ISSN 1026-2040

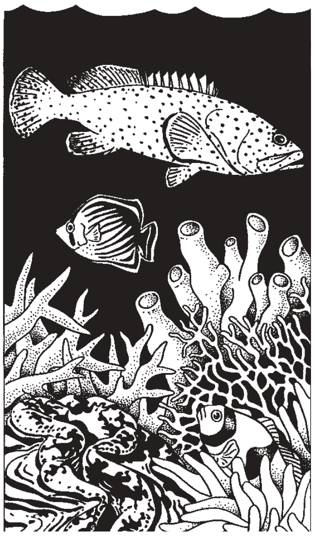
Secretariat of the Pacific Community

LIVE REEF FISH

The live reef fish export and aquarium trade

Number 12 — February 2004

INFORMATION BULLETIN



Editor and group coordinator: Tom Graham, PO Box 235, Honolulu, HI 96809 USA. [Phone/fax: +1 (808) 625 8755; email: ThomasRGraham@aol.com]. **Production:** Information Section, Marine Resources Division, SPC, B.P. D5, 98848 Noumea Cedex, New Caledonia. [Fax: +687 263818; email: cfpinfo@spc.int; http://www.spc.int/coastfish]. **Produced with financial assistance from France.**

From the Editor

As the previous issue of this bulletin went to press in April 2003, Hong Kong and other Asian cities were suffering from the widespread health and economic effects of the SARS (severe acute respiratory syndrome) outbreak. The live reef food fish industry felt it, too. Residents of Hong Kong and other market centres responded to the outbreak by curtailing their restaurant-going activity, causing the demand for live fish to plummet. This was quickly felt by fishermen and middlemen throughout the far-flung producer countries of Asia and the Pacific in the form of lower prices.

So we can add SARS to the list of events that have rocked the market for live reef food fish, along with the occasional consumer-scaring ciguatera poisoning incidents, the red tides that wiped out inventories of live fish in Hong Kong waters, and the economic crisis that hit Asia in 1997. Of course, this kind of volatility is not unexpected in markets for luxury products such as live groupers. It is something that fishermen have to cope with on a day-to-day basis and that policymakers in producer countries need to consider when pursuing the development of fisheries aimed for high-end export markets.

While it looks like the industry has largely recovered from this latest jolt, I understand that as the northern hemisphere winter approaches, public health officials in China are anxiously looking out for signs of another SARS outbreak.

In this issue Lida Pet-Soede et al. give us an update on Indonesia's fisheries for live reef food fish, focusing on the effects of the SARS outbreak. They report that things have pretty much returned to normal with respect to SARS, but they identify at least one long-lasting effect of the outbreak.

Inside this issue

→

I have not seen any detailed accounts of what other live reef food fish producing countries experienced in 2003 as a result of the SARS outbreak. But to give an idea of what transpired in other parts of the region, a few news items from the April–July 2003 period are reprinted in the "News and Events" section of this issue.

SARS is not the only topic covered in this issue. We have an article that examines the "marine ecological footprint" of the live reef food fish trade, a story about a new larvae collection device, a report on the natural spawning of groupers in floating cages, and updates on a variety of initiatives related to the trades in live food fish and aquarium organisms.

As part of our efforts to include news and articles about reef fish aggregations in this bulletin, accompanied with this issue is the newsletter of the Society for the Conservation of Reef Fish Aggregations (SCRFA). The newsletter is also available on the SCRFA website at http://www.scrfa.org. Please see the article in this issue by Yvonne Sadovy for further information about the organisation.

Tom Graham

Correction

In the article by Being Yeeting on the Pacific Regional Live Reef Fish Trade Management Workshop in the previous issue of this bulletin (number 11), the "capture and culture of coral reef fish project" was incorrectly noted as being implemented by, among other entities, the Queensland Department of Primary Industries (page 40). In fact, the project was undertaken by the WorldFish Center (formerly ICLARM) and the Australian Institute of Marine Science, and it was funded by the Australian Centre for International Agricultural Research (ACIAR).

SARS and the live food fish trade in Indonesia: Some anecdotes

Lida Pet-Soede[1], Hirason Horuodono[2] and Sudarsono[3]

Background

The live reef food fish trade is still going strong in Indonesia, fuelled by high prices and supported by expansion into the remoter parts of eastern Indonesia where there are still some grouper resources that were previously little exploited. For example, a scientific expedition conducted during May 2003 in Wakatobi National Park (Tukang Besi Islands in Southeast Sulawesi) observed a large mothership supporting some 30 small canoes trolling for grouper and catching 200 live fish during three days. The mothership transported these fish to Makassar in Southwest Sulawesi for export. Additionally, interviews at local fish cages in Wakatobi Park confirmed that a vessel from Hong Kong recently loaded 500 live grouper (60 were rejected). From the interviews it appears that this vessel visits two to three times per year. Accounting for rejects and a conservative estimate of 5 per cent mortality during capture and holding, at least 1150–1750 fish are going through this particular trade chain annually. Considering the other holding pens observed during the expedition through Wakatobi Park, the total number of grouper taken from Wakatobi reefs and subsequently exported must be several times this amount (Pet-Soede and Erdmann 2003).

According to official Indonesian catch statistics, the production of wild-caught grouper increased from nearly 16,000 tonnes (t) in 1990 to 48,500 t in 2000[4] (Fig. 1) (DKP 2002). The same statistics indicate that Sumatra is the major area for the capture of wild grouper (38% of total production in 2000), followed by Sulawesi (22% of wild-caught production in 2000). Production of farmed grouper has been increasing slightly. In 2000, another 7000 t of grouper were added to the total production. Kalimantan is the largest grouper farming coastal area with 55 per cent of total farmed production, followed by Sulawesi with 27 per cent.

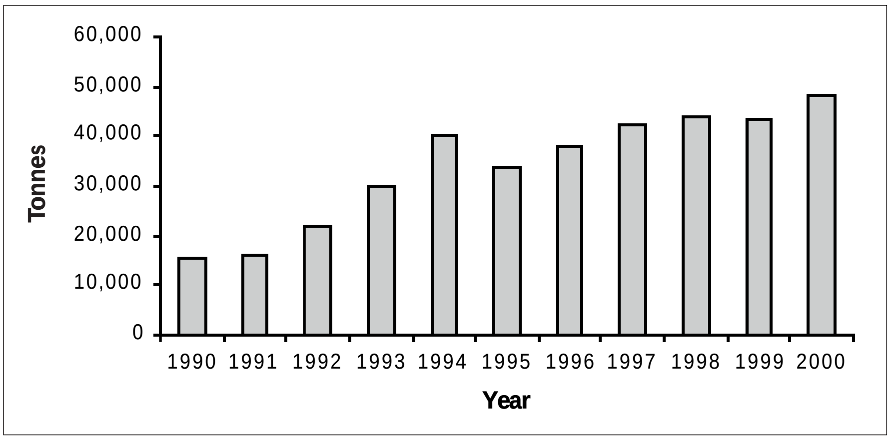


Figure 1. **Trends in production of wild-caught grouper in Indonesia, based on official Indonesian fisheries statistics.**

Species commonly targeted for live export include Serranidae (groupers), including *Cromileptes altivelis* and species in the genera *Cephalopholis*, *Plectropomus* and *Epinephelus*, and the Napoleon wrasse (*Cheilinus undulatus*), a member of the Labridae family. As an indication of trends in prices, inflation-adjusted prices paid to fishers for *Plectropomus* species increased steadily from approximately USD 2–4 per kilogram (kg) in 1990 to USD 5–12 per kg in 1995 (Erdmann and Pet-Soede 1996) to USD 7–14 per kg in 2003. These high prices continue to provide sufficient incentive for a vast number of live grouper fishers to participate in the fishery, offsetting the higher expenses of expansion into remote areas. Prices paid to exporters also increased during this period, maintaining their ratio of approximately two to five times the price paid to fishers. This price increase allowed many traders to export their live fish via airplane, shortening the transport time significantly.

The high export prices are supported by continued high demand in places such as Hong Kong,

1. WWF Indonesia – Marine Program, Denpasar, Indonesia. Email: lidapet@attglobal.net
2. The Conservation and Community Investment Forum Asia. Email: hirason@yahoo.com; website: www.cciforum.org
3. Yayasan Taka, Semarang Indonesia. Email: yayasan_taka@yahoo.com
4. In Indonesia, official statistics only include data on general wild-caught and farmed grouper production, not specifying which are kept alive for export, yet these trends are likely similar for live grouper.

Singapore and mainland China. Recent Hong Kong import statistics show that Indonesia ranked fifth as a supplier of live grouper and Napoleon wrasse combined, contributing some 1200 t, or 11 per cent, to the total imports of live food fish into Hong Kong (Chan 2003).[5] Interestingly, wholesale, and especially retail, prices in Hong Kong seem to have dropped significantly in recent years.[6] For example, the retail price for *Plectropomus leopardus* in the 2000–2003 period (Chan 2003) was down to almost half of its retail price in 1997, as reported by Lau and Parry-Jones (1999).

Adverse effects of the live reef food fish trade include destruction of reef habitat from cyanide use and the breaking of coral during capture, and overfishing of grouper stocks, particularly at grouper spawning aggregation sites. These effects are thought to contribute to an imminent collapse of grouper populations. At many reefs in Indonesia it is currently rare to observe significant numbers of target species, especially the high valued grouper species *Plectropomus leopardus* and *Cromileptes altivelis*. Even when some remain, their small sizes often indicate high local fishing pressure. For example, the scientific expedition in Wakatobi National Park reported significant numbers of grouper species only in deeper waters. Among the 647 individuals of Serranidae observed during the expedition, only 100 were species sought after by the live reef food fish trade. Additionally, 29 Napoleon wrasse were observed. Even though these observations may under-represent the actual presence of these highly valued species, 129 individuals observed in 25 dives that totalled nearly 20 hours does not appear to be very much (Pet-Soede and Erdmann 2003).

Conservationists have for a long time tried to reduce the pressure on grouper populations by influencing the market demand and reducing trade. For example, awareness campaigns in importing countries were conducted by The Nature Conservancy (TNC) and the International Marinelife Alliance (IMA) to increase consumers' understanding of the fact that groupers were not sustainably harvested and ecosystems were damaged as a result. Cultured grouper was promoted as a good alternative to wild-caught grouper. Awareness and education campaigns were conducted in exporting countries calling for stricter enforcement of existing bans on the use of cyanide and other illegal substances in the fishery. Policy campaigns were initiated, calling for new protective measures in the form of in-country fisheries regulations and new international trade agreements. However, in spite of these campaigns the market has continued to exert a strong demand. Furthermore, at some locations enhanced enforcement of nationwide bans on the use of cyanide as well as hookah gear have reduced the local use of cyanide, yet grouper stocks continue to face high pressure because of a lack of limits or restrictions on the capture of grouper with hook-and-line or traps. Attempts to regulate the trade of Napoleon wrasse through the application of size regulations and by allowing only farmed individuals to be exported have not resulted in significantly reduced pressure on natural stocks, as legal loopholes in the laws have been found and used. The law treats wild-caught Napoleon wrasse that have been fattened for some time in holding pens or other facilities as farmed fish, allowing them to be exported.

Interestingly, only recently, when consumers in Hong Kong and Singapore chose to reduce their outdoor dining as a result of the acute outbreak of SARS (severe acute respiratory syndrome) did some Indonesian industry members start reporting reduced demand, with resulting reduced prices for live grouper. The SARS outbreak kept the world in its grip for several months. The number of infected people and casualties peaked in early 2003. The disease, a pneumonia caused by coronavirus, was first seen in Guangdong Province in China in November 2002 and quickly spread to Hong Kong, Singapore and even Canada and the USA, carried by international travellers.

The IMA team in Hong Kong reported that 7 per cent of the restaurants normally visited for data collection were closed temporarily or permanently during the April–June 2003 period. The IMA team could not collect price data in February, April or May 2003 because of the risk of SARS infection. The impact of the SARS outbreak on Indonesia as a live reef fish producing country appears different from the impact of the Asian financial crisis in 1997. The financial crisis actually intensified the live reef food fish fisheries in Indonesia due to much higher prices offered to fishers in local currency and the greater profit margins available to exporters as a result of the collapse of the local currency against the US and HK dollars (Erdmann and Pet 1999).

In order to assess the impact of the SARS outbreak on Indonesia's live reef food fish industry, we examined some of the trends in Hong Kong wholesale and retail prices using data made available by IMA (Chan 2003) and we investigated anecdotal reports from South Sulawesi in eastern Indonesia

5. The relative contributions of imports from Indonesia vary by species. For example, Indonesia contributed 17 per cent of all Hong Kong imports of Napoleon wrasse, 50 per cent of *Cromileptes altivelis* and 50 per cent of "other groupers" (Chan 2003).
6. This assumes that the price data were corrected for differences in currency rates and adjusted for inflation.

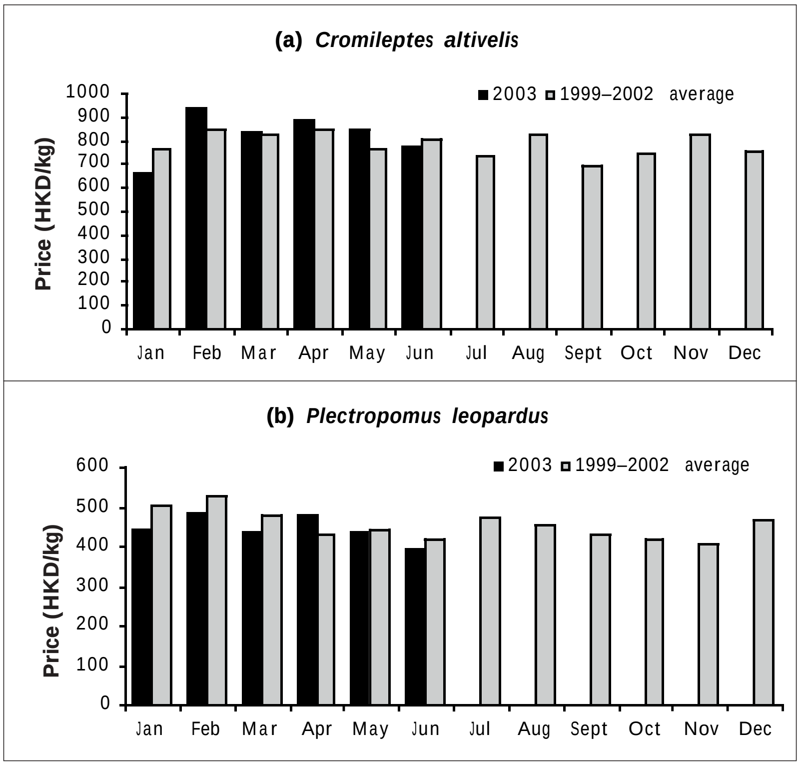


Figure 2. **Monthly variation in Hong Kong retail prices for: (a) *Cromileptes altivelis* and (b) *Plectropomus leopardus* during 1999–2003 (Source: Chan 2003).**

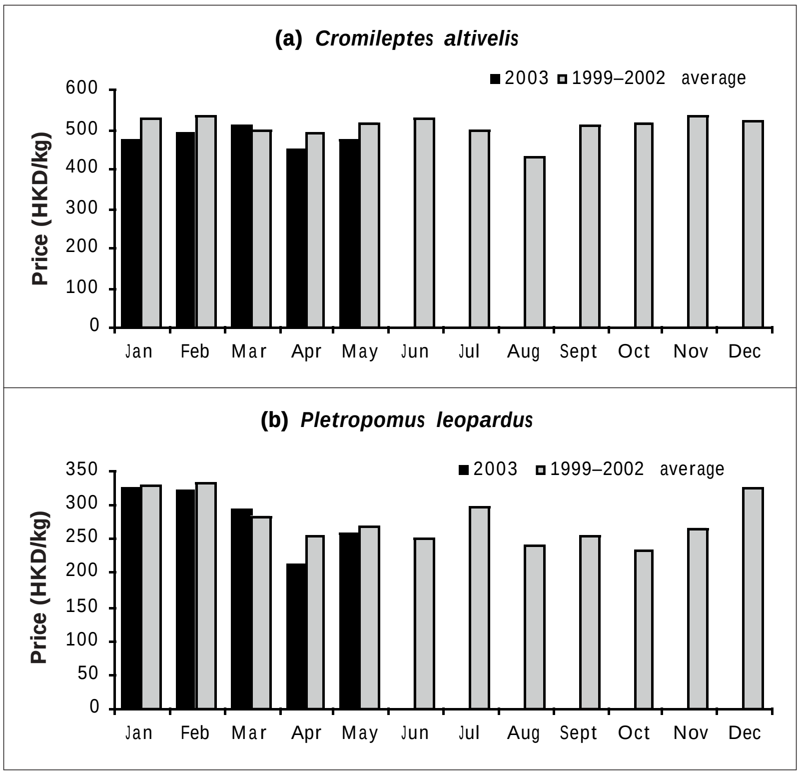


Figure 3. **Monthly variation in Hong Kong wholesale prices for: (a) *Cromileptes altivelis* and (b) *Plectropomus leopardus* during 1999–2003 (Source: Chan 2003).**

and Karimunjawa in central Indonesia. To check the validity of these reports, we also reviewed export data from Bali Ngurah Rai airport, one of the major points of export for live reef food fish in Indonesia. Where there was agreement among these data sources, the impacts on fishers' fishing practices were further examined.

Trends in Hong Kong wholesale and retail prices and import volumes

Graphic presentation of the monthly variance in retail prices for two species, *Cromileptes altivelis* and *Plectropomus leopardus*, does not indicate significantly lower prices during the months of the SARS outbreak (Figs. 2a and 2b) compared to the same months in previous years. The same is true with wholesale prices (Figs. 3a and 3b).

It was not possible to determine whether the volume of live reef food fish imports to Hong Kong declined during the peak of the SARS outbreak in early 2003, as data were not available. Records of import volumes through 2002, however, are available. In November and December 2002, imports into Hong Kong of live fish from all sources did not decline, while Indonesia's share of imports decreased (Figs. 4a and 4b). The pattern was the same with respect to just *Cromileptes altivelis* and *Plectropomus leopardus* — imports of these two species from all sources combined did not decline during November and December 2002. It is probable that at that time, news of the seriousness of the SARS outbreak had not spread very far.

Export of live grouper from Bali airport during the SARS outbreak

Bali Ngurah Rai Airport is known as the main gate for exporting live grouper from eastern Indonesia. Data on exports of live reef food fish from Bali for the early months of 2003 show a clear drop in both shipment frequency and numbers of live fish exported (Figs. 5a and 5b). This occurred at the height of the SARS outbreak in Hong Kong. Unfortunately, due to lack of Hong Kong import data for 2003, these trends could not be confirmed.

Impacts of SARS on the trade from South Sulawesi

South Sulawesi continues to be one of the most important areas for the live reef food fish trade. Catching live grouper began in Indonesian waters in the 1970s, conducted by foreign fishing boats from Taiwan and China, which transported the fish directly to Hong Kong. To Indonesian fishers, the live food fish trade became known in the early 1990s when people from Hong Kong linked up with family members that lived in Makassar, who then became middlemen. Indonesian fishers were trained how to catch and care for their fish, and in return they sold their fish to Chinese middlemen in Makassar. Once every one to two months, transport vessels would come from Hong Kong and export the fish. The live food fish trade kept growing, and Chinese businessmen hired local businessmen to become suppliers and to deal with the local side of the business.

In South Sulawesi, the main collection and trade areas are located around Makassar and Pangkep (Spermonde Archipelago), Bulukumba, Sinjai District (Sembilan Islands), the Selayar District (Selayar island and Taka Bonerate National Park) and Buton District (Wakatobi National Park). In 2001, the total amount of grouper exported from South Sulawesi Province was 1662 t, with an estimated local value of nearly USD 3.1 million[7] (Table 1).

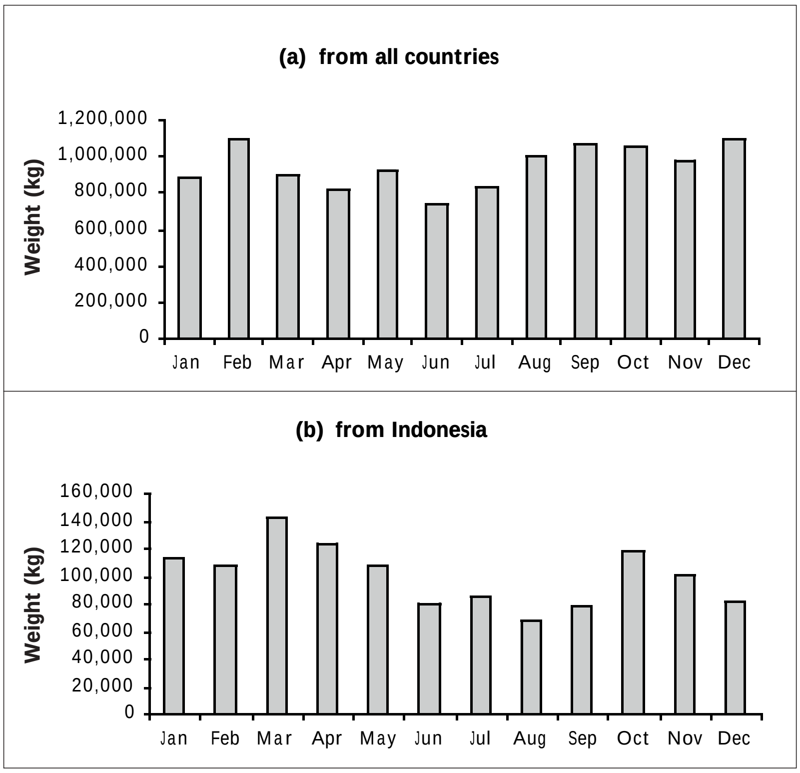


Figure 4. **Monthly variation in Hong Kong imports of live fish from: (a) all countries and (b) Indonesia for 2002 (Source: Chan 2003).**

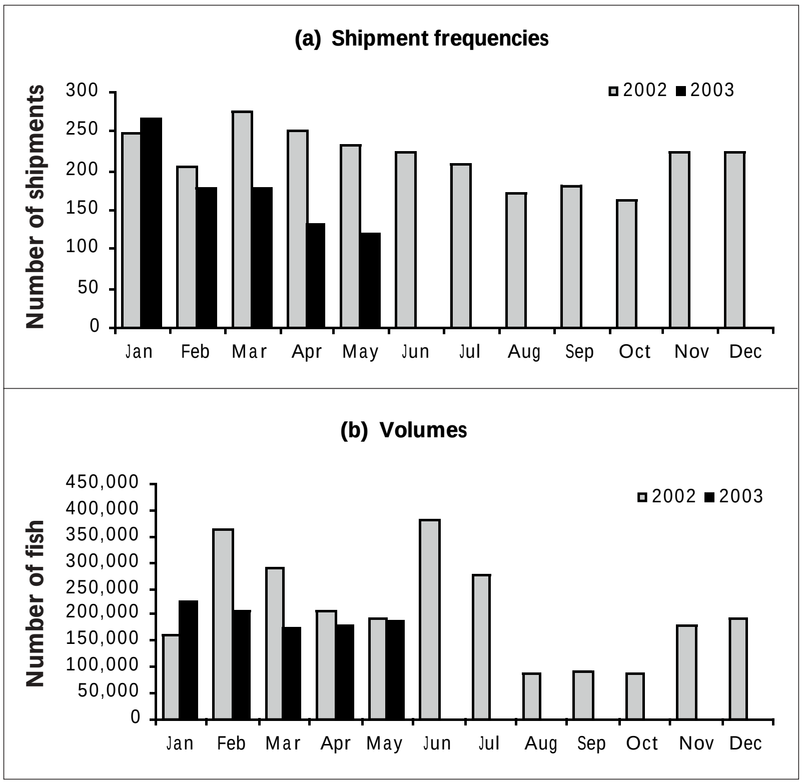


Figure 5. **Monthly live grouper exports from Bali airport, 2002–2003: (a) shipment frequencies and (b) volumes.**

7. Please note that this value from the government statistics works out to approximately USD 2 per kg for all product types combined, and these prices are much lower than what fishers reported receiving for live grouper. The low value is probably a result of both provincial government offices and exporters under-reporting the actual value, for tax-related reasons.

Table 1. **Exports of grouper from South Sulawesi in 2001.**

Commodity	Volume (kg)	Value (USD)	Destination
Fresh grouper	1,547,693	2,653,540	Singapore, Hong Kong, Taiwan, Korea, Malaysia, Australia
Live grouper	25,971	99,594	Hong Kong
Frozen grouper	14,290	16,044	Vietnam
Frozen fillet grouper	74,331	290,819	USA, Australia, Japan

Source: DKP (2001).

Table 2. **Reported prices (in rupiah) paid to fishers for live grouper (mainly *Plectropomus* species), by size class.**

Size class	Before SARS (March 2003)	Spreading of SARS (March–May 2003)	Currently (June 2003)
Sunu Ekoran (1.3–2 kg)[8]	150,000 per fish	60,000 per fish	100,000 per fish
Sunu Super (0.6–1.2 kg)	120,000 per kg	80,000 per kg	120,000 per kg
Sunu Baby (0.3–0.5 kg)	60,000 per kg	30,000 per kg	60,000 per kg

Source: Interviews by the authors (H. Horuodono) with five key people in South Sulawesi (fishers and main traders).

In South Sulawesi, fishers use *jolloro* (traditional boats) that are modified for grouper fishing and short-distance transport. The boats contain small holds for daily catches. Previously, South Sulawesi fishers did not make distant trips, but currently, fishers from Barrang Lompo Island, for example, travel as far as Wakatobi National Park, the waters close to Kalimantan, the reefs of Masalima Islands and sometimes even Halmahera's waters. These remote sites are distant enough that fishing there involves a mothership. In the early days of the trade from South Sulawesi most grouper fishers used cyanide. In the mid-1990s some started to use hook-and-line gear, which is somewhat cheaper to use and does not require payment of "penalties," or bribes, to the marine surveillance apparatus. In these types of operations, smaller boats, called *lepa-lepa*, with only one fisher per boat, are used. During longer trips, catches are held in the hold of the mothership.

Starting in March 2003, many people in the South Sulawesi trade thought that the live food fish trade was collapsing. Prices started to drop (Table 2), and as a result, fishers that had no source of income other than from live grouper saw their incomes decrease.

Table 2 indicates a large reduction in prices during the SARS outbreak. Before the SARS outbreak, classifications included *Sunu Ekoran* (1.3–2 kg), *Sunu Super* (0.6–1.2 kg), and *Sunu Baby* (0.3–0.5 kg). During the SARS outbreak the weight ranges in the top two classes shifted downward to *Sunu Ekoran* (1.1–2 kg) and *Sunu Super* (0.5–1 kg). This meant that the value of a fish slightly larger than 1 kg had become really low, as it was now being traded on a per-individual basis for the price of *ekoran* instead of on a per kilogram basis for the price of *super*. The *Sunu Baby* class did not change. Another effect during the SARS outbreak was that fish larger than 2 kg were no longer wanted at all.

Interviewed traders explained that due to increased holding times stemming from fewer orders, some fish lost weight before being exported, and this was part of the reason that the prices paid to fishers decreased.

Most traders have since shifted back to using the pre-SARS size classes, and as indicated in Table 2, prices rebounded substantially by June 2003.

Most of the fishers in South Sulawesi, especially those that live on the islands near Makassar (Barrang Lompo Island, Barrang Caddi Island, Lae Lae island, and Karanrang Island), do not target only grouper. They also collect sea cucumber, lobster and corals. So, when the price of live grouper

8. Note that prices paid for fish in the Sunu Ekoran size class are per fish, regardless of weight, rather than per kilogram.

dropped, most fishers shifted their attention to these other products. Now that the price for live grouper has rebounded, they have shifted back to capturing grouper as much as they can.

Impacts of SARS on the trade from Karimunjawa

The trade of grouper and lobster in Karimunjawa was also impacted as a result of the SARS outbreak, as indicated by a drop in prices (Table 3). Grouper prices here were at their lowest during April 2003. As many of the grouper fishers in Karimunjawa depend solely on live-grouper fishing for their income, these reductions in prices were felt hard.

The drop in price was not the only thing happening in early 2003. Costs for fuel had increased in late 2002, so total operational expenses increased. Many fishers tried to limit their expenses by fishing closer to home, but grouper stocks in those areas had already been nearly depleted so their catches were smaller than previously, when they would travel farther. Reduced catches and lower prices created significant declines in the incomes of Karimunjawa grouper fishers. Their buyers or bosses tried to find other activities for them to complement their incomes. They provided nets to the divers, who started using their now-idle dive gear (hookah compressors) to fish for schooling fusiliers (*Caesio* spp.) in a way derived from the *muro ami* fishing method. The catch was sold in domestic fish markets. This fishing method is now frequently used in the Philippines, since the traditional *muro ami* method was banned (Pet-Soede 2001).

The adjusted *muro ami* method was being used in Indonesia by fishers operating in Pulau Seribu, off Jakarta, who showed it to Karimunjawa fishers when they fished Karimunjawa waters some two years ago. At that time, Karimunjawa fishers were not interested and actually recognised that this method was potentially very damaging to fish stocks due to its effectiveness. But now that their economic situation has deteriorated and their middlemen are providing them with nets, they have started fishing with this new technique, claiming that they have little other choice. The method involves placing a very fine-meshed barrier net on the reef and divers releasing bubbles from their compressor hoses to create a "bubble-screen" that scares the fish into the net. The method has been reported to be highly effective, catching a large proportion of the fish in the vicinity. The bycatch includes many undersized fish and unmarketable species that get entangled or otherwise damaged in the barrier net.

Currently there are some 27 operations that deploy this form of *muro ami*, with about 20 from the main island of Karimunjawa, four from Kemujan Island and three owned by people from Parang. Each operation typically involves between 15 and 21 people operating from three boats. In one day, an operation can catch between 500 and 1000 kg of fish. Using preliminary data from visual censuses at four fixed monitoring sites, fusilier abundance has declined approximately 40 per cent (Taka 2003). The same trend was observed and reported by dive operators in the Karimunjawa area.

Discussion

It appears that the SARS outbreak significantly affected the incomes of Indonesian fishers during the early months of 2003 as a result of substantial price reductions. Wholesale and retail prices in Hong Kong, however, did not reflect these declines, remaining fairly steady through the early months of 2003. Indonesian traders claimed that

Table 3. Prices paid for grouper (rupiah per kg)[9] to fishers and middlemen in Karimunjawa before and during the SARS outbreak.

Species	Price to fishers		Price to middlemen	
	Before SARS	During SARS	Before SARS	During SARS
Plectropomus areolatus	30–35,000	20–25,000	Ex-fisher price	Ex-fisher price
Plectropomus laevis	40–50,000	30–40,000	plus 50%	plus 50%
Plectropomus leopardus	70,000	50,000	or more	or more
Epinephelus fuscoguttatus	40–50,000	30–40,000		
Epinephelus spp.	30–35,000	20–25,000		

Source: Interviews conducted by the authors (Sudarsono and team) with fishers and traders in Karimunjawa.

9. Note that the preferred size range is 0.9–1.8 kg. These are called super. Smaller fish are usually fattened until they reach the super class. Fish larger than 1.8 kg are not accepted for export.

they needed to pay lower prices so they could afford to export fewer fish in response to the decline in demand, which required that they bear the greater costs of holding the fish longer. Unfortunately, the trends in export volumes of live grouper from Indonesia to Hong Kong could not be examined due to a lack of data for that period. However, the data from one of the most important export airports, Bali, showed a slight reduction in shipments from early 2003 until May 2003. This supports the claims made by the Indonesian traders as to their rates of export.

Things are now mostly back to pre-SARS conditions and the search for live grouper and Napoleon wrasse continues as before. One exception is the shift to the use of the modified *muro ami* fishing method, which continues. Although the method is not used to produce live reef food fish, its adoption was caused by the effect of the SARS outbreak on live grouper prices. This has resulted in yet another threat to Indonesia's already heavily exploited coastal fisheries resources.

References

Chan, T.C. 2003. Import figures and prices for the Hong Kong live reef food fish trade. Unpublished data in Excel spreadsheet. Hong Kong: International Marinelife Alliance, Hong Kong.

DKP. 2001. South Sulawesi export and trade data. Department of Fisheries and Marine Affairs Makassar (DKP).

DKP. 2002. Indonesian statistical data on capture fisheries and aquaculture. Jakarta: Department of Marine Affair and Fishery.

Erdmann, M.V.E. and Pet J.S. 1999. Krismon & DFP: Some observations on the effects of the Asian financial crisis on destructive fishing practices in Indonesia. SPC Live Reef Fish Information Bulletin 5:22–26.

Erdmann, M.V.E. and Pet-Soede C. 1996. How fresh is too fresh? The live reef food fish trade in Eastern Indonesia. Naga, The ICLARM Quarterly 19(1):4–8.

Lau, P. and Parry-Jones R. 1999. The Hong Kong Trade in Live Reef Fish for Food. Hong Kong: TRAFFIC East Asia and World Wide Fund For Nature Hong Kong.

Pet-Soede, L. 2001. Destructive fishing practices mini symposium. SPC Live Reef Fish Information Bulletin 8:16–19.

Pet-Soede, C. and Erdmann M.V.E. 2003. Rapid Ecological Assessment - Wakatobi National Park. A combined report by the Marine Program of World Wide Fund for Nature (WWF) Indonesia and South East Asia-Center for Marine Protected Areas (SEA-CMPA) of The Nature Conservancy (TNC) Indonesia. 73 pages plus figures, tables and annexes. Obtain via lidapet@attglobal.net.

Taka. 2003. Unpublished data from field observations in Karimunjawa. Yayasan Taka is a non-profit NGO supporting park authorities with monitoring of grouper spawning aggregation sites in Karimunjawa National Park.

Acknowledgements

The authors would like to thank the quarantine office of Bali airport for their statistics; they also thank the fishers and traders in South Sulawesi and Karimunjawa for their information.

Acknowledgements are also due to Thomas Graham for his valuable comments and suggestions that improved the manuscript.

SPC *Live Reef Fish* activities online

The first 12 issues of this bulletin, as well as many other publications from the SPC Coastal Fisheries Programme, are available on SPC's website at: **http://www.spc.int/coastfish/**

An email discussion group has been set up at SPC to provide a more immediate way of exchanging news and information between members of the Live Reef Fish network, and to enable faster responses to issues. To subscribe, send a blank message to: **join-live-reef-fish@lyris.spc.int**

For more information, check the following Internet address:
http://www.spc.int/cgi-bin/lyris.pl?enter=live-reef-fish

Marine ecological footprint of the live reef fish food trade[1]

Kimberley Warren-Rhodes[2], Yvonne Sadovy[3] and Herman Cesar[4]

Introduction

The demand for live seafood in Asia has spawned a lucrative trade in live coral reef fish that in 1995 had a global annual retail value of over USD 1 billion (Johannes and Riepen 1995; Cesar et al. 1997). There are concerns that the live reef fish food trade is inflicting an unacceptably heavy impact on coral reefs and reef resources in Southeast Asia and the Indo-Pacific.[5] These areas contain over 90 per cent of the world's coral species and include the highest global marine biodiversity (Norse 1993). Because these reefs provide over one billion people in Asia with food (Barber and Pratt 1997; Bryant et al. 1998), their destruction and overexploitation threaten current and future regional food security and socioeconomic development (Barber and Pratt 1997; Williams 1997).[6] This article examines the marine ecosystem area appropriated by major Asian economies, particularly that of Hong Kong, to satisfy their demand for live reef fish food products. Hong Kong was chosen as the focus of the article for two reasons. First, it is the largest trader and major consumer of live reef food fish in the world. Second, in contrast to other demand-side economies (e.g. Singapore, mainland China), data are available to examine Hong Kong's role in the trade, facilitating an in-depth analysis of its marine ecological footprint. However, even the available data for Hong Kong are known to be incomplete, making it difficult to determine the true scale of live fish imports into Hong Kong (Lau and Parry-Jones 1999).

Marine ecological footprints

The concept

Marine ecological footprints (MEFs) measure the marine ecosystem area appropriated by human populations to supply seafood and other marine products and services (Folke et al. 1991; Folke et al. 1998).[7] Because these products and services are often not fully reflected in conventional economic and trade analyses, MEFs are important tools for calculating the "hidden" support provided by natural marine ecosystems and the real "costs" of that support (Folke et al. 1997). MEFs can be computed for global, regional and local (e.g., country or city) scales, or they can focus on specific activities such as mariculture or the live reef fish food trade (FT) (Folke et al. 1997; Wackernagel et al. 1999; WWF 2000). MEFs are calculated either as ratios (e.g. the number of times above or below sustainable levels) or as spatial areas (e.g. km^2 of appropriated coral reef).[8]

---

1. A fuller account of this study is available in: Warren-Rhodes, K., Sadovy Y. and Cesar H. 2003. Marine ecosystem appropriation in the Indo-Pacific: A case study of the live reef fish food trade. Ambio 32(7):481–488.
2. NASA-Ames Research Center and Dept. of Civil and Environmental Engineering, Stanford University. Address: NASA-Ames Research Center, Mail Stop 245-3, Moffett Field, CA 94035, USA. Email: kwarren-rhodes@mail.arc.nasa.gov
3. Department of Ecology & Biodiversity, The University of Hong Kong, Pokfulam Road, Hong Kong, SAR, China. Email: yjsadovy@hkucc.hku.hk
4. Institute for Environmental Studies, Vrije Universiteit, Amsterdam and Cesar Environmental Economics Consulting. Web site: www.ceec.nl
5. In this article, Southeast Asia is defined (and included in calculations) as part of the Indo-Pacific. Thus, calculations for the Indo-Pacific include Southeast Asia, even when Southeast Asia as a region is highlighted separately.
6. In Indonesia, for example, cyanide fishing and the FT have been estimated to exhaust grouper stocks within an area of 3000 square kilometers per year (km^2 yr^{-1}) with significant destruction of corals and other marine life, reducing future fisheries income by USD 40,000 km^{-2} reef in net present value terms and incurring total net societal losses of USD 43,000–476,000 km^{-2} reef in net present value terms (Cesar 1996).
7. Wackernagel and Rees (1996) introduced the concept of ecological footprints to measure the "corresponding area of ecologically productive land and aquatic ecosystems required to produce the resources used, and to assimilate the wastes produced, by a defined population at a specified material standard of living, wherever on earth that land [or aquatic ecosystem] may be located" (Rees 1996; Wackernagel and Rees 1996).
8. MEFs can be derived using the following basic formula:

Surface needed to produce the consumed quantity	=	SC	=	C / P
Consumption of a defined area	=	C		
Production per hectare	=	P		
Actual productive surface of defined area	=	AS		
Marine ecological footprint (MEF)	**=**	**SC/AS**		

From this definition, computed MEF values are as follows: *i)* = 1, the population is exactly self-sufficient; *ii)* > 1, resource consumption and / or waste assimilation are not locally self-sufficient, i.e., more surface area is needed than is actually part of the population's defined area; or *iii)* < 1, the region or population is more than self-sufficient and living within its own ecological means. Because waste assimilation services of marine ecosystems are not considered here, our results are likely to be underestimates of the MEFs.

Case study: Marine ecosystem appropriation by the FT

The high revenues of the FT in Southeast Asia and the Indo-Pacific are counterbalanced by two serious ecological problems: *i)* overexploitation of target species and *ii)* cyanide fishing (Johannes and Riepen 1995; Barber and Pratt 1997). In this article, we apply the MEF concept to coral reef fisheries in order to answer the following questions: What proportion of Southeast Asia's and the Indo-Pacific's coral reef fisheries production is needed to supply the FT in Asia, and in particular, Hong Kong's annual demand for live reef fish; and, Can this demand be sustained by available reef resources?

Sustainable coral reef fisheries production in the Indo-Pacific and Southeast Asia

To estimate the impact of the FT, the sustainable production of coral reefs must be considered. Because production is a function of many factors, we present a range of optimistic to pessimistic scenarios based on varying production linked to coral reef health, reef fishery maximum sustainable yields, and fishing pressure.

Estimates of coral reef area, health and fishery yields

The sections below outline our assumptions for subsequent calculations and analyses.

i) *Coral reef surface area.* Coral reefs comprise approximately 0.1 to 0.5 per cent of the world's ocean floor (Spalding et al. 2001).[9] Thirty per cent of the world's coral reefs are in Southeast Asia, with 18 per cent of the total located in Indonesia and the Philippines (Wilkinson 1998). We assume the following coral reef surface areas (Spalding et al., 2001): *i)* global—284,300 km^2; *ii)* Southeast Asia—91,700 km^2; and *iii)* Indo-Pacific—259,600 km^2 (excluding the eastern Pacific).[10] While these figures are based on a restricted definition of a coral reef (see footnote 9), limiting the area to known, mapped shallow-water reefs, we employ these estimates because near-surface reefs are the most biologically productive and economically important fisheries (Munro 1996), they are the main targets of the FT, and higher figures may overestimate total global reef habitat (see footnote 9). However, for comparison, sensitivity analyses with higher reef area values were run and are discussed in the following sections as upper bounds for coral reef production.

ii) *Coral reef health.* Coral reef health significantly affects fisheries production, with healthier reefs being more productive (Chou 1998). Coral reef health is typically assessed based on total live coral cover. For health status, we employed data from Bryant et al.'s (1998) comprehensive survey, which revealed the following percentages for coral reefs in the Southeast Asia and the Indo-Pacific regions, respectively: "excellent" condition—3% and 20%; "good"—15% and 40%; "fair"—26% and 30%; and "poor"—56% and 10%.

iii) *Coral reef fishery yields.* We base optimistic reef fishery yields on McAllister (1988) and pessimistic yields on Dalzell (1996). McAllister showed total reef fishery production of 3–18 tonnes per square kilometer per year (t km^{-2} yr^{-1}) for reefs in poor to excellent health. Dalzell reviewed sustainable yields from tropical reef fisheries, which varied from 0.1–44 t km^{-2} yr^{-1}. From this and other reviews (Russ 1991; McClanahan 1995), it seems reasonable to conclude that while total yields much higher than 5 t km^{-2} yr^{-1} are possible for some reefs in Southeast Asia and the Indo-Pacific, those well in excess of 15 t km^{-2} yr^{-1} are rare.

iv) *Reef fishery finfish and grouper yields.* The reef fishery yields reviewed above include both finfish and invertebrates (Dalzell 1996). The FT, however, focuses heavily on finfish, and in particular, on groupers and larger reef fish. Based on Cesar (J. McManus, pers. comm., as cited in Cesar 1996), we assume finfish constitute two-thirds of total yields. Groupers comprise 0 to 15 per cent of the finfish yields, depending upon the reef's health status and the degree of fishing pressure (Russ 1991; Cesar 1996).

v) *Fishing pressure.* Fishing intensity also reduces yield, with catch rates of grouper and other top predators declining (down to one-third or one-half of virgin reefs in less than five years) as fishing pressure intensifies (Dalzell 1996). We assume that half of the coral reef surface area (for any

9. The full range of estimates for global coral reef cover is 284,300 to 4 million km^2: *i)* 617,000 km^2 from Smith (1978); and *ii)* 0.6 to 4 million km^2 from Kleypas (1997).
10. Spalding et al.'s (2001) global coral reef surface area of 284,300 km^2 is broken down into the following regional categories: *i)* Middle East—21,600 km^2; *ii)* Indian Ocean—32,600 km^2; *iii)* Southeast Asia—91,700 km^2; *iv)* Pacific Oceans—115,900 km^2; *v)* Caribbean—20,000 km^2; and vi) Atlantic Ocean—1600 km^2. The Indo-Pacific region has an estimated 261,200 km2 of coral reefs (259,600 km^2 excluding E. Pacific) and is defined as including Southeast Asia, the Indian Ocean, the Red Sea, Northern and Southern Pacific Oceans, and the Arabian Gulf (Spalding et al. 2001). The differences between the various estimates arise because of the way that coral reefs are defined—in particular the maximum depth to which reef growth (typically from 150 m to less than 30 m) is restricted by ambient light levels.

health condition) is under heavy fishing pressure, which reduces estimated yields by 50 per cent, and that half is under moderate or light fishing pressure, which we assume has a negligible effect on long-term yields.

Final yields adopted for our analyses are shown in Figure 1. From these analyses, it can be seen that coral reefs in excellent and good condition could furnish approximately 80 to 90 per cent of grouper yields in Southeast Asia and the Indo-Pacific, whereas those in fair and poor condition would contribute only 10 to 20 per cent of the total (Fig. 2). These results underscore the critical importance to fisheries in these regions of keeping reefs in good condition and rehabilitating reefs in less healthy states.

Estimates of total sustainable reef fisheries production in Southeast Asia and the Indo-Pacific

Based on the assumptions above, coral reef production values for Southeast Asia and the Indo-Pacific are indicated in Table 1.[11, 12] Sensitivity analyses for all factors were run, resulting in a range of estimates. However, for simplicity we report the point estimate we believe to be the most representative value for current coral reef fisheries production, which assumes coral reefs to be typically in fair to poor condition in this region (Bryant et al. 1998) and a midpoint figure for fishery yields (i.e. a total of about 10 t seafood km^{-2} yr^{-1} and 5 t finfish km^{-2} yr^{-1}) from Dalzell (1996). With these assumptions, total sustainable production of coral reef finfish and groupers, respectively, in the Indo-Pacific is estimated at approximately 650,000 t yr^{-1} and 50,000 t yr^{-1}. Within Southeast Asia, annual coral reef sustainable production is 135,000 t of finfish and 7300 t of groupers. Southeast Asia, therefore,

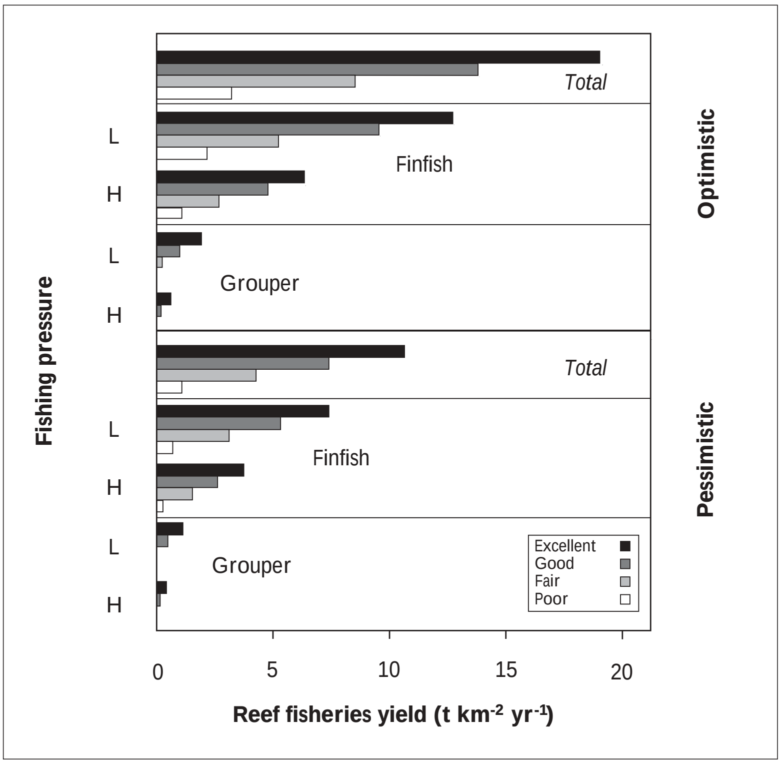


Figure 1. **Optimistic and pessimistic estimates of the coral reef fisheries yields for reefs in excellent, good, fair and poor condition under light (L) or heavy (H) fishing pressure.**

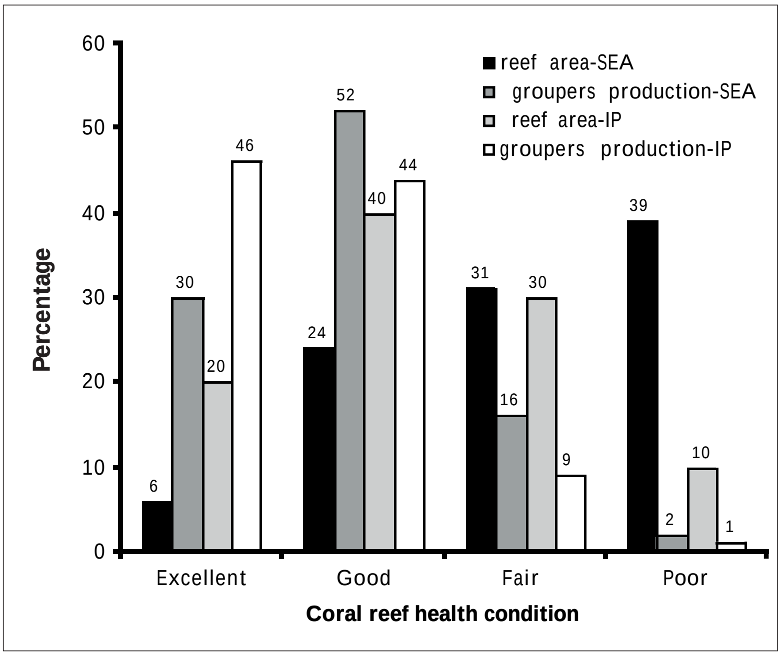


Figure 2. **Contributions of high value grouper species production from coral reefs in Southeast Asia and the Indo-Pacific based on varying reef health conditions.**

11. As Bryant et al. (1998) note, their figures may be underestimates, since 90% of the coral reefs in the Pacific remain unexplored and only 10% of the reefs in Southeast Asia have been thoroughly surveyed. A World Bank assessment (see World Bank 1998) of coral reefs in Indonesia presents a more optimistic picture for reef health, with 6%, 24%, 31% and 39% in excellent, good, fair and poor condition, respectively. These percentages are similar to those found in a ten-year (1984–1994) ASEAN-Australia Living Coastal Resources project that surveyed reefs in Malaysia, Indonesia, Singapore, the Philippines and Thailand (see Chou 1998).
12. Sensitivity analyses performed using a combination of coral reef health data from Bryant et al. (1998) and the World Bank (1998) give a larger range than the results shown in Table 1 for the total maximum sustainable production of coral reef fisheries in the Indo-Pacific: finfish: 463,502–1,325,348 t yr^{-1}; groupers: 28,627–103,247 t yr^{-1}.

can potentially supply only about 15 per cent of the Indo-Pacific's total estimated sustainable grouper production. These estimates approximately double when McAllister's (1988) higher yields are used (Table 1).

Table 1. Coral reef surface area and estimated finfish and grouper sustainable yields for Southeast Asia and the Indo-Pacific.

	SE Asia	Indo-Pacific
Coral reef surface area (km^2)		
excellent	2,751	36,331
good	13,755	80,915
fair	23,842	74,212
poor	51,352	68,142
Total	91,700	259,600
Total sustainable coral reef finfish production ($t\ yr^{-1}$)		
optimistic scenario	286,563	1,251,988
pessimistic scenario	135,258	647,353
Total sustainable coral reef groupers production ($t\ yr^{-1}$)		
optimistic scenario	13,828	95,260
pessimistic scenario	7,287	51,557

Notes:
i. Coral reef surface area is based on Spalding et al. (2001).
ii. Coral reef health conditions are from Bryant et al. (1998).
iii. Optimistic scenario assumes total yields of 3–18 $t\ km^{-2}\ yr^{-1}$ from McCallister (1988); pessimistic scenario assumes total yields of 1–10 $t\ km^{-2}\ yr^{-1}$ from Dalzell (1996).

Estimates of coral reef ecosystem appropriation

Consumption of seafood in Hong Kong and for the FT

The Hong Kong Special Administrative Region is a highly developed metropolitan area supporting nearly 7 million people on a total land area of 1097 km^2 (actual city built-up area, 120 km^2). Hong Kong possesses abundant sea area (1700 km^2), but with its own fisheries stocks severely depleted, no local management, little mariculture to supplement fishery yields, and a high and growing demand for seafood, it is almost exclusively dependent upon marine ecosystems beyond its borders for seafood (Warren and Keonig 2001). Total per capita seafood consumption in Hong Kong is 46–60 kg yr^{-1} (Hong Kong Government Census and Statistics Department 1998; Warren and Keonig 2001).

MEF for Hong Kong's role in the FT

As the largest FT importer, Hong Kong's demand accounts for about 60 per cent of the FT (with an estimated 50 per cent re-exported to mainland China, Chan 2001). Hong Kong's estimated annual imports of live reef fish in 1997 were 32,000 t (Lau and Parry-Jones 1999), placing the total annual volume of the FT at 25,000 to 54,000 t, with 15,000 to 31,500 t mainly from grouper but also from other reef fish such as snappers and humphead wrasse (Johannes and Riepen 1995; Lau and Parry-Jones 1999). Based on Hong Kong's estimated annual imports, our results show that this single economy appropriates 3–5 per cent of the Indo-Pacific's, or about 10–25 per cent of Southeast Asia's, estimated sustainable reef fish harvest (Table 2). This corresponds to a minimum MEF for Hong Kong's annual share in the FT of approximately 0.1 to 0.2 hectares per capita. Put another way, Hong Kong appropriates the production from an area of at least 6500 to 13,000 times the size of its own coral reef area.

If Hong Kong's demand for groupers is specifically examined (18,900 t yr^{-1} in 1997), it can be seen that 140 to 260 per cent of Southeast Asia's total sustainable grouper production is appropriated (Table 2). Although some percentage of Hong Kong's demand is re-exported to China, this total demand exceeds Southeast Asia's entire coral reef fisheries' regenerative capacity for groupers. The implications of Hong Kong's (and southern China's) high and very probably unsustainable appropriation of annual coral reef fisheries production in Southeast Asia are sobering. As our analysis shows, demand in Hong Kong (and southern China) leads to the removal each year of up to one-quarter of Southeast Asia's total sustainable reef fisheries catch and virtually all of its grouper catch. This high appropriation of coral reef resources presumably partly explains why Hong Kong fishing fleets and traders must continually relocate to sustain annual market demand (Sadovy and Vincent 2002).

MEF for the entire FT

On an annual basis, the FT in Asia markets constitutes as much as 40 per cent of Southeast Asia's sustainable coral reef finfish production. For groupers, the trade sells up to four times the sustainable yield of Southeast Asian reefs, or as much as 60 per cent of the entire Indo-Pacific region's annual sustainable grouper production (Table 2). The FT as a whole is a significant consumer of coral reef fisheries resources throughout the Indo-Pacific region, and its annual demand must be considered and integrated into regional coral reef management and protection plans.

Table 2. **Estimates of the appropriated marine ecosystem area and percentage of coral reef production appropriated by Hong Kong and the live reef fish trade (FT).**

	Appropriated ecosystem area (km^2)		Percentage of reef fisheries production appropriated	
	SE Asia coral reefs	Indo-Pacific coral reefs	SE Asia coral reefs	Indo-Pacific coral reefs
Hong Kong's total reef fish consumption				
optimistic scenario	10,552	6,838	12	3
pessimistic scenario	22,356	13,224	24	5
Hong Kong's grouper consumption				
optimistic scenario	129,153	53,076	137	20
pessimistic scenario	245,088	98,068	259	37
FT's total reef fish consumption				
optimistic scenario	17,067	11,059	19	4
pessimistic scenario	36,158	21,388	39	8
FT's total grouper consumption				
optimistic scenario	208,886	85,843	228	33
pessimistic scenario	396,393	158,610	432	61

Note: The percentage of reef fisheries production appropriated refers to that from either SE Asia or the Indo-Pacific, but not both —the percentages are not additive. For example, under the optimistic scenario, current consumption by Hong Kong appropriates either 12% of SE Asia's production or 3% of the Indo-Pacific's total.

Impacts on the MEFs from cyanide fishing, mariculture and overfishing

Other activities exacerbate the high levels of exploitation. In addition to overfishing, the use of cyanide in some areas damages coral reefs (Jones and Hoegh-Guldberg 1999; Mous et al. 2000), possibly impairing their capacity to produce fish and seafood. High rates of fish mortalities and poor fishing practices also characterise FT operations, with average mortality rates estimated at 50 per cent between capture and the point of retail sales (Sadovy and Vincent 2002), as well as a heavy focus on reef fish spawning aggregations which cannot withstand heavy fishing pressure (Johannes and Riepen 1995). Lastly, coral reef fish mariculture, which supplements the wild grouper supply for the FT, also engenders negative ecological impacts. Hundreds of millions of juveniles are caught for this industry throughout Southeast Asia and traded internationally around the region. Many of these young fish die from poor culture and transport conditions, while the pollution and use of wild fish to feed cultured groupers is also a matter of some concern (Sadovy 2000; Sadovy and Lau 2002). Coral reef destruction and biomass lost in the above ways are not reflected in trade figures or regulatory initiatives. If such losses were included in our analyses, the MEF estimates would be substantially higher.

Discussion and conclusions

Although the MEF analyses presented in this article are limited to the quality of the underlying data and assumptions, and reflect only a static picture of coral reef fisheries (e.g. do not incorporate dynamics in seafood demand, such as the reduced demand in Hong Kong following economic downturns, or the complex nature of reef ecosystems) (Holling 1973; Folke et al. 1998; Moberg and Folke 1999), the results are valuable in assisting policymakers to *i)* identify the largest regional "consumers" of coral reef resources, *ii)* assess the ramifications of this consumption, *iii)* quantify the pressures on and limits of coral reef ecosystems' regenerative capacity, and *iv)* identify management and conservation needs at local and regional scales. Our analysis and those of others on the FT highlight an important problem in monitoring and managing the trade: the lack of systematic and accurate data for coral reef fish fisheries and the general paucity of fishery information in Southeast Asia (Watson and Pauly 2001). We recommend that organisations such as the Food and Agriculture Organization of the United Nations and the Asia-Pacific Economic Cooperation (APEC) foster the collection of more accurate and detailed annual statistics on coral reef fisheries.

The MEF analyses presented in this article also suggest that economic assessments of the potential benefits of the FT to source countries in the Pacific must factor in the likelihood for the FT to rapidly lead to overexploitation of their reef resources. Clearly, overexploitation of coral reef fisheries in Southeast Asia and the Indo-Pacific is no longer an issue to be managed solely on the supply end. Demand-side participants in the FT through their seafood consumption are directly responsible for the significant appropriation of reef fish in these regions and the concomitant ecological impacts; consequently they share a large responsibility for the proper management of the trade on their end. Our analyses reflect the need for institutional actions that include: *i)* reducing coral reef fish capture and protecting healthy reef fish populations from overexploitation by the FT, *ii)* establishing marine protected areas and instituting temporary and permanent closures of at least a portion of the fishing grounds in Southeast Asia, and certainly in the case of spawning aggregations, to allow depleted fisheries to recover (Andersson and Lindroth 2001), *iii)* revitalising local fisheries in demand countries, *iv)* requiring live reef fishermen and traders to adopt codes of responsible fishing practices, *v)* monitoring trade (both export and import), *vi)* taking a precautionary approach to becoming involved in the FT, and *vii)* investigating full-cycle grouper aquaculture to supply reef fish, if it is carried out in a sustainable way (Sadovy and Lau 2002).

Without urgently needed reform, the FT will continue to deprive people in the Indo-Pacific of the full economic benefits from their reef fish resources and the world of its potentially irreplaceable marine biological heritage.

> "It is clear … that the environmental, social and political problems arising from the live reef fishery are not just enormous, but also enormously complex. There is no simple solution. The issues must be addressed at a variety of levels using a variety of regulatory, educational, scientific, and economic tools" (Johannes and Riepen 1995).

Acknowledgements

This article is dedicated to the lifelong scientific contributions, dedication and marine conservation efforts of Robert Johannes. The authors thank M. Spalding at the UNEP World Conservation Monitoring Centre (www.wcmc.org.uk) for coral reef area data. Valuable insights and improvements to the manuscript from Kevin Rhodes, Denise McCorry, Andrew Cornish and Daniel Pauly were also greatly appreciated.

References

Andersson, J. and Lindroth M. 2001. Ecologically unsustainable trade. Ecological Economics 37:113-122.

Barber, C. and Pratt V. 1997. Sullied Seas: Strategies for Combating Cyanide Fishing in Southeast Asia and Beyond. Washington D.C.: World Resources Institute, and Manila, Philippines: International Marinelife Alliance. 57 p.

Bellwood, D. and Hughes T. 2001. Regional scale assembly rules and biodiversity of coral reefs. Science 292:1532–1534.

Bryant, D., Burke L., McManus J. and Spalding M. 1998. Reefs at risk: A map-based indicator of threats to the world's coral reefs. Washington, D.C.: World Resources Institute, Manila, Philippines: International Center for Living Aquatic Resources Management, and Oxford: UNEP World Conservation Monitoring Centre.

Campos, W. 1994. Yield estimates, catch, effort and fishery potential of the reef flat in Cape Bolinao, Philippines. UP Mar. Sci. Inst. Contrib. 21:82–95. University of the Philippines.

Cesar, H. 1996. Economic analysis of Indonesian coral reefs. Washington, D.C.: The World Bank.

Cesar, H., Lundin C., Bettencourt S. and Dixon J. 1997. Indonesian coral reefs: An economic analysis of a precious but threatened resource. Ambio 26:345–350.

Chan, P. 2001. Marketing aspects of the live seafood trade in Hong Kong and the People's Republic of China. In: B. Paust and A. Rice (eds). Marketing and Shipping Live Aquatic Products: Proceedings of the Second International Conference and Exhibition, November 1999, Seattle, WA. Fairbanks: University of Alaska Sea Grant. 201–206.

Chou, L. 1998. Status of Southeast Asian coral reefs. In: C. Wilkinson (ed). Status of Coral Reefs of the World: 1998. Global Coral Reef Monitoring Network and the Australian Institute of Marine Science. 79–87.

Costanza, R., d'Arge R., de Groot R., Faber S., Grasso M., Hannon B., Limburg K., Naeem S., O'Neill R., Paruelo J., Raskin R., Sutton P. and van den Belt M. 1997. The value of the world's ecosystems services and natural capital. Nature 387:253–260.

Dalzell, P. 1996. Catch rates, selectivity and yields of reef fishing. In: N. Polunin and C. Roberts (eds). Reef fisheries. London: Chapman and Hall. 161–192.

Folke, C., Hammer M. and Jansson A.M. 1991. Life-support value of ecosystems: A case study of the Baltic Sea region. Ecological Economics 3:123–137.

Folke, C., Jansson A., Larsson A. and Costanza R. 1997. Ecosystem appropriation by cities. Ambio 26:167–172.

Folke, C., Kautsky N., Berg H., Jansson A. and Troell M. 1998. The ecological footprint concept for sustainable seafood production: A review. Ecological Applications, 8 Suppl.: 63–71.

Holling, C.S. 1973. Resilience and stability of ecological systems. Annual Review of Ecology and Systematics 4:1–23.

Hong Kong Government, Census and Statistics Department 1998. Hong Kong Statistics December 1997 Imports (Vol. 1) and Domestic Exports and Re-exports (Vol.2). Hong Kong, SAR.

Johannes, R. and Riepen M. 1995. Environmental, Economic and Social Implications of the Live Reef Fish Trade in Asia and the Western Pacific. Jakarta: The Nature Conservancy.

Jones, R. and Hoegh-Guldberg O. 1999. Effects of cyanide on coral photosynthesis: implications for identifying the cause of coral bleaching and assessing the environmental effects of cyanide fishing. Marine Ecology Progress Series 177:83–91.

Kleypas, J.A. 1997. Modeled estimates of global reef habitat and carbonate production since the last glacial maximum. Paleoceanography 12:533–545.

Lau, P. and Parry-Jones R. 1999. The Hong Kong Trade in Live Reef Fish for Food. Hong Kong: TRAFFIC-East Asia and World Wide Fund for Nature (WWF-Hong Kong). 65 p.

McAllister, D. 1988. Environmental, economic and social costs of coral reef destruction in the Philippines. Galaxea 7:161–178.

McClanahan, T. 1995. A coral reef ecosystem-fisheries model: Impacts of fishing intensity and catch selection on reef structure and processes. Ecological Modelling 80:1–19.

Moberg, F. and Folke C. 1999. Ecological goods and services of coral reef ecosystems. Ecol. Economics 29:215-233.

Mous, P., Pet-Soede L., Erdmann M., Cesar H., Sadovy Y. and Pet J. 2000. Cyanide fishing on Indonesian coral reefs for the live food fish market-What is the problem? In: H. Cesar (ed). Collected essays on the economics of coral reefs. Kalmar, Sweden: CORDIO, Kalmar University. 69–76.

Munro, J. 1996. The scope of tropical reef fisheries and their management. In: Polunin V. and Roberts C. (eds). Reef fisheries. London: Chapman and Hall. 1–14.

Norse, E. 1993. Global marine biological diversity. Washington, D.C.: Island Press.

Rees, W. 1996. Revisiting carrying capacity: Area-based indicators of sustainability. Population and Environment 17:192–215

Russ, G. 1991. Coral reef fisheries: Effects and yields. In: P.F. Sale (ed). The ecology of fishes on coral reefs. San Diego, California: Academic Press. 601–635.

Sadovy, Y. 2000. Regional survey for fry/fingerling supply and current practices for grouper mariculture: Evaluating current status and long-term prospects for grouper mariculture in South East Asia. Asia-Pacific Economic Cooperation Completion Report. 102 p.

Sadovy, Y. and Vincent A.C. 2002. Issues and the trades in live reef fishes. In. P.F. Sale (ed). Coral reef fishes, dynamics and diversity in a complex ecosystem. San Diego, California: Academic Press. 391–420.

Sadovy, Y. J. and Lau P.F. 2002. Prospects and problems for mariculture in Hong Kong associated with wild-caught seed and feed. Aquaculture Economics and Management 6:177–190.

Smith, S. 1978. Coral reef area and the contribution of reefs to processes and resources of the world's oceans. Nature 273:225–226.

Spalding, M. and Grenfell A. 1997. New estimates of global and regional coral reef areas. Coral Reefs 16:225–230.

Spalding, M., Ravillious C. and Green E. 2001. World atlas of coral reefs. Berkeley, California: University of California Press. [For methodological details see Spalding and Grenfell (1997)]

Wackernagel, M., Lillemor L. and Borgstrom Hansson C. 1999. Evaluating the use of natural capital with the ecological footprint: Applications in Sweden and subregions. Ambio 28:604–612.

Wackernagel, M. and Rees W. 1996. Our ecological footprint: Reducing human impact on earth. Gabriola Island, British Columbia: New Society Publishers.

Warren, K. and Keonig A. 2001. Ecosystem appropriation by Hong Kong and its implications for sustainable development. Ecological Economics 39:347–359.

Watson, R. and Pauly D. 2001. Systematic distortions in world fisheries catch trends. Nature 414:534–536.

Wilkinson, C. (ed). 1998. Status of coral reefs of the world: 1998. Global Coral Reef Monitoring Network and the Australian Institute of Marine Science. [http://www.aims.org.au/]

Williams, M. 1997. Transition in the contribution of aquatic resources to food security. In: de Silva, S. (ed). Perspectives in Asian fisheries: A volume to commemorate the 10th anniversary of the Asian Fisheries Society. Makati, Philippines: Asian Fisheries Society. 58 p.

World Bank. 1998. Indonesia Coral Reef Rehabilitation and Management Project. Project Appraisal Document. Washington, D.C.

World Wide Fund for Nature (WWF). 2000. Living planet report 2000. [http://www.panda.org/lpr]

The "C.A.R.E." (collect by artificial reef eco-friendly) system as a method of producing farmed marine animals for the aquarium market: An alternative solution to collection in the wild

Gilles Lecaillon[1]

Nature does things well

Life cycle

Most marine animals undergo a planktonic larval phase in their life cycle. This period of development, which for coral reef fish generally takes place in the open sea (oceanic) environment, is followed by return to the original habitat of the breeding stock of the species concerned. The oceanic larval phase duration varies from 10 to 100 days depending on the species of fish (Wellington and Victor 1992). This return is first passive, as dictated by the movements of water masses and ocean currents, thus favouring the dispersal of larvae, and then active for a short period (less than one week), during which time the larvae seek the reef habitat that will suit them best. This nocturnal (to diminish the risk of predation) phase, during which colonisation occurs, is a crucial phase in recruitment. It is only after this stage that the animals are called juveniles (associated with a change of diet, colour and sometimes shape) (Doherty and Williams 1988).

High mortality through natural predation

The various stages (from egg to juvenile) of the life cycle of these reef animals are marked by high natural mortality, mainly due to predation. It has been scientifically demonstrated that more than 90 per cent of the post-larvae disappear in the week following initial colonisation (Planes and Lecaillon 2001).

But nature in her providence enables female coral reef fish to produce more than 1 million eggs during each spawning event. Depending on the species, spawning may take place once per year or as frequently as every fortnight, such as in the case of the clownfish. The purpose is that at least two individuals of breeding age survive to ensure survival of the species.

Phototropism of post-larvae

Various scientific studies have shown that the majority of the oceanic ichthyoplankton is phototropic, or attracted to light. This characteristic, common to many marine animals, is also specific to fish larvae. Even more surprising is the fact that this characteristic disappears once the young fish has settled in (Leis 1991).

Conclusion

If larvae are collected before the intense predation event that occurs during colonisation, the impact of collection is negligible because the captured animals are part of a large pool of individuals, most of which are destined to become meals for lagoon predators.

Eco-friendly collection by C.A.R.E.

The many advantages of this new technique

ECOCEAN / ECOMAY has developed a new collection device, C.A.R.E. (collect by artificial reef eco-friendly). This new C.A.R.E. device, which is associated with collecting, sorting, weaning and growing procedures, is INPI-patented (Institut National de la Proriété Industrielle). Our need to protect the design of the device prevents us from sharing some of the design features in this article. ECOCEAN manufactures C.A.R.E. in France. C.A.R.E can be purchased by research centres or private partners for less than USD1000 (please email us for more information).

The C.A.R.E. device is illuminated at night with a waterproof lamp emitting a special spectrum. It is not only a trap; it is a lighted artificial reef. Post-larval fish spontaneously enter the cod-end of the device because they want to protect themselves from predation. The latest design was tested, improved and then compared with other post-larvae collection systems for more than one year in the Indian Ocean, where we have experimented with a pilot post-larvae collection farm. These devices are being used to collect post-larval fish in Florida and New Caledonia and have also been tested in French Polynesia and the China Sea. They have been designed and optimised with produc-

1. Gilles Lecaillon is, with Sven-Michel Lourié, a founder of ECOCEAN ® (a farmed marine animals development and marketing company) and ECOMAY (rearing company by ocean collection based in the Indian Ocean); 80 rue des Graves; 34980 Saint Clément de Rivière; France. Website: www.ecocean.fr. Email: ecocean_label@yahoo.com

tion in mind. Some of their advantages are described below.

1. The collected post-larvae are alive and have no surface abrasion. This is very important because most existing collection systems damage the animals, considerably increasing the risks of pathological reaction. This is especially true for plankton nets and crest nets. The algae (e.g. *Turbinaria*) that grow on collection devices and constantly brush against the larvae, the violence of the strong incoming currents, and the action of predators and sunshine near the surface all increase the stress experienced by the animals. With C.A.R.E., the post-larvae spontaneously opt to move to the inside of the artificial reef present in the water column, with neither stress nor physical contact.

2. There is no seaweed inside the receptacles and this facilitates the next stage of sorting. This is different from other larvae collectors, which sometimes harvest more algae than animals!

3. Certain models of C.A.R.E. will avoid catching pelagic species, such as Clupeidae (sardines) and Engraulidae, which are typically not wanted. Most other light traps catch these pelagic fish, which then die rapidly, as they need to be constantly moving. Sometimes more than 2000 dead pelagic fish are found in a light trap.

4. A C.A.R.E. system can easily be set from a boat in order to optimise collection and watch over the devices at night (as many as 10 C.A.R.E. can be deployed in a string, depending on the speed of the surface currents). If the devices are to be anchored, a five-kilogram brick is sufficient. The devices can be installed and uninstalled very quickly (e.g. in preparation for approaching storms).

5. Lastly, these collection devices are ergonomic for the user, easy to deploy, and inexpensive to transport. The total weight of a C.A.R.E. device is less than seven kilograms.

Negligible impact on the environment

It is very important to emphasise that the C.A.R.E. devices only collect phototropic post-larvae and that these post-larvae are collected just before intense natural predation, as explained above. The C.A.R.E. devices primarily collect post-larval finfish (all the families have already been collected), but they also collect crabs, prawns, cuttlefish and sometimes octopus if these animals are recruiting at the time and place of collection.

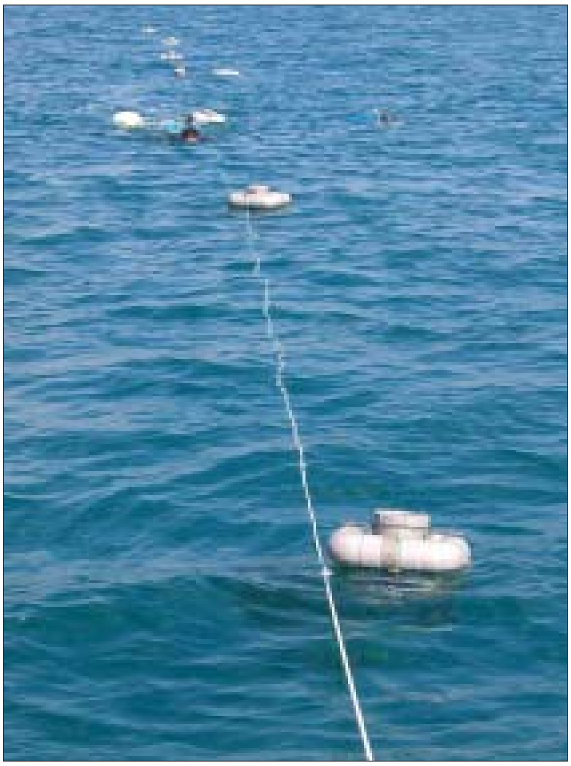


Figure 1. **A string of C.A.R.E. devices (© ECOMAY/ECOCEAN).**

As an example, if we were to collect 1000 post-larvae nightly from an island where several million post-larvae recruited daily, this would represent a negligible impact (less than 0.05%) on the natural stock. This impact is even more negligible if it is compared to that of direct collection from the breeding stock in the natural environment.

The environmental benefits of the C.A.R.E. system are therefore threefold: eco-friendly larvae collection, protection of the adult stock targeted by traditional fishing methods, and conservation of coral ecosystems.

Some fish grow-out operations start with very small juveniles rather than post-larvae. This method is very different than post-larvae collection because collection takes place *after* the period of intense predation, rather than *before*, so the environmental consequences are quite different.

Rearing marine animals

Juvenile and adult coral fish are often very colourful and therefore very highly regarded in the marine aquarium market. This rapidly developing market requires and implies major collection activities in the wild to meet the high demand. In order to avoid uncontrolled collection, farming would appear to be the only solution.

Status of the activity

Fish

At the present time, only a tiny proportion of all tropical marine fish species are bred artificially. Approximately 50 species of the 1000 used for marine aquaria (5%) are reproduced in captivity. Many of these are reared only on an experimental basis — they are not produced and marketed on a large scale. The most popular commercialised fish species are the clownfish, followed by the *Pseudochromis* (dottybacks) and certain cardinalfish, together with some gobies and blennies. It should be noted that some food fish are also bred in captivity. The ratio is reversed for freshwater aquarium fish, in which case there is a clear predominance of farming over collection in the wild.

Invertebrates (other than corals)

Giant clams are bred in many places but only a few companies market them consistently. Other invertebrates, such as shrimps, particularly *Lysmata wurdermanii* (peppermint shrimp) and *Lysmata seticaudata* (Monaco shrimp), and a few others, are reproduced in captivity.

Corals

An increasing number of hard and soft corals are being farmed, or more precisely, propagated, but few ventures are as yet really profitable.

Live rock

Lastly, cultured "live rock" is reaching the market from various places. The attractiveness and richness of the product is determined by the amount of time the rock is left in the water to build up growth of various organisms (from one to ten years). Cultured live sand also exists. These two products are used both as decoration and for filtration in marine aquariums because of their anaerobic component.

ECOCEAN: A new approach to eco-friendly fish

Various larval collection techniques have been experimented with, including plankton nets, crest nets, and channel nets, but these techniques often have the drawback of wounding the animals during capture. Indeed, the original idea behind designing the C.A.R.E. devices was to avoid having any contact between the larvae and anything else during capture, during sorting, or during the following stages of farming. The grown-out fish, having been carefully attended to for more than six months in some cases, is "domesticated," robust, readily eats inert food and is ready for transportation. The result: a farmed fish guaranteeing a very high survival rate!

In the course of developing the C.A.R.E. system, we met professional fish farmers in various countries, established partnerships, and introduced a logistical system enabling us today to offer a unique range of farmed marine animals with a high quality label.

These farmed fish (from eggs or post-larvae) should be considered as an "eco-friendly" product, as they have been carefully produced over a longer time with care and under the guidance of a clear and strict quality charter (ECOCEAN®). But, producer, importer and distributor must agree to reduce their profit margins in order to play the game and produce a final cost acceptable to the consumer, bearing in mind the quality offered. This aspect of the trade in farmed marine organisms — the costs associated with producing eco-friendly products — is an important one and worthy of further discussion, but it is not addressed in detail here.

Figure 2. **Example of new farmed species, butterflyfish (© ECOMAY/ECOCEAN).**

Practical solutions

The problems encountered by some countries exporting wild animals for the aquarium market could be rapidly resolved by the solution described here. It is easy to say that overfishing and damaging techniques such as cyanide fishing must be stopped, but indigenous people need other economic avenues and not just prohibitions.

Countries that regulate or simply ban the collection of marine animals for the aquarium market could look to other job-creating activities, such as the farming of wild-caught post-larvae. To this end, we are working in conjunction with international non-governmental organisations but also with locally based organisations. ECOCEAN / ECOMAY often works with scientists such as those from the University of Perpignan in France and the University of California at Santa Cruz in the USA in order to validate the results obtained during our research and to appraise the consequences.

Some governmental environment departments are preparing to amend their laws to make these plankton collection activities for rearing marine animals possible and accessible. This is the case with the Service des Pêches et de l'Environnement Marin (SPEM) on Mayotte Island in the Comoros, Indian Ocean, as well as the Florida Fish and Wildlife Conservation in the USA.

The greater the diversity of farmed species that is available on the market, the more consumers will focus on farmed animals, and the more the environment will be protected. This is why ECOMAY / ECOCEAN is today trying to obtain permission to work in and collect specimens from other potentially beneficial sites.

Bibliography

Doherty, P.J. and McWilliams D. 1988. The replenishment of coral reef fish populations. Annual Review of Oceanography and Marine Bilogy 26:487–551.

Leis, J.M. 1991. The pelagic stage of reef fishes: The larval biology of coral reef fishes. In: P.F. Sale (ed). The ecology of fishes on coral reefs. San Diego: Academic Press Inc. 183–227.

Planes, S. and Lecaillon G. 2001. Caging experiment to examine mortality, during metamorphosis of coral reef fish larvae. Coral Reefs 20(3):211–218.

Wellington, G.M. and Victor B.C. 1992. Regional differences in duration of the planktonic larval stage of reef fishes in the eastern Pacific Ocean. Marine Biology 113:491–498.

Figure 3.

Aquaculture technician, Mayotte Island, Comoros.

Natural spawning of three species of grouper in floating cages at a pilot broodstock facility at Komodo, Flores, Indonesia

Sudaryanto[1], Trevor Meyer[1] and Peter J. Mous[1]

Abstract

Broodstock of mouse grouper, *Cromileptes altivelis*, tiger grouper, *Epinephelus fuscoguttatus*, and estuary grouper, *E. coioides*, are commonly housed in shore-based tanks. Often, hormone injections are used to induce spawning. Broodstock of a pilot fish culture project in the Komodo area (Flores, Indonesia) were kept in floating fish cages with a surface area of 16 m^2 and a depth of 6 m, where they reproduced naturally without hormonal treatment. The grouper species stocked at Komodo were found to typically spawn around the period of new moon. Duration of spawning varied from 3–14 days. Spawning occurred in groups (*E. fuscoguttatus*) or in discrete pairs (*E. coioides*, *C. altivelis*). Time of spawning varied between dusk (*E. coioides*) to beyond midnight (*C. altivelis* and *E. fuscoguttatus*). Possibly, natural spawning was facilitated by the broodstock compartment's water depth, which was about two times greater than in the shore-based tanks that are most commonly used. The greater water depth of floating fish cages appears to facilitate pre-spawning behaviour ("dancing") and spawning itself. Furthermore, cage systems also allow for the provision of good water quality, ambient and stable water temperature and reduced stress, presumably leading to improved fecundity from the broodstock.

Introduction

Indonesia, a large equatorial island republic of more than 220 million people with a total coastline of over 81,000 km, is the prime source of live groupers for the Hong Kong-based reef fish trade. However, overexploitation by legal fishing methods and by the widespread use of illegal fish anaesthetics such as cyanide has led to a dramatic decrease in the wild population of groupers. This has forced the trade to source groupers from remote destinations such as the West Coast of Africa and the Pacific islands (Hughes et al. 2003). Grouper culture has the potential to make this profitable trade sustainable (see Anonymous 2003a; 2003b).

Groupers (family Serranidae, subfamily Epinephelinae) are popular food fish now widely cultured in net cages and earthen ponds throughout Southeast Asia. However, growth and development of the grouper farming industry has been constrained by an inadequate supply of fish juveniles for stocking (Chao and Lim 1991). The existing supply of wild-caught juveniles cannot meet the demand of the expanding grouper culture industry, so the development of this industry is reliant upon the successful hatchery production of grouper juveniles.

At least 23 species of serranids have spawned naturally in captivity, mostly during the natural spawning periods under ambient temperatures and partial or full levels of natural light. Optimum rearing conditions and feed are critical to induce natural spawning in captivity (Tucker 1994). Captive spawning of *Epinephelus fuscoguttatus* has been reported by Kohno et al. (1990) and Lim and Chao (1990) and natural spawning in captivity has been reported by Chao et al. (1993). Artificial spawning by hormone injection of *Epinephelus coioides* has also been reported by Chao and Lim (1991).

Females of some species of epinepheline serranids are capable of spawning more than once during a season, often very frequently. A single caged female *Epinephelus coioides*, kept with two males, was reported to have spawned 5–10 times per month over a period of 4 months (Lim and Chao 1990). Ten female and ten male *Epinephelus fuscoguttatus* kept in a cage spawned 2–5 times during each of nine periods of 2–6 days, usually starting between the lunar last quarter and new moon (Lim and Chao 1990). Forty female and nine male *Epinephelus coioides* spawned almost continuously for 50 days during April to June 1976 (Hussain and Higuchi 1980). *Cromileptes altivelis* have spawned voluntarily in net cages in Singapore, in tanks at Gondol, Bali and Situbondo, Java, and in 50-m^3 tanks in Lampung, Sumatra.

Although broodstock are often collected and conditioned in floating cages, most hatcheries are reliant upon egg production from broodstock housed in

1. The Nature Conservancy, Southeast Asia Center for Marine Protected Areas, Jl. Pengembak 2, Sanur, Bali, Indonesia.
Email: pmous@tnc.org

shore-based tanks (Ruangpanit 1993). This paper describes the spawning activity and husbandry methods for three protogynous grouper species (*C. altivelis*, *E. coioides* and *E. fuscoguttatus*) maintained in floating cages as a low-cost alternative to holding broodstock in shore-based tank systems.

Materials and methods

The Komodo fish culture project

The Nature Conservancy, a global environmental organisation, works closely with the Indonesian Park Authority (PHKA, Balai Taman Nasional Komodo) to protect the marine biodiversity of Komodo National Park and to safeguard the park's function as a source of recruits for surrounding fishing grounds. One of The Nature Conservancy's alternative livelihood projects is based on the development of a sustainable fish culture industry that provides alternative income to local fishers. The project rationale is to establish a multi-species marine fish hatchery that supplies reef fish juveniles and training on fish husbandry to village-based cage grow-out units that are being developed around Komodo National Park (Anonymous 2003c). A secondary aim of the project is to contribute to the transformation of the live reef fish trade from an unsustainable, capture-based industry to a sustainable, culture-based industry.

Based at Loh Mbongi, near Labuan Bajo on the West coast of Flores, the project maintains broodstock housed in cages to provide eggs and larvae for hatchery production.

Broodstock maintenance and development

Three species of grouper are maintained as broodstock, namely mouse grouper (*Cromileptes altivelis*), tiger grouper (*Epinephelus fuscoguttatus*) and estuary grouper (*Epinephelus coioides*). The fish culture project also maintains broodstock of Asian seabass (*Lates calcarifer*) and mangrove jack (*Lutjanus argentimaculatus*), but these species are not discussed in this paper.

All broodstock were captured from surrounding waters by trap and hand line during late 1997 and 1998, and as such are of locally pure genetic stock. Size at capture varied between a few grams and several hundred grams. Fish were on-grown for a period of three years, on a diet of fresh fish at 5–10 per cent of body weight per day. These mostly immature fish were stocked in cages of 3-m diameter, containing nets initially 3 m in depth. Stocking density varied between 30 and 100 fish per cage.

By August 2000 some of the brooders were found to be mature and ready for spawning. Mature fish were transferred to simply constructed wooden square floating cages of 16-m^2 surface area, fitted with nets of 6-m depth. The cages were arranged into a platform holding 24 cages, grouped as four rows of six cages. The cages were moored in a sheltered bay, about 150 m from the shore in waters about 18 m deep. The 20-mm-mesh-sized nets were cleaned every four weeks to ensure high water exchange and thus optimum water quality within the cage. The stocking density of the broodstock was maintained at 25 fish per cage. The sex ratio at the start of the observations was approximately 1 male to 3 females for mouse grouper and tiger grouper, but for estuary grouper, females vastly outnumbered males. By 2003, the sex ratio changed due to females changing sex to become males. The species composition, sex ratio and average body weight of the broodstock in August 2003 are summarised in Table 1.

Mature broodstock were fed with fresh fish and squid at 4–5 per cent of body weight every other day. Fish used for feeding were caught by the local pelagic fishery and included purse-eyed scad, *Selar crumenophthalmus*, mackerel scad, *Decapterus macarellus*, spotted halfbeak, *Hemiramphus far*, and hound needlefish, *Tylosurus crocodilus*. Feed fish were immersed in freshwater for 30 minutes prior to feeding to remove external parasites. To ensure high egg quality, the fresh fish used for feeding were enriched with a commercial preparation containing essential fatty acids and vitamins A, B and E. The feed fish were cut into appropriate sized morsels prior to feeding.

Table 1. **Species composition, sex ratio and mean body weight of broodstock in August 2003.**

Species	Number of males	Number of females	Total number	Mean body weight (kg)
C. altivelis	15	24	39	2.0
E. coioides	22	131	153	7.5
E. fuscoguttatus	39	39	78	10.0

Fine-meshed skirts (0.5 mm mesh size), measuring 3.75 m x 3.75 m x 3 m depth were fitted to cages that contained gravid females and males in spawning coloration to prevent eggs drifting out of the cages. Fertilised eggs may be positively or neutrally buoyant; unfertilised eggs are negatively buoyant (Rimmer 2000). Within an hour after spawning, the buoyant eggs were collected by seine scoop-net with 0.5-mm mesh for transport in 15-litre plastic buckets to the incubation tanks at the hatchery.

Observations on the timing of spawning behaviour of *Cromileptes altivelis*, *Epinephelus coioides* and *E. fuscoguttatus* were made over the period October 2000 to June 2003.

Results

Natural spawning of mouse grouper, tiger grouper and estuary grouper in the floating cages was first observed in late 2000. Spawning was preceded by pairing of the fish and a brief "dance" leading to spawning itself. During spawning, the sperm and eggs were released into the water column and fertilisation occurred externally.

Spawning of mouse grouper

Spawning of *C. altivelis* stocked in two separate cages was observed over the period October 2000 to July 2003 (Table 2).

Mouse grouper spawned in discrete pairs, following a period of "dancing" during which a pairing was established. Just prior to spawning, the pair swam together whilst maintaining physical contact between their heads. The fish then swam in a circular upward motion (presumably to remain within the confines of the cage) up to the water surface, where the eggs and sperm were released.

Spawning occurred from the third quarter to the first quarter of the moon, with 57 per cent of spawning observations made during the fourth quarter, 24 per cent during the first quarter and 19 per cent during the third quarter. No spawning activity was recorded during the second lunar quarter. Eighty-one per cent of spawning observations were made between 2100 h and 2300 h, with the remainder taking place between 2300 h and midnight. These observations show that spawning within a single cage can continue for at least eight consecutive days.

Spawning of estuary grouper

Spawning of *E. coioides* stocked in five separate cages was observed over the period December 2000 to July 2003 (Table 3).

Table 2. **Observed natural spawning events of mouse grouper, *C. altivelis*, housed in two cages.**

Cage	Date	Lunar day*	Time
1	29 Oct 2000	2	2140
1	30 Oct 2000	2	2120
1	22 Nov 2000	24	2125
1	23 Nov 2000	25	2150
1	24 Nov 2000	26	2130
1	25 Nov 2000	27	2105
1	26 Nov 2000	28	2200
1	27 Nov 2000	29	2215
1	28 Nov 2000	30	2145
1	29 Nov 2000	1	2150
1	15 Dec 2000	17	2110
1	16 Dec 2000	18	2205
1	17 Dec 2000	19	2240
1	18 Dec 2000	20	2135
1	19 Dec 2000	21	2155
1	1 Sep 2001	2	2230
1	7 Oct 2001	20	2120
1	18 Oct 2001	1	2105
1	11 Nov 2001	23	2130
1	6 Feb 2002	23	2100
1	8 Feb 2002	25	2130
1	9 Feb 2002	26	2300
1	7 Mar 2002	22	2200
1	8 Mar 2002	23	2100
1	8 Oct 2002	1	2230
1	2 Dec 2002	27	2330
1	6 Dec 2002	1	2100
1	28 Mar 2003	24	2150
1	28 Mar 2003	24	2135
1	29 Mar 2003	25	2215
1	29 Mar 2003	25	2300
1	30 Mar 2003	26	2235
1	30 Mar 2003	26	2115
1	4 Apr 2003	19	2235
1	3 May 2003	19	2230
1	24 Jun 2003	23	2300
2	24 Jun 2003	23	2300
1	25 Jun 2003	24	2315
2	25 Jun 2003	24	2345
1	27 Jun 2003	26	2250
2	27 Jun 2003	26	2250
1	1 Jul 2003	1	2400

* Lunar day 1 represents new moon, while lunar day 14 represents full moon.

E. coioides spawned in pairs. Typically the male searched the stock of females for a suitable partner, whilst the females remained relatively inactive on the cage floor. Once the pair was established, spawning commenced as the pair swam together from the cage floor up to the water surface, where eggs and sperm were released.

Spawning was concentrated in the fourth quarter of the moon, when 64 per cent of all spawning events were observed. Onset of spawning occurred later than for *C. altivelis* (lunar day 21 as opposed to lunar day 17), but it continued up to lunar day 9 in the second quarter, whereas *C. altivelis* spawned only up to lunar day 2. *E. coioides* spawned much earlier in the evening than *C. altivelis*, with 84 per cent of spawning observations made between 1700 h and 1800 h.

Table 3. **Observed natural spawning events of estuary grouper, *E. coioides*, housed in five cages.**

Cage	Date	Lunar day	Time
1	19 Dec 2000	21	1910
1	17 Feb 2001	21	1945
1	18 Feb 2001	22	1905
1	19 Feb 2001	23	1940
1	20 Feb 2001	24	1950
1	11 Sep 2001	24	1810
1	11 Oct 2001	24	1740
2	11 Oct 2001	24	1820
1	12 Oct 2001	25	1755
2	12 Oct 2001	25	1730
1	10 Feb 2002	27	1900
1	9 Sep 2002	1	1900
2	8 Oct 2002	1	1700
1	2 Dec 2002	27	2300
2	2 Dec 2002	27	2300
1	28 Feb 2003	26	2000
1	1 Mar 2003	27	1800
1	2 Mar 2003	28	1620
2	2 Mar 2003	28	1825
2	4 Apr 2003	21	1750
2	3 May 2003	9	1820
3	4 May 2003	9	1815
4	5 May 2003	9	1755
5	5 May 2003	23	1805
2	3 Jul 2003	3	1800

Spawning of tiger grouper

Spawning of *E. fuscoguttatus* stocked in three separate cages was observed over the period November 2000 to July 2003 (Table 4).

Tiger grouper spawned in pairs, but different pairs would often spawn at the same time, thus giving the effect of a "group spawning". Typically, a male displayed or "danced" to establish a pairing with a chosen female, who lay relatively inactive on the cage floor. Once the pair was established, spawning behaviour started with the pair swimming together up from the cage floor to the water surface, whereupon both fish released their eggs and sperm.

Spawning was concentrated in the fourth quarter of the moon, when 97 per cent of all spawning events were observed. This shows that *E. fuscoguttatus* exhibits a much more confined spawning period than mouse grouper and estuary grouper. Ninety-four per cent of spawning events were recorded between 2100 h and midnight.

Table 4. **Observed natural spawning events of tiger grouper, *E. fuscoguttatus*, housed in three cages.**

Cage	Date	Lunar day	Time
1	22 Nov 2000	24	2200
1	23 Nov 2000	25	2130
1	24 Nov 2000	26	2135
1	25 Nov 2000	27	2215
1	26 Nov 2000	28	2150
1	27 Nov 2000	29	2205
1	28 Nov 2000	30	2145
2	22 Nov 2000	24	2230
2	23 Nov 2000	25	2245
2	24 Nov 2000	26	2300
2	25 Nov 2000	27	2315
2	26 Nov 2000	28	2210
2	27 Nov 2000	29	2150
2	28 Nov 2000	30	2315
1	16 Oct 2001	29	2320
1	6 Feb 2002	23	2300
2	8 Feb 2002	25	2330
1	1 Dec 2002	26	2100
2	1 Dec 2002	26	2100
3	1 Dec 2002	26	2100
1	2 Dec 2002	27	2100
2	2 Dec 2002	27	2100
3	2 Dec 2002	27	2100
1	29 Mar 2003	25	2210
2	29 Mar 2003	25	2130
3	29 Mar 2003	25	2210
1	30 Mar 2003	26	2120
2	30 Mar 2003	26	2310
3	30 Mar 2003	26	2240
1	24 Jun 2003	23	2300
2	24 Jun 2003	23	2300
3	24 Jun 2003	23	2300
2	28 Jun 2003	27	0100
2	2 July 2003	2	1900

Discussion

These observations show that naturally spawning mouse grouper, estuary grouper and tiger grouper can be maintained in floating cage systems, and that the broodstock can be managed so as to supply fertilised eggs for hatchery rearing. This is advantageous in that the additional costs of maintaining broodstock in land-based tanks, primarily the energy costs of seawater supply and aeration, can be avoided. The use of cages allows a much larger holding volume of water, which allows the grouper more space to conduct spawning behaviour. Furthermore, ambient physicochemical conditions reduce stress to a minimum.

The collection of eggs is reliant upon staff manning the broodstock facility throughout the night and manually collecting eggs after spawning. Egg collection should not be delayed by more than two hours post-spawning, since the grouper eggs are rapidly consumed by small fish swimming into the cages through the mesh of the nets.

Fecundity and spawning frequency of the three grouper species discussed in this paper were found to vary through the year, with a seasonal low occurring during the months of June, July and August. This low availability of fertilised eggs through part of the year may cause bottlenecks in hatchery production. Spawning frequency and fecundity during the low season can probably be increased by administration of hormones to feed or by injection.

This production system does have some disadvantages. Photoperiod control, used to induce spawning in other cultured fish species, is not possible. Inclement weather can disturb and postpone spawning of broodstock. Furthermore, broodstock are vulnerable to the spread of infectious disease, since the cages cannot be isolated and supplied with filtered and sterilised water in the way that tank-based systems can. Consequently, it is recognised that this method of husbandry may be more appropriate for small-scale fish culture projects in remote areas than for areas where large-scale production takes place and where diseases are a constant threat.

Broodstock that are maintained in floating cages may also benefit capture fisheries in surrounding waters. Uncollected eggs will disperse through the cage nets into the surrounding waters. It is estimated that the three species of grouper held by the Komodo Fish Culture Project may, together, naturally produce in excess of 200 million eggs per month. Since no more than 1 million eggs per month are required by the project, this represents a significant contribution of eggs to surrounding waters. In this way, the broodstock facility at the Komodo Fish Culture Project may be contributing to the natural re-stocking of depleted stocks of grouper in and around Komodo National Park. In many areas in Indonesia, badly managed fisheries have extirpated high-value grouper stocks (Johannes 1997; Mous et al. 2000). For instance, in 80 hours of reef fish population surveying using scuba in Sangihe-Talaud, a heavily fished archipelago stretching 400 km between North Indonesia and the Philippines, only 8 coral trout (*Plectropomus* spp.) and no mouse grouper were sighted (Mous 2002). In such situations captive broodstock may contribute to a faster recovery of the stocks after more effective capture fishery management measures have been put in place. The downside is that if broodstock of non-native species or races of fish are kept in cages, these fish may rapidly establish themselves in the local environment, becoming pests or causing genetic pollution.

Acknowledgements

The authors would like to thank The Nature Conservancy for encouraging research work at the Fish Culture Project in Loh Mbongi. The authors also thank the Gondol Research Centre for Mariculture (Bali) and the Komodo National Park Authority for their support and assistance in the development of the Komodo Fish Culture Project.

References

Anonymous. 2003a. Fish farming: The promise of a blue revolution. The Economist, 7 August 2003.

Anonymous. 2003b. The blue revolution: A new way to feed the world. The Economist, 7 August 2003.

Anonymous. 2003c. When fishing grounds are closed: Developing alternative livelihoods for fishing communities. MPA News 5(2):1–4.

Chao, T.M. and Lim L.C. 1991. Recent developments in the breeding of grouper (*Epinephelus* spp.) in Singapore. Singapore Journal of Primary Industries. 19(2):78–93.

Chao, T.M., Lim L.C. and Khoo L.T. 1993. Studies on the breeding of brown-marbled grouper *E. fuscoguttatus* (Forsskal) in Singapore. Tungkang Marine Laboratory Conference Proceedings 3:143–156.

Hussain, N.A. and Higuchi M. 1980. Larval rearing and development of the brown-spotted grouper, *Epinephelus tauvina* (Forsskal). Aquaculture 19:339–350.

Hughes, T.P., Baird A.H., Bellwood D.R., Card M., Connolly S.R., Folke C., Grosberg R., Hoegh-Guldberg O., Jackson J.B.C., Kleypas J., Lough

J.M., Marshall P., Nyström M., Palumbi S.R., Pandolfi J.M., Rosen B. and Roughgarden J. 2003. Climate change, human impacts, and the resilience of coral reefs. Science 301:929–933.

Johannes, R. 1997. Grouper spawning aggregations need protection. SPC Live Reef Fish Information Bulletin 2:13–26.

Kohno, H., Philip and Imanto T. 1990. Reproductive performance and early life history of the grouper, *E. fuscoguttatus*. Buletin Pen. Perikanan. Special Edition I:27–29.

Lim, L.C. and Chao T.M. 1990. Observation on the breeding of brown-marbled grouper *E. fuscoguttatus* (Forskal). Singapore Journal of Primary Industrie. 66–84.

Mous, P.J., Pet-Soede L., Erdmann M., Cesar H.S.J., Sadovy Y. and Pet J.S. 2000. Cyanide fishing on Indonesian coral reefs for the live food fish market – What is the problem? SPC Live Reef Fish Information Bulletin 7:20–27.

Mous, P.J. 2002. Draft Report on the rapid ecological assessment in Sangihe-Talaud, North Sulawesi, Indonesia. Report from The Nature Conservancy Coastal and Marine Program – Indonesia, Bali.

Rimmer, M. 2000. Broodstock maintenance and spawning. Department of Primary Industry, Queensland:1–4.

Ruangpanit, N. 1993. Technical manual for seed production of grouper (*Epinephelus malabaricus).* National Institute of Coastal Aquaculture, Dept. of Fisheries, Thailand and the Japan International Cooperation Agency.

Tucker, J.W. 1994. Spawning by captive serranid fishes: A review. Journal of the World Aquaculture Society 25:345–359.

Toward MAC certification of Hawaiian Islands collectors: A project update

Rezal Kusumaatmadja[1], John Parks[2], Scott Atkinson[3] and Jan Dierking[4]

Background

Over the past 30 years, the marine aquarium trade in the Hawaiian Islands has quadrupled. Annually supplying USD 3.2 million in live reef organisms, primarily to US and European markets (Dierking 2002), at present the Hawaiian marine aquarium fishery is a flourishing business in the islands and the source of hundreds of people's livelihoods. Over the past decade, the majority (58 per cent average annually, Miyasaka 2000) of organisms exported are captured off of the Kona (west) coast of the Big Island of Hawaii (see Fig. 1). Public concern over the sustainability of the trade has been voiced for a quarter century, highlighting the need for increased study and careful industry regulation. Decreasing reef fish abundance and overall reductions in the West Hawaii coral reef community health are increasingly being blamed by the public on current levels of aquarium trade operations, and these suspicions are supported by at least one recent study (Tissot and Hallacher 1999; Tissot 1999).

In response to growing public concern, the State of Hawaii Division of Aquatic Resources has strengthened the management of the West Hawaii aquarium fishery by developing new fishery regulations, enhancing monitoring and enforcement of such regulations, and regularly conducting scientific research on the state of West Hawaii's coral reefs and fish populations to help clarify what levels of catch are sustainable. One of the most important of these new state-led management efforts has been the establishment of nine Fish Replenishment Areas in 2000. These areas prohibit marine aquarium organism collection within approximately 30 per cent of the Kona coast's nearshore habitat.

MAC efforts initiated in Hawaii

As a result of a reduced collection area without a corresponding decrease in the number of collectors, there is now increased fishing effort in West Hawaii waters remaining open to collection. While the Hawaiian industry largely uses non-destructive collection techniques, overharvesting of target species is therefore an increasing concern that is difficult to control alone through the use of no-take zones and state-mandated catch reporting. Specifically, since the mid-1990s there has been increasing interest in how market incentives,

1. Author to whom correspondence should be addressed; Marine Aquarium Council, 923 Nu`uanu Avenue, Honolulu, HI 96817, USA. Tel: +1 (808) 550-8217. Email: info@aquariumcouncil.org
2. Community Conservation Network, 212 Merchant Street, Suite 200, Honolulu HI 96813, USA.
3. The Nature Conservancy of Hawaii, 923 Nu`uanu Avenue, Honolulu, HI 96817, USA.
4. Dept. of Zoology, U. of Hawai`i, 2538 McCarthy Mall, Edmondson 152, Honolulu, HI 96822, USA.

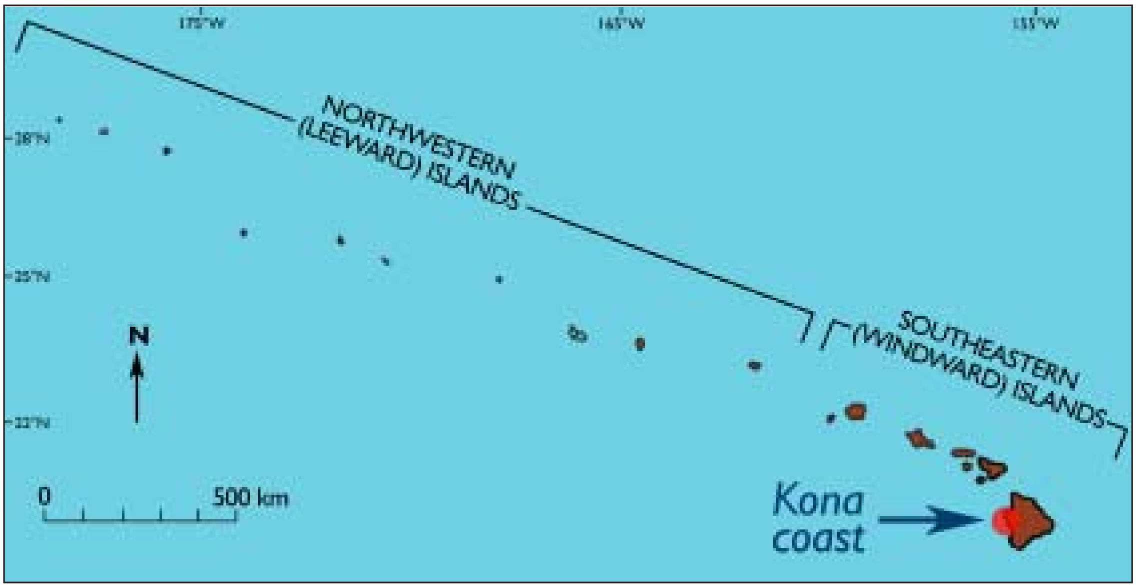


Figure 1. **Location of the Kona coast on the Big Island of Hawaii, in the southeastern island group of the Hawaiian Islands.**

expressed through "green label" certification by volunteer industry operators, can move the fishery toward ecological and economic sustainability in the islands.

As a result, in 2002 the Marine Aquarium Council (MAC) initiated a three-year project designed to enhance coral reef conservation in the islands by facilitating MAC certification of qualifying marine aquarium industry operators and encouraging market incentives to help move the fishery toward long-term ecological and economic sustainability (MAC 2003). In partnership with the Community Conservation Network (CCN) and The Nature Conservancy (TNC) of Hawaii, and with support from the Hawaii Community Foundation, the first phase (May 2002 through September 2003) of this new project has been completed. A summary of results generated during phase one follows.

Project results to date

First, a baseline investigation characterising the operations and socioeconomics of the West Hawaii marine aquarium trade was completed by the project during 2002. Key findings from this study are as follows (all from Dierking 2002):

- The West Hawaii aquarium trade is a lucrative one, with reported profit margins for independent contractors ranging from 43 to 68 per cent and wholesalers about 25 per cent.
- Estimates of post-collection mortality rates of Hawaiian fishes within the chain-of-custody have dropped noticeably since 1984, and are now estimated at less than 1 to 2 per cent within each stage of the chain.
- Nearly all (estimated 95–98 per cent) aquarium fish caught along the Kona coast are exported (via Oahu-based wholesalers) to US mainland and European markets.
- Four tang species make up 90 per cent of Hawaii's total annual ornamental catch, representing 87.2 per cent of total catch value. The endemic yellow tang (*Zebrasoma flavescens*; see Fig. 2) accounts for well over 50 per cent of all aquarium fish collected, and the Achilles, naso, and kole tangs (*Acanthurus achilles*, *Naso lituratus*, and *Ctenochaetus strigosus*, respectively) account for the remainder.
- The total range of species caught for market is much wider than these four species, and even low catches of particularly rare species may have greater ecological consequences than the high catches of more abundant species, such as the four tangs.
- The concentrated collection of only a few species within an increasingly restricted area raises further questions regarding whether or not current harvest rates are sustainable under existing management efforts.
- Leverage points and relevant economic incentives to encourage potential industry operators to become MAC certified have been identified, and will be used in the second (initial certification) phase of the project.

Secondly, based on initial outreach and consultation with industry operators of the West Hawaii industry, a small group of marine aquarium industry operators along the Kona coast have identified themselves as being potential volunteers for MAC certification over the next year or two. Phase two of this project will focus on working with and preparing these operators for adoption of industry best practices (where not already in place) and subsequently being reviewed and accredited by a third party as being MAC certified.

Finally, a public outreach and consultation process was initiated with members from the various primary stakeholder groups in and around West Hawaii with interests in or influence over the coastal environment and/or the marine aquarium trade. This process is being used to identify and secure the critical public support across a diverse group of individuals from the Kona coast community that will be necessary for the MAC certification process and to encourage volunteer industry representatives to comply with industry best practices. As part of this process, the project is conducting a structured, in-depth assessment of stakeholder attitudes and beliefs regarding the issues, trends, and opportunities facing the use of West Hawaii's coastal resources, including the marine ornamental trade (see Parks 2003). The purpose of doing this study is to ensure that a diverse and balanced set of perspectives and considerations is incorporated into the certification planning and implementation process, thereby strategically guiding future project activities and investments.

Looking forward into Phase Two

The achievement of these three outcomes has positioned the project to move forward into a second, pilot certification implementation phase in late 2003. During this second phase, MAC and its project partners will work closely with volunteer "early adopter" trade operators in West Hawaii to adopt industry best practices and prepare them for MAC certification. In addition to the preparations for the certification of individual companies, the project also seeks to achieve certification at the collection area level to MAC Ecosystem and Fishery Management Standards by developing a collection area management plan to encourage coordinated, sustainable resource use by certified parties.

To learn more about this project, visit the MAC website at: www.aquariumcouncil.org

References

Dierking, J. 2002. Socio-economic study of the aquarium fish industry in West Hawaii. Unpublished report. Arnhem, the Netherlands: Cesar Environmental Economics Consulting. 23 p. [Available online at: www.aquariumcouncil.org]

MAC (Marine Aquarium Council). 2003. Conserving the outstanding coral reef ecosystems of the Hawaiian islands by enhancing economic opportunities in the marine aquarium fish trade. Unpublished project summary document. Honolulu, Hawaii: Marine Aquarium Council. 5 p. [Available online at: www.aquariumcouncil.org]

Miyasaka, A. 2000. Status report: Aquarium fish collections statistics, fiscal years 1995–1999. Honolulu, Hawaii: Division of Aquatic Resources, State of Hawaii Department of Land and Natural Resources.

Parks, J.E. 2003. A strategy for the identification, outreach, and consultation of relevant marine aquarium trade stakeholders in West Hawaii. Unpublished project document. Honolulu, Hawaii: Community Conservation Network. 13 p. [Available online at: www.aquariumcouncil.org]

Tissot, B.N. 1999. Adaptive management of aquarium fish collecting in Hawaii. SPC Live Reef Fish Information Bulletin 6:16–19. [Available online at: www.spc.org.nc/coastfish/News/LRF/6/06-Tissot.htm]

Tissot, B.N. and Hallacher L.E. 1999. Impacts of aquarium collectors on reef fishes in Kona, Hawaii. Final report. Honolulu, Hawaii: Division of Aquatic Resources, State of Hawaii Department of Land and Natural Resources. 32 p.

Figure 2.
Hawaii's endemic yellow tang (*Zebrasoma flavescens*).
Photo © 1997 by Richard L. Pyle, Bishop Museum.

Spawning aggregations need managing: An update on the work of the Society for the Conservation of Reef Fish Aggregations

Yvonne Sadovy

The Society for the Conservation of Reef Fish Aggregations (SCRFA) was formed in 2000 with the recognition that fish spawning aggregations are particularly vulnerable to fishing, are increasingly being targeted, and are rarely managed or considered in the design or implementation of marine protected areas. We also recognise and advocate that effective management and conservation must be informed by good science. Given that spawning aggregations are often the only reproductive opportunity for many commercially important species, their loss or declines can have severe impacts on stock viability, as has been clearly shown in the case of the Nassau grouper, *Epinephelus striatus*, in the Caribbean and tropical western Atlantic. This formerly important commercial species is now a candidate for the Endangered Species List in the United States, and is listed as endangered on the IUCN (World Conservation Union) Red List of Threatened Species, largely, it seems, because of uncontrolled aggregation fishing. From the Indo-Pacific, an increasing number of examples is coming to light of targeted aggregations that have shown marked declines from fishing pressure for both live and dead (chilled) fish markets.

Funded in 2002 by the Packard Foundation and with a current membership of almost 200 biologists, managers, conservationists and fishery researchers, SCRFA is working towards several goals to ensure that spawning aggregations gain a higher profile in conservation and management agendas. A major focus of our work is to promote protective approaches that are not only practical but have a sound biological basis. The major aims of our work are to:

1. raise awareness of the vulnerability of spawning aggregations to exploitation;
2. seek options and practical means for managing reef fish spawning aggregations;
3. conduct or foster research that addresses key biological, management and monitoring needs;
4. provide information and advice, either directly or by developing materials and publications on aggregation research, monitoring, etc.; and
5. develop a comprehensive and global database on reef fish spawning aggregations, making it available in the public domain for data input and output to assist and promote initiatives in aggregation research and management.

Progress to date includes:

1. A Call for Action was endorsed by the second International Tropical Marine Ecosystem Management Symposium (ITMEMS2) held in March 2003, in Manila, that formally recognises the biological significance and vulnerability of spawning aggregations and calls for their protection and management in tropical ecosystems, globally. The Call for Action concludes with the following recommendation (for the full statement, see Attachment 1 of Action Statement in the website www.icriforum.org/itmems.html):

   "*. . . fish spawning aggregations should be conserved, through robust management strategies. Whenever possible, this should include complete or managed protection, to ensure persistence of the populations that form aggregations, the integrity of reef ecosystems and the livelihoods and food supply of communities that depend on aggregating species.*"

2. A website has been developed that incorporates materials and information, ranging from a newsletter (No. 3 came out in August 2003; No. 4 came out in December; submissions for the next newsletter are welcomed), scientific, educational and popular articles, video material, relevant publications, and information on the work of the Society (www.scrfa.org).

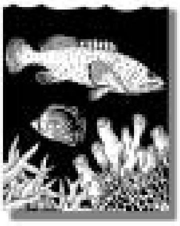
3. A comprehensive Methods Manual (available on our website or directly from me in hardcopy or as a CD — see email address below) that addresses all aspects of aggregation-related work, from monitoring fish at aggregation sites, to carrying out research on reproductive behaviour, fisherman interviews for current status and history of exploited aggregations, egg production, water movement, and covering management and conservation options. Key references and case studies are provided.

4. A new aggregation monitoring method is being developed that directly uses GPS (global positioning system) information together with counts of aggregated fish, linking them spatially within the aggregation site. The method is easy to use and reduces a lot of the error and problems inherent in more conventional monitoring approaches (see SCRFA Newsletter No. 3).

5. The Global Database now has records from more than 500 aggregations and the development of a programme for data input and retrieval through the SCRFA website is almost complete. Information has been collected by literature review, personal communications and by field surveys to collect information, through detailed interviews, in areas from which little has been published. Over 100 interviews have now been completed for the Solomon Islands, Papua New Guinea, Fiji, Palau, and Federated States of Micronesia, and partially completed for the Philippines; and they will shortly be conducted in eastern Malaysia and eastern Indonesia. Summaries of completed field surveys will be posted on the SCRFA website and results to date have revealed at least 50 exploited aggregations, all previously unrecorded. Although aggregation sites are documented in the database, actual locations are not made available in the public domain to avoid the possibility of further exploitation as a result.

We continue to provide support and information and to focus attention on spawning aggregations through activities ranging from technical input into conservation and management initiatives by other NGOs (non-governmental organisations) and fishery departments, to presenting our work in international forums, providing information and preparing educational materials. Most recently, presentations were made in Palau and the Philippines (June and July 2003), at the SPC Heads of Fisheries meeting (August 2003), the Gulf and Caribbean Fisheries Institute meeting (November 2003), and to NGOs and fishery departments wherever field surveys have been conducted. In 2004 we will participate in the 4th World Fisheries Congress in Canada, and the 10th International Coral Reef Symposium (ICRS) in Japan, among other meetings. We encourage submissions to participate in our aggregation mini-symposium at the 10th ICRS.

If you wish to learn more about SCRFA's work, or if you have particular information needs, please contact us at scrfa@hkucc.hku.hk.



Project update: Developing industry standards for the live reef food fish trade

Rezal Kusumaatmadja[1], Geoffrey Muldoon[2] and Peter Scott[3]

Introduction

As described in the previous issue of this Bulletin (Number 11, April 2003, pages 47–52), a project is being undertaken by the Marine Aquarium Council (MAC) and The Nature Conservancy (TNC) to develop industry standards for the live reef food fish trade (LRFFT). The goal of the project is to bring together stakeholders and build a consensus on what "best practices" are needed to improve the conduct of the industry and enhance industry sustainability, including sustainable reefs, fish stocks, and fishing communities. Support for the project is being provided by the Asia-Pacific Economic Cooperation (APEC) Fisheries Working Group, the United States Department of State, the MacArthur Foundation, and the Packard Foundation.

The standards identify best practices relating to assessment and management of fish stocks, capture and culture methods, transportation and holding and human health and safety issues. The implementation of the standards is done on a voluntary basis.

It is envisaged that industry operators, governments, marine conservation organisations and other stakeholders will use these standards as a guide to ensure that the LRFFT becomes a sustainable, high-value fishery providing improved livelihoods for local fishers while conserving the reef habitats upon which those fisheries rely. For example, government agencies may use the standards as input in developing rules and regulations governing the LRFFT in their respective countries. Industry operators may benefit from the standards by learning what best practices are in place so that they can improve their operations accordingly.

To ensure credibility, these standards are being developed via an open consultative process that, as much as possible, brings together and engages all relevant stakeholders through the use of advisory groups and standards review workshops in source and market countries. This process not only creates

1. Marine Aquarium Council, 923 Nu'uanu Ave., Honolulu, Hawaii 96817, USA. Email: rkusuma@aquariumcouncil.org
2. Consultant. Email: g.muldoon@impac.org.au
3. Marine Aquarium Council. Email: peter.scott@aquariumcouncil.org

a mechanism to compile information on the LRFFT but also provides a medium for various stakeholders to connect with each other. In other words, the standards development process acts as an information clearinghouse for LRFFT best practices.

Standards content and structure

The draft LRFFT standard is divided into three parts:

1. The wild harvest of live reef food fish (i.e. resource assessment and fishery viability, fishery management and planning, fishing operations).
2. Live reef food fish aquaculture.
3. Importing, holding, distribution, and marketing of live reef food fish.

The standards documentation consist of three levels: 1) the standard, 2) the best practice document, and 3) training and implementation manuals (the latter known collectively as "tool kits"). At the first level, the standard consists of bullet-point criteria, called "Requirements." For example:

Requirement 10 of Part B states: "Destructive methods of fishing are not used within the fishery."

At the second level, the best practice document expands each of the bullet points of the standard and is intended to describe how a participant in the LRFFT industry may seek to satisfy each criterion. For example:

"… Hook and line gear has been identified as the fishing technique that has the least impact upon coral reef habitats and may, although not always in practice, have the least impact upon bycatch species. The use of destructive fishing techniques such as poisons, explosives, traps and recruitment traps should be prohibited …"

The third level of documentation consists of a series of "tool kits," which include training and implementation manuals (e.g. "Training manual: How to catch food fish alive, practical lessons on the hook and line decompression technique").

As development of the standards progresses, the project team will receive further information from the Standards Advisory Group (see below), industry, government and other relevant organisations, especially at the tool-kit level. Government agencies, for example, may be able to share existing rules and regulations. Industry operators may share their operation manuals on issues such as holding and transportation practices. Fishers may also share various practical techniques on non-destructive harvest methods. Relevant regional bodies, such as the Secretariat of the Pacific Community (SPC), may share practical techniques on the assessment and management of fish stocks.

Standards development process

During 2003, a Standards Advisory Group (SAG), a group of experts, was formed specifically to review the draft standards and provide comments and inputs into the standards development process. The SAG now consists of 71 individuals representing the industry, government agencies, academic institutions and non-governmental organisations from 16 countries. To ensure wider stakeholder input, standards review workshops have also been conducted in Hong Kong, New Caledonia, Thailand, the Philippines and Indonesia during the second half of 2003.

The first round of SAG review (SAG 1) was originally scheduled to take place in the first half of 2003. The process was delayed due to the outbreak of SARS (severe acute respiratory syndrome) and the Iraq war and by the nature of the consultative, multi-stakeholder process, whereby participants need sufficient time to respond to requests to review and comment on the draft standards. The project team has had to strike a balance between making sure that comments from SAG members are received within an agreed timeline and at the same time keeping an open door to valuable late comments that might be received.

Overall, the structure and scope of the standards documentation were received well by the reviewers during SAG 1. Most comments received to date had to do with fine-tuning of the wording of the standards documentation rather than significant changes in intensity or extent of the requirements. Most SAG members were supportive of the iterative review process and expressed an interest in remaining involved in the second round of the SAG review (SAG 2).

From August to November 2003, the standards documentation has been undergoing SAG 2. Figure 1 outlines the standards development process and shows our progress to date.

Running concurrently with the SAG review process, a series of in-country standards review workshops have been conducted in the Philippines, Indonesia, Australia, Hong Kong and the Pacific Islands. The workshops are an important outreach activity and essential to the review and comment process to ensure the draft standards and the standards development process are known to stakeholders. The purpose of the workshops is to

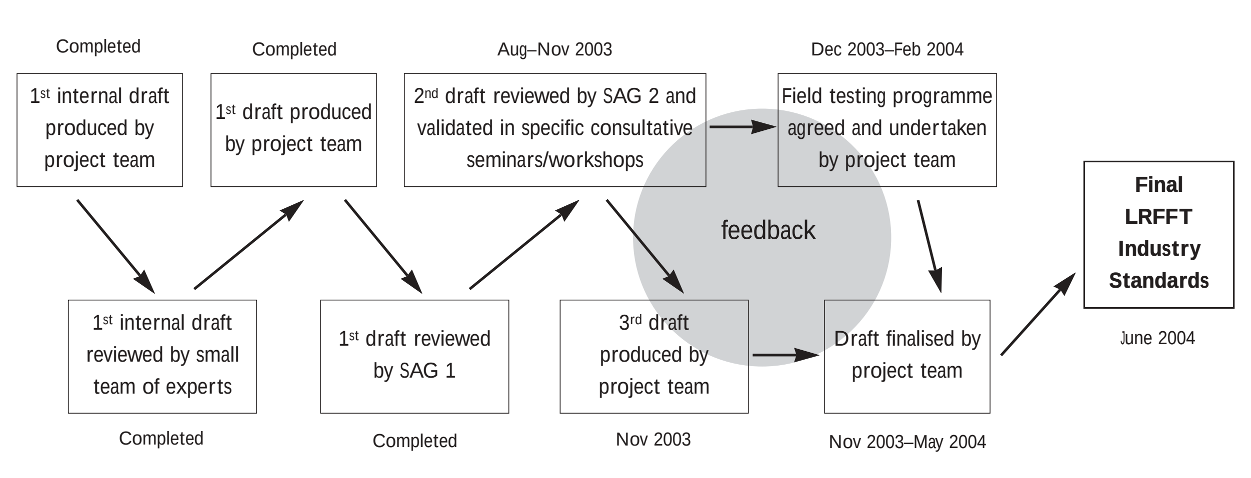


Figure 1. Standards development process for the live reef food fish trade.

encourage broad stakeholder participation and to receive feedback on the standard in terms of the practicability and the capacity of industry and other stakeholders to implement its requirements.

The first standards review workshop was conducted in Hong Kong in April 2003 and attended by representatives of industry, the Hong Kong Chamber of Seafood Merchants (HKCSM), government (Agriculture, Fisheries and Conservation Department — AFCD), and restaurateurs (Federation of Restaurants). A workshop for the Pacific region was conducted as part of the Heads of Fisheries meeting in Noumea, New Caledonia, in August 2003. Fisheries representatives from Fiji, the Marshall Islands, Tonga, Tuvalu, Solomon Islands, the Federated States of Micronesia, Papua New Guinea, Nauru, Vanuatu and Kiribati attended the workshop, as well as observers from SPC, FAO (Food and Agriculture Organization of the United Nations) and the University of the South Pacific.

At the Asia-Pacific meeting of the World Aquaculture Society held in Bangkok in September 2003, an update on the standards project was presented to a special session on grouper aquaculture issues. This was followed by a half-day workshop attended by farmers and representatives of research agencies such as the Network of Aquaculture Centers in Asia Pacific (NACA), the Australian Centre for International Agricultural Research (ACIAR), industry and government, and which facilitated specific feedback on the aquaculture aspects of the standards.

In October 2003, standards review workshops were conducted in the Philippines and Indonesia. The former was conducted in conjunction with the launch of the "Cyanide Free Palawan" movement organised by the Palawan Council for Sustainable Development (PCSD) and the Philippine exporters association (*Industriya Sa Dagat* — ISDA). The workshop was held in Puerto Princessa and attended by representatives from local and national governments in the Philippines, industry operators and non-governmental organisations.

The Indonesia standards review workshop was co-organised by MAC and the *Forum Kerapu*, an informal group that consists of government officials and industry operators with an interest in grouper aquaculture and trade. The focus of this workshop was to give a general introduction to the standards development project to the Indonesia stakeholders. As a follow up, workshop participants requested that a second workshop be conducted to review standards in more detail in January 2004.

During these in-country standards review workshops, the project team conducts a standards validation exercise to verify the applicability and robustness of the standards. For each of the requirements for which tool kits are developed, the validation exercise involves assessing the capability of source countries to undertake assessment and monitoring activities and to implement the requirement. Results of this analysis will feed into the standards development process to produce realistic and achievable best practice standards.

Conclusion

As the standards development process moves forward, attention is increasingly being given to the issue of standards implementation, especially the capacity to implement the standards. Discussions thus far have revealed that while some countries have formulated and implemented a fishery viability assessment process, the process needs strengthening, as it is not a rubber stamping exercise. This is of particular importance where there are currently no LRFFT operations but where baseline assessments show there is insufficient stock to support the trade. In those cases, mechanisms must be put in place to discourage commencement of LRFFT activities.

Overall, the standards development process has enjoyed a positive response from all relevant stakeholders. This is evidenced by the fact that all the standards review workshops have been co-hosted by local organisations, signifying buy-in to the standards development process. Support has been further demonstrated by the high level of workshop attendance and the valuable input the workshops have been able to generate.

News and events
live reef fish

Marine Ornamentals '04 and Aquaculture 2004

Marine Ornamentals '04, the 3rd International Conference for the Marine Ornamental Community, will meet on 1–4 March 2004, in Honolulu, Hawaii, concurrently with Aquaculture 2004, the triennial meeting of the World Aquaculture Society. Marine Ornamentals '04 has the stated goal of creating an economically and environmentally viable future for the dynamic marine ornamentals industry and its diverse clientele by:

- improving the methods for the collection, distribution, and management of wild marine ornamental species;
- increasing the variety, quantity and availability of cultured marine ornamental species; and
- encouraging education and outreach activities in the husbandry and conservation of marine ornamental species.

In addition to presentations and posters on the above topics, Marine Ornamentals '04 will feature a Trade Show that will be part of the larger Aquaculture 2004 Trade Show and Exposition.

A special session of Aquaculture 2004, "Economics, Socio-economics and Markets of Marine Finfish Culture," will be sponsored by the International Association of Aquaculture Economics Management (IAAEM) and the Network of Aquaculture Centres in Asia-Pacific (NACA).

For more information on Marine Ornamentals '04, go to the website http://www.hawaiiaquaculture.org/marineornamentals04.html. For more information on Aquaculture 2004, go to http://www.was.org/meetings/Hawaii/Pages/Hawaii2004.asp.

Study programme on marine finfish aquaculture and markets 2004, Guangzhou and Hong Kong, China

Source: *Marine Finfish Aquaculture Newsletter*, No. 6, July-September, 2003

The study programme is intended to provide participants with an insight into the live marine fish markets and aquaculture in southern China and Hong Kong. The study programme will be organised by NACA [Network of Aquaculture Centres in Asia-Pacific] in cooperation with the Guangdong Dayawan Fishery Development Center (Department of Marine & Aquatic Products, China), Guangdong Provincial Bureau of Ocean and Fisheries, Guangdong Fisheries Society, and the Agriculture, Fisheries and Conservation Department (AFCD) - Hong Kong SAR. Tentative schedule will be around July 2004 period. More information on this study programme will be provided on the marine fish network website when available. Interested parties can contact Mr Sih-Yang Sim (grouper@enaca.org) to register their interest.

Note from the editor: *Marine Finfish Aquaculture Newsletter* is a newsletter of the Network of Aquaculture Centres in Asia-Pacific (NACA). The newsletter is devoted to grouper and coral reef fish aquaculture research, development and commercial farming. It is available at http:// www.enaca.org/grouper/

Queensland adopts new fisheries management plan

After years of development and debate, the Queensland government has adopted the Great Barrier Reef's first comprehensive fish management plan, the Coral Reef Fin Fish Management Plan. The various new controls called for in the plan will be phased in piece by piece over the next year.

Among the new controls are prohibitions on the capture of seven species, including the humphead Maori wrasse (*Cheilinus undulatus*), the barramundi cod (*Cromileptes altivelis*), the Queensland grouper (*Epinephelus lanceolatus*), and the potato cod (*Epinephelus tukula*).

The plan also features period closures aimed at protecting key species during their peak spawning aggregation periods. There will be three, nine-day closures each year, around the new moon in the months of October through December.

A dramatic new measure will be a reduction in the number of reef finfish licences from 1700 to less than 400. The available commercial catch will be reduced from almost 5000 tonnes in 2001 to 3061 tonnes, and it will be allocated as individual transferable quotas.

The plan also includes size limits for a range of reef finfish species. The limits "have been chosen to allow at least 50 per cent of the fish to reach maturity and spawn at least once before being able to be caught", said Henry Palaszczuk, Minister for Primary Industries in Queensland. Recreational fishermen will be subject to bag limits in addition to the fish size limits.

Aquarium fish collectors, which are licensed separately from other commercial fishermen, are generally subject to the new rules, but they will be exempted from the minimum size limits for certain species.

For more information or to download the management plan, visit http://www.dpi.qld.gov.au/fishweb/

MAC Certification

Source: *MAC News*, 3rd Quarter 2003 (extracted from "Director's Note")

Industry participation in MAC Certification is growing steadily. There are now 20 MAC Certified operations, including two collection areas, two collectors associations and four exporters in the Philippines; four importers and six retailers in North America; and two importers in Europe. The only official list of MAC Certified entities is on the MAC website at http://aquariumcouncil.org/subpage.asp?page=130&section=3.

Public commitments to seek to become MAC Certified have now been made by 95 companies in 18 countries, including 40 in the United States; 20 in the Philippines; 9 in Indonesia; 5 in Fiji; 3 each in Australia and UK; 2 each in France, Germany and Solomon Islands; and 1 each in Bahrain, Belau, Brazil, Canada, Israel, The Netherlands, Norway, Spain and Taiwan. These companies are listed on the MAC website at http://aquariumcouncil.org/subpage.asp?page=167&section=3.

Note from the editor: *MAC News* is the newsletter of the Marine Aquarium Council, available at http://aquariumcouncil.org

Pacific Islands: SMART Project to bring MAC Certification to 10 countries

Source: *MAC News*, 2nd Quarter 2003

The Sustainable Management of the Aquarium Reef Trade (SMART) Project is a two-year MAC initiative to ensure Pacific communities involved in collecting marine ornamentals are part of a responsible trade that contributes to sustainable livelihoods and MAC Certification. The SMART Project will assist communities in ecosystem management plans, responsible collection of aquarium products and market linkages within the added-value context of MAC Certification. The project will also seek to increase the number of MAC Accredited certifiers in the region. The SMART Project will focus on economically disadvantaged coastal fishing communities in the Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Palau, Samoa, Solomon Islands, Tonga and Vanuatu.

The SMART Project is supported by the European Union. Project partners include the Foundation of the Peoples of the South Pacific (FSPI) and Just World Partners (a United Kingdom-based group and FSPI member). FSPI is a network of non-governmental organisations throughout the Pacific with metropolitan members in the United States, United Kingdom, Australia and elsewhere.

Field surveys: Reef monitoring protocol for the aquarium trade now available

Source: *MAC News*, 2nd Quarter 2003

Reef Check unveiled the initial working version of the Marine Aquarium Trade Coral Reef Monitoring Protocol (MAQTRAC) at the 2nd International Tropical Marine Ecosystems Management Symposium (ITMEMS), 24–27 March in Manila. Reef Check's reef monitoring specialists and other scientists designed the protocol on behalf of the Global Coral Reef Monitoring Network (GCRMN), the international network of scientists who develop reef assessment methods.

The purpose of MAQTRAC is to monitor coral reefs and populations of organisms harvested for the aquarium trade. It includes 1) carrying out baseline assessments and regular monitoring of coral reefs where harvesting is planned or ongoing and at locations that are seeking MAC Certification or have been MAC Certified, 2) determining the effects on reef health of collection of fish, plants, invertebrates and live rock from coral reefs by MAC Certified collectors working in a MAC Certified collection area, and 3) comparing the health of the reefs where collection occurs with that at reefs where no known harvesting is occurring.

MAQTRAC is the culmination of a two-year development and testing period. Design involved two international peer-review workshops (Indonesia, April 2001, and Hawaii, August 2001), extensive literature reviews and discussions with stakeholders. MAQTRAC was field tested in the Philippines, Indonesia, Fiji, Hawaii and the Maldives from June 2001 through December 2002. The resource assessments carried out in the first two MAC Certified collection areas in the Philippines were part of MAQTRAC development phase.

During the week following ITMEMS, several participants attended MAQTRAC training sessions in Cebu.

MAQTRAC will now be submitted to the MAC Board of Directors for formal review and, if approved, will become an addendum to the MAC Standards. The MAC Board may also authorize training in MAQTRAC as an "Approved Training Course," as per Annex 2 of the MAC Standards. In the interim, MAQTRAC training is proceeding in several areas.

The Ecosystem and Fishery Management Standard [http://aquariumcouncil.org/subpage.asp?section=19] requires that a Collection Area Management Plan (CAMP) be developed. A CAMP must include, among other things, a "basic description of the aquatic ecosystem," "details of any critical environments" and "arrangements and responsibilities for regular monitoring." MAQTRAC provides a standardised, scientifically robust and practical method for meeting these requirements. With the authorisation of the MAC Board, MAQTRAC would become an approved method for gathering this information.

For more on MAQTRAC, contact Reef Check at Rcheck@UCLA.edu.

Good news/bad news in the Marshall Islands: Boosting fisheries observer coverage in the live reef food fish operation

Source: *eMarinelife Newsletter*, June–July 2003

During an April 2003 visit to the Marshall Islands funded by IMA's Coral Reef Conservation Grant from NOAA, IMA staff Karness Kusto and Steve Why, and consultant fisheries adviser Wayne Haight completed an assessment of the live reef food fish operation on Enewetak Atoll and also held discussions with MIMRA on Majuro about boosting fisheries observer coverage. No evidence of cyanide used for fishing was encountered while interviewing the Chinese operator and Filipino fishermen camped on Enewetak and onboard the vessel. That is the good news. Observer coverage during fishing is needed to confirm this.

Now the bad news: 10,000 groupers and Napoleon wrasse were observed being held in 60 cages awaiting shipment to Hong Kong. All of the Napoleons were juvenile. The real bad news is that at least two grouper spawning aggregation sites are targeted each year between November and April by this operation, and the foreign fishermen employ longlining in Enewetak lagoon to catch the fish needed to feed the thousands of caged groupers held for months.

Many of the practices associated with this trade are destructive and unacceptable. According to the Marshall Islands Marine Resources Authority (MIMRA), longlining in the Marshall Islands lagoons is illegal and fishing of spawning sites would not be allowed under a management plan. With this in mind, IMA is participating with MIMRA on the difficult job ahead of improving observer coverage for this operation under a management plan applying to all islands targeted by this trade. Contact stevewhy@marine.org for further information.

Note from the editor: *eMarinelife Newsletter* is a publication of the International Marinelife Alliance (IMA), available at http://www.marine.org

Report of the Grouper Hatchery Production Training Course, May 2003

Source: *Marine Finfish Aquaculture Newsletter*, No. 5, April-June, 2003

In May 2002, the first regional grouper hatchery production training course was organised by the Asia-Pacific Marine Finfish Aquaculture Network under the coordination of the Network of Aquaculture Centres in Asia-Pacific (NACA), in cooperation with Northern Fisheries Centre, Queensland, Australia (QDPI) and Research Institute for Mariculture – Gondol. Support for the training course came from the Ministry of Marine Affairs and Fisheries, Indonesia, NACA, the Australian Centre for International Agricultural Research (ACIAR), the Asia-Pacific Economic Cooperation (APEC) and the Japan International Cooperation Agency (JICA). The training course was successfully conducted in the Research Institute for Mariculture at Gondol, northern Bali, Indonesia.

The second course was organised in May 2003 and it was again successfully completed with 14 participants come from 6 countries. The full report for the second training course is available from the Marine Fish Network website www.enaca.org/grouper/. For further information and future training courses in 2004 contact Mr. Sih Yang SIM at grouper@enaca.org.

Note from the editor: A third training course, Regional Grouper Hatchery Production Training Course 2004, is tentatively scheduled for 17 March–6 April 2004. Interested parties should contact Mr Sih-Yang Sim at grouper@enaca.org.

Price, demand and supply of live reef food fish species – the SARS effects

Source: *Marine Finfish Aquaculture Newsletter*, No. 5, April–June, 2003

The outbreak of SARS during first half of 2003 has had significant impact on the live reef food fish trading in the Asia-Pacific region. The large exporting countries in the region have felt the pinch, with demand dropped significantly for the first half of 2003.

During an interview in April 2003, the Hong Kong Restaurant Association Chairman said that since the SARS outbreak started, 50 restaurants in Hong Kong suspended their business activities and more were predicted to close down if the epidemic is not under control in 3 months. The effect will be significant as there are some 20,000 people working in restaurant business in Hong Kong.

Exporters and fishermen in Australia who are in the live seafood industry were hit hard by this epidemic. An article written by Peter Barker in the Cairns Post (Australia) on the 9th April 2003 asserted that the price for live coral trout has dropped from AUD 35 to AUD 15 per kilogram. The quantity exported also dropped significantly from 5 tonnes a week to a trickle.

In May 2003, most of the live reef fish exporters in Bali, Indonesia suspended their trading activities, as the demand reduced significantly. This negative effect also extended to fingerling traders and hatchery operators where the ex-farm price for grouper fingerlings has reduced by 25%.

Thai and Vietnamese grouper farmers are also being hit by the SARS epidemic, and the farmers in these two countries are sitting on tonnes of market size groupers that they are unable to sell. In Khanh Hoa, Vietnam, farmers were reported to be sitting on stocks of over 300 tonnes of *Epinephelus coioides* and *E. malabaricus* (mainly), with smaller quantities of *E. fuscoguttatus* and *E. bleekeri*, in ponds and cages, waiting to sell. The impact on farmer livelihoods is likely to be significant.

Although, there is a sign of recovery in Hong Kong market the demand is still doubtful. In the short term the demand will probably still be weak and the ex-farm prices for grouper will still be depressed as the supply site is still holding excessive grouper stocks.

SARS fears

Source: *eMarinelife Newsletter*, June–July 2003

Due to the outbreak of SARS in Hong Kong and Southern China, there was a rapid decline in the imports of live reef food fish into the region. On a visit to Kwun Tong Wholesale Fish Market, the largest live fish market in Hong Kong, on Friday 4 April 2003, plenty of empty holding tanks were found in the market, as restaurants were not buying any fish as people were not going out. When asked, one of the major traders said business was "terrible". The trade in Hong Kong is really very depressed, restaurants are really suffering, and this is having a knock on effect throughout the supply chain.

Australian fishermen are reporting huge losses in earnings, with potential bank foreclosure of loans on boats and houses.

Thierry T.C. Chan (International Marinelife Alliance Hong Kong) said that "based on what I have seen so far, there have been 3 out of 40 restaurants closed temporarily due to the SARS (fewer people go out for food) since 1st April."

However, things have improved slightly and overseas suppliers are reporting having received new orders from their Hong Kong clients.

SARS lays low city fishermen

Source: *Cairns Post*, 9 April 2003 (article courtesy of *The Cairns Post*, written by Peter Barker, Business Writer).

When six million people in Hong Kong sneeze, fishermen in Cairns stay home.

Hong Kongers fearing the SARS virus sweeping their city are locking themselves in their high-rise flats.

The karaoke bars are silent, usually bustling restaurants are deserted and the live-fish tanks are empty.

As demand dropped off this week for the Far North's live coral trout exports, prices plummeted from AUD 35 a kilogram to AUD 15, sparking a crisis for the region's third largest industry.

Just two months ago, at Chinese New Year, fishermen were getting up to AUD 80 a kilogram for the reef fish.

Today they sit at home and wait, hoping the epidemic blows over before the banks come knocking on their doors looking for payments on boats and licences that can cost more than a million dollars.

"It's not just the person catching the fish, it's also all the people that work in the industry, the processing and others," said Barry Ehrke of the Queensland Seafood Industry Association.

"It's hundreds, probably thousands, of people from Rockhampton up to the Cape, and that impacts on towns all along the coast because people are not spending the money they usually have."

With five tonnes a week of seafood usually going to Asia through Cairns airport reduced to a trickle, the outlook was not good.

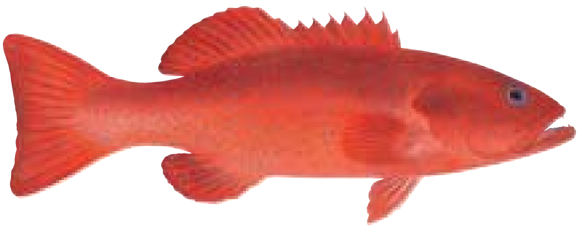
"They've got to wait it out because the profit margins are just not there," Mr Ehrke said.

While the live fish trade was hardest hit because of its popularity in East Asia, prawn prices in the recently opened season were also down on the international market.

The fishing industry, which flew more than AUD 60 million worth of seafood out of Cairns last year, is the hardest hit locally by the Asian SARS outbreak.

Inbound tourism operators reported little drop-off in forward bookings from the region, but Lily Wan of Ranix Chinese Visitor Service Centre said operators were expecting cancellations and reduced bookings in coming weeks.

Bill Calderwood of Tourism Tropical North Queensland said while visitor numbers from East Asia might drop, the region might gain visitors from elsewhere who saw Cairns as a safe destination.



Plectropomus leopardus
Artwork: Les Hata © SPC

Noteworthy publications
live reef fish

Amblard, F. and Chalias V. 2003. The Lombok Frags – an unique initiative in coral culture. INFOFISH International 3/2003:14–20.

Anon. 2003. Destructive live food fish trade opposed locally in PNG: Current status of the live reef food trade operations in the Tigak Islands of New Ireland Province, Papua New Guinea. Website of the International Marinelife Alliance, 31 August 2003. [http://www.marine.org/Content/News/ PNG.html]

Colin, P.L., Sadovy Y.J., and Domeier M.L. 2003. Manual for the study and conservation of reef fish spawning aggregations. Society for the Conservation of Reef Fish Aggregations. Special Publication No. 1 (Version 1.0). 98+iii p. [available in hardcopy or CD from scrfa@hkucc.hku.hk or downloadable from www.scrfa.org]

Domeier, M.L., Colin P.L., Donaldson T.J., Heyman W.D., Pet J.S., Russell M., Sadovy Y., Samoilys M.A., Smith A., Yeeting B.M. and Smith S. 2002. Transforming coral reef conservation: Reef fish aggregations component. Spawning Aggregation Working Group Report. The Nature Conservancy, Hawaii. 85 p. [www.scrfa.org/doc/FSAS.pdf]

Estudillo, Ch.B., Duray M.N. 2003. Transport of hatchery-reared and wild grouper larvae, *Epinephelus* sp. Aquaculture 219(4):279–290.

Halim, A. 2003. A prospect for adoption of grouper mariculture in Indonesia. Marine Policy 27(2):159–167.

Gruenberg, D. 2002. Novel live seafood shipping and freshness preservation technology from Japan. Proceedings of the 3rd International Conference on Recirculating Aquaculture, Roanoke, Virginia (USA), 20–23 July 2000. U.S. Department of Agriculture, Virginia Cooperative Extension Program, Virginia Polytechnic Institute and State University [Blacksburg, Virginia, VA 24060, USA].

Kolm, N. and Berglund A. 2003. Wild populations of a reef fish suffer from the "nondestructive" aquarium trade fishery. Conservation Biology 17(3):910–914.

Abstract: The commercial fishery for coral reef fish for the aquarium trade has begun to change, at least in some parts of the world, from destructive methods such as cyanide and dynamite fishing to less-destructive methods such as hand-net fishing. However, data on the effects on wild populations of such relatively nondestructive methods is nonexistent. The Banggai cardinalfish (*Pterapogon kauderni*) is a paternal mouthbrooder living in groups of 2–200 individuals in the proximity of sea urchins (*Diadema setosum*). This fish has limited dispersal abilities because it lacks a pelagic larval phase, and it is believed to be endemic to the Banggai archipelago off the east coast of Sulawesi, Indonesia. Since its rediscovery in 1995, the Banggai cardinalfish has become a popular aquarium fish, and thousands have been exported—mainly to North America, Japan, and Europe. To study the effects of the aquarium trade fishery on wild populations of the Banggai cardinalfish, we performed a field study in which we quantified density, age distribution (quantified as the ratio of numbers of juveniles to adults) and habitat quality (i.e. sea urchin density) at eight sites in the Banggai archipelago. Through interviews with local fishers, we estimated the fishing pressure at each site and related this to data on fish density. We found a marginally significant negative effect of fishing pressure on density of fish and significant negative effects on group size in both sea urchins and fish. We did not find any effect of fishing on fish size structure. To our knowledge this is the first study to compare sites under different amounts of fishing pressure that has demonstrated the negative effects of the aquarium trade on wild populations of reef fish, despite the widespread use of relatively nondestructive fishing methods. (Reprinted by permission from Blackwell Publishing Ltd.)

Mapstone, B.D., Davies C.R., Slade S.J., Jones A., Kane K.J., and Williams A.J. 2001. Effects of live fish trading and targeting spawning aggregations on fleet dynamics, catch characteristics, and resource exploitation by the Queensland commercial demersal reef line fishery. Report to Fisheries Research and Development Corporation. Project no. 96/138, 72 p. [www.reef.crc.org.au/publications/scientific/]

Olivotto, I., Cardinali M., Barbaresi L., Maradonna F. and Carnevali O. 2003. Coral reef fish breeding: the secrets of each species. Aquaculture 224:69–78.

Osenberg, C.W., St. Mary C.M., Wilson J.A., and Lindberg W.J. 2002. A quantitative framework to evaluate the attraction–production controversy. ICES Journal of Marine Science 59(S1):S214–S221.

Parks, J.E., Pomeroy R.S., and Balboa C.M. 2003. The economics of live rock and live coral aquaculture. In: Cato J.C. and Brown C.L. (eds), Marine Ornamental Species: Collection, Culture, and Conservation. Blackwell Publishing/Iowa State University Press, Inc., 185–206.

Note from the editor: This chapter presents the results of an assessment of the financial feasibility of aquaculture technologies for live rock and live coral, two increasingly popular products in home aquaria. Most of the production of live rock and live coral takes place in Indo-Pacific countries, particularly in Fiji and Indonesia. The global demand for both products — dominated by the United States — has been increasing, and there are concerns that the rates of production of wild product may be unsustainable. Aquaculture is consequently being explored as a way to reduce the extraction rates of wild live rock and coral. Using data from experimental and commercial production facilities in the U.S. and the Indo-Pacific, the authors investigated the feasibility of two types of enterprises, both of them relying on strict aquaculture, with no wild production. The first scenario was a medium-scale U.S.-based producer; the second was a small-scale rural producer based on an Indo-Pacific Island. The results were not particularly encouraging. Strict live rock and live coral aquaculture operations appeared not to be economically feasible, at least not as long as cultured product must compete against wild product and in the absence of a "green" premium that consumers might put on cultured product. However, the authors identified a variety of benefits of live rock and coral culture — including coral reef health — that would appear to justify at least short-term operational subsidies for culture operations, particularly in the small-scale Indo-Pacific scenario. The chapter concludes with a set of recommendations aimed at encouraging a trade in cultured live rock and corals, including some that would improve the profitability of cultured product via green labelling, such as through the third-party certification scheme established by the Marine Aquarium Council.

Paterson, B.D., Rimmer M.A., Meikle G.M. and Semmens G.L. 2003. Physiological responses of the Asian sea bass, *Lates calcarifer* to water quality deterioration during simulated live transport: acidosis, red-cell swelling, and levels of ions and ammonia in the plasma. Aquaculture 218(1–4):717–728.

Power, R.M. 2003. Harvest of settlement stage reef fish for small-scale grow-out or stock enhancement: A feasibility study on the family Haemulidae. In: Creswell, R.L. (ed), Proceedings of the Gulf and Caribbean Fisheries Institute 54:401–412.

Rhodes, K.L., Lewis R.I., Chapman R.W. and Sadovy Y. 2003. Genetic structure of camouflage grouper, *Epinephelus polyphekadion* (Pisces: Serranidae), in the western central Pacific. Marine Biology 142:771–776.

Rhodes, K.L. and Sadovy Y. 2002. Reproduction in the camouflage grouper, *Epinephelus polyphekadion* (Pisces: Serranidae), in Pohnpei, Federated States of Micronesia. Bulletin of Marine Science 70(3):851–869.

Russell, M. 2003. Reducing the impacts of fishing and tourism on fish spawning aggregations in the Great Barrier Reef Marine Park. Gulf and Caribbean Fisheries Institute 54:681–688.

SEAFDEC/AQD. 2001. Husbandry and health management of grouper. Aquaculture Department, Southeast Asian Fisheries Development Center, Tigbauan, Iloilo, Philippines. 94 p.

Note from the editor: This guide has been available in English since 2001, but it is now also available in Bahasa, Thai, Mandarin, Filipino, and Vietnamese. Copies in Vietnamese can be requested

from Le Dinh Buu, email: lbuu.suma@fsps.com.vn or fax: (84-05) 8822921, or from Vu Ngoc Diep, email: vndiep.suma@fsps.com.vn or fax: (84-04) 7716517. For all other languages, contact Dr. Erlinda Cruz-Lacierda, email: eclacier@aqd.seafdec.org.ph or fax: (63-33) 5118709, 3351008.

Sim, S.Y. 2003. Report of the Grouper Hatchery Production Training Course May 2003, Research Institute for Mariculture – Gondol, Bali, Indonesia, 1–21 May 2003.

Singh, T. 2002. Live fish transport and marketing. INFOFISH International 1/2002. [Also published as: Live fish transport and marketing, Fact Sheet No. 5/2002, INFOFISH *Trade News*, No. 6/2002, 18 March 2002.]

Somga, J.R., Somga S.S. and Reantaso M.B. 2002. Impacts of disease on small-scale grouper culture in the Philippines. In: Arthur J.R., Phillips M.J., Subasinghe R.P., Reantaso M.B., MacRae I.H. (eds), Primary aquatic animal health care in rural, small-scale, aquaculture development. Technical Proceedings of the Asia Regional Scoping Workshop, Dhaka, Bangladesh, 27–30 September 1999. FAO Fisheries Technical Paper, no. 406:207–214.

Sugama, K., Ismi S., Kawahara S., and Rimmer M. 2003. Improvement of larval rearing technique for Humpback grouper, *Cromileptes altivelis*. Aquaculture Asia 8(3):34–37.

Wabnitz, C., Taylor M., Green E., and Razak T. 2003. From ocean to aquarium. UNEP World Conservation Monitoring Centre, Cambridge, UK.

Note from the editor: This publication includes a comprehensive survey of the global trade in marine ornamental organisms, based in part on information collected through the Global Marine Aquarium Database. The database was developed by the UNEP World Conservation Monitoring Centre and the Marine Aquarium Council. It is accessible at http://www.unep-wcmc.org/marine/GMAD/. The report is downloadable at http://www.unep.org.

Wood, E.M. and Dakin N. 2003. The responsible marine aquarist. Marine Conservation Society, Ross-on-Wye, UK. 160 p.

Note from the editor: “The responsible marine aquarist” is written for aquarium hobbyists and dealers. According to the book’s publisher, the Marine Conservation Society, the aim of the book is “to help eliminate wastage and pressure on natural resources caused by people buying specimens that are endangered on the reef, collected in a way that causes damage, impossibly difficult to look after, or inappropriate for their level of expertise or tank set-up.” The book includes guidance for making responsible buying decisions and is organised using directory-style entries of particular groups of invertebrates and finfish, with information on the level of trade, the species’ distribution and status in the wild, and their suitability for captivity. A summary provides highlights of conservation issues associated with particular groups of species and gives colour-coded ratings of the ease of caring for particular species groups, like those that are increasingly becoming available for consumers of food fish. The book also gives rough ratings of the level of resource management in the various source countries, along with their respective levels of production of marine ornamentals. Like any effort of this type, some readers will undoubtedly take issue with some of the judgements made, but the book appears to be well researched and is based on the substantial first-hand experiences of its authors. Almost any reader is sure to get something useful out of it. The book is well organised, very readable, and packed full of gorgeous pictures. That, along with its handy size and even the texture of its cover, makes it irresistible to pick up and thumb through.

PIMRIS is a joint project of 5 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 South Pacific Forum Fisheries Agency (FFA), the University of the South Pacific (USP), the South Pacific Applied Geoscience Commission (SOPAC), and the South 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.

PIMRIS

Pacific Islands Marine Resources Information System