a result, second- and third-generation collectors have needed to journey progressively farther away from their homes in search of the target species.

The Bali situation

The fringing reefs of north Bali have been major collection areas for ornamental fisheries since the late 1970s. There are now two types of collectors operating in north Bali. Some villagers still collect along the Buleleng coast (Fig. 1) where common, “cheap” species (called “trash fish” by some traders) such as damselfishes (Pomacentridae) can still be collected nearby. Second, there are roving collectors, who must travel long distances to fulfil orders from traders. Roving collectors may be away from their

homes for as long as three weeks at a time, traveling in small boats over wide expanses of open sea.

One group of experienced roving collectors comes from Sumber Kima, a village located in the Buleleng district of north Bali (Fig. 1). Nearly 88% of the people in Sumber Kima depend on ornamental fisheries as their major source of livelihood. The village can be reached in three to four hours from the international airport in south Bali. Collection on the Sumber Kima reefs began in the early 1970s. In the 1980s, when demand increased and more varieties were requested by the market, the Sumber Kima collectors started to travel farther away from their village in search of new reefs. The first roving destinations were the reefs of west Lombok, with a distance from Sumber Kima and Madura of approximately 250 km, and farther to Sumbawa, Flores and Sulawesi.

The target species for rovers, some shown in Table 1, include high-value fish such as the palette surgeonfish (*Paracanthurus hepatus*), known locally as *leter six*, or the “letter six fish”.

Nowadays, roving collectors travel to remote reefs throughout the archipelago, including those in the waters of Sumatra, Kalimantan (Indonesian Borneo), Sulawesi, and along the island chain as far east as Papua. The 10 most-collected species from the Karumpa Reefs of Sulawesi are shown in Table 2.

These long boat journeys are undertaken in poorly maintained craft, without adequate navigational equipment, communications, dive gear or even life vests. Equipment for catching and holding the

Table 1. Target species for north Bali roving collectors.

Scientific name	Market name	Local name
<i>Abalistes stellatus</i>	Starry triggerfish	Triger batu
<i>Amblyeleotris guttata</i>	Spotted prawn-goby	Cabing titik merah, jabingan guttata
<i>Amblyeleotris steinitzi</i>	Steinitz prawn-goby	Bunglon lorek, jabing lorek, jabingan steni, cabing lorek
<i>Amphiprion ephippium</i>	Saddle anemonefish	Tompel tomat, tompel jakarta
<i>Amphiprion melanopus</i>	Fire clownfish	Tompel biasa, tompel lombok
<i>Apogon semiornatus</i>	Oblique-banded cardinalfish	Capungan merah
<i>Balistapus undulatus</i>	Orange-lined triggerfish	Triger liris
<i>Balistoides conspicillum</i>	Clown triggerfish	Triger kembang, pogot bintang
<i>Callopleiops altivelis</i>	Betta marine grouper / comet	Godam, komet, beta
<i>Centropyge bispinosus</i>	Coral beauty angel	Enjel kennedy/ enjel model
<i>Chrysiptera parasema</i>	Goldtail demoiselle	Betok blustar, blustar biasa
<i>Corythoichthys amplexus</i>	Brownbanded pipefish	Bajulan lorek
<i>Doryrhamphus dactyliophorus</i>	Ringed pipefish	Bajulan zebra
<i>Doryrhamphus exicus exicus</i>	Blue stripe pipefish	Bajulan kembang
<i>Doryrhamphus janssi</i>	Janss' pipefish	Bajulan api, bajulan merah
<i>Exallias brevis</i>	Leopard blenny	Cabing bunga, kapalan, jabingan bunga
<i>Melichthys vidua</i>	Pinktail triggerfish	Triger kaca
<i>Pomacanthus navarchus</i>	Majestic angel	Enjel piyama
<i>Pomacanthus sextriatus</i>	Sixbar angel	Enjel kalong, enjel roti
<i>Pomacanthus xanthometapon</i>	Blueface angel	Enjel napoleon, bidadari bercadar, kepe napoleon
<i>Paracanthurus hepatus</i>	Palette surgeonfish	Leter six
<i>Pomacanthus imperator</i>	Emperor angelfish	Enjel betmen
<i>Rhinacanthus acuelatus</i>	Blackbar triggerfish	Triger matahari
<i>Rhinomuraena quaesita</i>	Ribbon eel	Ular hitam, ular biru, selendang biru, belut hitam, belut kuning, belut pelangi biru,
<i>Stonogobiops xanthorinica</i>	Yellownose prawn goby	Cabing anten zebra, jabingan zebra model
<i>Sufflamen chrysopterum</i>	Halfmoon triggerfish	Triger celeng, triger babi
<i>Synchiropus picturatus</i>	Picturesque dragonet	Mandarin B
<i>Synchiropus splendidus</i>	Green mandarinfish	Mandarin asli

Table 2. Ten most-collected species from the Karumpa Reefs (three days travel from north Bali).

Scientific name	Market name	Local name
<i>Amphiprion ocellaris</i>	Clown anemonefish	Clownfish, klonfish, kelon
<i>Pseudanthias dispar</i>	Peach fairy basslet	Gadis
<i>Nemateleotris magnifica</i>	Fire dartfish	Roket anten merah, anten merah
<i>Labroides rubrolabiatus</i>	Redlip / blackspot cleaner wrasse	Dokter mas
<i>Odonus niger</i>	Red tooth trigger	Triger biru
<i>Forcipiger flavissimus</i>	Yellow longnose butterfly	Monyong asli
<i>Chrysiptera cyanea</i>	Blue/sapphire damsel	Blue devil
<i>Oxymonacanthus longirostris</i>	Spotted/harlequin filefish	Jagungan, jagungan biasa
<i>Labroides bicolor</i>	Bicolor cleaner wrasse	Dokter asli
<i>Amphiprion clarkii</i>	African clown	Polimas

fish during the long sea voyages are woefully inadequate. Collectors use whatever materials are at hand for collecting, and tend to “make do” with what they have in terms of collecting equipment. For example, mosquito netting may be the only locally available store-bought netting that has a small enough mesh for catching ornamentals, but this is expensive and tears very easily. Collectors spend considerable time weaving their nets by hand, using cotton or nylon thread. Handmade nets tend to be highly visible to the fish, and their coarseness causes bruising to the fish. Collectors use old jerry cans set in inner tubes as floating containers for their fish. Very often, the plastic fish storage bags provided by the supplier are in short supply, and of the wrong sizes, so they must be reused many times. Bag shortages lead to “gang-packing” — the packing of large numbers of fish into single bags. This increases the risk of stress and injuries to the fish. Finally, once piled up in the holds of the boats, a significant number of bags burst, either because of the weight of other bags from above, or because of nails and splinters in the wood of the boat.

The collectors often fall prey to marine police patrols that extort money from them before allowing them to continue. All these factors increase stock mortality rates and risks to the safety of the collectors. Meanwhile, the marine ornamentals trade continues to treat marine organisms like a commodity and expects a steady, continuous supply of stock, with a constant stream of “new” products becoming available to satisfy demand. Collectors and suppliers are often the ones blamed when orders are late or of poor quality, although these problems can happen anywhere along the trade chain. Incorrect identification of ordered organisms at the supply end leads to frustration and rejection of stock. Such misidentifications are caused in part by a lack of agreement between buyer and seller on which identification guides and reference lists to use. However, some importers have helped by providing their exporters with pictorial identification guides that can be passed down the chain through the suppliers to the collectors. The problem of suppliers sending fish of the “wrong” sizes also occurs, because there is no agreement within the industry (particularly between different importing countries) as to what constitutes “small”, “medium” and “large” for a given species.

Hookah divers

In areas where shallow reefs (on which collecting can be done without the aid of compressed air) are already damaged and unproductive, collectors use compressors (of a type normally used to inflate car tires) with long hoses to supply them with air during their dives. This practice is called hookah diving, and enables collectors to dive to depths of

up to 50 m. At these depths, they are able to catch high-priced species that live at depth, as well as those that have been fished-out on shallower reefs. Without watches, pressure gauges or knowledge of safety diving and the need for decompression stops, these divers run the risk of decompression sickness, paralysis and even death. Some local authorities are restricting the use of compressors, which helps to reduce the negative impacts of fishing for such products as food fish, lobster, abalone, sea cucumber and other marketable marine organisms.

Cyanide use

In spite of claims to the contrary and the introduction of laws and increased frequency of patrols by law enforcement officers, the use of potassium cyanide (locally known as “potas” — burns with a blue/purple flame) to catch fish is still widespread in Indonesia. Some traders maintain that many of the fish caught using cyanide do survive and flourish even after they are purchased by the end buyers. They ignore the immediate and subsequent damage to the reef and the impacts to the thousands of non-target organisms that are affected by the use of cyanide. They do not see the numbers of target fish that die or are rejected and left underwater when the concentration of cyanide used is too high. Certainly, many fish do survive to reach the market, but the hidden costs are unacceptably high.

The problem of seasonality

Another source of pressure put on collectors by the buyers stems from the seasonality of both supply and demand. Bearing in mind that their only other source of income may be the capture and immediate sale or barter of food fish (as they have no cold storage facilities), being financially indebted to their buyers, the life of the average collector is comparatively difficult. Collectors may have families, extended families and friends who are all out of work, and who depend on the collectors for support. Schooling and health facilities are rudimentary but still cost money, so it is likely that collectors and their children have to forgo schooling in favour of being able to buy food. Some fish species are only available during certain seasons, and there may be long periods when collectors cannot go out in their boats because of rough seas. Demand for stock is also seasonal, with demand declining during times when hobbyists are on holiday (e.g. in the summer). These low periods of supply and demand do not coincide. During these times, collectors generally have no other sources of income, which is a major reason why so many of them get into debt through having to borrow money. Buyers may not place regular orders with collectors, and then might refuse the catch from the collectors at the last minute because the exporter has changed his order. Because of the lack

of adequate holding facilities in collectors' villages, stock cannot be held for any significant length of time after capture. Therefore, at times when no collecting is possible, or when demand is low, collectors sit idly in their villages, repairing their hand-made nets. Some exporters are attempting to hold stock in their facilities for longer periods in order to see them through times when supply is low or until demand picks up again. Holding fish for longer periods can ensure a more continuous supply of stock to the buyer, but it adds costs. Increasing the price of the fish would help to cover these costs, but that would require understanding and support from the buyers. In spite of many exporters' claims, collectors have no bargaining power whatsoever, especially if they are in debt to their suppliers. If collectors do ask for more money for their catch, then the buyer simply threatens to recall all their loans and go elsewhere for his fish. Another advantage of holding fish for longer periods before exporting them is that they have more time to recover from their journey to the exporters and are fed and monitored for a while, putting them in better condition to face the next (international) leg of their journey. This would be a radical departure from the traditional practice of each link in the chain selling on stock as quickly as possible.

Coral and live rock

Collectors of corals and live rock face problems similar to those faced by fish collectors. Corals command a higher price than fish on the international market, yet the methods of collection and transportation remain simple and inadequate. Reefs are subject to boat and anchor damage and trampling by collectors. Coral fragments or whole colonies are hewn out of the reef using pliers and crowbars. Corals are piled into buckets of seawater and then brought ashore. Without individual packing, many pieces become damaged in transit to the facility and are later rejected.

The trade in live corals for marine aquaria requires substantial investment, partly because, although the quantities traded are smaller than in the case of fish, the price paid per piece is higher, space requirements are greater, and breakages and losses through poor handling (and therefore rejects) are frequent. Transportation of live corals requires more space on the boat than is needed for bags of fish. Investment requirements include the purchase of wooden boats with inboard or outboard engines, compressors for supplying air to divers via hookah gear, a variety of containers, holding facilities, and means of transportation. This investment is generally made by exporters in return for regular supplies of corals by collectors, who are also given the responsibility of looking after and maintaining the boats. Unfortunately, rou-

tine maintenance is not part of the culture of collectors, and spare parts are expensive and hard to find. Consequently, breakdowns are frequent, and much time is lost while waiting for spare parts to arrive and repairs to be carried out.

Sometimes collectors rent motorbikes on the backs of which they balance Styrofoam boxes for transport to the suppliers. Suppliers generally either rent small open flatbed trucks, or use local long-distance public bus services to transport their boxes to exporters' facilities. Very rarely, the exporter will supply the trucks, but these are mostly open flatbed trucks, and the fish boxes (or just the bags of fish) are covered with a tarpaulin to protect them from the heat of the sun. Air-conditioned trucks are a rarity, although a very few exporters have invested in them.

The land-based ponds needed for holding corals are simply too expensive for most suppliers, so corals must be sent on to the exporters on the same day that they arrive ashore. Using sea-based coral storage facilities near the village runs the risks of pollution and theft.

Live rock — loose pieces of coral rubble covered in pink/purple algae and containing thousands of water-purifying micro-organisms — is used extensively in marine aquaria for both water purification and its aesthetic appeal. It is often collected by free divers (not using breathing apparatus) from the deep trough beyond the reef crest and brought to shore in small dugout canoes with outriggers.

Trader relationships

There are generally three steps in the chain of custody within Indonesia: the collectors, the suppliers that buy stock from the collectors, and the exporters that buy from the suppliers. The collectors live in coastal villages — some of the poorest communities in Indonesia. Many collectors are illiterate, have no land or other assets, and originally became collectors when buyers approached them to catch tropical fish. The suppliers are frequently ex-collectors who have had a little education and developed simple business skills. Occasionally there are other middlemen involved between the suppliers and the exporters. These middlemen are generally involved in the transportation of the stock between the supplier and the exporter. The exporters are business people for whom the sale of marine tropical fish is only one of their businesses. Many of the exporters are of Chinese descent, and run their export trade as small family businesses. There are no big companies, and certainly no multinationals, supplying the marine aquarium trade from Indonesia. The term "traders" refers to the suppliers and export-

ers, as they run businesses with export in mind, in contrast to the collectors. There are almost no foreigners working in the trade in Indonesia, apart from the occasional technical advisor sent from overseas to work with an exporter in order to improve stock quality.

Some exporters have been known to withhold payments to suppliers in order to keep prices low, believing that if they pay immediately, they will be perceived to be “rich”, leading to higher prices. In contrast, suppliers tend to live close to collectors and feel a greater moral obligation to pay collectors as soon as possible. Honest and transparent trading is clearly difficult to promote in a climate where there is little sense of obligation, loyalty or mutual trust. It is ironic that, in a market that is still expanding, suppliers appear to be fighting a constant battle to find and keep customers. This reflects a lack of binding contractual arrangements between sellers and buyers, as much as the unreliability of stock supply and variable quality.

As long as there are still fish in the sea, plenty of desperate collectors to catch them, and many suppliers to choose from, the number of buyers paying fair prices will remain small. Some argue that there first has to be a significant improvement in stock quality before they will consider paying higher prices. However, a few traders understand that it is the low prices paid for fish at the source that are driving collectors to overfish, use cyanide, and use poor methods of collecting, handling and transportation. Catching and sending far more stock than was ordered will hopefully continue to offset the high mortalities caused by the poor methods used. The collectors’ reasoning behind catching and sending far more stock than was ordered is that such opportunistic attempts at sales will offset the high mortalities caused by the poor capture, holding and transportation methods used.

Unlike the people they sell to, the concept of time being money is alien to collectors. They accept the high levels of waste in time, stock and money and the large amounts of rejected stock as normal. Their understanding of business is so meagre that, when simple business-training sessions are given for them and the potential savings and profits are itemized for them and presented as lost income over a year, they are usually genuinely surprised at how much money they are losing. (And they are always shocked when told of the price at which the stock they collect is finally sold to the hobbyist!)

There is simply too little investment by the trade in general to help support collectors and give them financial incentives to upgrade their skills and facilities. As time goes on, more reefs are destroyed or overfished, leading to further exploitation else-

where, and increasing competition among collectors’ groups for diminishing resources. This in turn promotes the use of more destructive collection techniques in order to catch larger quantities of fish, which collectors try to sell at any price before they die, further constraining the productivity of the resource.

There is an urgent need for the industry to work more closely with collectors and others at the supply end to help them improve stock quality, find responsible, trustworthy buyers, and promote reef management to help sustain the resources on which all players in the trade depend.

Recent initiatives to help the marine aquarium trade

The introduction of various capacity building measures for collectors, suppliers and exporters has started to show a positive impact, including an improvement in the quality of fish sold by some groups of collectors. These improvements are admittedly still very limited in scale because of the sheer size of the country, the large number of collectors involved, and constraints in funding and manpower for training and monitoring. However, awareness of the various problems is steadily growing among coastal communities that depend on marine resources for their livelihoods. The challenge is to help them recognize their power as a vital link in the trade chain, and then to encourage them to adopt the tools needed to achieve greater resource sustainability.

A few enlightened importers and exporters are already working more closely with their suppliers, providing them with expertise, training and equipment. These pioneers are being closely watched by the rest of the marine ornamentals trading community and are leading the way for the rest of the industry.

Together with several local nongovernmental organisations (NGOs), the Marine Aquarium Council (MAC) has begun to provide training for collectors, suppliers and exporters in Indonesia. It has welcomed the help of some foreign divers/collectors and a very few foreign trainers (including technical advisors sent by importers to work with their exporters). These trainers have provided technical assistance and instruction in capturing, holding, packing and transportation skills and methods. Experienced local collectors are being recruited to provide hands-on practical training in net-only capture techniques.

Dive instructors have given dive safety courses to collectors, and a local hospital in Bali allows collectors access to the only decompression chamber on the island. Representatives of MAC spoke

to doctors there, and it was discovered that collectors could use the facility at a reduced cost, provided they supplied evidence of their status as poor coastal villagers. The hospital had never had any collectors use the chamber until recently. Once the first group of collectors had visited the chamber, they took back to their villages the message that this was something to help cure them, rather than something to be afraid of. The collectors' group has now established its own fund to pay for transportation and treatment in the event of a decompression case. (It must be remembered that none of these villagers had ever considered making the three-hour journey to the main town, let alone visit a hospital! Many more collectors still rely on traditional cures, and cases of death and paralysis from deep diving accidents still occur all too frequently.)

The Community and Conservation Investment Forum (CCIF), a San Francisco-based non-profit organisation with a field office in Bali, is developing training materials for basic financial management and marketing of marine aquarium products. The organisation encourages suppliers to become part of MAC-certified supply chains, form traders' associations, and link with MAC-certified buyers. Sales and species selection will hopefully become better managed, more rational and less arbitrary as communication among exporters, importers and retailers improves and the trade links between them are strengthened.

Sustainability also requires scientific assessments of the aquarium fishery resources and management plans for the collection areas, such as those that are beginning to be implemented in Indonesia, the Philippines and Fiji. This will take time and effort. The collectors and collectors' groups, supported by local governments, are in the front line in terms of learning to manage their resources more carefully. They need to be encouraged to use a precautionary approach to resource exploitation. This is not easy at a time when there is increasing competition for dwindling marine resources. The international Reef Check Foundation, together with the Indonesian Scientific Authority and local NGOs, is developing methods of determining sustainable harvest levels and establishing total allowable catches (TACs). These methods use both data from in-water visual surveys at collection sites, and catch data from collectors and suppliers. At the same time, efforts are being made to enable local communities to apply these methods so that they are able to assess the state of the resources in their area and adjust collection rates accordingly.

The current economic situation in Indonesia is putting great pressure on collectors. Fuel prices

for sea and land transport have recently doubled, sometimes making the costs of collecting trips prohibitive. Where the collectors and collectors' groups have made an effort to manage their local resources more responsibly, the financial rewards of their efforts will act as incentives for sustained positive change and help to reduce the need for roving collection. Increased prices paid for better quality stock are an obvious example of such incentives, but assistance in the form of cheap masks, snorkels, fins, and suitable netting, as well as regular support visits by the importers and exporters, would all serve to increase the sense of self-worth of the collectors. (Very few exporters and even fewer importers have ever visited a collectors' group to see how they live and how stock is caught.)

Educating collectors about how important they are as the first link in the trade chain serves to increase their sense of responsibility in providing a quality product, as well as pointing out the bargaining power many did not realize they had.

The frequency of government enforcement patrols has recently increased, so more cyanide users are being caught and fined. Meanwhile, local governments plan to provide trained collectors with individual collector licenses, which will allow them to collect legally in certain areas. The issuance of licenses will increase the collectors' sense of resource ownership and reduce the possibility of their being victims of extortion by unscrupulous enforcement officers. Licenses will be issued only to those collectors who have followed a particular training programme. If any collector is subsequently found to be using destructive collection methods, for example, their training certificate and license would be withdrawn. MAC is also helping with capacity building for local government officials so that they have the tools and skills necessary to regulate collection activities in the future, in cooperation with collectors' groups.

Coral propagation

Some exporters are moving towards coral propagation, which necessitates considerable investment in facilities and equipment and the adoption of new skills by their staff. Formerly, all corals for sale were collected from the wild, but now more corals are being propagated in shallow coastal waters from coral fragments ("frags") collected from reefs, and this provides local villagers with another opportunity for income. Broodstock colonies or fragments are relocated to "dead" areas of reef flats, and corals are grown from these original fragments. These corals are in turn fragmented, and successive generations are grown from them. Currently, many small-polyped species (e.g. *Acropora* spp.) are being grown because of their rela-

tively rapid growth rates. The market pays higher prices for the slower-growing large-polyped species (e.g. *Euphyllia* spp.), and it remains a challenge to manage the flourishing coral mariculture trade so that the market is not flooded with only a few fast-growing species. The development and spread of low technology mariculture will, in time, decrease market reliance on the collection of wild corals, while providing coastal villagers with an alternative source of income.

Corals are now being propagated in several areas around Bali and Java, both in the sea and in land-based facilities. Coral fragments are glued or tied onto bases or pegs, and these are arranged on racks, often situated in shallow water near the beach. The fragments and bases need to be cleaned periodically, and performing these simple maintenance tasks for hire can provide a source of income for local villagers.

A portion of the propagated corals can be used to rehabilitate damaged reefs, although efforts to do this have been very localized and limited. The steady increase in the numbers of coral species being propagated is an important first step in improving the prospects for sustainability of the Indonesian coral trade and in reversing the trend of reef destruction.

Future of the trade

The power of the hobbyists as consumers to demand a “better” product should not be underestimated. Increased awareness among hobbyists of the origin of the organisms they buy and the circumstances under which they are caught and shipped will help them to make more informed purchases. The collective mindset of consumers, many of whom still treat marine ornamentals as a disposable commodity, needs to evolve to one that recognizes them as being a valuable living resource that has a limited supply.

The number of marine ornamental species that are being captive-bred is still very low. Very few people will want to invest in expensive captive-breeding facilities as long as cheap wild-caught specimens are available. The development of low technology captive-breeding and rearing techniques that can be successfully adopted by coastal villagers would do much to reduce fishing pressure on wild stocks, as well as provide a more sustainable source of income. An interesting challenge would be to take the few “high-tech” techniques developed by experts in the marine ornamentals industry in the developed world and try to adapt them for use in the less-developed supply countries.

Some marine species are receiving legal protection in Indonesia. Their collection, sale and export are prohibited. For example, giant clams (*Tridacna*

spp.) were once very abundant throughout the archipelago but were over-collected to the point of extirpation in many areas. A number of giant clam species are now being successfully bred in captivity, and these can be used for restocking. Seahorses, once collected by the ton and dried for the Chinese traditional medicine market, are now being captive-bred. Clownfish are another very popular species that is now being captive-bred in quantity in Indonesia. Humphead wrasse (*Cheilinus undulatus*), a species that was widely caught for the live food fish export trade using cyanide, is now listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), meaning that exports must be documented by government authorities as having been taken legally. The list of captive-bred species produced in Indonesia is still pitifully short, but this may change as wild stocks decline and captive-breeding is recognized as a financially viable alternative.

All hard coral species are listed in CITES Appendix II, so their export and import are regulated. Indonesia has imposed further restrictions on coral exports. Since 1997, based on recommendations given by the Indonesian Government’s Scientific Authority, the Indonesian CITES Management Authority has set up annual catch quotas for corals, some at the genus level and others at the species level.

A few marine protected areas have been established in Indonesia, but rocketing fuel prices and high maintenance costs mean that there are too few enforcement patrols for these vast areas. Also, officially protected areas are a magnet for illegal fishermen because they contain some of the largest remaining intact reefs.

The need to protect marine species and habitats, at least in terms of providing a more sustainable source of saleable commodities, is a message that is slowly becoming more widely understood. Sadly, this realization has all too often come only after resources have been fished out and habitats destroyed. Furthermore, if the marine aquarium industry wants to reduce the likelihood of government officials taking rash and uninformed action to address issues in the trade, it will need to take greater initiative and be more proactive in reforming itself from within.

The amount of damage caused on a daily basis by the collection of marine organisms for the aquarium trade is relatively slight compared with the impacts of other human activities. Nevertheless, it is hoped that some of the positive initiatives towards a more sustainable aquarium trade will be expanded and will lead to a wider global understanding of the need to protect the wild natural resources on which so many people directly depend.

Summary of actions needed to promote a more sustainable marine aquarium trade

For Indonesia's marine aquarium industry to flourish and prosper in the longer term, a number of changes need to be made. In general, the buyers are best placed to provide greater support and incentives to those working lower down the chain (i.e. at the supply end). Actions to effect these necessary changes include:

- Training collectors in the use of non-destructive collection techniques.
 - Training in handling and shipping methods that maintain the health and quality of organisms.
 - Training in safe diving and compressor maintenance.
 - Empowering collectors through the formation of production cooperatives.
 - Teaching basic business skills for running viable collection and sales operations.
 - Promoting the use of written contracts between buyers and suppliers to encourage greater mutual loyalty.
 - Forming suppliers' and exporters' trade associations to increase their bargaining power.
 - Using the notion of increased environmental and social responsibility as a marketing strategy.
 - Promoting greater environmental awareness of coastal and marine issues in local communities and among participants in the trade, as well as among government personnel that could give greater support to them.
 - Establishing collection area management plans and empowering local communities to monitor and regulate natural marine resource extraction.
 - Establishing no-take zones within collection areas where stocks can recover and seed the rest of the reef, with management of such zones undertaken by local communities with local government support.
 - Campaigning to publicize the negative effects of cyanide use and developing portable cyanide detection test kits.
 - Establishing incentives for collectors and their communities to manage the reefs and control the trade at their end.
 - Encouraging buyers to share their expertise and information with their suppliers.
 - Providing basic equipment (e.g. simple water quality test kits, dive gear, nets) that may be expensive or not available to the suppliers.
 - Encouraging importers to provide training to exporters and suppliers.
 - Developing low-technology mariculture techniques as a viable alternative to collection from the wild.
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Consumer perspectives on the “web of causality” within the marine aquarium fish trade

Breck A. McCollum¹

Abstract

Collection, handling and transportation issues surrounding the marine aquarium fish trade have resulted in the degradation of many fishing communities and coral reefs worldwide. Currently, a number of conservation organisations are working in source countries to improve industry sustainability. An analysis of United States consumer perspectives on the marine aquarium fish trade suggests that additional attention to informing consumers and hobbyists is fundamental in creating the demand for sustainably caught organisms. In addition, such educational campaigns should link human health impacts for collectors with environmental ones in a manner that is appropriately honest, yet not antagonistic to this important industry. Content analysis of various US-based aquarium hobbyist resources and interviews suggests that the public discourse surrounding the negative environmental and human health issues of the aquarium fish trade is not well developed. Very little information on the processes involved in collection is readily available to the concerned aquarist or general public. Not surprisingly, hobbyist media generally avoid these challenging topics. As might be expected, trade books and magazines generally stress that the aquarium industry inspires its hobbyists to be conservationists. A recent expansion of online aquarium fish retailers has made it easier for hobbyists to make impulsive purchases with little knowledge on where the organisms were obtained, what condition they will arrive in, or the suitability of the organisms for their current aquarium systems. Websites occasionally offer “hand-caught” livestock, but with no definition of what “hand-caught” actually means, or it is specified that their organisms were not harvested from areas of common cyanide usage (i.e. Indonesia or the Philippines). The linkages between various stakeholders associated with the aquarium fish trade are summarised here in a “web of causality”. This analysis suggests that a holistic strategy addressing various unsustainable processes is fundamental to success.

Introduction

The use of cyanide as a means of collection in the marine aquarium fish trade poses a great threat to the health of already endangered coral reef ecosystems across the Indo-Pacific region. However, the aquarium fish trade alone is not responsible for the majority of the ecosystem degradation in this region, nor is stopping the use of cyanide likely to do more than slow the current rate of destruction. Additional threats, such as the removal of mangrove habitat for coastal development, urban pollution, blast fishing and increased sedimentation as a result of ongoing deforestation, among others, pose a danger perhaps greater than cyanide fishing. These issues must all be addressed in order to slow, if not stop, the current rapid rate of coral reef destruction. And to ensure the sustainability of any success that might be obtained, the complex root causes of these problems must also be addressed. In order to fully understand why cyanide is used in the Indo-Pacific

region, we need to expand our focus to look not just at the collection countries, but also at the importing countries and the consumer pressures that often reinforce its use.

In this paper the term “aquarium trade” refers to the chain of custody in which pet aquarium fish are provided to the consumer. The terms “aquarium fish,” “marine ornamental,” and “ornamental” are used interchangeably throughout this paper and all refer to marine organisms that enter the aquarium trade. This study looks specifically at the trade of ornamental finfish harvested from coral reefs in the Philippines, although some findings are applicable to corals and other invertebrates. It is important to note, however, that organisms for the trade are collected in waters throughout the tropics (Barber and Pratt 1998; Sadovy and Vincent 2002; Wabritz et al. 2003).

This study examines what is important to American consumers — who dominate the global market

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for aquarium fish — concerning where and how their aquarium fish are acquired, what aspects of the trade are commonly understood by consumers, and what influence additional knowledge about the environmental and human health impacts of collection procedures would have on the choices consumers make at the time of purchase.

The aquarium fish industry has promoted a hobby of growing popularity in the United States as advances in aquarium technology have opened the market to a larger proportion of potential hobbyists. Increasing success in the maintenance of private aquarium systems, in conjunction with the growing popularity of the aquarium-keeping hobby, due in part to the popular media, have increased the demand for aquarium fish, which are widely available in retail stores as well as on the Internet. Large chain stores have begun carrying simple aquarium supplies and livestock with the hopes of cashing in on this increased popularity.

With growing concerns about the health of the world's oceans, several media sources have increased the frequency at which issues related to sustainable fisheries and coral reef decline are discussed. The release of the Disney/Pixar animated film "Finding Nemo" spurred a flurry of interest in the environmental impacts of the aquarium fish trade (Moss pers. comm. 2005). Television appearances of the actor that played the voice of Nemo, along with magazine and newspaper articles across the US, have increased consumer demand for "Nemo-styled" tanks while promoting awareness about the manner in which ornamental organisms are collected. Similar to the impact of the film "101 Dalmatians" on consumer demand for pet Dalmatian dogs, "Finding Nemo" has greatly increased demand for ornamental fish, leading to the coining of the term in the pet industry, the "Nemo Effect" (Jackson et al. 2003). Along with issues related to releasing non-native species into public waterways (flushing unwanted pets down the drain or releasing them directly into rivers or lakes), recent television programs and articles have focused on collection practices in the Indo-Pacific region. International non-governmental organisations (NGOs) have teamed up with the media to increase consumer awareness about these issues. That increased awareness, however, has not extended to the negative health impacts of the trade on collectors. Scholarly articles mention this issue in passing or in reference to the live food fish trade (e.g. Johannes and Riepen 1995; Barber and Pratt 1998), but there is rarely any critical dialog surrounding these health impacts.

Background

The marine aquarium trade is extremely dynamic and widespread, providing income for millions of people worldwide both in the fishery sector and in

accessories retail and maintenance. While marine ornamental organisms are often the most profitable resource harvested from coral reefs, current collection practices have extensively damaged habitat and fish stocks internationally (Wabritz et al. 2003).

Up to 98% of all aquarium fish are believed to be wild-caught (Wood 2001). The majority are harvested from the Indo-Pacific, which is known as the centre of coral reef biodiversity (Johannes and Riepen 1995; Barber and Pratt 1998; Wood 2001; Sadovy and Vincent 2002; Wabritz et al. 2003). Centres of export are concentrated in Indonesia and the Philippines. Major importing countries are the US, United Kingdom, Taiwan and Japan, although the latter two are generally not the final destination (Wabritz et al. 2003). The US dominates the market, receiving approximately 60% of the world's catch (Baquero 1999).

It is estimated that of the 86 million American households, 11% have aquariums, although 90% of the 12 million aquariums contain only freshwater fish (NFO Research, Inc. 1992, as cited in Waltonne 1994). Aquarists spend an average of 200 US dollars (USD) annually on livestock and supplies (Baquero 1999). The majority of fish tank owners maintain "fish tank" style aquariums with fish as the only inhabitants due to ease of maintenance and lower cost. Advances in technology have opened the market for increasing demand for "mini reef" style aquariums, which tend to include coral, live rock and other invertebrates (Baquero 1999).

Collection

Fishers work alone, in family or small community groups, or for various fishing companies (Wabritz et al. 2003). Employed fishers may be salaried or paid by the piece (Baquero 1999). Common collection methods include mist nets, hand nets, drop nets, hook-and-line, specialized spears, slurp guns, tickle sticks, muro-ami, poisons, and a variety of specialised and traditional methods (Halim 2002; Tissot and Hallacher 2003; Wabritz et al. 2003; Lunn and Moreau 2004; Sadovy pers. comm. 2005).

Nets, slurp guns and tickle sticks tend to be the least damaging to the environment. In a study of fishing methods used at Malalison Island, Philippines, nets appeared to bring the greatest net income to fishers, followed by hook-and-line, due to ease of operation and low initial cost to the fisher (Smith et al. 1980; Amar et al. 1996). Nets are generally considered a sustainable method; however, nets can snag on corals, causing damage if the fisher is not careful (Tissot and Hallacher 2003). Further, improper use may damage the collected organisms, making them unfit for export (Robinson pers. comm. 2006; Cruz pers. comm. 2006; Green pers. comm. 2006). Slurp guns use suction from a pressurized chamber

to catch the desired organism (Sadovy pers. comm. 2005). The use of tickle sticks involves the fisher chasing the fish into a crevice, placing a net over the entrance, and using a stick to “tickle” the fish out of the crevice and into the net (Wabritz et al. 2003). Muro-ami involves placing a net over a section of reef and bouncing tethered rocks off the coral in order to scare the fish into the net (Mitchell 2002; Christie pers. comm. 2005-2006). Variations on this method include beating the coral with sticks rather than rocks, or using hookah pipes to bubble water into the coral crevices to scare the fish out, the latter being much less damaging (Wabritz et al. 2003; Sadovy pers. comm. 2005).

Most ornamentals caught in deeper waters require long dives, for which fishers use scuba or surface-supplied pressurized air with devices known as “hookah” (Wabritz et al. 2003; Wood 2001). Due to the shallow habitat of many desirable species, several marine ornamentals are also caught while free-diving (Sadovy pers. comm. 2005). Common poisons used are sodium cyanide, potassium cyanide, bleach, and quinaldine (Barber and Pratt 1998; Tissot and Hallacher 2003; Wabritz et al. 2003). Poisons are typically mixed with seawater in a squirt bottle and the hookah or scuba diver squirts the solution into a coral head. The poison stuns all the fish that come into contact with it, making them easier to collect. The stunned fish often take refuge inside a crevice before the poison takes effect, in which case the fisher may use a crowbar to pry apart the coral. If the diver is free-diving, larger amounts of poison are typically dumped from a boat over large areas of reef in order to save time collecting underwater (Barber and Pratt 1998). Fish are believed to metabolize and excrete cyanide rapidly; however, due to their weakened state, fish caught with cyanide are more likely to die due to the stress of transportation and handling (Barber and Pratt 1998; Baquero 1999; Wabritz et al. 2003).

Independent fishers, using their own boats, often stay close to shore, making daily fishing trips (Lunn and Moreau 2004). Employed fishers or staff collectors may use boats supplied by the employer and often make multiple-day fishing trips (Lunn and Moreau 2004). Local governments and employers often require staff collectors to be trained in what species are most desirable and in collection methods that result in less harm to the species and environment (Barber and Pratt 1998; Baquero 1999). However, this is not always the case, as some employers actually supply the poison and require the fishers to use it (Johannes and Riepen 1995; Cruz pers. comm. 2006; Christie pers. comm. 2006.). Staff collectors often work long hours under dangerous conditions, with little or no knowledge of diving safety (Johannes and Riepen 1995; Barber and Pratt 1998; Jacques 2001; Halim 2002; Sadovy pers. comm. 2005; Christie pers. comm. 2006).

Handling and transport

Generally, immediately following collection, ornamentals are stored in containers of seawater for transportation to a holding facility (Wabritz et al. 2003). Temporary holding facilities are often in the house of the collector until picked up by or delivered to the first buyer (Sadovy pers. comm. 2005). Once delivered, the fish are generally quarantined without food for a minimum of 48 hours in order to prevent them from excreting in their transport bags (Baquero 1999; Wabritz et al. 2003). Fish excretions contain ammonia and can be fatal in high concentrations (Baquero 1999). The exporter or transporter will then acclimatize the ornamentals for transport (Albaladejo and Corpuz 1981; Wabritz et al. 2003). Typically, fish are placed in a plastic bag filled with two parts oxygen to one part seawater (Wabritz et al. 2003). In general, the smallest bag possible is used in order to cut back on shipping weight and volume (Baquero 1999). Some exporters and transporters will add an antibacterial and water sterilizer before sealing the bag (Baquero 1999). The bags are then packed into insulated cardboard boxes for shipment (Albaladejo and Corpuz 1981; Baquero 1999; Wabritz et al. 2003). Shipments are often required to be accompanied by a veterinary clearance; however policies and practices differ among exporting countries (Wabritz et al. 2003).

Importers sell the ornamentals to a wholesaler or a retailer, or re-export them (Wabritz et al. 2003). Aquarium owners, which include hobbyists and public aquariums, buy from retailers or occasionally directly from wholesalers (Wabritz et al. 2003; Sadovy pers. comm. 2005). Internet stores have made the retailing process easier for consumers.

Cyanide fishing

The use of cyanide as a fishing technique was first documented in the Philippines in 1962 (Wabritz et al. 2003). More than 150,000 kg of cyanide is believed to be used in the Philippines annually in the collection of marine ornamentals and more than 1 million kg have been used since the 1960s (Pratt 1996; Barber and Pratt 1998). Cyanide has been demonstrated to cause mortality in laboratory corals; however, these findings are difficult to interpret with respect to the effects of cyanide on wild populations of corals (Jones and Stevens 1997). The use of cyanide is also known to produce high mortality in non-target organisms, such as invertebrates that might be in the surrounding area when cyanide is used (Baquero 1999). Local fishermen and dive operators, however, have no doubt about its detrimental effects (Barber and Pratt 1998). Recent studies have shown that the combination of cyanide use and the stress caused by post-capture handling results in mortality of up to 75% of fish within 48 hours of capture (Wabritz et al. 2003; Bunting et al. 2003). With such a high mor-

tality rate, a greater number of fish must be caught in order to compensate for post-capture deaths.

Health impacts

The impacts of collection for aquarium fishers are often overlooked when compared to the environmental impacts of the trade. However, personal accounts of health conditions in fishing communities cannot overstate the importance of looking closer at these impacts (Johannes and Riepen 1995; Johannes and Djohani 1997; Jacques 2001; Sadovy pers. comm. 2005; Christie pers. comm. 2006; Reksodihardjo-Lilley pers. comm. 2006). According to these accounts, fishers in many Indo-Pacific fishing communities have little knowledge of dive safety. Frequently, air compressors used to fill tires or for paint sprayers are used with hookah or to fill scuba tanks, and a variety of non silicone-based oils, such as motor oil and coconut oil, are used in the maintenance of diving equipment (Johannes and Riepen 1995). Breathing air contaminated with these oils or without proper filtration can be fatal. Breathing these contaminants at depth increases the concentration at which they are absorbed, as a greater volume of air is inhaled per breath while at increased pressure. Safe diving practices such as slow descents and ascents and the use of safety/decompression stops are often unthought-of or considered a waste of time in such a competitive industry. Divers are often over-weighted to achieve a faster descent, and then dragged to the surface by a partner when the dive is over (Jacques 2001). As the resource is depleted, desirable species are often available only on deeper reefs, leading fishers to make deeper dives, and increasing the chances of developing decompression sickness (commonly referred to as the “bends”). It is not uncommon to hear of divers making deep dives

in rapid succession for the duration of the working day (Jacques 2001). Standard safe diving practices call for increasingly long intervals at the surface between dives in order to let the body expel the nitrogen gas that has accumulated in the tissues.

Analysis of consumer perspectives

This study posed the questions: What is the hobbyist’s responsibility to ensure industry sustainability? What is the appropriate response of a well intentioned consumer to the environmental and health related impacts of the trade? Should the consumer stop buying aquarium fish, boycott those fish collected from regions of suspected cyanide use, or seek out certified or sustainably caught organisms? Given these and other possible responses, what information is available to consumers to help them make the proper decision?

Web of causality

Inspired by the work of John Vandermeer and Ivette Perfecto (1995) on rain forest deforestation as a result of the banana trade, this analysis resulted in a model used to graphically represent the complex linkages between resources and resource users in the marine aquarium trade. According to Vandermeer and Perfecto, when “viewed as a web of causality, it is quite pointless to try to identify a single entity as the “true” cause [of deforestation]”. “The true cause is the web itself” (Vandermeer and Perfecto 1995:162). The web in Figure 1 depicts how most hobbyists would describe the structure of the aquarium industry, as determined in this study. In this model, the environmental outcome is a direct result of the fisher choosing to use destructive or non-destructive methods.

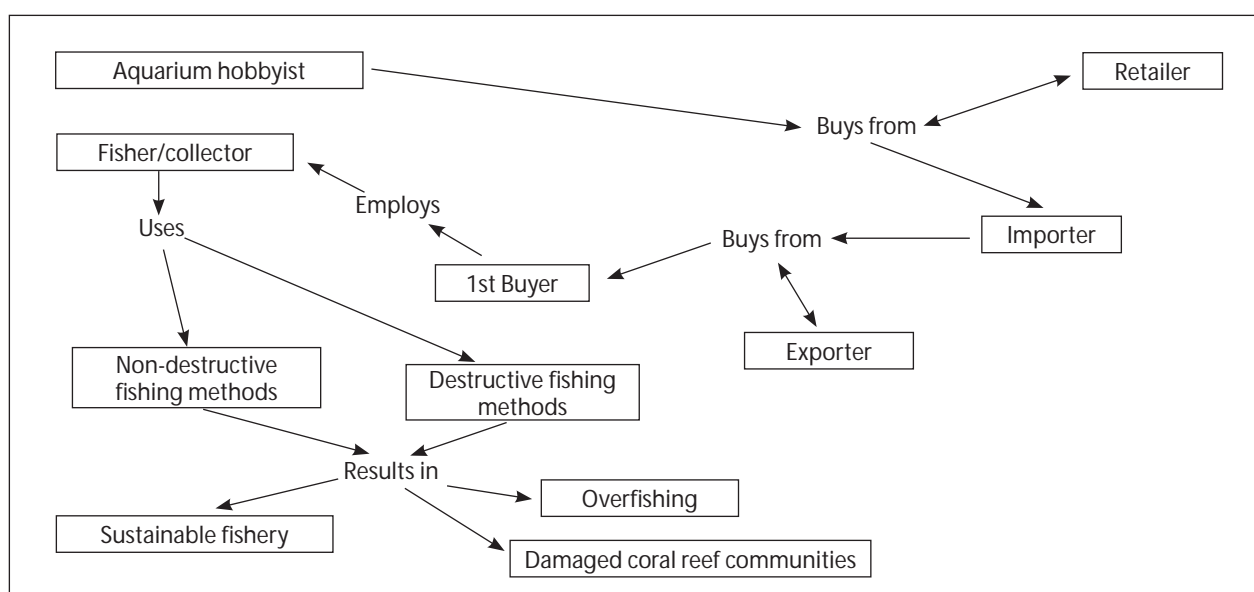


Figure 1. Web of causality for the aquarium fish trade, as perceived by hobbyists.

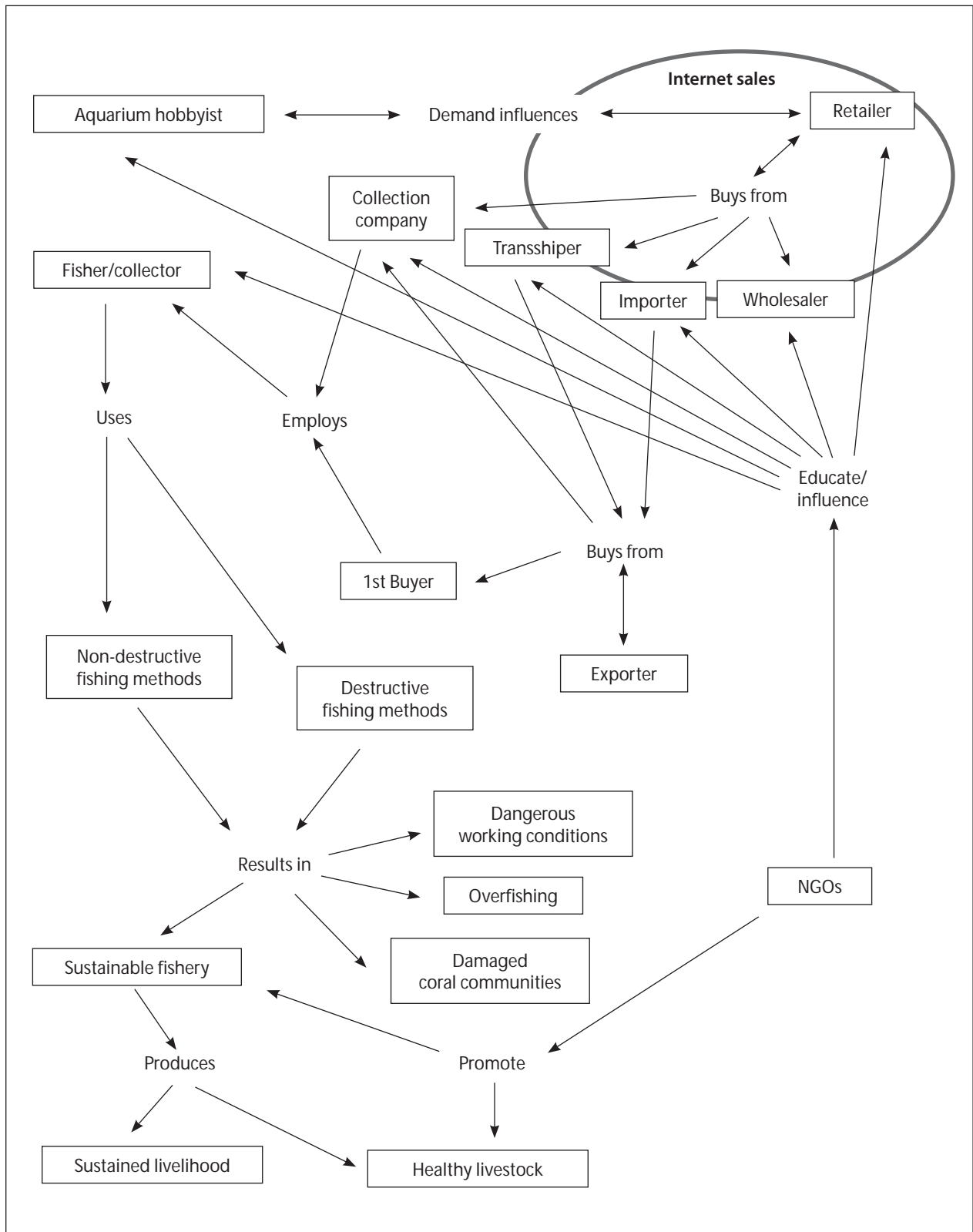


Figure 2. Expanded web of causality for the aquarium fish trade, showing the complex linkages between entities, actions and consequences.

With additional research on the complexities of the industry, the model was expanded to include several more actions and resource users along the chain of custody (Fig. 2). While this model is not by any means complete, it gives a better indication of the difficulty involved in understanding the trade from the point of the consumer. In this model, it is more difficult to place the responsibility for environmental outcomes on the fisher's decisions alone, or to identify a "true cause" for the environmental degradation resulting from the trade. Both models explain the idea that a fishing method can result in either a sustainable or unsustainable fishery. Cyanide, when used in small doses as a sort of anaesthetic, can be used as a sustainable method. On the other hand, non-destructive fishing methods, such as slurp guns, certain nets and other specialised fishing techniques, can, like destructive methods, result in overfishing.

The expanded model also captures the idea that any fishing method used can result in dangerous working conditions, as similar diving equipment is used by both net fishers and cyanide fishers. Additionally, the expanded web shows the influence that e-commerce, or online sales, can have on demand. This model points out the important fact that focusing management efforts on one or even a few of the links in the chain of custody will not solve all of the problems involved with the trade.

This study aimed at determining which issues are important to hobbyists and how a misunderstanding of the complexity of the entire trade process has compounded human health problems and environmental degradation in collection countries. The sources used to gain a better understanding of consumer perspectives were: a list of hobbyist accessible articles from 2001–2005 as supplied by

the Marine Aquarium Council (MAC) (Fig. 3 and Table 1), back issues of Freshwater and Marine Aquarium magazine, a selection of hobbyist message boards (Table 2), nine retailer websites (Table 3), and informal interviews with Puget Sound Aquarium Society members and pet store employees in the Puget Sound area and elsewhere in the US. The lack of discussion about these sources of problems faced by collectors and environmental issues prompted the development of the two "webs of causality" in Figures 1 and 2.

Hobbyist-accessible articles

MAC is an international NGO working to encourage industry sustainability by introducing a certification process for the trade that includes a labelling scheme similar to the popular "organic" and "fair trade" labels. MAC has been producing a quarterly newsletter (available both in print and online) since 2001, and most issues contain a section called "MAC in the News", which attempts to list all the news articles and other popular publications in which MAC is discussed. This list was used in this study as an index for articles likely to address environmental or human health issues associated with the trade. It was found that although several of the listed articles discussed environmental impacts, only one discussed in detail human health impacts (Jacques 2001). Figure 3 shows the number of articles that were listed in "MAC in the News" per quarter from 2001 through the beginning of 2006 (data for the 4th quarter of 2004 and 2nd quarter of 2005 are missing). The remarkable spike in the 2nd quarter of 2003 occurred simultaneously with the release in the US of the film "Finding Nemo", which created a great deal of interest in the aquarium trade. Table 1 shows the publications in which the listed articles appeared.

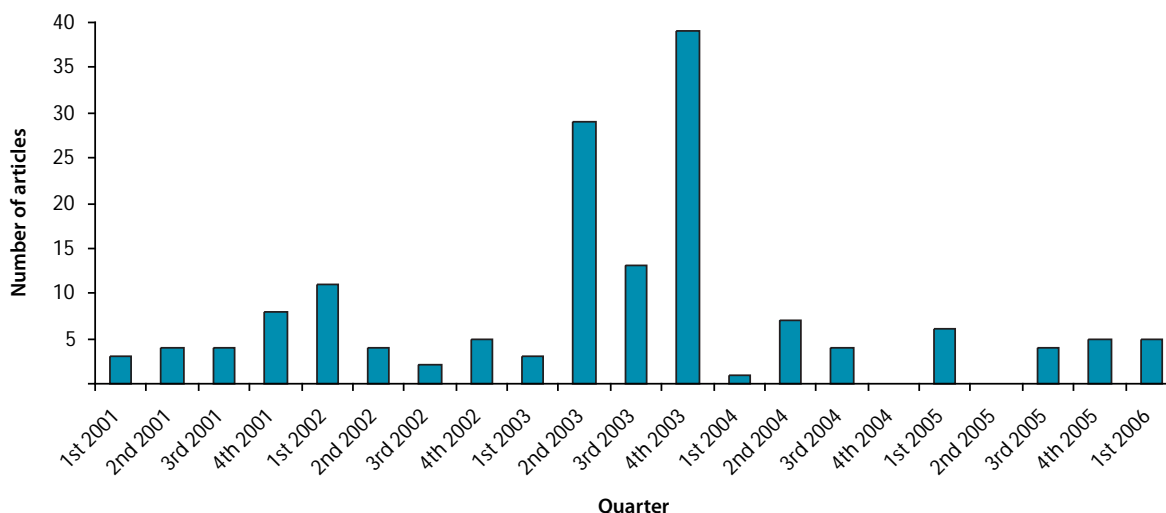


Figure 3. Number of hobbyist-accessible articles listed in "MAC in the News", by quarter.

Table 1. Sources of articles in which MAC is discussed, as listed in “MAC in the News”, 2001–2006.

Number of articles	Source
48	Newspaper/online articles
22	Other publications
18	Television shows
12	Ornamental Fish International
10	Pets International Magazine
7	Freshwater and Marine Aquarium
5	Pet Age
3	Aquatic Trader
3	Diver magazines
3	Radio programs
2	Advanced Aquarist's Online Magazine
2	Online fora
2	Tropical Fish
2	Aquarium Fish Magazine

Freshwater and Marine Aquarium magazine

The tables of contents and indices of Freshwater and Marine Aquarium volumes 3–29 (except issue 11 of volume 8 and issues 1, 5 and 9 of volume 13), which covered the period January 1980 through January 2006, were searched for any mention of collection issues, sustainability in the trade, environmental issues, human health issues, or cyanide use. The advertising sections were also searched for advertisements by NGOs involved in the trade. Nine articles were found that met these criteria, and no advertisements by NGOs were found. The first was an April 2001 article that described the efforts and goals of MAC as quoted from MAC's document “Core Collection and Fishing Practices International Performance Standards for the Marine Ornamental Trade”. This article briefly explains the importance of coral reefs and the threats of human activities (Sprung 2001). The next article that met the search parameters was an August 2001 article by Jeff Bernier in the “Responsible Reef Keeping” section. In this article Bernier stated that “...government agencies have been accosted with information citing the marine aquarium industry for irresponsibly damaging coral reefs” and “[the] hobby is full of conservationists intimately aware of and concerned with the welfare of coral reef habitats” (Bernier 2001:178). This article did not mention any of the other parameters. The third article, from March 2002, was also about MAC but included more details on environmentally destructive practices involved in the trade (FAMA staff 2002). The fourth article, in the October 2002

issue, was an editorial, also by Bernier. He urged hobbyists to ask questions at their local fish stores about where and how organisms were collected, and to patronize stores that offered sustainable alternatives to wild capture (Bernier 2002). This editorial took a more critical stance on the industry than his first article and warned consumers to be wary in their purchases. Bernier stated that consumers had power over what livestock was sold in the local fish stores they patronize, as well as how and where it was collected. He did not discuss the impacts of collection on collectors. The reader is left with the feeling that there are “good collectors” and “bad collectors” and that it is up to the reader to decide which ones they will support. Three of the next five articles were written as guest editorials by MAC staff or are about MAC practices but did not go into further details on any of the search parameters other than mentioning destructive fishing practices (Spalding 2002; Brandt 2003; Wedman-St. Louis 2003). The July 2005 article was written by an undergraduate student who studied the impacts of collecting for the marine aquarium trade on a small village in Costa Rica. While this article did not mention health impacts on the collectors, it did discuss their lack of ability to regulate the price they are paid for each organism (Lowenstein 2005). The final article, from October 2005, stated that “the use of cyanide present[s] an important ethical and moral issue to aquarists” and encouraged aquarists to look for and purchase MAC-certified organisms (Gosnell 2005:124). These articles succeed in introducing their readers to the issue of unsustainable collection and the certification scheme of MAC; however no article found in this search discussed the human health impacts faced by collectors.

Hobbyist message boards

Message boards are a useful Internet-based communication tool. Registered users can post messages about a given topic and other registered users can respond (generally at no charge). Many message boards can be viewed without having to register. Message board communities exist for nearly every subject matter imaginable. For aquarium hobbyists, they are useful as a means to share information about their current aquarium systems, to describe mistakes they have made in their own systems, and to ask for and receive advice. Twelve US-based aquarium hobbyist message boards were visited in December of 2005. At each message board, a search was conducted for the terms “cyanide”, “poison” and “collection”. Search results were then analysed in terms of the previously mentioned search parameters. Table 2 indicates for each message board the degree of attention paid to these issues, using the subjectively-assigned indicators “heated debate”, “moderate mention”, “little mention” and “no mention”. “Heated debate” means there were extensive,

often passionate, arguments between users on a variety of pertinent issues. “Moderate mention” means there was occasional discussion about issues related to the effects of collection on ecosystems and fishing communities. “Little mention” refers to message board communities where discussion was limited to blaming cyanide collection as a probable cause of death for organisms in seemingly perfect tank conditions or when the user thought “they had done everything right”. The message boards marked “no mention” returned no search results as of December 2005.

Table 2. Hobbyist message board search results for the terms “cyanide”, “poison” and “collection”, accessed in December 2005.

Website	Degree of attention paid
www.aquariacentral.com	moderate mention
www.saltwaterfish.com	little mention
www.reefs.org	heated debate
www.reefcentral.com	heated debate
www.aquahobby.com	little mention
www.aqualinkwebforum.com	little mention
www.marinebio.org	heated debate
www.aquatic-hobby.com	no mention
www.aquaticquotient.com	no mention
www.fishadviceforum.com	no mention
www.fishboard.net	no mention
www.fishforums.com	little mention
www.forums.fishindex.com	little mention

Retailer websites

As more and more purchases are made online, it is important to know what information is available to the customer at the point of sale. The websites examined in this study were for retailers that dealt only in Internet sales. As done for the message boards, searches were made for any information related to capture methods, cyanide, or environmental or health impacts of collection. Not surprisingly, retailers did not use the word cyanide, as indicated in Table 3. Of those retailers that referred to poisons at all, most specified that their organisms were obtained from areas that do not use “drugs”. It was not expected to find retailers discussing the negative environmental or human health impacts of the trade, and none of these retailers did on their websites. Most websites offered net-caught organisms exclusively or whenever possible, but with little or no explanation of whether this method was used

sustainably or in conjunction with cyanide. Several of these retailers indicated that they boycotted organisms collected in Indonesia or the Philippines. The retailer with the website www.fish2u.com bred many of its own organisms, but since it sold freshwater as well as marine ornamentals, it was unclear what portion, if any, of its marine products were captive-bred. The website www.saltwaterfish.com had a sponsored message board that included a brief discussion among customers of cyanide use.

Puget Sound Aquarium Society

The population of the city of Seattle, in the US Northwest, is known for its widespread environmental ethic, which might have an impact on consumer purchases. The questions posed to members of the Puget Sound Aquarium Society (PSAS) were:

- 1) What is the size and influence of the marine aquarium hobbyist community in the Seattle area?
- 2) Do most people tend to buy their ornamentals online or locally?
- 3) What qualities do you look for in a good aquarium store?
- 4) What species tend to be more popular and why?
- 5) What are the difficulties in operating a reef-style or marine tank when compared to a freshwater system?

As of November 2005, there were about 300 members on PSAS’s email list. Interviews with members revealed that they tended to favour supporting local fish stores where employees were often more knowledgeable and cared more about the survival of their livestock than some larger chains or online retailers. However, because local stores’ products could be twice as expensive as those of online retailers, more expensive livestock was often purchased online. PSAS members often made group orders online to lower shipping costs. The interviewees described a good aquarium store as one with a knowledgeable staff, a clean appearance, a practice of quarantining livestock for at least three weeks, a good supply of high-quality tank maintenance products, and reasonable prices. Unfortunately, members did not know of any one store that had all these qualities.

PSAS members tended to focus on reef-style tanks, involving mainly corals and functional livestock, such as a variety of algae grazers and other cleaning fish and invertebrates. For fish-only tanks, livestock with interesting behaviour or appearance were preferred. Popular species were Amphiprioninae, *Zebrafish*, *Blenniidae*, *Siganus vulpinus* and Chaetodontidae. The difficulties in maintaining reef or marine tanks were found to be linked to how much effort the hobbyist wanted to put into their

Table 3. Online retailer website search results for discussion of capture methods, cyanide, and environment or health impacts of the trade.

Website	Capture method	Cyanide	Environmental/health
www.liveaquaria.com	Net-caught, farm-raised when possible	Focuses on fish from countries where drugs are not used	No mention
www.fish2u.com	Many captive-bred (possibly only freshwater stock)	No mention	No mention
www.marinedepotlive.com	Net-caught when possible	Focuses on fish from countries where drugs are not used	No mention
www.themarinecenter.com	Net caught	No mention	No mention
www.aquacon.com	No mention	No mention	No mention
www.premiumaquatics.com	Many farm-raised	No mention	No mention
www.thepetstop.com	No mention	No mention	No mention
www.saltwaterfish.com	No mention	Mention on sponsored message board, but not on retail website	No mention
www.justrarefish.com	No mention	No mention	No mention

system. Most hobbyists failed on their first attempt at a marine tank as they are “less forgiving” than freshwater systems. A lack of knowledge starting out, bad advice from shop employees, purchasing poor quality equipment as a means of saving money, and inappropriate livestock were other reasons given for a high failure rate with first-time hobbyists. The list of important factors given for a high-quality local fish store included the availability of captive-bred organisms, but there was no mention of “cyanide free” or “sustainably caught” organisms.

Local and national fish stores

My questions about fish collection procedures put to personnel at Seattle-area fish stores were met with a variety of attitudes and responses. Personnel at some stores became quite defensive when I, as a university researcher, raised these topics: I was given a phone number and referred to their head-quarter offices. Finding I was getting nowhere with this approach, I started asking questions as a concerned consumer. With this approach, retailers were more helpful and tried to educate me about making proper decisions on potential livestock (I was nearly convinced on several occasions to purchase my own reef tank). However, most employees were uncertain of where their organisms originated, as they came from wholesalers that stock ornamentals from all over the world. Livestock of the same

species, from different source countries, were often placed in the same tank. I found that at the retail point of sale it was often nearly impossible to determine the country or origin, let alone the method of collection. One retailer had a method to determine with certainty where and how their livestock was obtained: they only sold live stock collected by their own collection company unless a customer made a special order. This retailer was particularly interested in discussing the various unsustainable fishing methods with me.

Discussion

Although an estimated 85% of marine aquarium fish are caught with cyanide (Barber and Pratt 1998), the majority of retailers claim to sell only net-caught or captive-bred or captive-raised organisms (Table 3). Approximately 5% of hobbyists were, as of 2004, aware of the MAC certification scheme (Alencastro et al. 2005). Apparently there is some misinformation being presented to consumers about how their fish are collected. The information that is reaching the consumer does not appear to adequately address all of the issues involved with collection procedures and, at most, has promoted a bad image of collectors as being solely responsible for environmental damage caused by the industry. This perspective is not helpful in alleviating the adverse conditions in collection countries that commonly use destructive

fishing methods. Taking business away from these areas in the form of a retailer- or hobbyist-led boycott would potentially only worsen the conditions that exist. Collectors' incomes would be further jeopardized and they would be forced to find other means of livelihood. Available livelihoods include destructive fishing for the live reef food fish industry and coral mining for construction materials.

MAC and its labelling scheme have the potential to play a significant role in educating stakeholders at all levels of the trade. However, there are some questions among hobbyists and retailers as to the reliability of MAC standards and certifications of fish imported into the US. Some retailers have expressed concerns that wholesalers and importers mix shipments of certified fish with non-certified fish so they are never quite sure of the origins of the livestock they receive. Currently, consumers do not have many opportunities to purchase guaranteed cyanide-free livestock that provides sustainable benefits to collectors without harming the environment. Consumers can apply the pressure needed to increase the number of MAC-certified retailers, if this is indeed the solution.

Another potential solution rests with community-based organisations that are dedicated to cyanide-free collection. Organisations such as those in the Les and Serangan communities of Bali, Indonesia, where they are supported as a project of Telapak (www.telapak.org) (Ruwindrijarto pers. comm. 2006), engage in all aspects of the trade from collection to export, and ensure that fair prices are paid to collectors, and provide proper care and handling for each organism. By removing several of the links in the web of causality and relying on a cooperative system, profits are more likely to remain in the community and the organisation can be held fully responsible for the health of its fishers and the organisms it supplies. Jobs remain stable as long as they maintain the health of their coral reefs, and there are additional opportunities for women to find work in the trade.

Educational campaigns sponsored by NGOs can have a positive effect on consumers, as television programmes and magazine articles already have. Advertisements can be placed in hobbyist magazines and discussions at local club meetings and on message boards can be easily facilitated. The Internet is a powerful tool that can both influence hobbyists to buy impulsively and educate them about current issues. Retail stores cannot be expected to report on negative aspects of the industry, but as a source of information for hobbyists, they too are responsible for the choices made in their stores. The responsibility to educate consumers ultimately lies with consumers themselves. The purchase of an organism without consideration of its origin or

method of collection or the fate of the collector happens far too frequently in importing countries, and it cannot continue if the industry is to achieve sustainability.

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Applying the triangle taste test to wild and cultured humpback grouper (*Cromileptes altivelis*) in the Hong Kong market

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Introduction

Live reef fish are regarded as premium fish for consumption in Southeast Asia and China, and higher value species are principally consumed in restaurants. With the economic growth in Hong Kong during the last 30 years, the demand for live reef fish has increased substantially. It is estimated that imports into Hong Kong account for about 60% of the volume of live reef fish traded in the Asia-Pacific region (Sadovy et al. 2003). Recent estimates show that the declared annual volume of live reef fish imported into Hong Kong is 12,000–14,000 tonnes, with a retail value of about 350 million US dollars (USD) (Muldoon et al. 2005).

There are concerns that the high demand for live reef fish has led to overexploitation of fish stocks and damage to coral reefs (Cesar et al. 2000; Sadovy et al. 2003). Practices used in fisheries for live reef fish, such as the use of destructive harvesting techniques, including cyanide fishing, and the targeting of spawning aggregations and juvenile fish, damage the marine ecosystem and threaten the sustainability of the supply of reef fish.

Because the supply of wild-caught fish from reefs is under pressure, the potential to supplement wild-caught supply with aquaculture production is considered important for the long-term sustainability of the trade. Aquaculture production of grouper species is now expanding rapidly, increasing at an average of 43% per year from 1999 to 2002 (Rimmer et al. 2006). Consumer acceptability of cultured product is obviously an important factor in terms of the degree to which cultured product can displace wild product on the market and thereby help ensure the persistence of wild stocks. We need to better understand consumers' preferences for live reef fish, particularly with respect to cultured versus wild fish.

The Australian Centre for International Agricultural Research (ACIAR) is funding research aimed

at ensuring the sustainable economic development of the trade. As part of this research, two projects related to consumer preferences for live reef fish in Hong Kong were undertaken during December 2005. One was a survey of consumer attitudes related to the consumption of live reef fish (Chan et al. 2006). The other was a taste test that aimed to determine whether consumers could discriminate between wild and cultured samples of a particular species of live reef fish in a "blind" situation (i.e. in which the tasters do not know which product they are tasting), and to examine which product attributes they prefer. This latter project is reported on here.

Methodology

There are a number of taste test techniques, such as pair comparison and contingent ranking, which were applied by The Nature Conservancy on cultured and wild-caught malabar grouper (*Epinephelus malabaricus*) (OmniTrak 1997). The triangle test technique was selected for this study because it is the most widely used discriminative test in sensory analysis, which has the aim of determining whether or not detectable differences exist between two samples (Huss 1995). In the triangle taste test, assessors receive three coded samples of fish. They are told, accurately, that two of the fish samples come from the same type of fish and that one is different, and are asked to identify the odd sample. These tests can be useful in determining whether consumers can detect sensory differences between cultured and wild fish products.

In the test, humpback grouper (*Cromileptes altivelis*) was selected as the taste test product (Fig. 1). Humpback grouper is a highly valued fish in the Hong Kong market, selling for approximately USD 83 per kilogram in Chinese seafood restaurants in Hong Kong. The wild-caught humpback groupers were supplied from Indonesia through a Hong Kong trader, while the cultured humpback

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groupers were supplied from the Gondol Research Institute for Mariculture (GRIM) in Bali, Indonesia. All the tested fish were of typical market size: 0.6 to 1 kilogram.

In the original test design, two types of cultured products were to be included for comparison with a wild-caught product. Both of the cultured humpback grouper products were raised from full-cycle aquaculture but one was fed “trash fish”, which is usually smaller sized species of low value, while the other was grown out on fish pellets, which consist of a scientifically formulated feed of fish meal and vegetable products. Unfortunately, the two types of cultured humpback grouper products were mixed together during transportation to the restaurant. It was consequently necessary to modify the taste test to solely compare wild-caught and cultured humpback groupers, without discrimination between the two types of feeding regimes.



Figure 1. Humpback groupers used in the taste test, swimming in a restaurant tank, November 2006, Hong Kong (photo by B.G. Johnston).

Thirty participants were recruited for the taste test: 16 were guests invited by the Hong Kong Chamber of Seafood Merchants (HKCSM), mostly merchants involved in the trade, and 14 were staff from local seafood restaurants.

The taste test was carried out in a Chinese seafood restaurant whose staff was highly skilled in preparing live reef fish for restaurant meals (Fig. 2). The fish were prepared in the manner typical of such meals. The fish were cut into pieces so that the assessors could not see the whole fish. Each assessor was given one bowl of each of the three fish samples. They were told that two of the bowls came from the same source, while one of the bowls was different. They were not told whether the odd sample was a wild-caught or a cultured sample, as illustrated in Figure 3. Although there were two types

of cultured fish, each assessor was given only one of the two types to compare with the wild-caught sample. Each assessor sat at his or her own table and was asked not to converse with the assessors at adjacent tables.



Figure 2. Restaurant placement setting for the taste test, Hong Kong (photo by B.G. Johnston).

Triangle taste test: wild versus cultured fish

In the 3 bowls of fish, two of them come from the same kind of humpback grouper, one is different. After tasting, please identify the odd one. Please provide ONE answer only. If you are not sure, please guess the odd one.

1 2 3

Figure 3. Sample triangle taste test questionnaire.

The taste test included three parts. First, assessors were asked to taste the samples, identify the odd one and identify the key sensory characteristics that made it different. Second, they were asked to identify the sample they preferred for each of five specific listed attributes: colour, taste, texture (smoothness), texture (elasticity) and skin. Third, they were asked to guess which samples were wild and which were cultured.

Results

In Test 1, 53% of assessors were able to correctly identify the odd samples (Fig. 4). In terms of the assessors who were live reef fish traders (the HKCSM guests) versus those who were not (the seafood restaurant workers), 44% of the former group correctly identified the odd samples, compared with 64% of the latter group.

In Test 2, it was found that most respondents preferred the sample of wild humpback grouper over the cultured product in all five of the sensory attributes (Fig. 5). Among those participants who were able to correctly discriminate between the wild-caught and cultured products (16 assessors; see Fig. 4), it was found that for all five attributes, most preferred the wild-caught product to the cultured product (Fig. 6).

In a triangle test, assessors can, even if they cannot discriminate among the samples, utilise random guessing to identify the odd sample. Therefore, in part 3 of the test, assessors were asked to describe the sample combination; that is, to indicate for each of the three fish samples whether it came from a wild or cultured source. It was found that 37% (11 assessors) were able to correctly identify their sample combinations (Fig. 7). Thirty-one percent of traders and 43% of non-traders did so correctly. Because Test 3 is more difficult (in terms of the probability of being correct by chance alone) than Test 1, we would expect the percentage of correct answers to be lower in Test 3 than in Test 1, as they were.

We further analyzed the attribute preferences of those respondents who correctly identified the sample combinations in Test 3 (11 assessors; see Fig. 7). It was found that all of them preferred the wild sample over the cultured one in colour, taste and texture (smoothness) (Fig. 8). However, for the texture (elasticity) attribute one person in this group preferred the cultured sample and another expressed indifference between the cultured and wild products, and for the skin attribute one person preferred the cultured product and two expressed indifference.

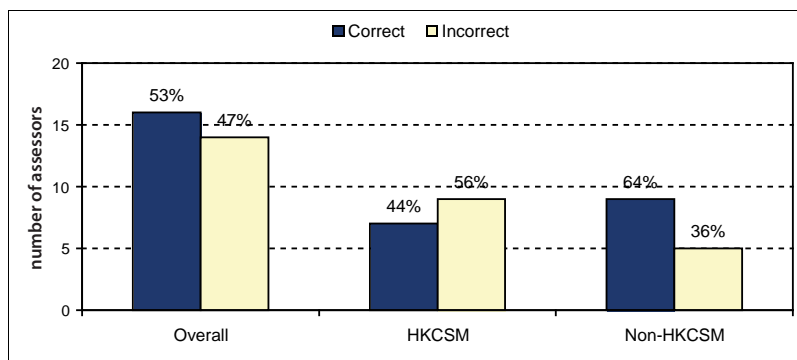


Figure 4. Number and percent of assessors that correctly identified the odd sample.

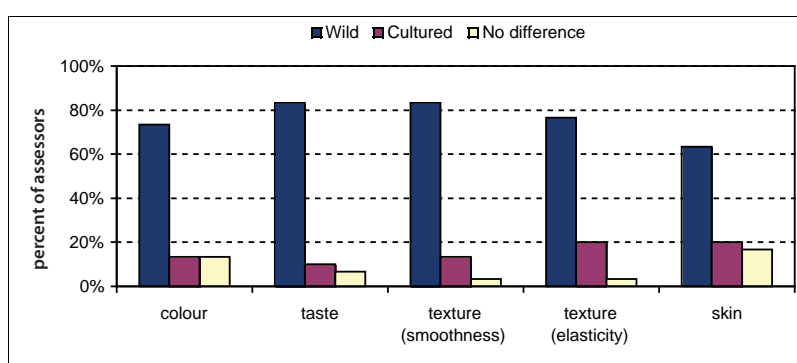


Figure 5. Preferences between wild and cultured products, by attribute.

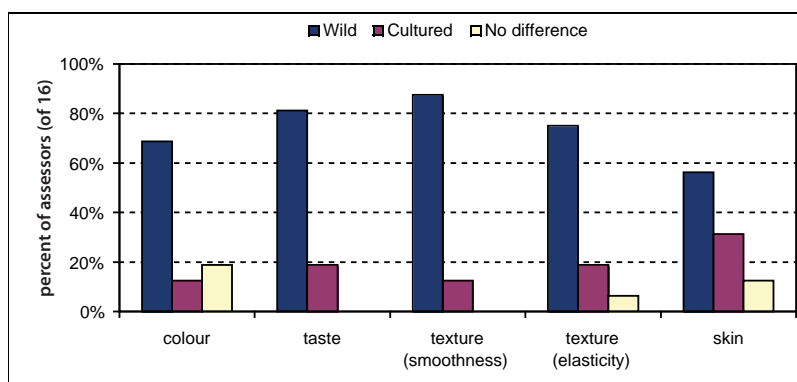


Figure 6. Preferences between wild and cultured products, by attribute, among the 16 assessors who correctly identified the odd sample.

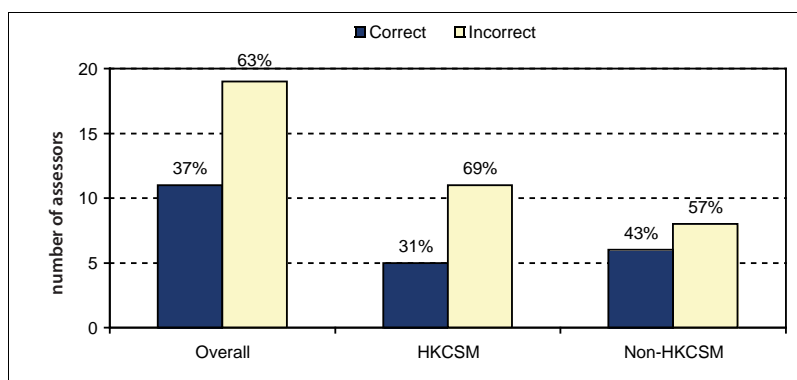


Figure 7. Success in identifying sample combinations.

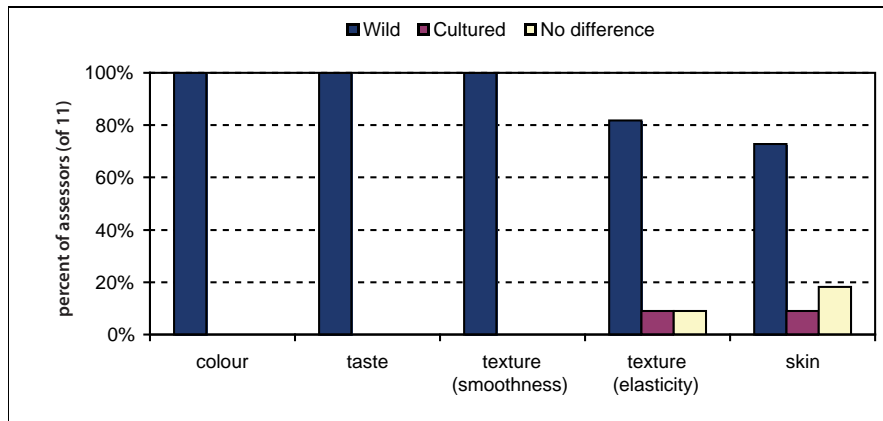


Figure 8. Preferences between wild and cultured products, by attribute, among the 11 assessors who correctly identified the sample combination.

Discussion

Overall, the triangle test methodology worked well and all participants were able to complete the test. They also provided positive feedback that suggests this methodology can be applied to assess the quality of cultured fish of other species in order to objectively test the widely perceived perception that cultured fish are of inferior quality relative to wild-caught fish.

The results indicated that there was a definite preference among participants for the colour, taste and texture of the wild-caught product (more than 70% preferred the wild-caught product in these attributes). However, informal feedback from participants after the test indicated that the cultured product was also highly acceptable to participants. This bodes well for the widespread commercial acceptance of cultured products in the future.

There were some aspects of the triangle taste test that we would do differently in the future. First, the cultured fish comprised two types (trash fish-fed and pellet-fed), but it was not possible to test for differences between them. It would be desirable to test the two types of cultured fish separately in future tests to ascertain whether there are preferences for trash fish-fed or pellet-fed products.

Also, it would be desirable to broaden the sample to include a larger group of more typical consumers of live reef fish, rather than relying on individuals involved in the industry to provide assessments. The blind triangle taste test methodology worked well in a restaurant setting and could be easily extended to a larger and more representative sample in the future. It would also be useful to evaluate the visual

aspects of the fish swimming in the restaurant tanks to ascertain whether consumers can discriminate between wild and cultured products when choosing the fish to consume in the restaurant.

At the completion of the taste test, in an open discussion, the seafood merchants offered a number of comments that might be valuable to aquaculture scientists and marketers of cultured fish.

- Many merchants thought there was a very good future for cultured live reef fish in the market in Hong Kong.
- The taste and texture of cultured fish is already considered quite acceptable to Hong Kong consumers, although it currently trades at a discount price relative to wild-caught product (the size of this discount varies across species and will require further market research to determine).
- Among the higher value species that are available from culture (which appear to only include humpback grouper and giant grouper, *Epinephelus lanceolatus*, at this time), the trade appears to be favouring giant grouper. It grows to market size relatively quickly, appears to be a more robust species for cage culture, and its flavour and texture appear to be well accepted. A merchant familiar with both cultured humpback grouper and cultured giant grouper said that the best tasting and textured cultured live reef fish was giant grouper from Taiwan raised on pellets.
- Individuals involved in the trade in live reef fish are highly aware of environmental and health issues associated with the trade. The import into Hong Kong of groupers raised with the applica-

tion of malachite green has heightened consumer awareness of the need to purchase healthy and safe fish, and the industry is responding to this issue. The Hong Kong aquaculture industry has been cooperating with Hong Kong's Agriculture, Fisheries and Conservation Department to introduce a Certified Fish Tag Scheme (Sun 2005) in which fish farms that comply with certain conditions, such as criteria related to pond size, drainage, source of water and protection from contamination, and that submit to regular government checks, can place a certifying tag on their fish at the point of sale in the market. The tag is fixed to the fin of the fish and is designed to be tamper-proof.

- Individuals involved in the trade are aware that overfishing has been occurring in wild populations and that future supplies of wild-caught live reef fish will be more limited. They consequently see the aquaculture sector as providing future growth opportunities for the trade.

Conclusions

The blind triangle taste test showed that most participants in this study could discriminate between wild and cultured fish samples in a "blind" situation and that the wild-caught product was preferred in most sensory attributes. The blind triangle taste test methodology was found to be a suitable method for assessing perceived taste differences in live reef fish products.

Some valuable lessons were learned from the test, including the need to protect the integrity of the samples being tested from the point of production through to the restaurant tank.

Future triangle taste tests of live reef fish products should test for differences in preferences and product attributes between cultured products produced from different food sources (trash fish versus pellets). They should also include a more representative sample of typical Hong Kong consumers to complement the "expert panel" approach used in this study.

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Monitoring the live reef food fish trade: Lessons learned from local and global perspectives

Helen Scales¹, Andrew Balmford and Andrea Manica

There are widespread concerns that the live reef food fish trade (LRFFT) is causing overexploitation of populations of coral reef fishes (Johannes and Riepen 1995; Bentley 1999; Lau and Parry-Jones 1999; Sadovy et al. 2003; Hamilton and Matawai 2006). A major challenge for achieving sustainable management of the LRFFT is obtaining data needed to quantify the influence of the trade on the natural resource base and to accurately characterize the trade in terms of spatial and temporal patterns. Such information is necessary for monitoring the impact of the trade on particular species (for example to provide non-detriment findings required for trading the CITES Appendix II-listed humphead wrasse,² *Cheilinus undulatus*; Chu et al. 2006) and for informing management initiatives, both in existing fisheries and in countries where the trade has not yet arrived.

We have been involved in two recently published studies quantifying the dynamics and impacts of the LRFFT at two different geographic scales: first, we investigated the global dynamics and regional impacts of the LRFFT using Hong Kong import data (Scales et al. 2006), and second, we assessed the local impacts of the LRFFT on populations of coral reef fish in northern Borneo using fish catch data from traders (Scales et al. 2007). Due to the nature of the datasets collected, both of these studies provided insights into the temporal and spatial dynamics of the LRFFT. Here we give an overview of these two studies, highlighting the data collection methods used and the features of the datasets that made them especially useful in monitoring the LRFFT. Based on lessons learned from these studies we make recommendations for future monitoring of the LRFFT.

Analysing global trends in the LRFFT

The LRFFT has spread dramatically since its initiation in Hong Kong in the 1970s (Johannes and Riepen 1995; Sadovy et al. 2003). We recently looked in detail at historical data in order to quantitatively

describe the dynamics of the geographic spread of the trade across countries. Despite the high value of the LRFFT, there is a relatively small volume of live reef fish traded internationally compared with other global fisheries. Consequently fisheries statistics rarely include live reef fish in a separate category (Cesar et al. 2000).

For our study, complete figures for imports of live reef fish to Hong Kong from 1988 to 2003 were collected directly from the Hong Kong Census and Statistics Department (CSD). This dataset went further back in time than the previously available Hong Kong import datasets, such as those used by Johannes and Riepen 1995, McGilvray and Chan 2002, Sadovy et al. 2003, and Muldoon et al. 2005. A shortcoming of the existing system for recording live reef imports into Hong Kong is the fact that approximately 100 locally licensed fishing and transport vessels are exempt from the declaration of imports of live reef fish (Sadovy et al. 2003; Muldoon et al. 2005). The total mass of live fish recorded by the CSD is therefore an underestimate of the total imports into Hong Kong. In 1998 a voluntary scheme was set in place by the Agriculture, Fisheries and Conservation Department (AFCD) to record volumes of live fish being imported by locally registered vessels. According to these AFCD statistics, between 1998 and 2002 the locally registered vessels that participated in this voluntary scheme imported an additional 13–53% of the fish biomass recorded by the CSD. It has been estimated that 60% of live reef food fish traded internationally is imported into Hong Kong (Sadovy et al. 2003), hence data on its imports are likely to be indicative of the dynamics and structure of the LRFFT as a whole. In addition, past trade studies have suggested that because Hong Kong is a duty-free port, its trade statistics are likely to reflect actual trade volumes more accurately than those from elsewhere, since there is little incentive to under-report declared imports in order to reduce tariffs (Lau and Parry-Jones 1999; Clarke 2004).

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2. International trade is permitted for species listed on Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) but only where it can be demonstrated that harvesting does not have a detrimental impact on wild populations.

Table 1. Revised trade categories of live reef fish imported to Hong Kong, as recorded in AFCD records from 1997 onwards.

Common name used by AFCD	FAO common name	Scientific name
Giant grouper	Giant grouper	<i>Epinephelus lanceolatus</i>
High-finned grouper	Humpback grouper	<i>Cromileptes altivelis</i>
Green grouper	Orange-spotted grouper	<i>Epinephelus coioides</i>
Tiger grouper	Brown-marbled grouper	<i>Epinephelus fuscoguttatus</i>
Flowery grouper	Camouflage grouper	<i>Epinephelus polyphekadion</i>
Leopard grouper	Leopard coral grouper	<i>Plectropomus leopardus</i>
Spotted grouper	Spotted coral grouper	<i>Plectropomus maculatus</i>
Humphead wrasse	Humphead wrasse	<i>Cheilinus undulatus</i>
Mangrove snapper	Mangrove red snapper	<i>Lutjanus argentimaculatus</i>

Before 1997, CSD trade data were only available as totals of “live marine fish” from a given exporting nation. However, since all the other import categories included freshwater and non-reef marine fish, we assumed that this “live marine fish” category represented mostly coral reef fish. Species-specific import data were available from 1997 onwards, following an initiative from the AFCD to revise the trade categories (Table 1).

Our newly compiled datasets included full information regarding the source nation of all the imports of live reef food fish into Hong Kong; those sources included 19 nations in Southeast Asia and the Pacific Islands.

Accelerating global expansion of the LRFFT

In order to assess the speed at which the LRFFT has spread away from Hong Kong, we collated available published start-up dates of the trade in individual exporting countries (Johannes and Riepen 1995; Bentley 1999) and measured the direct distance (in km) from the capital city of each exporting country to Hong Kong. These data indicated that the LRFFT has been spreading to new countries farther and farther away from Hong Kong at an accelerating pace: initially in the 1970s the trade expanded at a rate of about 100 km per year and by the late 1990s reached over 400 km per year (Fig. 1).

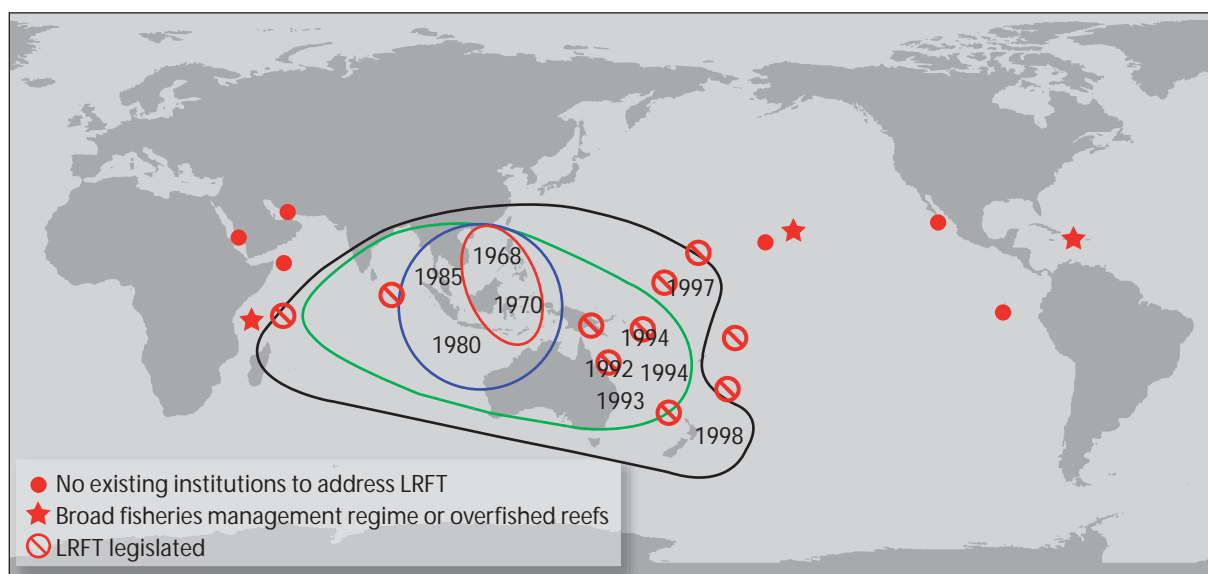


Figure 1. The global spread of the LRFFT, showing start-up dates for the trade in several areas and contours representing the area covered by the trade in 1970, 1985 and 1998. After Scales et al. (2007).

Boom-and-bust patterns

Boom-and-bust trends are often observed in marine and freshwater fisheries and have been reported in the LRFFT (Barber and Pratt 1998; Cesar et al. 2000; Clark 2001; Bruckner et al. 2003). When a potentially lucrative fishery resource is discovered in a particular area, such as when stimulated by new market demands or increases in price, fishing effort increases rapidly. Growing catches encourage other fishers to join the fishery, which expands rapidly (boom phase). In the absence of any management interventions, more and more fishers become involved in the fishery and soon fish populations are unable to replenish themselves rapidly enough to maintain catch rates; fish populations crash, catches fall, profits fall and the fishery collapses (bust phase). We looked at LRFFT trade data to search for boom-and-bust trends and investigated the magnitude of the boom phases and the location and timing of boom-and-bust trends.

We defined a boom-and-bust trend to be one in which there were data showing at least five years of trade, during which there was an increase in annual export weight over at least three years (boom phase) followed by at least two years in which the annual weight declined each year (bust phase) (Fig. 2a). If in a given case the data showed more than five years of trade activity, it was still defined as a boom-

and-bust trend if the boom-and-bust phases were interrupted by no more than two deviations from the overall trend (i.e. there were small year-to-year decreases or increases) (Fig. 2b). At the end of a boom-and-bust phase, according to our definition, the volume of trade is low but not necessarily zero. Where there were gaps in the dataset for a particular source nation, we assumed that there was no departure from the general trends.

Out of 19 source nations studied, 10 clearly showed a boom-and-bust pattern of development. Worryingly, the booms appeared to be increasingly ephemeral for countries farther from Hong Kong, with shorter boom phases (time between the start-up of the trade and the peak in trade volume). This was not explained by the more distant countries having smaller reefs and hence potentially smaller pre-LRFFT populations of targeted species: the time between start-up to peak was found to be unrelated to reef area.

Fishing down the price list

We also analysed the data by species instead of by source nation. Species-specific import figures from 1997–2002 were summed from CSD and AFCD datasets to provide total annual import figures for each species across all source nations combined. These data revealed the serial depletion of species in trade in descending order of price (based on ranking of prices paid to fishers in the main exporting countries in 2001; Sadovy et al. 2003) with more expensive species such as humphead wrasse and giant grouper undergoing bust phases first, followed by lower-priced species such as leopard coral grouper and spotted coral grouper.

What happens next to the LRFFT globally?

Taken together, these three main findings from our global study — the increasing pace of trade expansion, accelerating boom-and-bust trends, and fishing down the price list — pose a worrying scenario for nations located at the periphery of the current trade. At particular risk are Pacific nations with reef ecosystems that so far remain comparatively healthy and sustainably managed, since their relatively large distance from Hong Kong may not be enough to protect these nations from being the focus of attention of the expanding wave of the LRFFT. An issue raised by Berkes et al. (2006) was the threat posed by mobile fishing fleets that enter countries and rapidly deplete resources before regional or national institutions can address issues of overexploitation. Understanding

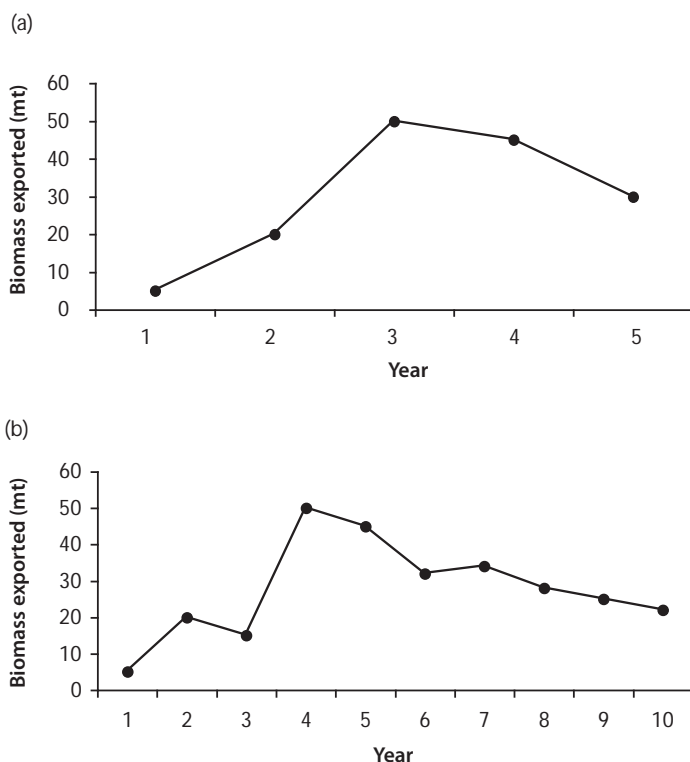


Figure 2. Illustration of minimum requirements for a boom-and-bust trend (as defined in Scales et al. 2006 and here) with: a) five years of export data, and b) more than five years of export data.

the global dynamics of the LRFFT is crucial to help pre-empt its continued expansion and to encourage countries to enter the trade under a controlled and precautionary basis. It is extremely encouraging that through the Secretariat of the Pacific Community's (SPC) Pacific Regional Live Reef Fish Trade Initiative, several countries have begun to approach the LRFFT in a precautionary way, introducing small-scale trial fisheries and developing LRFFT management plans (Yeeting 2006). There also remain some worrying gaps within existing regional coordination of fisheries management institutions for nations in the Indo-Pacific region, including those bordering the Red Sea, Persian Gulf and in the far eastern Pacific (Fig. 1). Reefs in these nations could well become attractive to the LRFFT in the near future; in our view these countries' fisheries would benefit greatly from following a management and conservation model such as that developed by the SPC.

Local impacts

Having looked at the wide scale, country-by-country trends in the LRFFT, we also investigated the local impacts of the LRFFT on populations of coral reef fish (Scales et al. 2007). The geographic focus for this study was the Malaysian state of Sabah on the northern tip of Borneo (Fig. 3). The LRFFT has operated in this region since the 1980s with a supply chain structure broadly representative of other live reef fisheries in Southeast Asia (Bentley 1999). There are two main types of fishing operations around the northwest coast of Sabah and offshore islands. First, individual fishers operate from small wooden boats, using hook and line to catch fish from reefs up to one day's journey from their home villages. Middlemen based in the villages buy live fish at a considerable premium (compared with prices for the same species dead). Traders send consignments of live fish to the town of Kudat on the mainland (Fig. 3). Second, larger vessels owned by live fish traders also operate out of Kudat, taking around 20 men to sea for up to 12 days at a time into the waters of the South China

Sea and the southwest Philippines. Fish are caught using either handlines from the surface or underwater using surface-fed *hookah* diving gear. None of the fishers or traders we visited in Sabah spoke of using cyanide, which is not unexpected given the illegal nature of this fishing technique; however, there was anecdotal evidence that cyanide is used (Barber and Pratt 1997). Consignments of live fish from Kudat are transported by road to the state capital, Kota Kinabalu, bound either for consumption in local up-market seafood restaurants or for export by air to Singapore and Hong Kong.

Data collection in northern Borneo

During our research in the area, we discovered that some LRFF traders kept continuous records of the daily fish catches bought from individual fishers and vessels, either in record books or as copies of cash receipts given to fishers. These records included the date of sale, the name of each fisher or vessel registration number, the local name for each species bought, the total weight (kg) of each species (but not the number of individual fish), and the price per kg paid for each species. Several traders were willing to let us study their receipts and record books on the understanding that we were conducting independent academic research. We were able to gain access to these scientifically valuable datasets only because we worked closely and openly with local fishers and traders.

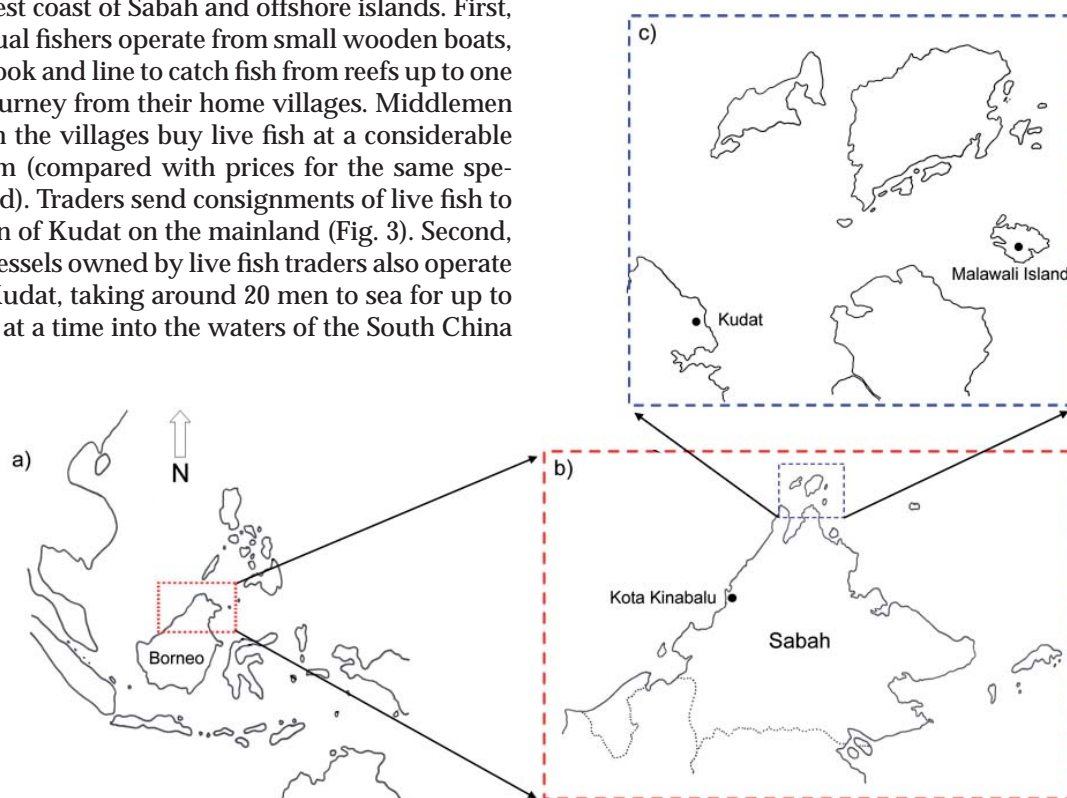


Figure 3. Maps of a) Southeast Asia, b) Sabah and c) north coast of Sabah.

Daily fish catch data were collected in 2002, 2003 and 2004 from two of the nine main traders in the mainland town of Kudat (these data represented about 30% of the overall trade in Kudat during that period) and from the single trader based on the island of Malawali (Fig. 3). The dataset covering the longest period was from one trader in Kudat: it included continuous catch data from January 1995 to January 2003 (excluding January 1998 through July 1999, due to a missing record book). The second Kudat trader provided data from November 1999 to June 2003. The Malawali trader provided catch receipts from August 2001 to August 2003.

For each of the three datasets we calculated the daily total catch (kg) of each species. Catch-per-unit-of effort (CPUE) was calculated by dividing these daily totals by the number of fishers (in Malawali) or vessels (in Kudat) operating each day. Each fishing trip from Kudat represented a consistent unit of fishing effort since there was no significant change over time in the length of trips made by vessels. Trip length in Malawali was always one day. In order to test for any significant changes in biomass of targeted species in the wild over time, we summed the fish catch data into monthly figures, which allowed us to subsequently take seasonal effects into account. We then used linear regression models on the monthly data to analyse temporal changes in total catch and CPUE for each species for each of the three traders. We assumed that CPUE is positively related to biomass in the wild and hence is a reasonable proxy for estimating relative abundance of species.

Local depletion of coral reef fish

We found that the total monthly catches in the longest dataset declined significantly for all species between 1995 and 2003 (Table 2). Despite a decline in the number of vessels selling fish to this trader over the same time period (which may reflect a general downturn in the fishery, a view that is backed up by informal interviews with fishers and traders in the region), CPUE also declined for three species – humphead wrasse, *Epinephelus* spp. and humpback grouper. We interpret the declines in CPUE of these species as quantitative evidence for population impacts of the LRFFT.

Results from the shorter datasets were less clear-cut. Total monthly catches in the medium dataset declined significantly for all species except spotted coral grouper. However, the number of vessels selling to this trader also declined — in this case to such an extent that it explained the declines in total catches, since none of the species showed declines in CPUE. Patterns in the short dataset were very unclear. The only significant temporal change was an increase in the total monthly catch of humphead wrasse.

We tested whether differences in results across datasets were likely due to their different lengths by truncating the longest dataset so that it only spanned the years included in the medium or short datasets. Doing so removed all the significant patterns that were detected in the long dataset, thus confirming that the lack of patterns in the other time series was probably due to their short coverage, which only provided information on the bust phase. We also lumped all the species together in each of the three datasets and looked for trends. For the long and medium datasets there was still a significant decline in total monthly catch, but there were no significant declines in CPUE.

By gaining access to these highly detailed datasets, we were able to demonstrate just how rapid and drastic catch declines of species in the LRFFT can be. The declines were species-specific, took place in less than a decade, and are especially worrying given the mobile nature of the Kudat fishing fleet: it is likely that when the most accessible populations became depleted, the fishery ranged farther and, thus, maintained catches and catch rates for a longer period than they otherwise would have. In other words, the declines we observed at points of sale masked greater declines at points of capture. The masking of serial depletions by spatial shifts in exploitation range is a major obstacle in assessing the impacts on fish populations of mobile fishing fleets (Berkes et al. 2006).

The declines in biomass of LRFFT species we have inferred from declines in CPUE could have been caused by overfishing or by habitat degradation. However, it is unlikely that these declines were a consequence of widespread declining reef health, since the reefs around Borneo were relatively unaffected by the 1998 global coral bleaching event (Wilkinson 2000). Also, as described above in our study of global dynamics, the international trade data showed that stocks of LRFFT species did not simultaneously decline but were serially depleted according to distance from Hong Kong and price. The species targeted by the LRFFT in northern Borneo do not appear in local markets (A.M. and H.S., pers. observs.) and we therefore believe the LRFFT is the main source of fishing mortality for these species.

Given that the LRFFT is generally legal (which facilitates data collection), and that the structure of the supply chain is similar throughout Southeast Asia and beyond (e.g. traders outside Sabah, such as in Indonesia, are also known to issue cash receipts; Bentley 1999), it is likely that other daily catch datasets could be collected from fishers and traders to further investigate the impacts of the trade on local fish stocks.

Table 2. Temporal changes in total monthly catch and CPUE for fish species bought by three LRFF traders in northern Sabah (from Scales et al. 2007).

	Total catch			CPUE		
	Long dataset (8 years)	Medium dataset (3 years)	Short dataset (2 years)	Long dataset (8 years)	Medium dataset (3 years)	Short dataset (2 years)
Humphead wrasse	↓	↓	↑	↓	↔	↔
Leopard coralgroupers	↓	↓	↔	↔	↔	↔
<i>Epinephelus</i> spp.	↓	↓	↔	↓	↔	↔
Spotted coralgroupers*	↓	↔	↔	↔	↔	↔
Blacksaddled coralgroupers**	↓	No data	No data	↔	No data	No data
Squairetail coralgroupers†	↓	No data	No data	↔	No data	No data
Highfin coralgroupers††	↓	↓	No data	↓	↓	No data

Red arrow = significant decline ($p < 0.05$), green arrow = significant increase, white horizontal arrow = non-significant ($p > 0.05$).

Plectropomus maculatus*, *Plectropomus laevis*, †*Plectropomus areolatus*, ††*Plectropomus oligacanthus*

Recommendations for monitoring the LRFFT

Despite focusing on two contrasting geographic scales of the LRFFT, the datasets used in these two studies share some features that lead to important recommendations for future data collection that can be used for impact assessment throughout the LRFFT:

1. Catch or trade datasets need to cover as long a time period as possible.

This is necessary to increase the likelihood of detecting changes in catches and CPUE as well as boom-and-bust patterns of fishery development. Truncating our longest dataset in the northern Borneo study removed all the significant patterns that were apparent in the original, eight-year, time series.

2. Catch or trade datasets need to be as disaggregated as possible, both spatially and by species.

The disaggregated nature of the northern Borneo datasets was due to our having collected information directly from traders and not from further along the supply chain, such as consignments leaving from Kudat by road or from Kota Kinabalu by air. If we had done that, the data would not have been broken up into individual days, with information on particular fishing vessels and fishermen, meaning that effort and therefore CPUE would have been difficult or impossible to calculate. At a broader

scale, even though the Hong Kong trade data were in some senses highly aggregated into annual trade volume from each country, they still provided details of fish species and country of origin and thus remained useful in gaining a widespread picture of the dynamics of the trade.

3. An estimate of harvesting effort (e.g. in terms of fishing trips, as in this northern Borneo study) can be crucial for interpreting catch data (i.e. estimating CPUE) and determining local impacts (i.e. using CPUE as an indicator for in-water stock biomass), but the lack of such information does not preclude the use of catch data for determining broad trends, especially when it is possible to compare local datasets across regions, as in our global study.

Again, our ability to estimate levels of fishing effort in the northern Borneo fishery was due to the fact that we collected daily fish catch data, from which we were able to determine the number of fishing trips undertaken to catch a given biomass of fish and hence make reasonable estimates of effort.

4. It is possible that there were other factors that could have influenced the trends in live food fish exports that were not apparent in the relatively crude import data used in the global study. However, the regional perspective these data provided was important for putting local

changes into a wider context. Therefore, data collected for purposes other than fisheries management, such as customs data, can be useful.

5. Similar datasets to those compiled in these studies should be collected where possible to help further understand the temporal and spatial dynamics of the LRFFT.

For example, other points of importation may hold trade data that could be analysed in the same way as the Hong Kong data were here. It would be useful to update estimates of the respective shares of the global live reef fish market that each main importing nation/city accounts for.

To effectively regulate the trade in threatened species it is important to be able to determine whether or not the trade is having a detrimental impact on wild populations. For example, trade in CITES Appendix II-listed humphead wrasse should now only take place from exporting nations that have demonstrated (through non-detriment findings) that the LRFFT is not impacting wild populations (Chu et al. 2006). Assessing the status of naturally rare and widely dispersed species — for CITES non-detriment findings or any other management or conservation programmes — is extremely challenging. Species-specific catch data, such as those collected in northern Borneo, are very useful in investigating local impacts of the LRFFT. It is possible that other coral reef fish species could, in the future, be listed in CITES appendices or protected under national legislation, which would bring about the need for similar levels of monitoring.

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The live reef fish trade in the Pacific: A look at recent trends and developments¹

Being M. Yeeting²

Introduction

The Regional Live Reef Fish Trade Initiative of the Secretariat of the Pacific Community (SPC) is in its ninth year of operation. The Initiative addresses issues and concerns of SPC's Pacific Island member countries and territories regarding their live reef fish trade (LRFT). This article provides a short account of what the LRFT Initiative has done to date with regards to trends and development in the trade.

The LRFT includes two totally different types of commercial fisheries: the live reef food fish trade (with Hong Kong and China as the main markets) and the marine aquarium fish trade (with the USA, Europe and Japan as the main markets). The LRFT continues to exhibit great potential as an income earning opportunity for coastal fishing communities, especially small Pacific Island countries with limited agricultural and mineral resources. This, together with the sustained high demand from international markets for products from these fisheries, has maintained interests for active operations, including new interests by investors (both local and foreign), especially in Pacific Island countries where operations did not exist in the past.

A quick look at the past

Of the two live reef fish trades, the marine aquarium trade was the first to begin in the Pacific, with the first operations occurring in Fiji and Kiribati in the early 1970s (Fig. 1). The marine aquarium trade further expanded to other Pacific islands, with the Federated States of Micronesia, French Polynesia, and New Caledonia being the latest additions to this trade in the early 1990s. To date, 13 Pacific Island countries participate in the marine aquarium trade. Throughout the years of operation, there has been very little concern about the trade, especially from local communities.

This is probably due to the fact that the marine aquarium trade was not competing with food fish

fisheries — an important part of the subsistence livelihood of most Pacific Island communities. Also, the marine aquarium trade was seen as making use of a resource that would otherwise be left unutilized. The collection of marine aquarium species and the establishment and operation of land-based marine aquarium facilities requires considerable technical knowledge, as well as substantial capital investment. For these reasons, most operations have been foreign-owned.

The live reef food fish trade (LRFFT) took hold in the Pacific much later, in 1984, with the first operations in Palau (Fig. 1). This was not surprising given Palau's proximity to the demand centre for live reef food fish: Hong Kong.

Because the trade was new to the Pacific, there was generally a lack of understanding of the trade and its dynamics. The target species for this trade, groupers and humphead wrasse — which had not been previously commercially harvested in most Pacific Island countries — were present in abundance. The income from this trade to local fishers was instant and quite attractive, compared with the traditional "fresh dead" fishery, especially in remote islands where ice plants are not available for preserving catches. Along with the desperate need of fishing communities to find income earning opportunities, the LRFT trade quickly developed its reputation as an attractive fishery for local fishers in remote island areas.

This resulted in a big boom and expansion of the LRFFT trade into the insular Pacific in the 1990s, and by the late 1990s, 10 Pacific Island countries were involved in the trade. The spread of the LRFFT in the Pacific was so fast that most government fisheries departments did not have time to consider or establish any management controls on the fishery.

Typically, foreign operators come in as foreign investors on a joint venture business with a local partner. The foreign partner (usually with nearly total

1. This is a brief version of an article published in issue 119 of the SPC Fisheries Newsletter, available at www.spc.int/coastfish/News/Fish_News/accueil-fish-news.htm

2. Live Reef Fisheries Specialist, Secretariat of the Pacific Community. Email: BeingY@spc.int



Figure 1. The distribution and starting dates of live reef fish trade operations in Pacific Island countries and territories.

ownership of the operation) runs the entire operation, with the local partner playing a role only in negotiating with local communities to gain access to fishing grounds.

Once the agreement has been sealed, the foreign operator works directly with local fishing communities, and provides all the necessary cage facilities to hold and keep fish alive, as well as boats, engines, fuel and fishing gear (lines and hooks) to fishers. This is usually done in the form of a loan to fishers.

This loan is repaid back to the company through fish catches. For the foreign operator, this ensures that fishers fish only for them. Some loans, however, have been too much for fishers to pay back, and even after several shipments to Hong Kong, most fishers with a loan still owe the company. Foreign companies often require a 15 tonne minimum of fish per shipment from the Pacific to Hong Kong in order for it to be economical. The minimum requirement, however, is a problem for most fishing communities to meet and, as operations stay longer in one fishing area, the harder it becomes for fishers to supply the required catch.

Spawning aggregations have been hit hard and as catches drop, operations are forced to move to new

locations. In such cases, facilities are abandoned and unpaid loans are written off. This makes no business sense unless of course, the companies have made profits great enough to have already paid off their investment in facilities.

Unlike the marine aquarium trade, soon after the start of LRFFT operations in the Pacific, problems and conflicts between communities and operators — and even within communities — began developing. With the perceived potential of the LRFFT to provide value-adding fisheries and good income earning opportunities for rural fishing communities, Pacific Island countries requested that SPC take a look at the trade in order to address issues and concerns, and to set up sustainable LRFFT operations in the region.

In 2001, SPC's member countries and territories endorsed SPC in developing the capacity to address these concerns. Following this, the SPC Regional Live Reef Fisheries Trade Initiative was developed.

Recent trends and developments

Both the marine aquarium trade and the live reef food fish trade have experienced changes over the last 20 years (Figs. 1 and 2).



Figure 2. The current status of live reef fish trade operations in the Pacific.

The number of countries participating in the marine aquarium trade has remained nearly constant. Eleven countries are actively involved; two countries that had previously imposed bans were now considering reopening the trade; and new interests are being expressed by three countries that have never had operations.

One of the main changes has been the opening of new markets in Europe and Asia (Hong Kong, Singapore and mainland China) in addition to traditional markets in the USA and Japan. The species being traded have not changed, except that there has been an increasing interest in the trade of live rock, with some operators totally switching their operations to live rock from marine aquarium fish (e.g. in Fiji and Tonga). Market demand has nevertheless been increasing steadily with the new markets. This is expected to increase rapidly with China's economic growth. Fish prices have generally increased slightly except for some species such as *Centropyge loriculus*, which at one time were collected excessively from Christmas Island. The resulting flooded market meant a drastic drop in price given to Christmas Island exporters, from 20 US dollars (USD) a piece to USD 1 a piece. (The value has improved subsequently over the last few years and is now about USD 5–10 a piece.)

One of the main issues now is the number of increasing conflicts between tour and dive operators and marine aquarium operators. This has occurred in several Pacific Island countries, indicating an urgent need to establish management guidelines that include the allocation and mapping of resources for different users.

Because live corals are listed under CITES, their export is limited and only allowed with a CITES permit. Coral farming, which allows only second-generation corals to be exported, gets around this restriction.

Although the definition of "second generation" corals is spelled out by CITES, there are disagreements about the interpretation. It is therefore important that such definitions are clearly described and clarified in order to avoid misunderstandings and future conflicts. The supply of cultured giant clams from hatcheries has remained quite successful and seems to be stable.

Also, there is now a growing interest in the rearing of post-larval reef fish for the marine aquarium trade, with successful commercial trials in French Polynesia and the Philippines.

The LRFFT in comparison has shown considerable changes. Of the eight countries participating in the trade at the end of 1990s, only three remain with an interest, and only one of these (Papua New Guinea) is actively exporting fish. The decrease in the number of interested countries is due to improved awareness by the public and fisheries departments on the implications and consequences of the trade, especially in attempting to meet the minimum shipping tonnage. For fish transported by sea, exporting companies are now requesting 20–30 tonnes of fish per shipment (compared with 10–15 tonnes 10 years ago).

As a result, several Pacific Island countries are pushing their exporting companies to consider air freighting, which is highly recommended over sea freighting as smaller amounts of fish are required (500 kg of fish per fish bin) and less pressure is placed on resources.

Hong Kong remains the major market, but the mainland China market is expanding very quickly, and as it improves its trade links internationally, suppliers will be able to deal directly with mainland China buyers, rather than going through Hong Kong as is currently the case. There is a small market on the US west coast that a Fijian company exported to for awhile. The USA provides a good market option for most Pacific Island countries, given that it is closer than Hong Kong and the Hong Kong market is already dominated by Asian suppliers (Indonesia and Philippines) that Pacific Island suppliers cannot compete with.

The species composition of exports from the Pacific has remained the same but with a slight increased acceptance of low-value species by operators and exporters. The humphead wrasse is still in great demand, but supply is likely to become limited in the near future with the recent “red listing” of the species under CITES Appendix II, and with Hong Kong’s strong intentions to enforce its CITES obligations (Fig. 3).



Figure 3. Humphead wrasse, *Cheilinus undulatus*, a species often targeted for the live reef food fish trade, now under CITES Appendix II listing (artwork: Les Hata, ©SPC).

The mariculture of groupers has had success with full-cycle commercial rearing of two important species, *Cromileptes altivelis* and *Epinephelus fuscoguttatus*, for a number of years now (Fig. 4). It was expected, therefore, that these two species would flood the market, causing significant drops in the prices of even wild-caught supplies. But this has not happened, and there is still quite a high demand for these species from the wild.



Figure 4. Two important LRFFT species that have had success in full-cycle mariculture: *Cromileptes altivelis* (top) and *Epinephelus fuscoguttatus* (bottom) (artwork: Les Hata, ©SPC).

The SPC Live Reef Fish Trade Initiative

The LRFT Initiative was established to develop a common framework among SPC members for licensing live reef fish enterprises and for monitoring and regulating these fisheries. The long-term goal of the Initiative is to have locally supported and administered effective management and monitoring arrangements for the LRFT in Pacific Island countries. Several areas of focus for assistance to Pacific Island countries were identified, including:

- Collecting baseline information about the resource, information about the existing fishery, or relevant information required to measure the potential of the fisheries (for new interests).
- Building the capacity of fisheries officers and other personnel to monitor (conduct resource surveys, analyze and interpret data) and manage the fisheries effectively.
- Developing management plans and regulations and monitoring programmes.

- Developing the supporting framework for management (management committee, management funds) and for monitoring (regional database to support monitoring and data collection).
- Assistance in implementing management plans and monitoring programmes.

To make the most of the limited funds available for the Initiative, it was decided to focus on capacity building, but at the same time to use the capacity building process to address the specific needs of particular countries.

In a typical project, the SPC Live Reef Fisheries Specialist makes a trip to a country that has LRFT concerns, and conducts field training for local fisheries staff (a team of four surveyors, at a minimum) on survey methods. The first week of training includes in-water sessions using underwater visual census (UVC) methods, fish species and habitat identification, and size estimation. Once the fisheries officers have mastered the survey method, they, together with the LRF Specialist, conduct a full survey in one of the areas of interest for live reef fish operations.

The data collected from the survey are taken to SPC and one of the fisheries officers is invited to take up a one to two-month attachment training there. At SPC, the attachment officer learns how to validate and enter the data on the database, how to make queries, and conduct analyses and interpretation of the data. Together with the LRF Specialist, the attachment officer then drafts the survey results into a technical report that provides information to support management decisions.

Also during the attachment, for those countries with existing live fish operations, the fisheries officer, with the LRF Specialist, develops, using the survey report as much as possible, a LRFT management plan with regulations as required. A monitoring programme is also developed for the trainee's country as well as an implementation plan. At the end of the attachment, the trainee is expected to go back to his country with:

- a survey report that interprets survey results and findings,
- a draft LRFT management plan and regulations (as needed),
- a draft monitoring programme (including regular UVC surveys), and
- an implementation plan (action plan).

(Note: The latter three documents only apply to those countries that have existing live fish operations or that have decided, based on survey results and findings, to start up operations.)

The proposed management plan and regulations and monitoring programme are distributed for review by relevant stakeholders before being finalized and submitted for endorsement by the government. This approach has been taken in several countries with great success. More importantly, it provides a way of addressing countries' needs with limited resources.

Some of the achievements of the Initiative are listed below.

- Production of a LRFFT public awareness information package.
- Surveys in Kiribati (LRFFT and marine aquarium trade), Vanuatu (LRFFT and marine aquarium trade), Fiji (LRFFT in two areas), Tonga (marine aquarium trade) and Tuvalu (marine aquarium trade).
- Training in UVC methods for Kiribati (five officers), Fiji (four officers), Vanuatu (four officers), Tonga (five officers), Marshall Islands (two officers, two locals) and Tuvalu (four officers).
- Attachment training at SPC: Kiribati (one officer), Marshall Islands (one officer), Vanuatu (one officer), Fiji (one officer) and Tonga (two officers).
- Draft management plans and monitoring programmes developed for Kiribati (Abaiang LRFFT), Fiji (Bua), Vanuatu (marine aquarium trade), Marshall Islands (marine aquarium trade) and Tonga (marine aquarium trade).

Initiative activities planned for the future include:

- Attachment training for Tuvalu.
- Implementation follow-up for Vanuatu, Tonga and Kiribati.
- UVC training and resource surveys for Nauru (marine aquarium trade), Federated States of Micronesia (FSM) (marine aquarium trade) and Samoa (marine aquarium trade).
- Attachment training for Nauru, FSM and Samoa.
- Development of a regional database and a regional workshop on its use.
- Development of an awareness information package for the marine aquarium trade.
- Integration of an ecosystem approach to fisheries management into the management of the two sectors of the LRFT.

For further information about the LRFT Initiative please contact: Being Yeeting (email: BeingY@spc.int)



News and events

Saving Nemo: Researchers hope to reduce mortality in marine ornamental fish

A 30 March 2007 story in the *Bend Weekly* (Oregon, USA) reports on the work of researchers at Oregon State University to examine and mitigate the causes of mortality of marine ornamental fish, from the point of capture to the point of purchase by hobbyists. See: <http://www.bendweekly.com/Science/4161.html>

Low mortalities with live fish transport system

The May 2007 issue of *Fish Farming International* magazine includes an article on a recent development by an Australian company of a live fish airfreight transport system with demonstrated mortality rates of less than 1%.

CITES rejects proposal to list Banggai cardinalfish

At its triennial conference in The Hague from 3–15 June 2007, the parties to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) considered 40 proposals to amend the trade rules for specific species. Among these was a proposal by the United States to include the Banggai cardinalfish (*Pterapogon kauderni*) on Appendix II of the CITES, which would call for strict monitoring and control of its trade. The Banggai cardinalfish, endemic to a small area of Indonesia, has been popular in the aquarium trade since 1995, with 700,000–900,000 fish collected annually. The proposal cited its limited geographic range, small population and particular reproductive habits (it is a paternal mouth brooder) as making it especially vulnerable to overexploitation. The parties to CITES rejected the proposal, finding that international trade was not threatening the species' survival.

Poaching in Palawan

Several incidents in the Philippine's Palawan Province involving the arrest of foreign fishermen and the seizure of their vessels have caught a lot of media attention. In one incident in December 2006, at Tubbataha Reef, 30 Chinese nationals were arrested and tons of live fish were found on board the vessel, including hundreds of humphead wrasse (*Cheilinus undulatus*), a species protected in the Philippines and listed on Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Tubbataha Reef, in the Sulu Sea, is a national marine park and a World Heritage Site. See an account of the incident by WWF-Philippines at: <http://www.wwf.org.ph/newsfacts.php?pg=det&id=66>

In a series of opinion pieces in the *Manila Standard Today*, attorney Rita Linda V. Jimeno comments on this and other cases and how they reflect the state of law enforcement in the Philippines. See: http://www.manilastandardtoday.com/?page=ritaLindaJimeno_jan15_2007 and http://www.manilastandardtoday.com/?page=ritaLindaJimeno_jan29_2007

Twenty grouper species found to be threatened with extinction

A workshop involving 20 experts from 10 countries convened in early 2007 at the University of Hong Kong to assess the status of groupers worldwide. The group found 20 species of grouper to be threatened with extinction unless effective management measures are established. See: http://www.iucn.org/en/news/archive/2007/03/6_coral_reefs.htm

Chinese hunger for reef fish emptying Asian seas

A March 2007 Reuters story looks at the live reef food fish trade and the steps Hong Kong is taking to monitor and control the trade of humphead wrasse (*Cheilinus undulatus*), now a CITES Appendix II-listed species. See: <http://www.alertnet.org/thenews/newsdesk/HKG58924.htm>

Creating new rural livelihoods from sustainable culture of ornamentals in Solomon Islands

Source: *MAC News*, 4th Quarter 2006

Out of the 27 participants in and around Gizo who attended the first workshop held last May on post larval fish and invertebrate capture and culture, only some participants from 4 communities (Titiana, Babanga, Vorivori and Saeragi) were supplying lobsters and shrimp to the Aquarium Arts Solomon Islands (AASI) on a regular basis. The supply of lobsters and shrimps from these communities mostly came from the coconut logs also called stump.

To improve the trade of those species and their outcome, this past semester the average productivity per community has been studied. The results have shown that the Babanga (Maeraki) farmers supply eighty (80) lobsters and shrimp per week, the Titiana ones about forty (40), and the Saeragi and Vorivori farmers about twenty (25) [sic] each. Those figures can be explained as apart from the aquarium trade, these collectors also participate in other activities such as fishing, pig farming, and growing cash crops for sale at the local markets.

From September 25th to 29th, 15 fishermen with among them two women, from different communities around Gizo attended the Coral Culture Workshop at Nusa Tupe. The first days of the workshop were focused on general presentation given on the collection and culture methods for soft and hard coral using environmentally friendly methods. Information about the aquarium trade and an introduction to the MAC certified chain of custody “from reef to retail” were also provided, along with practical information on responsible methods used to collect and transport marine ornamentals to Honiara, where an exporter is located.

After these general presentations, the remaining four days were organized around hands-on practical sessions. Participants were provided the opportunity to see different types of corals that were planted as broodstock, and to handle soft and hard corals and to pack them using best handling practices for export facilities.

In November and December, communities focused their activities on establishing coral broodstock in their respective areas. Broodstock is held on steel trestles and cuttings are allowed to attach to small discs. *Acropora* spp. is the species the most commonly cultured, even if several species of soft corals are also being farmed. Communities culture corals by adopting the cuttings techniques highlighted in the guideline of the Mariculture and Aquaculture Management (MAM) international Standard.

[MAC] Director's Note

Source: *MAC News*, 1st Quarter 2007

MAC's mission is “to conserve coral reefs and other marine ecosystems by creating standards and certification for those engaged in the collection and care of ornamental marine life from reef to aquarium.” MAC works to deliver on its mission based on measurable outputs, some of which are outlined below.

The facts speak for themselves. MAC certified collection areas and collectors are supplying an increased volume, variety and quality of marine ornamentals from managed reefs and fisheries, using environmentally sound practices that support sustainable livelihoods. MAC certified marine ornamentals from culturing facilities are also now available. An increasing number of MAC certified exporters, importers and retailers are delivering MAC certified marine aquarium organisms to hobbyists – and demand for MAC certified marine ornamentals is growing. Marine aquarists and the marine ornamental industry now have a choice in shaping the future of the hobby and industry.

Reef area for which management is being developed	22,947 hectares of reef (in the Philippines and Indonesia alone)
MAC certified reef area, i.e. reef management in place	15,085 hectares of reef (in the Philippines and Indonesia alone)
Number of collection areas where MAC is working	14 (Philippines: 10, Indonesia: 4)
Number of MAC certified collection areas	16 (Philippines: 7, Indonesia: 4, Fiji: 5)
Number of collectors and traders trained in non-destructive collection methods and prepared for third party certification assessment	718 (Philippines: 483, Indonesia: 235)
Number of MAC certified collectors and traders	426 (Philippines: 247, Indonesia: 179)

Number of collectors, traders, local government units and NGO workers trained in business skills	382 (Philippines/Indonesia total)
Number of MAC certified organisms from MAC certified collection areas to exporters	132,473 (Philippines/Indonesia total, July–December 2006)
Percentage of MAC certified organisms exported	In Fiji, shipments from one exporter to the US are regularly 100% MAC Certified organisms
Mortality (average fish mortality rate of MAC certified deliveries to exporters, July–December 2006)	Philippines: 0.31% Indonesia: 3.0%
Number of MAC certified species available	110 species of MAC Certified fish were recently available in the US
Number of MAC certified exporters, importers and retailers	43 total (Indonesia 6, Philippines 11, Fiji 2, Singapore 3, Canada 1, France 6, Germany 1, Netherlands 2, UK 3, US 8)
Number of MAC certified culture facilities	3 total (UK 1, US 2)

The communities, collectors and companies that have made the commitment to be sustainable and responsible providers of marine ornamentals deserve your support. The marine ornamental trade and hobby can be known either as contributing to the destruction of coral reefs, the poor treatment and death of fish, and the poverty, disability and possibly even the death of marine ornamentals collectors — or it can support the conservation of reefs, the sustainable management of marine ornamental stocks, the use of best practices to ensure fish health and sustainable livelihoods for impoverished fishers in rural villages.

The choice is yours.

Solomon Islands tsunami impacts MAC and the aquarium trade

Source: *MAC News*, 1st Quarter 2007

On 2 April a tsunami struck Gizo town and surrounding areas of the Western Province of the Solomon Islands. We were concerned about anyone that suffered from this, but were particularly concerned about MAC consultant Greg Bennet and the staff of our project partners in the area from World Wildlife Fund (WWF) and the WorldFish Center. These people are all based in the Gizo area and have been implementing the project on sustainable marine aquarium fisheries and aquaculture that is regularly reported on in *MAC News*. On 10 April, we thankfully were able to confirm that they were safe and sound. The aquaculture training facility in Gizo suffered significant damage. Many coastal communities in the area that harvest marine ornamentals were also hard hit by the tsunami. The home of Greg's family was destroyed and we encourage you to support the reconstruction needs in the Solomon Islands.

The tsunami highlights again the difficult and dangerous living conditions of many of the coastal communities involved in the marine aquarium trade. The collection and export of marine ornamentals provides one of the few potentially sustainable livelihood options in many of these areas, which usually have very limited social services for the local communities. Collectors deserve to work in safe conditions and be adequately compensated for their efforts, as this is often the only means they have to support themselves and their families.

Solomon Islands: Creating rural livelihoods through environmentally friendly aquaculture of marine ornamentals

Source: *MAC News*, 1st Quarter 2007

A *Tridacna* clam culturing workshop was held from 30 January–2 February 2007 at Nusa Tupe in Gizo, Solomon Islands. This was the third series of marine livelihood workshops made possible by the support of New Zealand – as part of the Solomon Islands partnership of MAC, the WorldFish Center and World Wildlife Fund (WWF) South Pacific. This workshop delivered the long awaited first batch of hatchery reared giant clams to the twelve (12) workshop participants from Gizo communities and nearby islands who now have the opportunity to become clam farmers and seek MAC Certification.

Upon consultation with project partners, two sites were selected: Babanga (Maeraki) and Saeragi for the development of a Mariculture Area Management Plan (MAMP). During February and March, visits were made to three farmers and to other members of their communities to gather information for the MAMP.

The fragmented corals from the project have been quite popular with the exporter, Aquarium Arts Solomon Islands (AASI). Since early January, the Nusa Tupe facility has sent about one hundred forty-five (145) hard and soft corals to AASI. In general, there is a preference for bright color ones (blue, pink and yellow) as well as for the ones with nice branches and being of appropriate size and well attached to the substrate.

Establishment of Non-Detriment Findings and hard coral quotas for Fiji

Source: *MAC News*, 1st Quarter 2007

As Fiji is a major exporter of live coral under CITES, developments are underway to establish quotas regulating the quantity of coral exported. At present, the export quotas for Fiji are set at arbitrary levels. The aim of this new effort is to provide scientific information towards the establishment of a comprehensive export quota for live hard corals that fulfils the CITES Non-Detriment Finding (NDF) requirements.

This work will be able to build on efforts undertaken by MAC in 2005 to develop proposed NDF methods and provide information to help ensure that the coral and live rock trade in Fiji were environmentally responsible and in compliance with CITES. Following two workshops, MAC developed potential methods for Fiji to use in assessing live coral and live rock resources and managing both the extraction operations and impacts. Field assessments were conducted in four (4) collection areas: Kalokolevu, Moturiki, Vitogo/Naviti/Marou and Vatukarasa. In addition, a system was proposed for ranking key attributes of the collection area and coral species under consideration, providing an adaptive framework for developing quotas as better information becomes available. An extraction rating system was also proposed as a method for establishing live rock quotas in Fiji, based on the extraction rate calculated from exported quantities over a certain period and the standing stock as determined from field surveys.

The work by MAC was undertaken for the Secretariat of the Pacific Regional Environment Programme (SPREP), based on a request to SPREP from Fiji. Recommendations from the project included:

- Capacity building in Fiji to undertake resource assessments and interpret results with training of local scientists and government officials.
- Resource assessments in all live coral harvesting areas and live rock extraction areas in Fiji to assist in the establishment of scientifically (resource) based quotas using the proposed methods for live coral and live rock.
- Site-specific management planning for all collection areas.

A copy of the MAC report to SPREP is available upon request to: info@aquariumcouncil.org.

Pulau Seribu [Indonesia] management plan to cover wider marine resources

Source: *MAC News*, 2nd Quarter 2007

Training for collecting techniques and post-harvest continues in Pulau Seribu, as over twenty (20) collectors were trained there early this year. The Pulau Seribu government will also give financial support to the local suppliers of Pulau Seribu, by helping them to upgrade their holding facilities.

The implementation of the marine ornamental fish management plan for Pulau Seribu District has now been replicated by the local government to cover other marine resources, including fishery management for the live reef fish food trade. One of the management tools being replicated includes harvest monitoring using logbooks. The management plan, which was originally developed only for marine ornamental fish, is now being updated and revised to become the management plan for other marine resources. MAC local non-governmental organization partner, the TERANGI Foundation, has requested MAC to assist them in facilitating the process of developing the management plan for marine resources in the DKI Jakarta Province.

Fiji stakeholders meeting

Source: *MAC News*, 2nd Quarter 2007

On May 7, MAC attended the regular Aquarium Trade Stakeholder Meeting organized by the Fiji Fisheries Department to discuss current issues, including the live rock situation and a local non-governmental organization's new coral culturing project.

The live rock situation encouraged suggestions to be given about the necessity to gradually phase out the collection of wild harvested live rock in favor of cultured rock. Indeed, cultured rock has lately gained better market acceptance, even if this activity still represents additional investment and costs for exporters compared to wild collection. In addition, there were some concerns about the tagging issue of coral cultured by this local NGO as only F2 generation is CITES exempt. These concerns will be transmitted to the Fiji CITES Scientific Council for further consideration.

Creating rural livelihoods from sustainable culture of ornamentals in the Solomon Islands

Source: *MAC News*, 2nd Quarter 2007

After two years of implementation of this project, a review meeting will be held in July. All partners should provide an update about the activities' past years, and the forecasted ones for this coming year. MAC will continue to assist local communities in capacity building with training in best practices and the development of a Mariculture Area Management Plan to achieve MAC Certification.

This meeting is important for the island due to the post-tsunami situation in Gizo. This crisis encouraged the WorldFish Center to conduct assessments on all project sites to determine the impact of the tsunami on the coral reef ecosystem.

SOPs for health certification and quarantine measures for the responsible movement of live food finfish within ASEAN

Source: *Asia-Pacific Marine Finfish Aquaculture e-News*, No. 39 (10 August 2007)

ASEAN Standard Operating Procedures (SOPs) have been developed to reduce the risk of spread of transboundary diseases of aquatic animals by the movement of live food finfish (LFF). These SOPs are a set of documents for health certification and quarantine measures to be used by Competent Authority for the responsible movement of LFF by land, sea and air among ASEAN Member Countries. These SOPs have been developed under the AADCP:RPS Project 370-018, Operationalise Guidelines on Responsible Movement of Live Food Finfish. This project is coordinated by ASEC, NACA and AusVet for Cardno ACIL who manage the AADCP:RPS program for ASEC and AusAID. The document can be downloaded at <http://www.enaca.org/modules/wfdownloads/singlefile.php?cid=5&lid=830>

Giant grouper facts

Source: *Asia-Pacific Marine Finfish Aquaculture e-News*, No. 39 (10 August 2007)

E. lanceolatus is the largest reef-dwelling fish in the world. The species can grow as large as 2.7 m (9 ft) long, weighing up to 600 kg (1320 lb); there are unconfirmed reports of it growing much bigger. It is also the largest and most widely distributed among all groupers but is locally rare. It occurs throughout the Indo-Pacific region from the Red Sea to Algoa Bay (South Africa) and eastward to the Hawaiian and Pitcairn Islands throughout Micronesia. Being such a large predator, it is rare even in areas unexploited by fishing and it has been severely depleted in many locations. It is much sought after for the live reef fish trade with Hong Kong import statistics revealing import of around 2.4 tonnes of giant grouper in 2004. Although Taiwan has had some success in breeding, and sells giant grouper fingerlings in SE Asia, the amount of hatchery reared fish available is thought to be small, and the proportion of traded individuals from wild versus hatchery production is unknown. Indonesia and Thailand are known to be conducting research on the breeding of this species. The species is now listed as "vulnerable" on the IUCN Red List.

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- Fish Base - <http://www.fishbase.org/Summary/SpeciesSummary.php?id=6468>
- Taiwan fish seed industry paper (outdated but interesting, with links to seed suppliers) <http://www.aquafind.com/articles/seed.php>

Code of practice on the import and sale of live marine fish for human consumption

Source: *Asia-Pacific Marine Finfish Aquaculture e-News*, No. 39 (10 August 2007)

Ciguatera fish poisoning is reported in Hong Kong from time to time and it is mainly associated with the consumption of coral reef fish shipped live from the Pacific. Fish accumulate ciguatera toxin in the body through eating small fish that consume toxic algae in coral reef areas. People that are affected by ciguatera may show symptoms of numbness of the mouth and the limbs, vomiting, diarrhea and pain of the joints and muscles. If excessive toxin is consumed, the circulatory and nervous systems can be affected. The Food and Environmental Hygiene Department of Hong Kong SAR has devised a Code of Practice which lists the minimum requirements in importing and selling live fish for human consumption to ensure food safety, especially in terms of the prevention and control of ciguatera fish poisoning. The Code is applicable to all importers, wholesalers and retailers who import or sell live marine fish. For further details or a copy of the Code visit http://www.cfs.gov.hk/english/whatsnew/whatsnew_fsf/whatsnew_fsf_fish_cop.html

Sustainable marine finfish aquaculture in the Asia-Pacific region

By Mike Rimmer

Source: Abstract of a presentation at Indonesian Aquaculture 2007, held in Bali, 30 July–2 August 2007, as presented in *Asia-Pacific Marine Finfish Aquaculture e-News*, No. 40 (19 September 2007)

Marine finfish aquaculture continues to expand rapidly in the Asia-Pacific region. Based on FAO production data, over the last 10 years regional marine finfish production has grown at around 10% per annum and in 2005 reached 1,143,719 tonnes valued at USD 4.1 billion. Value of marine finfish production has increased at around 4% per annum, although the most recent figures (2005) show a 9% increase in value in 2004–2005, suggesting that markets for marine finfish remain relatively strong. The largest producer remains China, with 659,000 tonnes of production in 2005 valued at USD 662 million, followed by Japan with 256,000 tonnes, valued at more than USD 2 billion. In 2005, Indonesia reported about 19,000 tonnes valued at USD 23 million. Milkfish (*Chanos chanos*) remains a popular commodity in Indonesia and the Philippines: production of milkfish increased from 514,666 tonnes in 2004 to 542,842 tonnes in 2005. However, value of production decreased from USD 627 million to USD 552 million over the same period. Worldwide, grouper production (most of which is from the Asia-Pacific region) increased from 59,146 to 65,362 tonnes from 2004 to 2005, an increase of 11%. In contrast, total value of production decreased by 12%, from USD 208.5 million to USD 183.6 million over the same period. This may reflect increasing market saturation by farmed product, particularly by some lower-value grouper species, and consequent price decreases. Although China is the largest producer of cultured grouper, Indonesia is also a major producer. Barramundi (*Lates calcarifer*) production (from marine and brackishwater only) stayed relatively steady at 26,584 tonnes, up slightly from 25,399 tonnes in 2004. Total value of production increased slightly from USD 65.08 million to USD 68.52 million. Thailand remains the largest producer of farmed barramundi. More recently, increasing demand for barramundi has seen many shrimp farmers in Thailand and the Philippines change to barramundi production in 2007. Cobia (*Rachycentron canadum*) is an emerging species of considerable interest to farmers in the Asia-Pacific region. Presently, China and Taiwan Province of China are the only two countries in the Asia-Pacific region to report production of cobia. In 2004–2005, cobia production increased from 20,461–22,745 tonnes. Total value of production increased from USD 36.2 million to USD 41.2 million. Most aquaculture development has focussed on small-scale producers, who mainly target the high-value (local or export) live fish market. However, this focus on small-scale production has in some cases provided only limited industry expansion. Some species, such as cobia, are not suitable for small-scale aquaculture but are ideal for large-scale commercial farming. Linkages between more mature aquaculture industries (e.g. in Europe) and start-up ventures in Asia, are becoming more common. Constraints to the sustainability of marine finfish aquaculture in the Asia-Pacific region include:

- consistency of supply and quality of hatchery-produced fingerlings, and continuing reliance on wild-caught fingerlings for some species;
- continued use of “trash” fish for feeding and limited uptake of formulated diets, particularly by small-scale farmers;
- environmental impacts of large-scale cage farming in coastal areas.

These constraints to the long-term sustainability of marine finfish farming in the Asia-Pacific region are being addressed through a regional program to develop Better Management Practices for marine finfish aquaculture in the Asia-Pacific region, coordinated through the Network of Aquaculture Centres in Asia-Pacific (NACA) under its Marine Finfish Program.

Live-fish market grows, stripping reefs

By Michael Casey, with Dikky Sinn

Source: The Associated Press, 24 January 2007

Kota Kinabalu, Malaysia – Amid banks of bubbling aquariums, Hong Kong resident Kerry To sat back and admired his plate-size steamed grouper plucked from one of the tanks in this Malaysian restaurant and cooked live. “It is very special,” said the 45-year-old To, who flew to the northwest coast of Borneo Island for a holiday featuring a chance to sample the rare delicacy. “These fish are so big and taste so good. I’ll be telling my friends.”

What he and other diners don’t realize is that their appetite for live reef fish — a status symbol for many newly rich Chinese — has caused the populations of these predators to plummet around Asia as fishermen increasingly resort to cyanide and dynamite to bring in the valuable catch. Entire reef ecosystems, already endangered by pollution and global warming, are at risk.

A study released Wednesday about the trade in Malaysia found that catches of some grouper species and the endangered Napoleon wrasse fell by as much as 99% between 1995 and 2003, a period coinciding with soaring economic growth in countries where the exotic fish are a delicacy.

“The removal of these large, predatory fish might upset the delicate balance of the coral reef ecosystem,” said Helen Scales, who co-authored the study for the Swiss-based World Conservation Union. The study appeared in the online edition of *Proceedings of The Royal Societies*, a respected scientific journal.

“With all the threats the reefs already face, these fishing practices take us one step closer to losing these reefs,” she said.

The study of daily fish catches and sales quantifies what conservationists have said for a decade — that hunger for live reef fish in Hong Kong, Taiwan and mainland China is causing populations of wrasse, grouper and coral trout on coastal reefs to plummet in Malaysia, Indonesia, the Philippines and Papua New Guinea.

There is also a growing live reef fish trade off the coast of California, where everything from rockfish to eels are caught and sold, mostly in Asian restaurants along the coast, according to Scot Lucas of the California Department of Fish and Game. But unlike Asia, the trade is heavily regulated and fishermen are not known to use the same destructive methods.

The U.N. and the World Conservation Union released a report last year warning that human exploitation of the high seas was putting many of its resources on the verge of extinction.

It noted that 52% of global fish stocks are over-harvested and that populations of the largest fish such as tuna, cod and swordfish declined as much as 90% in the past century. The report also said destructive fishing practices — including bottom trawling, illegal longline fishing and an increase in large industrial vessels — have led to the deaths of tens of thousands of seabirds, turtles and other marine life.

“Well over 60% of the marine world and its rich diversity found beyond the limits of national jurisdiction is vulnerable and at increasing risk,” Ibrahim Thaiw of the World Conservation Union said last year.

Reef fish — which are caught mostly by small fishermen who sometimes use cyanide poison to stun their catch — are prized mostly because they are cooked live. Traders are careful to ensure they arrive that way, packaging them in bags of water and placing them in coolers for trips that often stretch for thousands of miles.

In restaurants, diners can pay as much as USD 50 a pound for the fish. Business dinners and weddings in Hong Kong and other Asian cities routinely serve live reef fish alongside such delicacies as sharkfin soup.

“Most Hong Kong people now choose to eat grouper because of the firm flesh. It’s tastier,” said Ng Wai Lun, a restaurant owner in Hong Kong. “Farmed fish is less tasty and fresh.”

The World Wide Fund for Nature's Annadel Cabanban, who studies the trade in Malaysia, agreed with the study's finding that the numbers of reef fish were on the decline due to increasing demand. She said destructive fishing practices were as much to blame for the decline as overfishing because they destroy crucial reef habitats.

"There are no predators to check the fish that eat the plants and the shellfish," Cabanban said. "There is a cascading effect on the reef. With so many herbivores, the plant population declines and fish run out of food and they die."

Scales, the study's co-author, said it was impossible to quantify how many fish were taken by explosives or cyanide because fishermen refuse to say. But she said the cause of the decline was definitely the live reef fish trade, since reefs in the areas had been damaged by other environmental factors such as bleaching.

"These severe declines were rapid, species specific," Scales wrote.

Conservationists fear the growing demand for live fish — an industry worth more than \$1 billion a year — is increasing pressure on coral reefs already threatened by warming oceans, development and pollution.

Eighty-eight percent of Southeast Asia's coral reefs face destruction from overfishing and pollution, the US-based World Resources Institute estimates. Most threatened are reefs in the Philippines and Indonesia, home to 77% of the region's nearly 40,000 square miles of reefs.

Fishermen in Kudat — a South China Sea port in Malaysia that depends almost entirely on fishing — acknowledged that catches have declined. Their boats now travel to the Philippines for reef fish.

The fishermen argue there are plenty of fish and that they have few options.

"This is our livelihood," said Ismail Noor, 45, adding that he sometimes spends three days at sea in search of fish. "If we stop, we would have no income."

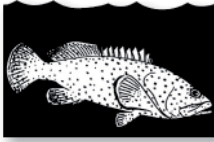
Noor and other fishermen insist they use only hooks and lines or nets. But the local fisheries department said the use of explosives is widespread, despite campaigns warning of the danger of losing arms, legs and hands.

"Most villagers are stubborn and have always done bombing since they were children," said fisheries official A. Hamid Maulana. "It is difficult to change attitudes."

Conservationists say the answer is to establish international standards for managing the import and export of reef fish. They also say consumers must be educated about the need to avoid certain endangered fish and promote captive breeding.

No international body has been willing to endorse standards commissioned by the Asia-Pacific Economic Cooperation forum, a group of Pacific Rim governments, that would ban explosives and cyanide in fishing, boost monitoring and enforcement, and label fish caught by conventional means.

"Traders are interested in ensuring they have a constant supply of product," said Geoffrey Muldoon, an Australian expert. "Their idea of a constant supply is not to say we have to protect this area, but that we need to find a new area because we have fished this one out."



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Editor's note: The contents of the workshop proceedings are listed below, followed by the entirety of the workshop overview by Brian Johnston.

- Forward (Peter Core)
- Workshop overview and next steps (Brian Johnston)
- Demand for fish in Asia: A cross-country analysis (Madan Mohan Dey and Yolanda T. Garcia, with M. Sirajul Haque, Jikun Huang, Praduman Kumar, Alias Radam, Somying Piumsombun, Athula Senaratne, Nguyen Tri Khiem and Sonny Koeshendrajana)
- Estimating wholesale demand for live reef-fish as food in Hong Kong (Elizabeth Petersen)
- Survey and taste test for live reef-fish in Hong Kong (Noel Wai Wah Chan)
- Wholesale and retail price integration in the live reef-fish food trade (E.H. Petersen and G. Muldoon)
- Recent developments in aquaculture of groupers in the Asia-Pacific region (Michael A. Rimmer, Michael J. Phillips and Koji Yamamoto)
- The role of the Network of Aquaculture Centres in Asia-Pacific (NACA) in addressing food safety and trade issues in cultured seafood (Koji Yamamoto)

- The impact of mortality and price risk on costs and value distribution along the market chain for live reef-fish as food: a spreadsheet analysis (Geoffrey Muldoon and Bill Johnston)
- Production and marketing of live reef-fish for food in Indonesia (Sonny Koeshendrajana)
- Disaggregated projections on fish supply, demand and trade for developing Asia (Madan M. Dey, U-Primo Rodriguez, Roehlano M. Briones and Chen Oai Li, with Muhammad Sirajul Haque, Luping Li, Praduman Kumar, Sonny Koeshendrajana, Tai Shzee Yew, Athula Senaratne, Ayut Nissapa and Nguyen Tri Khiem)
- Projections of supply and demand for the trade in live reef-fish for food (Roehlano M. Briones)
- Self-fulfilling mistake in the live reef-fish for food trade: a dynamic modelling approach (Akhmad Fauzi)
- Policy options to improve market performance in the live reef-fish food trade (Geoffrey Muldoon)

Workshop overview and next steps

Brian Johnston

Introduction

The Australian Centre for International Agricultural Research (ACIAR) is funding a three-year research project to study the economics and marketing of live reef-fish as food (LRFF) fisheries and trade. It aims to identify the conditions needed for the sustainability of supply and trade in the long term (Johnston and Yeeting 2006).

The first workshop for the project was held in Noumea, New Caledonia on 2–5 March 2005. It brought together for the first time key researchers from around the Asia-Pacific in order to present the project to the Pacific island countries involved in the trade. The workshop was successful in gaining their participation, including the sharing of information among fishery managers and discussion of the potential usefulness of the modelling approaches being developed for the project. The first workshop also secured the ongoing participation of Indonesian fishery researchers. The proceedings of that workshop have been published by ACIAR (Johnston and Yeeting 2006).

The second workshop, hosted by the WorldFish Center (WFC) in Penang, Malaysia, in March 2006, provided the opportunity for researchers to present the major findings of their investigations for peer group review and to identify critical gaps in the research to date.

Demand for live reef-fish as food

Live reef-fish are a food sought by higher-income groups. As incomes rise in Asia, particularly China, the demand for LRFF is expected to grow strongly. Three papers examine aspects of demand for LRFF. Dr Madan Dey's paper provides an overview of the importance of fish in food consumption patterns in Asian economies and how the WFC has undertaken analysis of the future demand for fish using estimated price and income elasticities derived from country data. The income elasticities for all fish types was found to be positive, implying that, as incomes rise in Asia, the demand for fish for food will continue to rise. This has major implications for the ability of fishery systems to continue to meet this demand.

Dr Liz Petersen's paper includes an analysis of the demand for LRFF in Hong Kong, the major market of the region. She found that price is not an important determinant of wholesale demand in the Hong Kong market, but income is. Live reef-fish can be considered a luxury item of food consumption and, compared to other fish products, is relatively unresponsive to price.

Ms Noel Chan's paper utilises a taste test procedure to identify whether consumers could discriminate between wild-caught and cultured fish samples of the same species. A triangular taste test method was used, in which a panel of consumers was presented with three fish samples, one of which was different. The samples were presented "blind" to the consumers. They were asked to identify the odd sample and to judge whether it was wild caught or cultured. It was found that just over 50% of the consumers were able to correctly identify the odd sample. Some 37% of the consumers correctly identified the odd sample as either wild caught or cultured. There was a general preference for the wild-caught sample, although the cultured fish sample was quite acceptable to all consumers sampled.

Developments in aquaculture

Because the future supply of wild-caught LRFF is highly constrained due to the effects of overfishing and destructive fishing practices (Sadovy et al. 2003), future growth in supply to meet rising demand is likely to come mainly from aquaculture. Recent developments in aquaculture production in the Asia-Pacific region are described in the paper by Dr Mike Rimmer and colleagues. This paper updates one presented in the first workshop proceedings (Rimmer et al. 2006). The aquaculture production of LRFF species (principally grouper species) is expanding rapidly in Asia as demand for these fish species exceeds supply from wild-caught sources. China's role in aquaculture production and consumption of LRFF species is significant yet remains poorly understood. Given the likely continued growth in incomes in China and its aquaculture capacity in other species, there is a need to gather better market intelligence on LRFF developments in China.

The Network of Aquaculture Centers in Asia-Pacific (NACA), based in Bangkok, Thailand, is playing a major coordinating role in the development of cultured seafood industries in the region. In his paper, Mr Koji Yamamoto outlines this role and covers NACA's work in improving market access and trade, food safety and trade issues, regional cooperation and information dissemination. A number of the challenges facing aquaculture are being tackled through the Asia-Pacific Marine Finfish Aquaculture Network (APMFAN) and these have direct relevance to the production and trade in live reef-fish species.

Analysis of the market chain

Fishers in relatively poor countries supplying the LRFF trade often do not have good market information. This arises because the market chain from catching to consumption is long and often involves the fish changing ownership along the chain. A frequent complaint from fishers in remote Pacific countries particularly, is that more transparency is required in the market chain. Geoffrey Muldoon and Bill Johnston analyse the impact of mortality and price risk on the costs and value distribution along the LRFF chain. They describe the market chain and develop a conceptual model that includes capital and distribution costs at each point in the chain and the possible impact of risk on production and mortality of the fish as they are transported to the market in Hong Kong. A spreadsheet model that incorporates these aspects is developed, with the intention of applying it to case studies in Indonesia and Papua New Guinea in the next stage of the work.

Production and marketing in the LRFF trade in Indonesia are examined in detail in Dr Sonny Koeshendrajana's paper. The paper reviews the background literature on the LRFF production and trade in Indonesia and provides valuable information on the production structures and financial returns from both wild-caught and aquacultured LRFF. Following the collection of data from key Indonesian institutions associated with the LRFF business, field visits and surveys were used to verify the information. In the wild-caught sector the main types of fishing are trap and hook-and-line, although evidence is also found for illegal fishing using cyanide. Aquaculture production has expanded rapidly since 1999 and now forms an important source of production. The author favours the establishment of a government plan of action to encourage sustainable live reef-fish fisheries in Indonesia and the removal of destructive practices from the fisheries.

Integrating supply and demand analyses

In order to integrate developments in Asian fisheries and to make future projections, the WFC has developed "AsiaFish", a supply and demand model. The development of the base model and its structure is outlined by Dr Madan Dey. The model, which includes the nine key supplying and consuming countries in Asia, includes demand functions for all main food-fish species and supply functions for both wild-caught and aquaculture fisheries. In its base structure, LRFF are excluded, but this is taken up in a following paper by Dr Roehl Briones. Baseline projections and projections of the AsiaFish model under different future scenarios are presented. Key future scenarios examined are higher productivity in the production of low- and high-value fish in aquaculture, reducing fishing effort and compliance with food safety and trade requirements.

In order to develop forward projections of trends and developments in the LRFF trade, the WFC was commissioned to extend its AsiaFish model to include supply and demand relationships for live reef-fish. Dr Roehlano Briones outlines in his paper how this was done and presents some preliminary projections from the initial modelling effort. The AsiaFish model had to be extended in two main ways to incorporate LRFF trade. First, data were collated on LRFF in the main producing and consuming countries for incorporation in the AsiaFish model. Second, data on individual countries' supply and demand had to be incorporated into the model and the major demand centres of Hong Kong and China included. The basic data and modelling

approaches are outlined, and the paper provides production and consumption information, supply and demand elasticities, and details of data weaknesses. Three exporting countries — Indonesia, Malaysia and the Philippines — are included in the initial model with the remaining exporters aggregated into “other”. Some simple projections are undertaken to explore the possible effects of management and technology on the fisheries and trade effects. It was found that the model was sensitive to elasticity estimates for Hong Kong — China as well as elasticities of substitution.

A paper by Dr Akhmad Fauzi outlines a new approach to modelling live reef-fish fisheries in Indonesia. In his research he applies the theory of the backward bending supply curve in a fishery to examine the dynamic conditions in a fishery for live reef-fish where the resource is limited and over-exploitation can easily occur. Applying this approach to a case study based on the Indonesian LRFF in southern Sulawesi yields some interesting results. Most notable is that, if the fishers continue to respond to increasing demand by additional fishing effort without regard to the impact on the productivity of the fishery, a chaotic dynamic occurs and the fishery collapses. This implies that fishers need to be fully informed about the possible consequences of increasing effort as prices rise and the need to ensure that there are controls over access to the resource. Further research is needed to validate the parameters of the model and to examine the economic, environmental and social consequences of new management approaches in the LRFF industry in Indonesia.

Regulation and management of the trade

The policy options for the regulation and management of the LRFF fisheries are reviewed by Geoffrey Muldoon in the final paper of the workshop. It is concluded that the unique features of these fisheries across the Asia-Pacific region will make effective management difficult to implement. These features include the limited productivity of the fisheries, the wide geographic spread of areas from which fish are taken—making policing of illegal fishing practices difficult, and the limited resource information currently available on which to base effective management strategies. Further work is needed to identify the costs and benefits of possible management strategies that could be implemented to change these fisheries from open-access to managed fisheries. Such analyses need to consider economic, environmental and social aspects.

Conclusions and next steps

The workshop participants agreed that the final stages of the project needed to focus on developing projections on further development of the LRFF trade, taking into account likely constraints on growth in a wild-caught sector that was, in many cases, already fully or overexploited. In contrast, scope for expansion exists in the aquaculture sector of the LRFF trade, particularly as the technology of hatchery production of higher-value species becomes more widely adopted. The aquaculture sector dependent on juvenile fingerlings or young fish caught from the wild is also likely to be highly constrained due to reduced stocks of wild fish.

The model developed by the WFC has considerable potential to provide projections of supply of and demand for LRFF from the major Asian countries, including China, that are already participating in the trade or developing major aquaculture capacity. It was agreed the model be extended to include all major Asian producers (Indonesia, Malaysia, the Philippines and Thailand), China and “other” (which includes Australia and Pacific island countries). There is a need to include both the wild-capture and aquaculture sectors in each country and two categories of production, low-priced species and high-priced species. Demand would be modelled for Hong Kong and China.

The market chain model also has considerable scope for further development to include case studies of Asian and Pacific island country fisheries and to include risk analyses. The information collected on the Indonesian fishery would provide a strong basis for a case study, for example.

A key challenge for the future is to identify management arrangements that would effectively constrain fishing effort in many wild-caught fisheries and stamp out unsustainable practices that damage coral reefs, such as cyanide fishing and use of explosives. The team will focus on these issues in the next stage of the project, to identify potential benefits and costs of improved management arrangements for the wild-caught fisheries across Asia and the Pacific.

The potential for aquaculture to meet the rising demand for LRFF as incomes grow across Asia and China is promising, but there are many issues warranting ongoing research. This economics and marketing project is closely integrated with the ACIAR marine finfish aquaculture project being coordinated by Dr Rimmer.

Further research and development will focus on improving the long-term sustainability of aquaculture to support the LRFF trade as well as other markets. Topics to be investigated include improving the quantity and quality of seedstock supply from hatcheries, developing sustainable grow-out feeds, documenting and promoting best management practices and addressing market issues. The growing affluence of China is a key demand issue to be studied, as is the current stated consumer preferences for wild-caught over aquaculture product. Consumers also seem to have a growing awareness of the negative impacts of both capture fisheries and aquaculture, and demand is increasing for sustainably produced fish. Improving the sustainability of the LRFF trade through both capture fisheries and aquaculture remains a significant challenge for fishers, traders, merchants and governments.

A number of follow-up actions were initiated at the workshop. The WFC is being contracted to extend the supply and demand model to include China and Thailand as supplying countries, to include two broad categories of LRFF—higher- and lower-value species, and to allow welfare effects to be captured in the model output. The market chain model is to be further developed to include risk analysis and to develop two possible case studies—one for a Pacific country and one for Indonesia. The demand analysis is to continue, to incorporate later data where these are available. All authors are continuing to develop their papers in preparation for publication in the final report for the project, due in 2007. Overall, the workshop was very successful in providing high-quality input into the research project, identifying gaps in data, information and analysis, and in providing expert guidance for the next stage of the work.

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