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# MONITORING AND MANAGEMENT OF THE HUMPHEAD WRASSE, *CHEILINUS UNDULATUS*

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# MONITORING AND MANAGEMENT OF THE HUMPHEAD WRASSE, *CHEILINUS UNDULATUS*

by
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## PREPARATION OF THIS DOCUMENT

The "*CITES and Commercially-exploited Aquatic Species, Including the Evaluation of Listing Proposals*" project (GCP/INT/987/JPN) implemented by FAO intends to improve capacity of fishing countries to ensure the sustainable use of commercially-exploited aquatic species that have been listed in the Convention on International Trade in Endangered Species (CITES) Appendices, including the humphead/Napoleon wrasse *Cheilinus undulatus* (listed in CITES Appendix II in 2004). Responding to the current lack of expertise and experience in the management of fisheries targeting the humphead wrasse, the project commissioned a desk study covering the characteristics of the live reef fish fisheries (one of the main fisheries exploiting the species), humphead wrasse biology, the relationships between CITES regulations and fisheries management, and issues relating specifically to the management of humphead wrasse fisheries. The results of the desk study are reported in this Fisheries and Aquaculture Circular with a view to begin the development of technical guidelines for managing and monitoring this CITES listed species.

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**ABSTRACT**

The humphead wrasse *Cheilinus undulatus* is a small but important part of the international trade in live reef food fish, being one of the highest species in unit value. The main threats of the live reef food fish trade to the sustainability of the species are overfishing and the effects of destructive fishing on the target species, non-target species and on the reef environment. In 2004 the humphead wrasse was listed on Appendix II of CITES. With the listing, international trade is only permitted if the export will not be detrimental to the survival of the species in the wild. For fisheries resources, in general, this requirement has been interpreted to mean that in the exporting country there must be a functional management plan and associated monitoring. In this context this report discusses the core elements of a management system for humphead wrasse, making considerations about major fisheries management objectives, management measures, enforcement, monitoring and fisheries assessment.

## CONTENTS

**ACRONYMS AND ABBREVIATIONS**

| | |
|---|---|
| AFCD | Agriculture, Fisheries and Conservation Department, The Government of the Hong Kong Special Administrative Region of the People's Republic of China |
| ASEAN | Association of Southeast Asian Nations |
| CITES | Convention on International Trade in Endangered Species of Wild Flora and Fauna |
| CPUE | Catch per unit effort |
| EAF | Ecosystem approach to fisheries |
| FAO | Food and Agriculture Organization of the United Nations |
| FL | Fork length |
| GBR | Great Barrier Reef (Australia) |
| GWSG | Groupers and Wrasses Specialist Group of IUCN |
| IUCN | International Union for Conservation of Nature |
| MA | Management authority |
| MPA | Marine protected area |
| MSY | Maximum sustainable yield |
| NDF | Non-detriment finding |
| NGO | Non-governmental organization |
| PNG | Papua New Guinea |
| PRC | People's Republic of China |
| SCRFA | Society for the Conservation of Reef Fish Aggregations |
| SPC | Secretariat of the Pacific Community |
| TL | Total length |
| TRAFFIC | The Wildlife Trade Monitoring Network |
| UVC | Underwater visual census |
| WWF | World Wide Fund for Nature |

## EXECUTIVE SUMMARY


**Live reef fish fisheries**

Fisheries for live fish from coral reefs have received much attention in recent years. This increased interest is largely due to concerns over the sustainability of the target species, destruction caused by the fishing techniques, expansion of the fishery to new areas, negative interactions with marine tourism, and the prospects of developing new fisheries with large earning for rural fishers. Except for Australia, this fishery is little managed.

**Some features of fishing for the humphead wrasse**

Important aspects include:

- Other than activities oriented to the live reef food fish trade, there are few directed fisheries for the humphead wrasse. This is due to its natural rarity and to the inherent difficulty of capturing the fish.
- In most countries where the fish occurs, most of the catch of this species is for domestic use. Fishing for the live fish trade is relatively important only in Southeast Asia.
- A large number of fishing techniques are used for humphead wrasse in Southeast Asia.
- There is much illegal fishing of this fish, especially the use of cyanide, and considerable illegal trade.
- Spearfishing is one of the important techniques for capturing the humphead wrasse in the non-live fisheries.

**The trade in live reef food fish**

Some 60 percent of the international trade in live reef food fish flows into China, Hong Kong SAR, much of this into the Mainland. Live reef food fish enter the trade either as wild-caught fish that are held briefly before export, about 50–70 percent of the total trade (15 000–21 000 tonnes); undersized fish that are grown in cages or ponds until they reach market size, 15–40 percent of the trade (about 5 000–12 000 tonnes); or (for a few of the groupers and snappers) reared from egg to market size in controlled conditions in full-cycle aquaculture, 10–15 percent (3 000–5 000 tonnes). The humphead wrasse does not undergo full-cycle aquaculture.

**The international trade in humphead wrasse**

Humphead wrasse is a small but important part of the over-all trade in live reef food fish. Although the fish is not even close to being the most important species in terms of volume in the China, Hong Kong SAR market, it is one of the highest in unit value. In 1997 the leading suppliers of the humphead wrasse to the China, Hong Kong SAR market were Indonesia, Philippines, China, Australia, and Malaysia. The total recorded international live trade in this species ranged from about 58 to 138 tonnes for the years 2000–2006. The global domestic trade is likely to be at least 50 tonnes, exclusive of Philippines, Malaysia and Indonesia. Although the humphead wrasse occurs in the waters of 48 countries, the important suppliers of this fish to the live trade are limited to a few countries in Southeast Asia and Papua New Guinea. In addition to its role in the live reef food fish trade, the humphead wrasse is valued for several reasons, especially for local food and its role in dive tourism. Illegal trade in this species appears to be intense in relation to Indonesia, Malaysia and Philippines. Illegal exports from Singapore to China, Hong Kong SAR also occur.

**Threats to sustainability**

The main threats of the live reef food fish trade to the sustainability of fisheries resources are the overfishing of the target species and the effects of destructive fishing on the target species, on non-target species, and on the reef environment. The main threats to the sustainability of these fisheries are whether a fishing enterprise can be profitable when kept on a scale consistent with the limited productivity of the resource and whether the public management costs needed to keep the fishery within sustainable bounds is prohibitive. The threats posed by the live reef food fish trade to the humphead wrasse resource are similar, but more severe. This is because the prices obtained from humphead wrasse are very high, the fish is relatively non-resilient to

fishing pressure, and it is likely that more destructive fishing is associated with this species than for others in the live fish trade due to the difficulty of capture using conventional techniques. The question arises whether this species can be adequately managed and monitored for sustainability.

**CITES and the humphead wrasse**

In October 2004 the humphead wrasse was listed on Appendix II of CITES. International trade of species on this list is permitted only if the export will not be detrimental to the survival of the species in the wild. For fishes, this has generally been interpreted to mean that in the exporting country there must be a functional management plan and associated monitoring. It is recognized that many states will be challenged to develop such monitoring/management for the humphead wrasse. Considerable efforts have therefore been taken to assist countries.

**Fisheries management and the humphead wrasse**

Some of the important desirable attributes of fisheries management are the precautionary approach, the ecosystem approach, adaptive management and participatory decision- making. The major difficulty is that few of the major humphead wrasse exporting countries have much functional management for small-scale commercial fisheries, not to mention these more sophisticated concepts. Some reconciling of ideals and realities is required to develop a workable management strategy.

**Major objectives in the management of humphead wrasse**

Common objectives in the management of humphead wrasse include efforts to:

- achieve a sustainable level of fishing;
- reduce destructive fishing;
- increase humphead wrasse abundance for viewing on reefs by dive tourists;
- increase abundance for cultural/subsistence purposes;
- generate government revenue.

**Management measures**

Various measures could be used to obtain the objectives commonly associated with the management of the humphead wrasse. Some considerations on these measures are:

- All the identified measures have significant deficiencies, especially in the extremely challenging management environment that exists in most range countries, especially major exporters.
- To attain any of the humphead wrasse management objectives that are commonly put forward, it is likely that more than one management measure will be required.
- This leads to the contention that humphead wrasse management requires considerable effort to be effective. Some countries may therefore conclude that attaining certain objectives is not cost effective.
- Many of the measures are applicable to attaining more than one objective. This may suggest that certain measures are especially important in humphead wrasse management. Accordingly, special attention should be given to the various restrictions on exports, the ban on scuba spearfishing, and marine protected areas (MPAs).

**Enforcement considerations**

Some of the recent suggestions for improving humphead wrasse management consist of otherwise sensible measures that are predicated on remarkable progress in enforcement. The reality is that national fishery enforcement arrangements are unlikely to undergo major transformation due to the requirements of the relatively small humphead wrasse fishery. However, some generic suggestions for humphead wrasse management can be made:

- giving priority to management measures that are carried out at the point of export;
- using the collector vessel level;
- using MPAs in appropriate situations;
- engineering enforcement cooperation at the one major overseas destination;
- creating incentives and constituencies for enforcement cooperation;
- using communities in enforcement;

- identifying opportunities for using awareness to facilitate enforcement;
- promoting appropriate legislation.

**Monitoring**

Some important considerations on the collection of information for humphead wrasse monitoring purposes are:

- Rarely will all the desirable monitoring be possible, hence a necessity for prioritising – something that depends on a hierarchy of objectives. In many range countries such a ranking is likely to result in the conclusion that collecting total catch and CPUE data is the most important.
- Should humphead wrasse data from a national fisheries statistical system be available, this could be valuable for monitoring purposes. This information could, however, be erroneous.
- Effective monitoring of the small-scale component of the humphead wrasse fishery in many countries is likely to be costly and/or time consuming and out of proportion with the size/benefits of the fishery. This suggests that, wherever possible, monitoring activities related to humphead wrasse take place at the level of the collector vessel or higher.

**Assessments**

The assessment of a stock of humphead wrasse can range in sophistication from trends in simple biological indicators to very complex stock assessment models. Trends have the advantage that they are simple, easy for developing country managers to use, and are readily understood by policy-makers, fishers and the general public. The more sophisticated models are able to integrate many different types of information on the resource and can give important information, such as potential yields.

**The new stock assessment approach for the humphead wrasse**

A new stock assessment approach has been developed for determining the sustainable catch of humphead wrasse. It is composed of a method for estimating stock density based on underwater visual surveys and a population model. The approach involves the following steps:

- Specifying an objective, such as maximum sustainable yield, or maintenance of a population size above some threshold level.
- Using the population model to determine the rate of fishing mortality that will on average achieve the above objective, and the associated uncertainty.
- Calculating the current size of the population.
- Multiplying the population size by the fishing mortality rate to give a raw catch limit.

The model represents a tremendous advancement in our ability to assess the status of humphead wrasse stocks. Where only analysis of trends in simple indicators was possible in the recent past, there is now a scientific basis for the establishment of catch limits and/or exports quotas. Added advantages are that the model is relatively easy to use and does not require large amounts of data. Drawbacks include the uncertainty in calculation of suitable reef area.

**Rules of thumb**

In countries where expertise in fisheries science is not available for humphead wrasse assessment, there could be considerable value in extending the model to developing simple "rules of thumb" yield estimates based on the model. This could consist of crude ranges in annual yields of humphead wrasse per linear or square kilometre of reef, under various conditions.

**The single species focus of current approaches**

Some simple management measures are needed to produce tangible benefits in an environment that has seen little management success – efforts which could conceivably be broadened in the future to include other species/fisheries or ecosystem considerations.

**Is the humphead wrasse exportable?**

Nothing in this report should be taken as supporting the contention that exporting humphead wrasse is sustainable. Given that the fish is naturally rare, cannot sustain much fishing pressure and is mostly caught in fisheries that are notoriously difficult to regulate, the logical solution in many range countries would be to simply ban the export of humphead wrasse.

## 1. INTRODUCTION

In the Indo-Pacific region the fisheries associated with coral reefs are immensely important as both sources of food and as foundations for numerous economic activities. Many of the fishers that depend on coral reef fisheries have limited alternatives for nutrition and employment. Despite this importance, the knowledge of the dynamics of the fishery resources is at a rudimentary level and the important target species of fishing activity face numerous and growing threats, such as overfishing, destructive fishing, and habitat degradation. There is general agreement that fisheries management interventions to mitigate threats such as these in small-scale, multispecies coral reef fisheries have enjoyed limited success.

Fisheries in the Indo-Pacific region that are oriented to the trade in live fish from coral reefs are especially challenging: they are associated with large economic opportunities, but the fishing activity often involves exacerbating existing threats, while attempts to mitigate those problems are constrained by poor knowledge of many of the concerned species/habitats and the lack of effective and suitable management mechanisms.

The humphead wrasse (*Cheilinus undulatus*, Figure 1) presents a stark example of these difficulties. It is a large spectacular fish that is in much in demand alive in East Asian countries, yet its existence is threatened by its susceptibility to overfishing, extremely high prices and lack of means of protecting the species in the characteristically small-scale fisheries in which it is caught.

**Figure 1**: The humphead wrasse

(*Source:* SPC/L. Hata)

The humphead wrasse (also known as the Maori wrasse and Napoleon fish) occurs on coral reefs and inshore habitats throughout much of the warm Indo-Pacific. For about three decades this species has been a small but significant component of the live reef food fish (LRFF) trade. In the 1990s, the growing concern that the humphead wrasse was suffering from increasing fishing pressure, led to a listing of the species as threatened on the International Union for Conservation of Nature (IUCN)'s Red List of Threatened Fauna and Flora. Subsequently there have been a number of international efforts to protect the species. These culminated in the fish being listed as threatened under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 2004.

The CITES listing had considerable impact. International trade in the fish is now only allowed if exporting countries certify that the trade is not detrimental to the survival of the species. The listing also has focused substantial international attention on the plight of the humphead wrasse. This resulted in technical assistance to countries to comply with CITES requirements, and efforts to develop new stock assessment, monitoring, and management approaches.

Five workshops related to the CITES listing of humphead wrasse were held in 2006.

- 13 January 2006 – in China, Hong Kong SAR, the major importer of the humphead wrasse, a local meeting was jointly held between the Agriculture, Conservation and Fisheries Department of the China, Hong Kong SAR government and the IUCN Specialist Group of Groupers and Wrasses (GWSG).

- 15 and 16 February 2006 – a national level workshop held in Jakarta hosted by LIPI (Indonesian Institute of Sciences) and co-organized with T-SEA, assisted by the IUCN-GWSG. The workshop is on trade dynamics and population status of humphead wrasse in Indonesia and its purpose is to enable a preliminary presentation of trade and underwater visual census (UVC) data collected and to identify remaining data and information gaps.

- 24 March 2006 – one day meeting on implementation and enforcement hosted by the CITES Management Authority of Indonesia.

- 5–7 June 2006– the Western Pacific Workshop on Policy, Enforcement and Sustainable Trade for the CITES Appendix II – listed humphead (Napoleon) wrasse, *Cheilinus undulatus*, was held in China, Hong Kong SAR. The workshop was jointly organized by CITES, IUCN, The Wildlife Trade Monitoring Network (TRAFFIC) and the World Wildlife Fund for Nature (WWF). Attendees included the CITES Scientific and Management Authorities of key exporting countries in Southeast Asia, representatives from fishery divisions, FAO and other relevant organizations.

- 3 November 2006 – one day meeting on the stock assessment model developed by FAO and IUCN-GWSG to assist CITES authorities of Indonesia to determine sustainable export quota for the humphead wrasse. The meeting was hosted by LIPI (Indonesian Institute of Sciences). The model developed was later published as an FAO Fisheries Circular and also presented during the International Expert Workshop on CITES Non-Detriment Findings, held in Cancun, Mexico, 17–22 November 2008 (see Section 3.2).

While the majority of the meetings were concerned with national issues (Indonesia, China, Hong Kong SAR), the Western Pacific Workshop involved most of the important countries in the international trade of the species to provide updates on implementing the CITES requirements and facilitate progress on humphead wrasse management. Recommendations of that workshop included the recognition for regional cooperation among the importing and exporting countries, the necessity for research related to CITES requirements, and the need for increased efficiency of trade monitoring, collection of fisheries data, legislation and law enforcement in compliance. The workshop also stressed the importance of developing guidelines for the monitoring and management of humphead wrasse.

## 2. LIVE REEF FISH FISHERIES

The live reef fish fisheries typically harvest groupers, snappers, and wrasses in the tropical Indo-Pacific region and ship them by air or sea to Chinese communities in east Asia. Although the consumption of live fish has been popular among affluent Chinese for decades, the trade in these fish has received much attention in recent years. This increased interest is due to several factors including concerns over the sustainability of the target species, destruction caused by certain fishing techniques, expansion of the fishery to new areas, negative interactions with marine tourism, and the prospects of developing new fisheries with large earning for rural fishers.

The live reef fish fisheries have been the subject of many recent studies. Johannes and Riepen (1995) was a seminal report in that it alerted a large audience to several important issues related to these fisheries and generated much of the initial enthusiasm to address the associated problems. Subsequent initiatives were undertaken by The Nature Conservancy, World Wide Fund for Nature, TRAFFIC, and the Secretariat of the Pacific Community, the latter of which includes a newsletter dedicated to the subject.[1] CITES and IUCN became very involved when there was some question over the survival of particular species. Presently, the most comprehensive study of live reef fish fisheries and the trade is that which was sponsored by the Asian

[1] Available at www.spc.int/coastfish

Development Bank (Sadovy *et al.*, 2003a) in which nine scientists experienced in live reef fish fisheries offered a history and an analysis of the situation in 2003.

For the purpose of the present study, a wide perspective is necessary. Besides the humphead wrasse, the live fish trade makes use of other several other species, some of which face threats from the trade similar to those of the humphead wrasse. The humphead wrasse is captured by many other techniques than that used for the live fish trade, and all of these methods contribute to its overexploitation. Accordingly, the sections immediately below cover the live fish trade in general, as well as the various fisheries (live and non-live) for humphead wrasse.

### 2.1 Target species of the live fish trade

Sadovy *et al.* (2003a) indicate that in the main destination markets of East Asia, the preferred types of fish in the live reef fish trade come from several taxonomic families. The bulk of the trade consists of the groupers (Serranidae). Also taken are snappers (Lutjanidae), wrasses (Labridae), small numbers of emperors (Lethrinidae), sweetlips (Haemulidae), seabream (Sparidae), and members of a few other families. Highest in unit value are the humpback grouper, the humphead wrasse, and the leopard coral grouper, followed by the squaretail coral grouper, brown-marbled grouper, and camouflage grouper. Table 1 gives the main species, their English/scientific names, and relative value.

**Table 1**: Common fishes in the live reef fish trade

| **Standard FAO English name** (in parentheses: English name used by China, Hong Kong SAR Officials) | **Scientific name** | **Value in China** |
|---|---|---|
| Giant (giant) grouper | *Epinephelus lanceolatus* | High value |
| Humpback (highfin) grouper | *Cromileptes altivelis* | High value |
| Humphead (Napoleon) wrasse | *Cheilinus undulatus* | High value |
| Leopard (leopard) coral grouper | *Plectropomus leopardus* | High value |
| Spotted (spotted) coral grouper | *Plectropomus maculatus* | High value |
| Squaretail (squaretail) coral grouper | *Plectropomus areolatus* | Medium value |
| Brown-marbled (tiger) grouper | *Epinephelus fuscoguttatus* | Lower value |
| Camouflage (flowery) grouper | *Epinephelus polyphekadion* | Lower value |
| Duskytail (duskytail) grouper | *Epinephelus bleekeri* | Lower value |
| Greasy (greasy) grouper | *Epinephelus tauvina* | Lower value |
| Hong Kong (red) grouper | *Epinephelus akaara* | Lower value |
| Malabar (Malabar) grouper | *Epinephelus malabaricus* | Lower value |
| Orange-spotted (green) grouper | *Epinephelus coioides* | Lower value |

*Source:* modified from Sadovy *et al.* (2003a)**.**

Lau and Parry-Jones (1999) indicate that the three most important single species by weight imported into China, Hong Kong SAR in 1997 were the mangrove snapper (*Lutjanus argentimaculatus*), the green grouper (*Epinephelus coioides*), and the leopard coral grouper (*Plectropomus leopardus).*

Individual countries supplying the major markets often produce a mixture of species different from that above. Prior to the closure of the live reef fish fishery in 2005, the major species exported from the Seychelles were *Epinephelus polyphekadion, Plectropomus punctatus,* and *Cheilinus undulatus* (Aumeeruddy and Robinson, 2006). Johannes and Lam (1999) state that the most important species of live food fish exported from the Solomon Islands are *Epinephelus fuscoguttatus, Epinephelus polyphekadion, Plectropomus areolatus* and *Cheilinus undulatus.* A total of 90 to 95% of all live food fish exports from Australia are coral grouper, particularly *Plectropomus leopardus* (Mapstone *et al*., 2001). Richards (1993) reports that in Papua New Guinea different companies targeted different species of live fish.

Sadovy and Vincent (2002) and Lau and Parry-Jones (1999) comment on the species in the live fish trade from the perspective of the demand side. Consumers show a clear preference for certain sizes, colours, and species of live food fishes in restaurants and markets and confer a high value on rarity. Groupers are favoured for their taste, as is the humphead wrasse. Chinese consumers prefer fishes that are reddish such as the coral trout, believing that color to be auspicious. Species or colour forms that are rare (e.g. the albino coral trout) or that have medicinal value (e.g. the giant grouper) fetch particularly high prices.

## 2.2 Fishing activities

### *2.2.1 Live reef food fish*

Johannes and Riepen (1995) provide the history of live reef fish fishing activities. For centuries it has been a popular Chinese custom to keep fish alive until moments before they are cooked. Until recent decades these fish were limited to fresh water species and marine fishes caught in local waters. In the 1960s a few marine species from more distant waters began appearing in China, Hong Kong SAR's live fish markets. These fish were mainly imported as fingerlings and raised locally in cages, but Chinese consumers acquired a preference for wild-caught adult fish. Initially the supplies came from nearby areas, but in 1968 Hong Kong fishers began exploiting a reef 200 miles southeast of Hong Kong using droplines, longlines and gillnets. As demand increased, fishers moved to more remote areas of the South China Sea, and then in about 1975 into the Philippines, where two innovations were introduced: the use of cyanide to catch fish and the shipping of the high value species by air. In 1984, a China, Hong Kong SAR company began fishing for groupers and humphead wrasse in Palau. By 1989 Hong Kong operations were moving quickly into Indonesia. Live reef fish fishing activities of Hong Kong companies expanded into new areas, including Papua New Guinea (1991), Australia (1993), Maldives (1993) and the Solomon Islands (1994).

A variety of techniques are used in live reef food fish fishing for both marketable size adults and for smaller fish destined for grow-out before marketing. Sadovy and Vincent (2002) state that fish are captured by hook and line, trap, nets, artificial reefs, and chemicals. Different fishing techniques are used depending on the fishing location. Erdmann and Pet-Soede (1997) describe the situation in the major supplying country, Indonesia:

> *Capture of the fish by stunning them with cyanide solution is the most common method. In addition to cyanide fishing, significant numbers of live fish are captured using hook and line, fish traps, or nets. Fish are collected in the country by two types of fishers: individuals working alone or in small groups in locally modified boats, often with loaned equipment/cyanide, and by well-organized teams of divers working from large "catcher" ships equipped with 6 to 10 fiberglass dinghies and livehold tanks that can accommodate one to two tonnes of live fish. Such vessels can range much further afield than small boats, although both types deposit their catch in the same holding cages at central collection points. Fish then await collation into volumes large enough to justify pick-up and transfer by large transfer vessel. "Storage" times can vary from only two weeks in the largest collection centres like Ujung Pandang and the Moluccas, to four months in smaller areas like the Togian Islands.*

Somewhat different techniques are used in other locations. SPC (2001) indicate that two methods are used legally to catch live reef food fish in Papua New Guinea: hand lines and traps. For the latter, the choice of bait and fishing time depends on the species targeted. The traps are mainly rectangular or arrowhead in design with a frame of steel or mangrove, covered with chicken wire. The traps are commonly placed by divers using hookah gear. Rocks and coral are packed around the trap to create a realistic habitat. Although the use of cyanide for fishing is illegal, according to fishers associated with past live reef food fish operations in Papua New Guinea, the chemical is often used. A squirt bottle is used to deliver the cyanide solution as close as possible to the target fish. Most operations (legal and illegal) fish from a specially fitted dingy with a sea water compartment that allows free flow of water into the compartment. The target live fish are held in the compartment for the duration of the fishing and used to transport the fish to a larger carrier vessel where they are kept or further transported to cages anchored off reefs. Fish held on the carrier vessels or in cages need food, which mainly comes from other fishing operations.

There are numerous variations of the Indonesia and Papua New Guinea techniques described above:

- In the Seychelles when a live fish fishery operated there, the use of scuba and hookah was not permitted and only hook-and-line gear was allowed (Aumeeruddy and Robinson, 2006).
- In the Solomon Islands Johannes and Lam (1999) report the use of special hooks designed to minimize mouth damage and canoes with special salt-water holding pens.
- McCullough and Hai (2001) report on live reef food fish operations in four provinces of Viet Nam. Some of the important features are the parallel fisheries for live lobster at many locations and the widespread use of cyanide.

The use of cyanide as a live fish fishing technique deserves special mention. McAllister *et al. (*1999) indicates that the use of the chemical[2] first began in the early 1960s in the Philippines to stun ornamental fish making them easy to capture. Its use for this purpose grew to at least 150 000 kg per year in the Philippines. Johannes and Riepen (1995) report that cyanide is widely used and readily available in the Philippines, Papua New Guinea and Indonesia for gold and silver mining, electroplating and for poisoning pest species in fish ponds. Pet-Soede and Erdman (1998) report that cyanide is the "gear" of choice in three main Indonesian fisheries: ornamental fishes, live reef food fishes and rock lobsters. The basic technique involves divers, often supported by hookah, using a burst of cyanide solution from squirt bottles to stun their targets. While an "overdose" results in the death of the target organism, a properly calibrated squirt allows the diver to easily remove the anesthetized animal from its refuge in the reef framework, often after the breakage of coral surrounding the refuge. Sadovy *et al.* (2003b) reports another method of using the chemical: cyanide-laced baits for trap and hook-and-line fishing. Those authors also report that some species, such as the humphead wrasse, especially small size individuals taken for "grow-out" to marketable size, can only be taken efficiently with cyanide. Cases have been documented in many countries which live reef food fish operations professed to be using legitimate fishing techniques, but subsequently were discovered to be using cyanide. This has occurred in several places, including Papua New Guinea (Lokani and Kibikibi, 1998; SPC, 2001), the Marshall Islands (Smith, 1997), Maluku Islands of Indonesia (Thornburn, 2003), Indonesia (CITES, 2006), and Solomon Islands (Johannes and Lam, 1999).

Another important feature of live reef fish fishing operations is mobility – they can easily move to new locations when fish stocks are depleted. Because of both high mobility and rapid depletion, a very large number of coastal locations in the Indo-Pacific region have been visited by live reef food fishing operations, to the point that certain discernible patterns have emerged. Sadovy *et al.* (2003a) discuss this phenomenon in Southeast Asia:

- The first phase involves the incursion of large foreign-owned or joint venture purpose-built LRFF catcher vessels with outside (non-Indonesian) fishers, using cyanide. These operations have relatively high overheads. Thus, they target the highest value fish and require large volumes of fish to be profitable. The high fishing pressure and the systematic use of cyanide to remove the target species result in significant overfishing of the target fish and damage to the reefs. As populations of the highest value fish dwindle, the vessels move on to new areas.
- With the departure of the more capital-intensive operators, the second phase has usually involved small- to medium-scale operators, frequently businesspersons operating locally taking over. Characteristically, their approach has been to provide credit to local fishers to purchase boats and equipment, accepting live fish as payment, and requiring the indebted fishers to use cyanide supplied by the trader. At times, a trader will enter into a contract with a whole village for permission to develop a live reef food fish operation in their waters.
- These fisheries are also typified by lack of management and considerable illegal activities in some places.

Johannes (1997) summarizes a study in Indonesia by Pet-Soede and Erdman that shows a similar pattern in which fishing methods appear to evolve from (a) cyanide fishing, to (b) hook-and-line and trap fishing, to (c) trap fishing for juveniles for grow-out, to (d) an "almost post-apocalyptic" no live reef fishery at all.

### *2.2.2 Fishing for fry for aquaculture*

There is another type of fishing associated with the live reef food fish trade – the capture of juveniles for aquaculture purposes.

Many of the high-priced species, such as coral trout, *Plectropomus leopardus* and humphead wrasse *Cheilinus undulatus*, still cannot be cultured from hatchery-produced eggs, but more and more reef species are being successfully raised in aquaculture operations. Although some live fish trade species are raised by full-cycle culture (i.e. giant grouper, *Epinephelus lanceolatus* and *E. coioides*), capture from the wild remains the main source of most grouper fingerlings for the grow-out industry (McGilvray and Chan, 2003;

[2] Both sodium cyanide and potassium cyanide are used in fishing activities. Both are potent toxins that stun fish, but sodium cyanide is apparently cheaper.

Mous, Halim and Pet, 1999). The annual grouper fry/fingerling catch in Asia is estimated to be in the hundreds of millions of fish (Sadovy *et al.,* 2003a).

Many different fishing techniques are used to capture juveniles to be cultured for the live reef food fish trade. Johannes and Ogburn (1999) describe fourteen collection methods in the Philippines alone for grouper post-larvae, fry and fingerlings. These include the use of artificial habitats that provides shelter for juvenile grouper, fyke nets, liftnets and push nets.

### *2.2.3 Fishing for humphead wrasse*

The techniques and gear described above are those for use in the live reef food fish fisheries in general. Focussing on the humphead wrasse, more specialized methods are used for this fish in various live and non-live fisheries. Sadovy *et al.* (2003b) using a large number of sources summarize the fishing activity for this fish in 20 areas from French Polynesia in the central Pacific Ocean to Madagascar in the western Indian Ocean. Table 2 updates that information.

From Table 2 a number of features are apparent:

- There is much illegal fishing of the humphead wrasse. In addition to the very common use of cyanide (illegal in all countries listed), there is scuba spearfishing (illegal in most countries) and the use of other illegal poisons (i.e. derris root).
- Other than activities oriented to the live reef food fish trade, there are few directed fisheries for this fish. This is likely to be due to its natural rarity and to the inherent difficulty of capturing the fish.
- In most countries where the fish occurs, most of the catch of this fish is for domestic use. Fishing for the live fish trade is relatively important only in Southeast Asia.
- A large number of fishing techniques are used for humphead wrasse in Southeast Asia.

There are two categories of live reef food fisheries that catch the humphead wrasse: directed and opportunistic. Some fisheries target this fish almost exclusively, while others catch the species on an opportunistic basis. This feature has implications for selecting management measure (Section 6.3).

Indonesia is the largest producer of humphead wrasse. Box 1 describes the fishing techniques used in that country that results in the capture of humphead wrasse.

**Table 2:** Fishing activities for the humphead wrasse

| Country | Fishing activity |
|---|---|
| **Australia** Great Barrier Reef | Handline/1–3 hooks; taken for live trade, also fresh, frozen, fillet and whole for domestic use – few for public aquaria. Prize catch in spearfishing contests and for recreation. Exports of live fish were only permitted by air. |
| **Fiji** | Night spearfishing and poison (derris) widely used; considered difficult to catch using other means; in the past some export both live and chilled. One live fish operation exported fillets taken from humphead wrasse considered too large to export live, and about 4 tonnes live annually. Only two live reef fish exporters currently active. Since September 2004 there has been a ban on the commercial take, capture for sale, offer for sale, or possession of live or dead specimens of the humphead wrasse. |
| **French Polynesia** Society Islands | Spearfishing for domestic use, more recently involving taking larger fish from sleeping holes at night. No known export. |
| **Guam** | Night spearfishing on SCUBA. No known export. |
| **Indonesia** | The species is heavily sought for live export. Many fish caught live with cyanide; other methods not considered so efficient. Small fish heavily taken for mariculture grow-out (see Mariculture) by small trap, hook and line, net or cyanide. Mariculture (from grow-out) is now a common means of procuring live fish. Illegal fishing and corruption are associated with the trade. Export of live humphead wrasses by sea and air; larger fish by sea, those <2 kg often by air. Some fillets are also exported by air, according to the Agriculture, Fisheries and Conservation Department, The Government of the Hong Kong Special Administrative Region of the People's Republic of China, AFCD'S confiscations in China, Hong Kong SAR. |
| **Japan** | Unknown capture method. Some aquarium trade. No known export for food. |
| **Kiribati,** Christmas Island | The species is considered to be particularly vulnerable to fishing. Export has occurred sporadically, but no operations were functional in mid-2007. |
| **Malaysia,** Mainly Sabah | Humphead wrasse is a prime target for live export. Fish are taken by cyanide and hook and line, and frequently captured while juvenile and grown-out in cages to market size, especially in Kudat, Sabah. Much illegal fishing also takes place in southern Philippines waters with fish exported via Malaysia, mainly by air. |
| **Marshall Islands** | The species is sought for live export and transported by sea to China, Hong Kong SAR. |
| **Mayotte** Comoro Archipelago **and Madagascar** | Spearfishing and handlining of small numbers of humphead wrasse for local use. No known export. |
| **New Caledonia** | There is no known export of live humphead wrasse. Small fish (<40 cm TL) occasionally sold dead in Noumea markets, with larger fish sold as fillets (recognizable by the skin attached to fillet). Not common, taken by spear. |
| **Palau** | Taken by spear at night, since 1970s with torch and increasingly with SCUBA at night although use of SCUBA with spear is illegal. Long used for local customs, it was briefly exported live in the mid 1980s. |
| **Papua New Guinea** | The species is especially sought for live export, although there is some local use for customs. Small fish are grown-out in cages. Sometimes caught by using derris to stupefy fish which is then put in a copra sack at night. Fish exported by sea and air. |
| **Philippines** | The species is a prime export fish. Juveniles are commonly caught and grown-out in cages to market size in certain areas (e.g. Palawan). Cyanide is the fishing method reported for this species. Small fish taken dead in traps sold locally. Export of live fish is principally by air and all is illegal. Much reaches China, Hong Kong SAR via illegal trade through Malaysia. |
| **Seychelles** | Not traditionally taken but targeted briefly for export of live fish; shipments transported by sea. |
| **Solomon Islands** | This species is sought for live export with some domestic sale. In the Western Province, fish are taken with traditional traps that are baited and closed by hand when the fish enters and with hook and line or spear. Export by sea only, when permitted; no export operations were functional in mid-2007. |
| **South China Sea** | Small numbers taken in the past from China, Hong Kong SAR, Hainan Islands, and especially from offshore reefs (Pratas Reef, Paracel and Dangan Islands), and Pescador Islands of Taiwan, largely by spear or cyanide. |
| **Tuvalu** | No known export. Occasionally taken by spear, or by hook and line baited with land crabs. Not a prized fish. |

*Source*: Sadovy *et al.* 2003b.

**Box 1:** Methods used in Indonesia for catching humphead wrasse

**Bubu:** A cage trap made of woven steel, nylon or rattan. Can be placed anywhere on a reef or on the seabed, and left for a "soak time" varying between one day and 1–2 weeks. The trap is often baited with dead fish, and weighed down with rocks, except steel bubu that can sink if heavy enough. It is an un-targeted method of fishing, although the size of the fish caught can vary with the size of the trapdoor. Fish caught using this method will be retrieved alive although sometimes injured by ramming against the cage in an attempt to escape.

**Hook-and-line:** A simple apparatus of nylon line and steel hook. Used without a rod these lines are often short, no more than 5 m, held up by the hand and suspended from boats over a reef or when standing on a reef flat or beach. Often used by children to pass time, and can be commissioned by collectors for their catches, as is largely the case in North and South Sulawesi provinces. Hook and line is apparently the most effective and deployed method for catching the humphead wrasse. Fish caught using this method will be retrieved alive and usually in good condition.

**Cyanide/SCUBA:** Cyanide (Potassium cyanide) is released into the water around reef habitat to stun fish and enable easy collection. This method allows for species-targeted fishing, as divers rigged with SCUBA units get within close range of the fish and squirt cyanide into reef crevices. When fitted with SCUBA units, divers can stay down for as long as their air or cyanide last. Being expensive, cyanide is allegedly supplied to subsistence fishermen by wealthier collectors and exporters because the fishermen are unable to afford it. Fish caught using this method are retrieved and sold live.

**Cyanide/hookah:** Basically the same as the SCUBA section above, however the divers this time are breathing air through a line attached to a surface compressor. This method of diving is extremely dangerous with high risk of decompression sickness or related illness. Fishermen using this method often go deep by using extremely long hoses, sometimes between depths of 30 and 60 metres. Using hookah, divers stay down for as long as they can physically tolerate. Fish caught using this method will be retrieved alive.

**Trawling**: This involves actively pulling a fishing net through the water behind one or more boats. Nets of varying sizes can be trawled in surface waters, deep water and over the bottom. This method is known for its non-selective catch. Reef fish caught using this method are often damaged or killed and are usually sold dead.

**Longline**: A technique adopted by subsistence fishermen from commercial fishing vessels, longline fishing involves hundred of baited hooks hanging from a single line. In Indonesia longlines are often made of nylon but also of steel, though the former is preferred for its lower cost. It is also non-selective, but catches mainly grouper and snapper, although humphead wrasse is also sometimes caught. Fish caught with this method are usually sold dead.

**Spear:** Spear-fishing involves free-diving or SCUBA diving, armed with a pneumatic powered speargun to strike the hunted fish. While spear-fishing with SCUBA unit is illegal in some countries, it remains legal in Indonesia. Most fishermen are unable to afford SCUBA units and continue to free-dive. Fishes caught with this method are always sold dead.

**Traditional purse seine**: Different from commercial purse seine, traditional purse seine fishing is carried out over a reef flat. It often involves two boats and people walking on the reef flat to frighten fishes into the net as it is narrowed and closed by pulling a drawstring along the bottom of the net. This method of catching reef fish is significantly destructive, often getting tangled with coral on the reef and hauling up undifferentiated fish and marine organisms. Fishes caught with this method are usually sold dead.

**Bomb**: Home-made explosives detonated on a reef that cause severe damage to an area of coral and associated species. An indiscriminate method of fishing that can also kill fish and other marine organisms by sonic boom. Bomb fishing was outlawed in Indonesia in 1995. All fish caught with this method are sold dead.

**Gillnets**: The gillnet is designed so that the fish get their head into the gap between the strands, but not their body. When the fish enters and then tries to get out, the net snags the gill covers or operculum and traps the fish. Normally, the mesh size of the net allows smaller fish to pass through unharmed. However, as more fish are caught by the net, smaller fish may be caught as well, unable to pass through the tangled netting caused by the initial layers of larger fish. These nets may also trap marine mammals and other non-target species.

**Free-diving**: Also known as breath-hold diving, this method is also used for the application of cyanide on reefs and spear fishing. Divers equipped with small, hand-held nets choose and harvest fish from the reef. Fish caught with this method can be sold live.

*Source:* CITES (2006)

Spearfishing is one of the important techniques for capturing the humphead wrasse in the non-live fisheries. Because the fish sleeps in reef caves or crevices, it is extremely vulnerable to night spear-fishing. Gillett and Moy (2006) examine spearfishing in several regions and make several observations relevant to the humphead wrasse:

- Spearfishing is completely banned in several countries of the Indian Ocean, including the Maldives, Seychelles, and Kenya.
- Night spearfishing and scuba spearfishing enables divers to target the usually higher value species, which often includes the humphead wrasse.
- Scuba spearfishing diminishes or eliminates the positive effects of deep water acting as a sanctuary for fish. This is especially serious for the humphead wrasse, which often seeks refuge in deep water from divers.
- In some of the more affluent countries/territories of the Pacific Islands region (e.g. Guam, New Caledonia, French Polynesia, parts of the Cook Islands) recreational spearfishing is quite important and the humphead wrasse is a prime target.
- Spearfishing is generally thought of as a small-scale fishing activity, but there are operations using vessels up to 40 metres in length with dozens of spearfishers.

Although not strictly a "fishing technique", the grow-out of wild-caught humphead wrasse is quite important in the production of this species for the live fish trade. This is commonly practiced in Indonesia and Malaysia and also occurs in the Philippines, where it is one of the most highly valued fish cultured. This has unknown impacts on adult stocks. Small individuals, typically 20–40 cm and mostly juveniles, are regularly taken from the wild and raised in floating net cages until they reach saleable size; this activity is commonly referred to as "culture", "farming" or "cultivation", but is essentially a capture fishery of juveniles and their maintenance in captivity to legal or marketable size. This appears to be one way around legal size limits on this species in Indonesia and the Philippines. Given the extensive capture of juvenile humphead wrasse for grow-out, the distinction between mariculture (hatchery produced juveniles) and wild-caught juveniles placed into grow-out is important. For CITES purposes, the grow-out of wild caught juveniles is considered to be a capture fishery (Chu *et al.*, 2006).

Juveniles, too small for grow-out, are also collected for the aquarium trade in some countries. In Indonesia this represents almost ten percent of the trade (Figure 4).

## 2.3 The trade

### *2.3.1 The general trade in live reef food fish*

The general trade in live reef food fish is reasonably well documented. The Secretariat of the Pacific Community's "Live Reef Fish Information Bulletin"[3] and "While Stocks Last: The Live Reef Food Fish Trade" (Sadovy *et al.*, 2003a) are especially informative publications. The former contains very current information by many authors and agencies, while the latter is a comprehensive summary of the trade and its implications.

Unless otherwise noted, information in this section on the general trade in live reef food fish is taken from Sadovy *et al.* (2003a), with updates from recent SPC information bulletins.

Live fish have long been traded around Southeast Asia as a luxury food item. Fish are displayed alive in aquaria in restaurants and markets (Figure 2). Consumers select individual fish that are then cooked and served in a restaurant of choice, or the fish are taken home to be prepared fresh. Chinese communities are the main consumers and the principal demand centres are China, Hong Kong SAR, Mainland China, and Chinese Taipei. Some 60% of the international trade in live reef food fish flows into China, Hong Kong SAR, but more than half of that is "re-exported" to Mainland China. China does not monitor its imports with thousands of fish with re-export permits into Mainland China leaving Hong Kong SAR per year and non registered as imported in the Mainland.

[3] Sixteen bulletins have been issued between March 1996 and December 2006; available at www.SPC.int/coastfish

**Figure 2**: Humphead wrasse on display in a Shanghai Restaurant

*Source:* M. McCoy

Live reef food fish enter the trade either as wild-caught fish that are held briefly before export, about 50–70% of the total trade (15–21 000 tonnes); undersize fish that are grown in cages or ponds until they reach market size, 15–40% of the trade (about 5 000–12 000 t); or reared from egg to market size in controlled conditions in full-cycle (i.e. hatchery-based) aquaculture, 10–15% (3 000–5 000 t). Transport of these fish is by sea or air, depending mainly on the location of the fishery or holding facilities and available air links.

Based on government data on imports and retail prices, the gross retail value of the trade in China, Hong Kong SAR, during 1999–2002 was around US$350 million per year.[4] Corrected for unreported fish, the total retail value in 2002 of the trade there was around USD 486 million and for the region as a whole, about US$810 million. The main exporting countries of live reef food fish are Indonesia, Philippines, Australia, China,[5] Malaysia, Thailand, Viet Nam and Chinese Taipei. Other countries involved are Fiji Islands, Marshall Islands, Papua New Guinea, Singapore and the Solomon Islands. The higher-priced fish come mainly from Indonesia, Malaysia, Philippines and Australia.

The international fish trade in live reef food fish is not well monitored. In most countries, export figures are either unavailable or unreliable. On the import side, the Government of China, Hong Kong SAR provides reasonable estimates of imports of each of the major fish in the trade, although there is substantial underreporting because vessels licensed in China, Hong Kong SAR are not required to report their landings, and these account for a significant proportion of imports. The Government collects data informally from this exempt sub-sector, but imports by exempted vessels are still underreported by a significant factor (50% by government estimates).

The international live reef fish trade was worth around US$350 million/year during 1999–2002. At its peak in 1997, the volume of fish in the trade was estimated to be about 50 000 tonnes at the retail end. Since then, the volume has declined to about 30 000 tonnes. The actual quantities of fish captured are probably much greater, given the sometimes considerable proportion of fish, averaging about 50%, that die before reaching the market. Although air transport results in less mortality en route, many fishing grounds are far from airline routes, and mortalities associated with cyanide use or during holding prior to export are common to both sea and air transport. Most conclusions made about the size of and trends in the trade will be questionable and superficial until such time when long-term and comprehensive data become available, not only for China, Hong Kong SAR imports, but also for other importing countries and for the source countries.

[4] Unless otherwise noted, all monetary units in this report are in US dollars.
[5] Mostly the Pratas, Paracel and Sprately Islands.

The trade in live reef fish has experienced a number of shocks in the last decade. This includes a high incidence of ciguatera poisoning in the early 1998, the Asian financial crisis in the late 1990s, and the outbreak of severe acute respiratory syndrome in 2003 (Sadovy, 1998; Erdman and Pet-Soede, 1999; Pet-Soede, Horuodono and Sudarsono, 2004).

There are several recent changes to live fish trade. On the technical side these include a shift towards fish produced in growout operations, greater use of air transport rather sea transport,[6] and more direct shipment of fish to mainland China from source countries (e.g. Viet Nam). In terms of the regulatory environment, the involvement of international agencies and non-governmental organizations (NGOs) has increased, leading to a greater awareness of problems. This has subsequently catalyzed action towards improving the monitoring and management of the live reef food fish industry. The listing on Appendix II of CITES of one species (humphead wrasse) has to some extent focussed international attention on the entire trade. Some countries have become disenchanted with the export trade (Seychelles banned the trade in 2005) while others have introduced controls that have resulted in companies scaling back or halting their activities (McGilvary and Chan, 2003; Aumeeruddy and Robinson, 2006; Ovasisi 2006).

### *2.3.2 The trade in humphead wrasse*

Humphead wrasse is an important part of the overall trade in live reef food fish. Although the fish is not even close to being the most important species in terms of volume in the China, Hong Kong SAR market, it is one of the highest in unit value and profit margin. Lau and Parry-Jones (1999) indicate that it was the second highest in value during their survey, after the giant grouper, *Epinephelus lanceolatus.*[7] As expressed by the Chairman of Hong Kong Chamber of Seafood Merchants.[8]

> *"In our opinion, people in Hong Kong consider humphead wrasse to be a luxury product. It is a delicious species, and is rare. The richer people are, the higher the demand, no matter how expensive it is."*

In 1997, the leading suppliers of the humphead wrasse to the China, Hong Kong SAR market were (in descending order) Indonesia, Philippines, China,[9] Australia and Malaysia (Lau and Parry-Jones, 1999). Since 1997, depletion of the fish in the waters of nearby countries has resulted in sourcing supplies further afield.

China, Hong Kong SAR import statistics on the humphead wrasse for recent years are given in Table 3.

If China, Hong Kong SAR imports represent 60 percent of the international trade in the humphead wrasse (Sadovy *et al.*, 2003b), then according to Table 3, the total international trade in this species is about 58 to 138 tonnes for the years 2000–2006. The data on which this assertion is made is, however quite poor, especially that concerning imports on HK registered fishing vessels (Lau and Parry-Jones, 1999; Chu *et al.*, 2006).

Even less is known about the size of domestic trade in humphead wrasse (Figure 3). For the three major producing countries of this fish (Indonesia, Philippines and Malaysia), data are not available. Most national fishery statistical systems in the many countries where this fish is taken either do not cover this fish specifically, or where they do, are dubious in accuracy. Using a large number of sources, Sadovy *et al.* (2003b) estimate that global domestic trade in this species is likely to be at least 50 tonnes, exclusive of Philippines, Malaysia, and Indonesia. On the other hand, Sadovy *et al.* (2007) uses a figure of 100 tonnes for domestic consumption in Indonesia reported to FAO in 2004 based on Anon. (2006).

The usual case in many countries is for live fish to be exported and non-live fish to be consumed domestically, but the opposite does occur. Chu *et al. (*2006) indicates that tourists from China, Hong Kong SAR go to Sabah in Malaysia to eat live humphead wrasse. There has been significant export of non-live humphead wrasse from Papua New Guinea (J. Kinch, unpublished data) and the China, Hong Kong SAR Government intercepted an illegal air shipment of humphead wrasse fillets during the Chinese New Year in 2007 (Y. Sadovy, personal communication).

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[6] Interest in land versus sea transport seems to change over time and may be linked to fuel costs among other factors.

[7] More recently the mouse grouper, *Cromileptes altivelis*, is likely to have surpassed the humphead wrasse in unit value (Peter Mous, personal communication).

[8] Comment made at the Western Pacific Workshop on Policy, Enforcement and Sustainable Trade for the CITES Appendix II – listed Humphead/Napoleon Wrasse, *Cheilinus undulatus* 5–7 June 2006, China, Hong Kong SAR.

[9] The Pratas, Paracel and Sprately Islands.

**Table 3**: China, Hong Kong SAR imports (in kilograms) of humphead wrasse

| Data source | Country of origin | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | Average 2000–2006 |
|---|---|---|---|---|---|---|---|---|---|
| **From HK Census and Statistics Department** Covers imports by all means except HK fishing vessels | Australia | 0 | 2 651 | 49 | 0 | 0 | 0 | 0 | 386 |
| | Cambodia | 1 497 | 0 | 0 | 0 | 0 | 0 | 0 | 214 |
| | Singapore[10] | 0 | 0 | 0 | 0 | 0 | 12 450 | 6 270 | 2 674 |
| | Papua New Guinea [11] | 0 | 0 | 0 | 0 | 0 | 4 516 | 4 330 | 1 264 |
| | Indonesia | 875 | 499 | 5 344 | 4 203 | 544 | 4 919 | 1 270 | 2 522 |
| | Philippines | 5 055 | 5 343 | 20 752 | 9 514 | 5 889 | 212 | 0 | 6 681 |
| | Malaysia | 4 503 | 3 438 | 2 497 | 2 541 | 2 221 | 0 | 0 | 2 171 |
| | Thailand | 30 483 | 0 | 0 | 0 | 509 | 0 | 0 | 4 427 |
| | Viet Nam | 4 | 360 | 0 | 16 | 89 | 0 | 0 | 67 |
| **From HK Agriculture Fisheries and Conservation Dept.** | Estimates of amounts transported by sea on HK fishing vessels (mainly from Indonesia) | 38 673 | 24 660 | 20 031 | 30 127 | 24 219 | 38 551 | 31 864 | 29 732 |
| | Total[12] | 83 090 | 38 952 | 50 675 | 48 404 | 35 475 | 62 653 | 45 740 | 52 141 |

*Source:* T. Nip (AFCD, personal communication) and CITES (2006). HK is for China, Hong Kong SAR

**Figure 3**: Preparing humphead wrasse for domestic consumption in Ha'apai, Tonga

*Source:* H. Genthe.

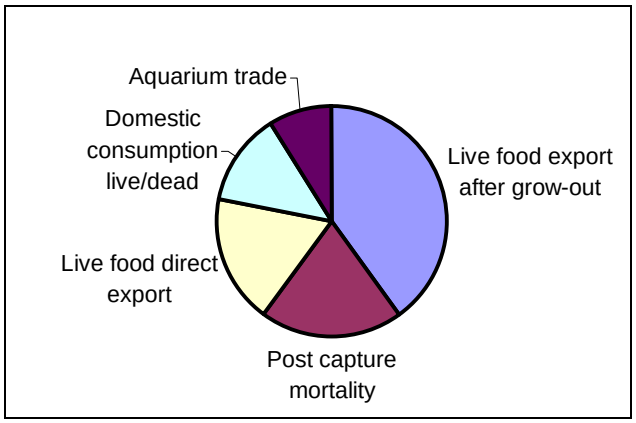
[10] Officials of the Wildlife Regulatory Branch, Agri-Food & Veterinary Authority of Singapore, indicate they did not issue CITES permits for the stated amounts in 2005 and 2006. If the Hong Kong figures are true, the amounts given are likely to be illegal re-exports from Singapore, with the original source being mainly Malaysia with lesser amounts from Sabah in Malaysia (Lye Fong Keng, personal communication).

[11] Papua New Guinea export data (L. Gisawa, National Fisheries Agency, personal communication) indicates that total recorded live humphead wrasse exports from Papua New Guinea in 2005 to all countries were 2 150 kg. This is less than half of the 2005 imports into China, Hong Kong SAR from Papua New Guinea.

[12] Chu *et al.* (2006) observes that the recorded large increase from 2004 to 2005 on Table 5 is counter-intuitive, as individuals familiar with the trade in China, Hong Kong SAR feel that less of this fish is being imported in recent years.

Indonesia, the major producing nation of the humphead wrasse, deserves additional attention. Humphead wrasse which are captured in Indonesia are used in several ways. Figure 4 partitions the catch into the various treatments/markets.

**Figure 4**: The fate of captured humphead wrasse in Indonesia. The chart presumably shows relative mounts by weight.




*Source:* Directorate General of Forest Protection and Nature Conservation (2006).

CITES (2006) reports on interviews conducted in mid-2005 with 94 individuals representing a selection of Indonesian government authorities, traders, and fishermen involved in the humphead wrasse trade. Anecdotal evidence collected from various actors in the trade across the five administrative jurisdictions points to a general decline in fish body size, as well as catch rates over time, and that some formerly abundant fishing grounds had become exhausted. Interview responses suggest that the catch and trade has declined up to 50% in the past 5–10 years.

Export figures compiled by the central fisheries agency of Indonesia show 24 exporters of humphead wrasse from Indonesia, 100% of which report China, Hong Kong SAR as a destination for their exports. In addition, Singapore (25% of exporters), Taiwan, Province of China (21% of exporters), China (13% of exporters), Japan (8% of exporters) and Thailand (4% of exporters) were also reported as destination markets. Papua New Guinea is the most reported source province in Indonesia of humphead wrasse catch (7 exporters), followed by South Sulawesi (6 exporters). Maluku, west Nusa Tenggara and North Sulawesi are of equal third importance (5 exporters each), followed by east Nusa Tenggara (4 exporters) (CITES, 2006).

Government officials state that the available data on catch and trade are inconsistent and not adequate for showing trends over time. Bearing this in mind, recent information (Directorate General of Forest Protection and Nature Conservation, 2006) indicates the exports of humphead wrasse were: 26 304 kg in 2001, 24 246 kg in 2002, 36 409 kg in 2003 and 20 384 kg in 2004.

On the other hand, China, Hong Kong SAR import statistics show between 499 and 5 344 kg of humphead wrasse imported annually from Indonesia between in 2001 and 2004 – exclusive of that amount transported by sea in China, Hong Kong SAR registered fishing vessels (for which the country of origin is mostly Indonesia) (see Table 3 Hong Kong fishing vessels). CITES (2006) reports that a comparison of Indonesia's DKP Budidaya[13] export data with import data in China, Hong Kong SAR, strongly suggests that significantly more humphead wrasse were imported to China, Hong Kong SAR in 2005 than were reported as exported from Indonesia. The report states that different agencies in Indonesia have different data sets, collected over differing periods of time and with varying degrees of specificity regarding humphead wrasse. An additional problem is that a substantial proportion of the fish come in by sea and is not declared by China, Hong Kong SAR vessels entering the country.

The above data difficulties are indicative of the problems encountered in attempts to elucidate the historical international trade in humphead wrasse.

[13] Indonesia Ministry of Marine Affairs and Fisheries, Mariculture Division.

## 2.4 Socio-economic importance of the live reef food fish trade

### *2.4.1 The general live reef food fishery*

The benefit of the trade to fishers varies widely across countries. In some, the difference in selling price between live and dead reef food fish is so great that it is easy to understand the incentives for overfishing to a high degree, for using illegal fishing methods, and for continuing to fish even when the target fish become rare (Sadovy *et al.,* 2003b).

Kronen *et al. (*2006) examines fishing for live fish in the Lau Islands of Fiji and compares the revenue to conventional fishing at that location. Live fish fishing in the presence of a mothership results in US$11.55 per hour fished. Live fish fishing in the absence of a mothership results in US$7.40 per hour fished. Small-scale fishing for finfish in the conventional style results in US$2.34 per hour fished. Sadovy *et al.* (2003b) indicate that in most countries where the trade operates, beach prices (those paid to the fisher or fishing company that catch live fish) are generally in the range of two to four times the price paid for the same fish when dead.

It is difficult to quantify the relative importance of the live reef food fisheries in source countries. Nevertheless, some rough indications may be useful:

- Indonesia's production from all marine capture fisheries in 2004 was 4.3 million tonnes, worth about US$3 billion (DKP 2005). The total global live reef food fish trade was about 30 000 tonnes in 2002 (extrapolated from Sadovy *et al.*, 2003a). The amount of Indonesia's contribution to this global trade is open to speculation, but if the country is responsible for one-third of the fish, this represents 10 000 tonnes, or 0.2 percent of Indonesia's recent annual fisheries production. The contribution of the LRFF fishery by value is obviously much higher but the available information does not allow an estimation.

- In Papua New Guinea total marine product exports have been about 125 million kina (1 kina = US$ 0.34) annually in recent years (Gillett and Lightfoot 2001). Chu *et al. (*2006) give Papua New Guinea's live reef food fish exports as 250 000 kina in 2005. This represents 0.2 percent of exports by value.

One of the major socio-economic issues in the live fish trade is the trade-off between short-term benefits to poor fishers and the long-term depletion of reef resources due to both overfishing and destructive fishing. Another important issue concerns the distribution of benefits. Sentiments such as "final traders are most benefited; fishermen remain poor" (Directorate General of Forest Protection and Nature Conservation, 2006) are commonly expressed. However, the Chairman of Hong Kong Chamber of Seafood Merchants[14] has a different view on the topic:

> *"To people from elsewhere, the price of live reef fish in HK seems very high. This has created the impression among foreign suppliers that they have been deceived by HK buyers, and the prices they obtain from the latter are too low. In fact, imported live fish must go through several traders before they reach the restaurants, and each requires a profit".*

Kronen *et al. (*2006) examine socio-economic aspects live reef food fishing in many Pacific Island countries and make some observations:

- Fishing for live fish is a commercial fishery but all members of the community may not be able to participate or benefit. This may result in detrimental social changes as there is a risk of inequities between groups in the community who do or do not have access to this fishery.
- It is found to be the case that fishers who participate in fishing for live fish often abandon fishing for subsistence (home consumption), and may alter established dietary and debt patterns.
- Participation of community members in live fish fishing may require them to obtain motorized boats and specialized equipment. This arrangement involves risk of financial dependency and may influence local decision making regarding exploitation of resources, possibly leading to overexploitation.

[14] Comment made at the Western Pacific Workshop on Policy, Enforcement and Sustainable Trade for the CITES Appendix II – listed Humphead/Napoleon Wrasse, *Cheilinus undulatus,* 5–7 June 2006, China, Hong Kong SAR.

### *2.4.2 The humphead wrasse*

Several references make the point that the humphead wrasse represents a small but valuable component of the live reef food fish trade (IUCN, 2006; Sadovy, 2006). The most recent study to specifically examine the situation appears to be Lau and Parry-Jones (1999) which gave both weights and values of this and other species and species groups imported into China, Hong Kong SAR in 1997. Although the importance of the humphead wrasse in that study was quite small (far less than one-tenth of one percent by both weight and value), the authors attribute that to under-estimation of imports on China, Hong Kong SAR registered vessels.

If live reef food fish imports into China, Hong Kong SAR are about 18 000 tonnes annually (Sadovy *et al.*, 2003b), and the volume of humphead wrasse imports in recent years is 52 tonnes (Table 3), then this fish represents 0.3 percent of the China, Hong Kong SAR trade by weight. The determination of importance by value is less straightforward. The China, Hong Kong SAR wholesale and retail values of the humphead wrasse vary considerably, but the McGilvary and Chan (2003) values of US$52 and US$87 and per kilo, respectively, can be taken as approximations. If it is assumed that the retail value of the entire live reef fish trade in China, Hong Kong SAR is US$486 million (Sadovy *et al.*, 2003a), the humphead wrasse represents about 0.9 percent of the China, Hong Kong SAR trade by value. Alternatively, Chan (2000) indicates the wholesale value of all live reef fish imported into China, Hong Kong SAR is US$490 million, in which case the fish represents about 0.55 percent of the China, Hong Kong SAR trade by value. These simplistic estimations are, however, complicated by several factors, including the acknowledged inaccuracy of the import statistics, methodology for valuing the trade, and relative amounts of various species re-exported to Mainland China. Extrapolation from the China, Hong Kong SAR situation presented here to the worldwide trade suffers from even more difficulties, but it can be safely assumed that the humphead wrasse is of relatively minor importance in the global live reef food fish industry.

It also should be noted that, although the humphead wrasse occurs in the waters of 48 countries (Chu *et al.*, 2006), the important suppliers of this fish to the live trade are limited to a few countries in Southeast Asia and Papua New Guinea. In other range countries the harvesting of live reef food fish either does not occur at all (e.g. Yemen, Samoa), or occurs only sporadically (e.g. the Solomon Islands, Kiribati), or the live trade in general has been banned (e.g. the Seychelles, Palau), or the export of humphead wrasse has been specifically prohibited (e.g. Australia, Palau, Fiji, Philippines[15]). Substantial benefits from harvesting this fish for the live reef food fish trade appear to be obtained legally in only Indonesia and Malaysia (although in 2010 there will be a zero quota introduced for the species) and to a much lesser degree in Papua New Guinea.[16]

The humphead wrasse is, however, valued for several reasons besides its role in the live reef food fish trade:

- Although the catches of the humphead wrasse for the domestic market are relatively small due to the rarity and difficulty of capture, they are highly valued as food in many countries, including Indonesia (CITES, 2006) and the Pacific Islands (Gillett and Moy, 2006). In many locations of the Pacific Islands the humphead wrasse is considered to be the *most* desirable eating fish: Palau (Kitalong and Dalzell, 1994), Fiji (Thaman, 1998).
- Several examples of the cultural significance of this fish in several Pacific Island countries are given in Sadovy *et al.* (2003b).
- Small but significant amounts of humphead wrasse are recorded in the fishery landings of most Pacific Island countries. Examples are Solomons (Russell and Buga, 2001), Fiji (Fisheries Department, 2004), Tonga (Bell, Fa´anunu and Koloa, 1994), Palau (Kitalong and Dalzell, 1994) and Vanuatu (Bell and Amos, 1993)**.**
- The value of the humphead wrasse for dive tourism is considerable. Where the diving industry is developed, the value of humphead wrasse for diving tourism *in situ* is likely to be considerably higher than for the export market (IUCN, TRAFFIC and WWF, 2004). Colin (2006) states: “Among more experienced divers, the presence (or absence) of this fish is one way that they assess the "quality" of a dive area”. In Fiji the humphead wrasse is considered one of the “seven wonders” of

[15] Technically, all CITES listed species and all live fish are banned from export from the Philippines, however these listings appear to be ignored and exports continue openly.

[16] Sadovy *et al. (*2003b) discounts Thailand as a significant source of humphead wrasse. The fish is not specifically mentioned in the McCullough and Hai (2001) study of the live reef fish trade in Viet Nam. The marine fisheries literature of Cambodia does not mention this fish, while Cambodia is suspected of laundering third country fishery products (e.g. shrimp [Gillett, 2007]) to avoid trade punitive duties.

the marine environment (Fiji Times, 2007) and for divers in Fiji "to see one underwater is truly an unforgettable experience" (Thaman, 1998).

- Not all the dive tourism value of this fish is non-extractive in nature. One of the dive operators in the Solomon Islands promotes his business on the basis of tourists of being able to spear "big fish that they cannot get at home" (Gillett and Moy, 2006).
- The humphead wrasse may have important value in controlling a major threat to coral reefs. Outbreaks of crown-of-thorns starfish *Acanthaster planci* have been a major issue on the Great Barrier Reef and other Indo-Pacific reefs for nearly 40 years. The outbreaks have generated great concern among the community and considerable debate among scientists. Although crown-of-thorns starfish have few predators, one theory suggests that predators play an important role in keeping starfish populations in check. Predators of adult crown-of-thorns starfish include the humphead wrasse as well as the giant triton snail, starry pufferfish and titan triggerfish (CRC, 2003). Evidence for the role of humphead wrasse is scant however.

Another important aspect of the socio-economic importance of the humphead wrasse in the live reef food fish trade is the costs attached to its harvest. It is generally recognized that due to the difficulty in capturing this fish with conventional techniques, cyanide fishing and the use of scuba and hookah gear is very common and probably more prevalent than in the live reef food fish trade in general. The cyanide causes considerable collateral damage to the corals that build the reef, other reef invertebrates, and non-target fish (Cesar *et al.*, 2000), and the use of compressed air for diving often results in injury and death to untrained divers.

## 2.5 Main threats to sustainability

### *2.5.1 Main threats to sustainability of the resources*

The main threats of the live reef food fish trade to the sustainability of fisheries resources are the overfishing the target species and the effects of destructive fishing on the target species, non-target species, and the reef environment.

Many of the economically important reef resources in the Indo-Pacific area are heavily exploited, especially those in the developing countries where there is fishing for live reef food fish. These live fisheries are relatively new and add to the often excessive fishing pressure of the existing fishing activity. The fishing pressure from the live food fish trade is however, more serious than most other types of fishing for two main reasons:

- The conventional market effects that limit over-fishing are distorted by high prices. Birkeland (1997) describes the situation as follows: in normal circumstances economics compels fishermen to switch gear or locations before the resource population nears local extinction. However, the high dollar value placed on many coral reef resources by Asian economies can encourage effort even after the targeted species is too rare to sustain a viable reproductive population. The rapid increase in dollar value of reef resources overrides management policies, traditional practice, and law.
- An additional factor is the biology of many of the target species of the live reef food fisheries. Many have low resilience to fishing pressure: slow growing, long-living and late maturing (Sadovy, 2005a). Furthermore, many of the groupers, wrasses, and other target species form spawning aggregations that are especially vulnerable is targeted and unmanaged (Box 2).

**Box 2**: Spawning aggregations

Many coral reef food fishes aggregate in large numbers at specific locations, seasons and moon phases in order to spawn. Such fishes include groupers, the main objects of the live reef food fish trade. These aggregations are prime targets for fishers, who often take large catches from them. Groupers have been virtually eliminated by overfishing in at least five Pacific Island locations within Palau, the Cook Islands, the Society Islands, the Tuamotu Islands, and on the Great Barrier Reef. Fishing overspawning aggregations at three of these locations has been specifically implicated in their demise. It may also have been a factor in the other two cases. One aggregation fished by Palauans for centuries was eliminated by a live reef fishing operation in just three years. A group of Indonesian fishers said they got such high catches from spawning aggregations they recently discovered that they no longer bother to fish for the trade during the non-spawning season. Such fisheries are not sustainable.

*Source:* Johannes (1997b).

The other main threat of the live reef food fish trade to the sustainability of fisheries resources is the effect of destructive fishing. This is primarily due to the use of cyanide (Section 3.2.1 above), but also from physical damage to coral in extracting fish. The situation in Indonesia (as described by Pet and Pet-Soede, 1999) appears typical of what has occurred in many locations: "In Indonesia reef fish stocks are declining as a result of over-fishing and destruction of habitats. The latter is caused by the dying of corals from cyanide and by the breaking of corals around holes where fish are hiding. In the capture of a single grouper, more than a square meter of corals is destroyed when the fish is removed from its hiding place. In areas where cyanide fishing has been practiced intensively, the reef is mostly dead, overgrown with algae, and has only very few animals still living on it".

The severity of the threat posed by the use of cyanide in live reef food fishing is obviously related to how prevalent the practice is – something that is open to considerable speculation. There is likely to be a large range in prevalence, between countries (e.g. Australia vs. Indonesia) and within countries (e.g. Viet Nam).

### *2.5.2 Main threats to the sustainability of fisheries for live reef food fish*

In addition to threats to the resource, other factors endanger the sustainability of fisheries for live reef food fish. In this respect, Sadovy *et al.* (2003a) raise three important questions:

- Whether a LRFF fishing enterprise can be profitable when kept on a scale consistent with the limited productivity of the resource.
- Whether the public management costs needed to keep the fishery within sustainable bounds is prohibitive.
- Whether overfishing can be effectively addressed in small-scale reef fisheries.

Experience in the past decade from countries where there have been LRFF operations, shows that sustainability of these fisheries is very difficult to achieve. There are few, if any, good examples where such fishing activity has been sustained over substantial periods of time. The more typical situation is one of "boom and bust" in which an operations flourishes for a short period of time at a particular location, but then needs to move to new areas to continue profitability.

Measures to assure sustainability could conceivably be implemented and, indeed many countries have attempted to do so. Such measures have included both input controls (e.g. bans on the fishing of spawning aggregations) as well as output controls (e.g. export quotas). The effectiveness of these measures, however, suffers from many of the same problems that plague the management of the multispecies, multigear small-scale fisheries that the LRFF are part of. These constraints include difficulties with enforcement, political will and poverty among fishers.

### *2.5.3 Main threats to the humphead wrasse*

The threats posed by the live reef food fish trade to specifically the humphead wrasse are similar to that to most target species, but more severe. This is because the prices obtained from humphead wrasse are very high (Section 2.3.2 above) and the fish is relatively non-resilient to fishing pressure (Sadovy *et al.*, 2003b). In addition, it is likely that more destructive fishing is associated with this species than for others in the live fish trade due to the difficulty of capturing humphead wrasse by conventional techniques (Section 2.2.3). It is also particularly problematic for the conservation of the species the extensive capture of juvenile fish for growout operations.

CITES (2004, 2006) states that the primary threat to this species is the lucrative demand for live reef fish in up-market Chinese restaurants in Asian countries. Several studies have attributed the sharp declines in humphead wrasse to the live reef food fishing (e.g. Richards, 1993; Scales *et al.*, 2006; Sadovy *et al.*, 2007). While these assertions are not disputed, the reality is that the live reef food fish trade is active in relatively few of the 48 countries where this fish occurs. This gives rise to two different perspectives on threats to the humphead wrasse: at the country level (where many of management interventions, including CITES, take place) and at the population level (where the effects of management on the species often occur):

- The country level: In the countries where the live reef food fish trade is not active (most range countries), demand from domestic markets is likely to be a major factor in the noted declines in abundance of this fish in most range countries. The available documentation suggests that the non-

live export trade in humphead wrasse is not great.[17] Comprehensive landings data are not available, but because this fish is naturally rare and not easy to catch, much of the catch seems to be as bycatch (gillnetting, line fishing), or from night spearfishing and scuba spearfishing – and therein lies what are probably the major threats to the humphead wrasse in most countries where it occurs. It is a non-resilient non-target species of several kinds of fishing gear and a vulnerable target species of spearfishing.

- The population level: Although the live reef food fish trade does not operate in most countries where humphead wrasse occurs, a significant portion of the species' population does occur in the three most important live fish supplying countries: Indonesia, Malaysia, and the Philippines.[18] It is therefore likely that the live reef food fish is having a large impact on the over-all biomass of the humphead wrasse.

Another important threat to the humphead wrasse is that its coral reef habitat is being destroyed by human activity throughout the Indo-Pacific region. The threats to coral reefs include destructive fishing techniques, overfishing, dredging, land filling, mining of sand and coral, coastal construction, sewage discharge, and sedimentation from upland deforestation and agriculture. In Southeast Asia, the center of humphead wrasse distribution, coral reefs are especially at risk (CITES, 2006). Burke, Selig and Spalding (2002) indicate that coral reefs in Southeast Asia face unprecedented threat levels from human activities, especially the cumulative threats of overexploitation, land-use changes, pollution, and coastal development.

Some speculation can be made about future threats. Given that the recent increase in prosperity in China is likely to continue into the future, the demand for live reef food fish, including the humphead wrasse, is likely to grow. The live reef food fish trade and associated threats to this fish will probably expand into new countries. As coastal populations expand, the fishing pressure on this fish for domestic use will increase. In addition, the present destruction of the coral reef habitat is not likely to abate in the short or medium-term future.

## 3. CITES REGULATION ON TRADE OF LISTED AQUATIC SPECIES

### 3.1 General CITES information

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an international agreement between governments.[19] Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival. States that have agreed to be bound by the Convention are known as Parties, of which there are now 173. Although CITES is legally binding on the Parties – in other words they have to implement the Convention – it does not take the place of national laws. Rather it provides a framework to be respected by each Party, which has to adopt its own domestic legislation to ensure that CITES is implemented at the national level.

Roughly 5 000 species of animals and 28 000 species of plants are protected by CITES against over-exploitation through international trade. They are listed in the three CITES Appendices. The species are grouped in the Appendices according to how threatened they are by international trade. They include some whole groups, such as primates, cetaceans (whales, dolphins and porpoises), sea turtles, parrots, corals, cacti and orchids. But in some cases only a subspecies or geographically separate population of a species (for example the population of just one country) is listed. Any type of wild plant or animal may be included in the list of species protected by CITES and the range of wildlife species included in the Appendices extends from leeches to lions and from pine trees to pitcher plants. While the more charismatic creatures, such as bears and whales, may be the better known examples of CITES species, the most numerous groups include many less popularized plants and animals, such as aloes, corals, mussels and frogs.

[17] Even in Indonesia, exports are probably not great. CITES (2006) reports "Some dead [humphead wrasse] HHW were reported to enter the export trade, but most interviewees reported that any dead specimens were sold immediately to domestic market consumers".

[18] Since the CITES listing of the humphead wrasse, it has been illegal to export the species from the Philippines but much goes through Malaysia from the Philippines.

[19] This information is modified from the CITES Web site: wwwcites.org

CITES works by subjecting international trade in specimens of selected species to certain controls. All import, export, re-export and introduction from the sea[20] of species covered by the Convention have to be authorized through a licensing system. Each Party to the Convention must designate one or more Management Authorities in charge of administering that licensing system and one or more Scientific Authorities to advise them on the effects of trade on the status of the species. Some of the basic requirements and roles under CITES are given in Box 3. Annex 1 presents a list of terminology used by CITES of relevance to the humphead wrasse.

**Box 3**: CITES basic requirements and roles

Parties to CITES must adopt national CITES legislation to, at the very least:

- Designate a Management Authority
- Designate a Scientific Authority
- Prohibit trade in specimens in violation of the Convention and penalize such trade
- Allow for confiscation of specimens illegally traded or possessed

The Management Authority has two basic roles:

- Granting permits and certificates under the terms of the Convention
- Overseeing general implementation at national level and communicate with the Parties, the CITES Secretariat and others

The Scientific Authority has one basic role:

- Giving advice to the Management Authority about levels of export that are non-detrimental to the survival of the species in the wild ["Make non-detriment findings"]

*Source:* CITES presentation at the Western Pacific Workshop on Policy, Enforcement and Sustainable Trade for the CITES Appendix II – listed Humphead/Napoleon Wrasse, *Cheilinus undulatus* 5–7 June 2006, China, Hong Kong SAR.

Appendices I, II and III to the Convention are lists of species afforded different levels or types of protection from overexploitation:

- Appendix I includes species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances.
- Appendix II lists species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled. International trade in specimens of Appendix-II species may be authorized by the granting of an export permit or re-export certificate. No import permit is necessary for these species under CITES but, as in China, Hong Kong SAR, they can be introduced to aid enforcement. Permits or certificates should only be granted if the relevant authorities are satisfied that certain conditions are met, above all that trade will not be detrimental to the survival of the species in the wild. The humphead wrasse is listed on Appendix II. The history behind the listing is given in Box 4.
- Appendix III contains species that are protected in at least one country, which has asked other CITES Parties for assistance in controlling the trade.

The export of any specimen of a species included in Appendix II requires the prior granting and presentation of an export permit. An export permit shall only be granted when the following conditions have been met:

- The Scientific Authority of the State of export has advised that such export will not be detrimental to the survival of that species;
- Management Authority of the State of export is satisfied that the specimen was not obtained in contravention of the laws of that State for the protection of fauna and flora; and
- The Management Authority of the State of export is satisfied that any living specimen will be so prepared and shipped as to minimize the risk of injury, damage to health or cruel treatment.

**Box 4**: The humphead wrasse and CITES

In 1996 a number of marine fish were added to IUCN's Red List of endangered species (www.iucnredlist.org). Included were 14 groupers and the humphead wrasse. While a red-listing in one of the "threatened" categories has no legal muscle, it was useful in that it focused considerable attention on the humphead wrasse. At the twelfth meeting of the Conference of the

[20] CITES defines "introduction from the sea" as "transportation into a State of specimens of any species which were taken in the marine environment not under the jurisdiction of any State".

CITES Parties in November 2002 a proposal to include the humphead wrasse in Appendix II was made, noting that there were no current or planned regional management plans, and that the species was not being aquacultured. The proposal was, however, marginally rejected. At the thirteenth meeting of the Conference of the Parties in October 2004 the delegation of Fiji introduced a proposal regarding the inclusion of *Cheilinus undulatus* in Appendix II, co-proposed with Ireland (on behalf of the European Union States), and the United States of America. Fiji stressed that they were speaking from the perspective of a range State that was also a Small Island Developing State. They noted that they were involved in various conservation activities regarding the species but that, despite these, its population was continuing to decline. The listing was accepted by consensus of the Parties.

*Sources*: Sadovy (1997) and CITES Web site www.cites.org.

### 3.2 Non-detriment finding

A crucial point in the CITES permit process is the determination that the export will not be detrimental to the survival of a species in the wild. An IUCN document (Rosser and Haywood, 2002) elaborates on this point: "international trade is not detrimental when it is part of a harvest, the sum of which is sustainable, in that it does not result in unplanned range reduction, or long-term population decline, or otherwise change the population in a way that might be expected to lead to the species being eligible for inclusion in Appendix I".

The Treaty does not specify how a non-detriment finding (NDF) is to be made. There is a degree of uncertainty and some interpretation is required. One fisheries-oriented view is that if an effective management regime for a species is in place and that harvest/export levels are being monitored accurately, then the controlled export should not be detrimental to the survival of that species. Accordingly, in many of the recent discussions of humphead wrasse and its relationship to CITES, a NFD is often equated to a sustainable management plan and associated monitoring (Sadovy *et al.*, 2007). The International Expert Workshop on CITES Non-Detriment Findings, held in Cancun, Mexico, 17–22 November 2008,[21] concluded that the following aspects were essential to enable the making of NDF for fish species:

- a need to consider all sources of significant mortality affecting species in trade;
- a need to consider whether establishing harvest/export quota is enough to achieve conservation goals;
- collaboration between Scientific Authorities and fisheries experts;
- transboundary migrants and shared stocks require regional NDF cooperation;
- when possible, base NDF on both fisheries independent and dependent information/data;
- need techniques and legislation to distinguish among farmed, captive bred and wild individuals;
- management on which NDF is based should employ principles of adaptive and participatory management;
- parties need to report to Secretariat methods by which NDFs are being made on an annual basis to enable transparency, learning between NDF processes and to ensure that fish species which range beyond the boundaries of one State are accounted for by all range States in their NDF processes.

It is recognized that many States will be challenged to develop such monitoring/management for the humphead wrasse. Considerable efforts have therefore been taken to assist countries in this matter, including:

- In early 2006 the CITES Secretariat contracted the IUCN Groupers and Wrasses Specialist Group to assist Indonesia, a key exporting country, in developing NDF for the humphead wrasse. The work involved a trade study and underwater visual census surveys.
- In June 2006 the Western Pacific Workshop on Policy, Enforcement and Sustainable Trade for the CITES Appendix II – listed Humphead/Napoleon Wrasse was held in China, Hong Kong SAR. One of the objectives of the workshop was to discuss the NDF model developed in Indonesia and its regional applicability.
- Funds for additional underwater visual census surveys have been made available, e.g. from the US Coral Reef Fund and from the CITES Secretariat.
- In 2006/07 FAO, together with the GWSG of IUCN and fishery experts developed a generic stock assessment model, based in part on the above studies, for the humphead wrasse in Indonesia to assist that country and other range countries with their NDF obligation.

[21] www.conabio.gob.mx/institucion/cooperacion_internacional/TallerNDF/wfunctioning.html

The June 2006 workshop made several recommendations on CITES Non-detriment findings, including that attention should be given to:

- Promoting collaborative research among countries, research institutions and organizations, including WWF, IUCN and TRAFFIC.
- Ensuring that research addresses critical issues such as the distribution and density of humphead wrasse populations, assessment of the benefits of marine protected areas and no-take zones, the impact of different production systems on wild populations, total allowable catch, minimum size considerations, trade statistics and trade routes, etc.
- In some cases, the implementation of national level action plans and/or the creation of national working groups (CITES Authorities, fisheries departments, law enforcement agencies) may be useful. This includes interagency cooperation on multiple levels, from local to national.
- Developing non-compulsory guidelines for the making of NDFs in consultation with range States and with the technical advice of the IUCN Species Survival Commission, IUCN Groupers and Wrasses Specialist Group and FAO.
- Based on appropriate research, framing guidelines as a "risk assessment" checklist, outlining step-wise protocols for conducting CITES NDFs.

### 3.3 Relationship of CITES requirements with other internationally agreed instruments

The Code of Conduct for Responsible Fisheries was unanimously adopted by FAO Member States in October 1995. Together with its Technical Guidelines for implementation and the International Plans of Action that were developed and adopted in its framework, the Code is now widely recognized by governments and NGOs as the global standard for setting out the aims of sustainable fisheries and aquaculture over coming decades and as a basis for reviewing and revising national fisheries legislation.

The relationship between CITES requirements and the Code deserves some attention. If effective management is required for an NDF, the Code provides an international standard for ascertaining the effectiveness. In another sense, in the process of developing a management regime to meet the relatively narrow CITES requirements, the principles of the Code can be of considerable value as they encourage the broadening of objectives and benefits. In other words, the Code can be instrumental in attaining benefits from a CITES-oriented management greater than just "survival of the species" or "maintaining its role in the ecosystem".

All key international fisheries agreements adopted over the last two decades, including the 1995 FAO Code of Conduct for Responsible Fisheries, stress the need for the adoption of an ecosystem approach to fisheries (EAF). In response to these, in 2001, 57 countries issued the Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem which included a declaration of their intention to work on incorporating ecosystem considerations into fisheries management. The FAO Technical Guidelines on the ecosystem approach to fisheries (FAO 2003) define EAF as follows: "An ecosystem approach to fisheries strives to balance diverse societal objectives, by taking into account the knowledge and uncertainties about biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries."

EAF has considerable relevance to the management of humphead wrasse, which goes beyond the mention of "ecosystem" in the text of CITES: "the export of specimens of any such species should be limited in order to maintain that species throughout its range at a level consistent with its role in the ecosystems in which it occurs". A major value of EAF with respect to humphead wrasse is that it, like the Code, promotes management objectives beyond those required for an NDF. This includes broadening away from a "single-species"' approach to encompass more general ecosystem and societal issues. In order to do this, managers in most humphead wrasse range countries will need to become more familiar with the ecological relationships and human activities affected by fishing for the humphead wrasse.

### 3.4 Linkages between CITES national authorities and fisheries agencies

CITES presently lists 33 658 species, of which only 0.22% are fish. Accordingly, government fishery agencies are not usually institutionalized as components of CITES national authorities. Because the considerations associated with endangered fish are often very different than those for other animals

(mammals, birds, amphibians, and invertebrates), and because countries have little experience with commercial fish in a CITES context, attention needs to be given to effective communication between fishery agencies and CITES authorities.

Humphead wrasse range countries include both some of the smallest and largest countries in the world. Generalizations and recommendations on the linkages between CITES national authorities and fisheries agencies are therefore difficult to make. Nevertheless, the issue of linkages/communication was examined in the case of the Caribbean queen conch (CITES Appendix II; Medley, 2006), and may have some applicability to humphead wrasse in the Indo-Pacific. In a study of the monitoring and management of the queen conch (*Strombus gigas*), Medley (2006) concluded that as CITES authorities may deal with many non-fished species, authorities may well be made up predominantly of non-fisheries staff. It is important that the Fisheries Department has representation in each such authority. Misunderstanding the way fisheries work can make it difficult for the authorities to implement appropriate export controls. For small states, it may be necessary to combine the management and scientific roles into a single authority.

In some countries, environmental and fisheries agencies do not work well together, often have antagonistic policies, and do not cooperate for a common goal. In such a situation, a CITES listing of an endangered fish (and associated publicity in the media) could have a positive effect on the level of coordination between these agencies.

## 4. HUMPHEAD WRASSE BIOLOGY

Sadovy *et al.* (2003b) contain much information on the biology of humphead wrasse. Beside the inclusion of the results of a few new studies, little can be done to improve on that comprehensive review. Accordingly, the following contains some updating (e.g. Choat *et al.*, 2006) but otherwise is straight from Sadovy *et al.* (2003b), where the source references can be found.

### 4.1 Distribution, habitat and ecology

The humphead wrasse occurs on coral reefs and inshore habitats throughout much of the warm Indo-Pacific. CITES (2004) states that the range of this fish falls within the jurisdiction of 48 countries and territories. It is found in most tropical areas from the Pitcairn Islands in the southeast Pacific to the Red Sea. However, within this general area of distribution it does not occur in the Hawaiian Islands, Johnston Island, Easter Island, or the Austral Islands. In the west the fish evidently is not found in the Gulf of Oman, the Persian Gulf, Reunion Islands, Mauritius or Rodrigues Islands.

The humphead wrasse produces pelagic eggs and larvae that ultimately settle on or near coral reef habitats. Eggs are 0.65 mm in diameter, spherical with no pigment. Nothing is known of the size at which *C. undulatus* settles out of the plankton, but the larvae of *Cheilinus* spp. are typically small, about 8–11 mm total length (TL), when they settle. In one study, small post-settlement humphead wrasses were found in a species of seagrass (*Enhalys acoroides*), four species of hard coral (three *Acropora* spp. and *Porites cylindricus*) and in the soft coral *Sarcophyton* sp. After settlement, juveniles and adults live associated with reef or near-reef habitats of seagrass beds and mangrove areas, with juveniles typically inshore and the largest individuals found in deeper waters of outer reefs or lagoons.

Juveniles of 3 cm TL and larger, occur in coral-rich areas of lagoon reefs, particularly among live thickets of staghorn, *Acropora* spp. corals, in seagrass beds, murky outer river areas with patch reefs, shallow sandy areas adjacent to coral reef lagoons and mangrove and seagrass areas inshore. Juveniles are generally solitary, wary and difficult to approach. Small, 10–20 cm TL, individuals may occur in shallow waters around seagrasses, algae and areas of mixed coral and rubble. Groups of small fish, numbering 12–75, have been seen in shallow bay areas in Palau. Underwater visual census surveys in New Caledonia suggest that recruitment is into shallow coastal areas that have heavy cover provided by branching corals; gradual movement out to more exposed reef likely occurs as the fish grows. Juveniles are rarely seen in some areas, such as the Red Sea.

Adults are more common offshore than inshore, their presumed preferred habitat being steep outer reef slopes, reef drop-offs, reef tops, channel slopes, reef passes and lagoon reefs to at least 100 m. They are usually found in association with well-developed coral reefs. Typically they are solitary or paired, but have

also been noted in groups of 3–7 individuals. They appear to be somewhat sedentary in that the same individuals, identifiable by distinct natural markings, may be seen along the same stretch of reef for extended periods. Indeed, many commercial dive sites have their 'resident' humphead wrasse, a favoured species for divers (Box 5).

**Box 5**: Wally the humphead wrasse

The "Caves" dive site along Norman Reef of Australia's Great Barrier Reef is home to "Wally" the humphead wrasse. At over a meter in length, this inquisitive creature has befriended the local dive staff and become quite an attraction. Particularly trusting of the cameraman aiming to shoot footage of student divers, Wally swims back and forth in front of the camera, in between the cameraman's legs and nuzzling at his hands until shown some affection. Occasionally this trusting fish allows the visiting divers to stroke his side as he swims curiously past.

*Source:* H. Williams, personal communication.

The humphead wrasse is a large carnivorous predator in reef ecosystems. It feeds primarily upon mollusks and a wide variety of invertebrates, including crustaceans, echinoids, brittle stars and starfish; heavy trochus and turbo shells are crushed with its pharyngeal teeth and larger individuals also take small fishes. It appears to be one of the few predators of toxic animals such as the crown of thorns starfish (*Acanthaster planci*), boxfishes (Ostraciidae) and sea hares. It is also known to eat *Arca* spp., *Barbati* spp. *and Striarca* spp.

In one study stomach contents from 72 specimens mainly contained molluscs, especially gastropods and pelecypods, echinoids and crustaceans, as well as fishes ranging from sand-dwelling gobies to morays. Humphead wrasses have been observed to turn over rubble to reach the animals beneath and crush large chunks of dead coral rubble to feed on burrowing mussels and worms.

### 4.2 Abundance and population status

Natural densities of the humphead wrasse are evidently never high, even in presumed preferred habitats. There have been several studies of the abundance of the humphead wrasse, the most comprehensive of which are:

- A detailed and standardized survey that examined areas in New Caledonia and the Tuamotu Archipelago in French Polynesia. Humphead wrasse densities were given for barrier reefs (4.5 fish per 10 000 $m^2$), reefs in the middle of lagoons (1.4), coastal reefs, lagoons, and passes (about 0.3 each). Density and total length were lower in areas of higher fishing pressure.
- A consolidation was done of UVC estimates of abundance of this fish by at least 12 different researchers in 24 locations scattered widely throughout its geographic range. The median humphead wrasse density in the one location with no fishing pressure was 20 fish per 10 000 $m^2$, while in most areas with moderate fishing pressure the abundance ranged from 0 to 5 fish per 10 000 $m^2$. Overall, the results suggest that lower abundances occur where fishing pressure is higher, although densities in presumed preferred habitats are variable.
- Colin (2006) studied the abundance of humphead wrasse at three general areas in Indonesia in 2005. In 125 linear km of surveying, the density ranged from 0.04 fish to 0.86 fish per 10 000 $m^2$ in Bali-Kangean and Raja Ampat, respectively (0.40 fish per square meters for entire survey).[22] Areas with large human populations and apparent high fishing pressure had lower numbers of humphead wrasse, often to the point that no fish were encountered.[23]

Assessment of the status of tropical reef fishes, especially larger, wide-ranging ones like the humphead wrasse, is particularly challenging, whether by fishery dependent or independent means. Notably, there is no long-term index of abundance for the humphead wrasse, either globally or nationally, and therefore there is a large dependence on grey literature and anecdotal observations.

[22] DKP (2006) indicates there are 2 346 782 full and part time marine fishers in Indonesia. There are various estimates of Indonesian reef area, but if we assume 51 020 $km^2$, then there are about 4.6 marine fishers per hectare of reef area in Indonesia, or ten times the density of humphead wrasse on reefs.

[23] Colin (2006) remarks: Despite the apparent lack of fish on many visual surveys, commercial fishers for the live reef fish trade are evidently able to continue to find a low number of these highly prized fish.

Overall, the available information on humphead wrasse populations suggests that the species cannot withstand anything other than light fishing pressure, as indicated by both qualitative and quantitative data from broadly throughout its geographic range. Although stocks appear to be in poor condition wherever uncontrolled spearing is involved (e.g. Madagascar, Fiji, Tahiti, Guam, China and islands of the South China Sea) and especially if compressed air is used to take fish from sleeping places at night, declines appear to be particularly marked when a live reef food fishery is introduced (e.g. Malaysia, Philippines and Indonesia); whether this is due to the targeted fishery for humphead wrasse, or simply reflects the generally high level of fishing in such areas, is unclear, but anecdotal accounts suggest the former. Where the species is fished heavily for live export, there have been marked losses of larger individuals, significant catches of juveniles and declines in catch rates. Conversely, in those places where some degree of protection is afforded and enforced or respected, the condition of local stocks appears to be reasonable, as far as can be determined (e.g. Australia, Maldives, and Wake Atoll).

CITES (2004) indicates the available information on humphead wrasse population trends includes both fishery-independent and -dependent data such as underwater visual censuses, fishermen's reports, dive operator reports, and anecdotal information. Collectively, these reports show declining populations in nearly all studied locations with suitable habitat subject to commercial fisheries.

In recognition of the need to obtain a more rigorous and quantitative assessment of the humphead wrasse, FAO, IUCN and other agencies collaborated to develop a stock assessment approach for this fish in Indonesia (Annex 2). It is intended to support the NDF process under CITES.

### 4.3 Reproduction

Accounts of reproductive activity in the field reveal that, depending on location, this species spawns between several and all months of the year, in small or large groupings, that spawning coincides with certain phases of the tidal cycle and that groups of spawning fish can form daily, at a range of different reef types. Spawning areas and aggregated adults have been noted regularly along specific sections of reef, sometimes associated with no obvious topographical features, sometimes close to the shelf edge on outer reefs, or adjacent to exposed reef passes near fairly steep drop-offs or on mid-shelf reefs. The species is evidently a daily spawner that probably does not migrate far to its spawning site(s), spawning for extended periods each year, i.e. a "resident" spawner.

Groups of up to 150 fish were observed in Palau along the shelf edge in a loose aggregation, which lasted 60–75 min, with about 10–15 females per male; females rise to pair-spawn joined by the male out over the drop-off and the smallest female observed to release eggs was estimated in the field to be about 35 cm TL (total length). Courting males have the caudal fin cocked upwards and the anal fin pointed at its end and males appear to have a size-based dominance hierarchy. In Malaysia, "sneaking" was observed by smaller males that were chased off by nearby large males when detected; small males and females are indistinguishable by their colouration and smaller males rarely spawn. Probable spawning aggregations have also been noted on Australia's Great Barrier Reef (GBR), Fiji, New Caledonia and in the Solomon Islands. Although spawning was not always observed, aggregated fish were ripe or exhibiting behaviour likely associated with spawning. On the GBR, aggregations of up to 10 large males and 20–50 smaller fish (35–95 cm TL) were noted; males arrive before females and patrol areas of open water off the reef crest. The same areas may be used daily by the same males and gatherings may occur for up to seven consecutive days. GBR aggregations from the Ribbon Reefs and north of Jewell Reef, once noted to include hundreds of fish, are no longer known at the same sites. In New Caledonia, a group of more than 20 humpheads (ranging in size from 60–90 cm TL) was noted in 2002 off the eastern coast. Around Yadua, Fiji, groupings of the species have been noted in a couple of places that may represent spawning aggregations. Groupings have also been noted in the Solomon Islands.

Humphead wrasse gonads (142 in total) from seven range countries in Southeast Asia and the Pacific Islands were studied to give information on various characteristics related to reproduction:

- Mature, ripe, females were those with vitellogenic or hydrated oocytes or with clear indications of spawning activity, such as post-ovulatory follicles; the presence of both features together in some individuals suggests that individual females spawn on multiple occasions during a reproductive season (see Box 6 for terminology).

- Mature, ripe males had a significant proportion of the gonad filled with sperm. Inactive males had a range of stages of spermatogenesis with few spermatids or sperm. The smallest male was 29.5 cm TL, while the smallest mature, ripe male was 59.5 cm TL.
- Individuals undergoing sexual transition from mature female to male had vitellogenic or degenerating vitellogenic oocytes and developing spermatogenic tissues. Two transitional fish were found (67 and 76 cm TL), indicating that the species is protogynous.

**Box 6**: Some reproductive terminology

Oocyte: A cell from which an egg develops.
Vitellogenesis: Formation of the yolk of an egg.
Ovarian follicles: Aggregations of cells that envelopes oocytes.
Hermaphrodite: An organism which has both male and female organs, and produces both male gametes (sperm) and female gametes (eggs). A sequential hermaphrodite has one type early in life and the other type later in life. A protogynous sequential hermaphrodite is female first and male later.

Choat *et al. (*2006) examined 164 specimens of humphead wrasse from NE Australia and determined:

- The size at age distribution indicates that not all individuals change sex and the oldest members of the population are females in the 80 to 90 cm range. These individuals have very large ovaries and have the potential to contribute significantly to the overall reproductive output of the population. However as the size distributions from catch records and underwater surveys demonstrate individuals in this size range are extremely rare.
- Ovary weight abruptly increased at approximately 55 cm FL (fork length) and at an age between 6 and 7 years, indicating that female sexual maturity first occurred at this combination of age and sizes.
- The youngest male observed in the population was 9 year and approximately 70 cm FL. Males get much bigger than females.

### 4.4 Age, growth and mortality

The maximum size of the humphead wrasse appears to be a record of 250 cm and 191 kg from Queensland, Australia. In general, however, fish considerably larger than 100 cm are documented only rarely, and are only male. It has been concluded that one or several of the following factors account for the absence of large individuals in samples; larger fish are naturally rare, appear to be rare because they are wary; have become rare; occur predominantly in waters deeper than those typically visited by divers, or are not often targeted or caught by fishers.

Unpublished age and growth studies using age determinations from sagittal otoliths and length data suggest a longevity of at least 32 years for females and 25 for males, assuming that the growth checks in otoliths are deposited annually; males up to 140 cm fork length (FL) were aged while the oldest females did not exceed 100 cm FL. In a study on the Great Barrier Reef (Australia), fish attain about 100 cm TL in 28 years and sexual maturity in 5–7 years. In another study, 27 fish were aged at 3–23 years, the largest one measuring 135 cm TL. In public aquaria in China, Hong Kong SAR and New Caledonia, three fish were known to live at least 16, 20 and 21 years.

The length–weight relationship was estimated from 209 fish obtained mainly from Papua New Guinea (33 fish) and New Caledonia (21 fish). The lengths ranged from 15–120 cm TL, except for two fish above 2 m. The relationship is: $w = 2.3178 \times 10^{-5} \times TL^{2.9589}$ (where w is in g and TL in mm; $r^2 = 0.99$).

The longevity of the species and our limited knowledge of reef fish biology would suggest that adult natural mortality is low.

Choat *et al. (*2006) (described in Section 5.3 above) gives some information from a recent study. Unlike previous thinking of slow growth and a long life span for the humphead wrasse[24], the results show:

[24] For example, CITES (2004) states: "Its large size, slow growth, longevity and variable recruitment imply that this species is expected to have low rates of replacement and to therefore be particularly vulnerable to over-fishing".

- Initial growth rates in humphead wrasse are relatively rapid resulting in a size of 50 cm at approximately seven years.
- The size at age plots demonstrate that sizes in the order of 100 cm are achieved in males after 16 years, a relatively short time period for many coral reef fishes.
- The total life span is modest with a maximum of 30 years for females and only 25 year for males.
- Following from this, it is suggested that factors other than slow growth and longevity are responsible for the humphead wrasse's lack of resilience to fishing pressure.

The recent Choat study has additional findings on growth, age and mortality. The age distribution of males suggests protogyny with male recruitment into the population commencing at 9 years at a size threshold of 70 cm. The age distribution of females confirmed that not all individuals changed sex. Analysis of the sample size revealed a strongly skewed distribution with a modal size peak at 50 to 70 cm and an extended tail of larger individuals. Estimates of size distributions from underwater surveys revealed a right-skewed distribution similar to that observed in the sample. Estimates of annual total mortality ranged from 0.10 to 0.14 per year, suggesting that less than 3.5 percent of the individuals from the study population live beyond 30 years.

### 4.5 Recruitment

Detailed information on the recruitment of the humphead wrasse is not available. In the estimation of sustainable fishing rates by the use of a newly developed model (Sadovy *et al.*, 2007), the relationship between stock and recruitment remains the major uncertainty.

Some accounts suggest that recruitment is sporadic, a pattern common to long-lived fishes in which populations tend to be dominated by relatively few year classes. This means that heavy pressure on pulses of recruits during infrequent productive years could have particularly severe long-term impacts.

Some clarification is required on the term "recruitment". In a fisheries sense, it usually means the growth and entry of small fish into a size category that can be captured by fishing gear. In the humphead wrasse literature it is also used to denote when fish becomes a different sex (Choat *et al.*, 2006: "male recruitment into the population"). Ecologically, "recruitment" refers to settlement out of the plankton onto the substrate.

With respect to fishery recruitment, the different fisheries for humphead wrasse have a huge difference in recruitment sizes. As an example, in Indonesia recruitment to the aquarium fishery[25] occurs at a very small size (one sample in the Choat study measured 62 mm FL). When individuals reach 20 cm they are captured for grow-out for the live fish trade. In Indonesia humphead wrasse can be caught below 1 kg but have to be grown out and cannot be exported below 1 kg or with more than 3 kg.

## 5. FISHERIES MANAGEMENT: IDEALS AND REALITIES

In this section some important principles and ideals in fisheries management are reviewed. Next, some sobering realities of the fisheries of important humphead wrasse range countries are given and finally, suggestions are made for reconciling the ideals with reality.

### 5.1 Principles and ideals

The Code of Conduct for Responsible Fisheries (Section 3.3 of this report) provides a standard for judging many aspects of fisheries, including fisheries management. The Technical Guidelines on Fisheries Management (FAO, 1997) that accompany the Code contain guiding principles, theoretical framework, and important elements of a fisheries management regime. In many respects, the Guidelines could be considered an ideal to strive towards.

The Guidelines indicate that a model fisheries management regime would include:

- Setting policies and objectives for the fishery or stock to be managed, taking into account the biological characteristics of the stock, the nature of existing or potential fisheries and other activities

[25] Figure 2 of Section 2.3.2 indicates that in Indonesia the aquarium trade of humphead wrasse is substantial.

related to or impacting the stock and the potential economic and social contribution of the fishery to national or local needs and goals.

- Determining and implementing the actions necessary to enable the management authorities, the fishers and other interest groups, to work towards the identified objectives. This task should be done in consultation with all interest groups. The actions required include: developing and implementing management plans for all managed stocks; ensuring that the stock or stocks, the ecosystems in which they occur and their environment are maintained in a productive state; collecting and analyzing the biological and fishery data necessary for assessment, monitoring, control and surveillance; adoption and promulgation of appropriate and effective laws and regulations necessary to achieve the objectives, and ensuring that fishers comply with them to achieve the objectives.
- Consulting and negotiating with users or interest groups concerned with resources and from areas not directly related to fishery activities but which impact on fisheries. The management authority needs to ensure that the interests of fisheries are appropriately considered and catered for in planning and integration of such activities.
- In consultation with the users, regularly reviewing the management objectives and measures to ensure they are still appropriate and effective.
- Reporting to Governments, users and the public on the state of resources and management performance.

Box 7 gives an interpretation of the fisheries management process.

**Box 7**: The fisheries management process

**Policy goals**
Broad economic, social
and ecological aims to benefit society

▼

**Objectives with reference points (targets)**
Practical level goals relating to policies.
Targets set as reference points.

▼

**Strategies**
Plan of action to achieve
the specific objectives.

▼

**Actions (tactics)**
Specific actions and regulations
required under each strategy

▼

**Indicators & performance measures**
Indicators of performance that will be
used to measure performance
in relation to reference points

▼

**Review & evaluation**
Review of performance in relation
to objectives and policies and feedback

*Source:* King (2007).

Ideally, a number of important features would be incorporated into a fisheries management regime:

Precautionary approach: This involves the application of prudent foresight. FAO (1995) indicates that the precautionary approach involves, *inter alia:*

- Explicit consideration of undesirable and potentially unacceptable outcomes and provides contingency and other plans to avoid or mitigate such outcomes. Undesirable or unacceptable outcomes include overexploitation of resources, overdevelopment of harvesting capacity, loss of biodiversity, major physical disturbances of sensitive biotopes, or social or economic dislocations. Undesirable conditions can also arise when a fishery is negatively influenced by other fisheries or other activities and when management fails to take action in the face of shifts in the external conditions affecting, for example, the productivity of the fish stocks.

- Developing, within management strategies and plans, explicit consideration of precautionary actions that will be taken to avoid specific undesirable outcomes. As over-development of harvesting capacity is a common cause of undesirable outcomes, a management plan should include mechanisms to monitor and control that capacity. Consideration needs to be given to how uncertainty and ignorance are to be taken into account in developing and varying management measures. For all fisheries, plans should be developed or revised to incorporate precautionary elements. The plans, even where no additional precautionary elements are considered necessary, should be re-evaluated in accordance with the process outlined below. Where there are multiple fisheries, plans will also be required to implement precautionary approaches to their aggregate impact on the marine environment. The plans should consider time scales of at least two to three decades, or longer in the case of long-lived species.

Ecosystem approach: An ecosystem approach to fisheries is a regime that strives to balance diverse societal objectives by taking into account the knowledge and uncertainties about biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries (FAO, 2003). Garcia *et al. (*2003) indicate that the approach is taken as requiring: (1) definition and scientific description of the ecosystem in terms of scale, extent, structure, and functioning; (2) assessment of its state in terms of health or integrity as defined by what is acceptable to society; (3) assessment of threats; and (4) maintenance, protection, mitigation, rehabilitation, etc., using (5) adaptive management strategies.

Adaptive management: Adaptive management is an institutionalized system for continually improving management policies and practices based on learning from the outcomes of operational programs. In adaptive management the effects of management interventions are monitored, and are modified if the results fall short of what was intended. An adaptive management cycle often entails the monitoring of indicators about the status of the resource and the regular review of the effectiveness of fishing controls and management decisions.

Participatory decision making: This involves the identification of relevant stakeholders in the fishery and establishing a process whereby they have a reasonable degree of input into the decision making process, and are informed of the results of monitoring progress towards established objectives.

### 5.2 Some realities

The very desirable attributes embodied in Section 5.1 above must be balanced with some harsh realities in many range countries. These concern both general fisheries management difficulties and some special problems dealing with the CITES regulations.

The major difficulty is that few of the major humphead wrasse exporting countries have much functional management for small-scale commercial fisheries, not to mention the more sophisticated concepts mentioned in the above section.

Other difficulties encountered in attempting to reconcile desirable management concepts, CITES requirements, and the peculiarities of this species are:

- If humphead wrasse is just a tiny fraction of a country's fisheries production, it is difficult to imagine that a country will re-orient its fisheries management regime for CITES purposes. It may be unrealistic to expect a country to carry out management for CITES that is far more costly/complex than that undertaken for important fisheries.
- Many of the management measures that have been suggested for the management of the humphead wrasse are highly dependent on enforcement – something that is virtually absent in the small-scale fisheries of many range countries: "reliance on non-existent enforcement". Even with the best of intentions, the enforcement situation is not likely to improve because of any CITES requirements.
- Even with vastly improved enforcement, management of this species will be extremely challenging or simply not possible. It is especially difficult to keep low income fishers from capturing an extremely valuable fish that is within their grasp. For commercial enterprises, as articulated by Birkeland (1997), the extra high fish prices created by demand in China can override management, law, and tradition.

- Night scuba spearfishing and the use of cyanide are likely to be the most common methods for taking the humphead wrasse, and are major threats to the species but their elimination is notoriously difficult – even in effective management regimes.
- In most range countries fisheries statistical systems that cover the humphead wrasse either do not exist or are non-functional.
- It may be very difficult to address the national obligations under CITES when dealing with the management of a resource that is not under direct national control. In many range countries lower levels of government, rather than the national government, have management control of coastal resources.

### 5.3 Suggestions for the way ahead

Prior to making management arrangements for the export fishery for the humphead wrasse, some serious thought should be given to the value of the fishery. Analysis and discussion of costs and benefits of the fishery and associated management should be carried out. In most cases a strictly quantitative analysis is not possible (i.e. balancing fishing jobs with biodiversity value), but such an exercise can lead to a qualitative appreciation of the net value of a fishery. A list of items to be included in a cost/benefit analysis for an export fishery for humphead wrasse is likely to be country-specific, but some obvious candidates for benefits include the gross value of humphead wrasse exports, contribution to GDP[26] of the export fishery, main beneficiaries, and jobs. The costs are likely to include those related to management, destructive fishing, reduction of tourism potential and any cultural/subsistence value.

Armed with this cost/benefit knowledge, countries may decide that the trade does not have a favourable cost/benefit ratio, or that the CITES requirements to enable the export of humphead wrasse are not worth the extra work/expense. In several countries (Box 8) such consideration has resulted in a decision to ban the export of the species.

**Box 8**: Countries banning the export of humphead wrasse.

| | |
|---|---|
| Maldives: | Exports banned since 1995. |
| Australia: | No food exports since 2003. |
| Fiji: | Ban on commercial harvest, sale or export since 2004. |
| Palau: | No export since 1998; presently all capture is banned. |
| Seychelles: | Banned all live fish exports in 2005. |
| Philippines: | Palawan banned exports since 1994; All exports from country of captured humphead wrasse banned after CITES listing. |

If an export fishery for the humphead wrasse is to proceed, some reconciling of the important management principles of Section 5.1 above with the difficult realities in Section 5.2 needs to be undertaken in order to develop a workable management strategy. In this regard, some points to be considered are:

- In areas where there is little functional fisheries management, there are advantages of instituting a basic management regime with limited objectives, prior to attempting more complex arrangements or accomplishing multiple objectives: "learning to walk before running". This may justify an initial single species focus (Section 7).
- Rather than viewing "adaptive management" as a complexity or a component of an advanced management regime, it could be a mechanism for improving even very ineffective management schemes. Because adaptive management entails formalizing procedures to learn from past successes/failures, it could be especially appropriate in making real progress in difficult environments.
- In situations where enforcement of management regulations is difficult, consideration should be given to using measures that are relatively easy to enforce. Included in this category are quotas at the point of export, attention to enforcement at the level of collectors/buyers/exporters, and sometimes, marine protected areas. Limiting the points of export or modes of transport can also aid enforcement.
- Ease of enforcement of regulations is also related to their clarity – it has been shown (World Bank, 2000) that simple rules ("Thou shalt not…") are easier to enforce than those that are conditional or have complex requirements ("If A and B, then….and…").

[26] The value added; gross value less intermediate inputs.

- Advantage should be taken of an important characteristic of the live trade of humphead wrasse: that there are relatively few demand centres.
- Although the management of small-scale fisheries can be extremely difficult, the collection of humphead wrasse mostly occurs on a much larger scale (i.e. the use of collection vessels), which offers some advantages and opportunities for monitoring of catches.
- Management approaches in which communities and governments share management responsibilities, including enforcement, have proven effective where previous centrally-controlled attempts have failed (King, Passfield and Ropeti, 2001).
- Previous attempts at the management of the humphead wrasse have suffered from lack of organized support at the country level. Creating a constituency for the conservation of the humphead wrasse could be an important foundation for effective management of this fish. Accordingly, consideration should be given to harnessing the enthusiasm of the dive tourism industry in countries where such businesses exist – as was done in the Maldives.
- Because some of the difficulties in the management of humphead wrasse are institutional in nature (e.g. difficulty of dealing with an issue that has both a fisheries and a CITES aspect), attention should be given to linkages between government agencies.
- The charismatic nature of the humphead wrasse could be a special advantage in generating interest in its conservation and should be put to use in a management regime – as was done in the "What makes Fiji special" campaign.

Success in the management of small-scale fisheries in many of the humphead wrasse range states is elusive. There are however, some positive examples that could be used as models. Although an inventory and analysis of these success cases is well beyond the scope of this report, some examples are:

- "Sasi laut", the well-documented system for prohibiting the harvesting of certain natural resources in Maluku, Indonesia (Harkes, 1999)
- The use of community-level inshore fishery management plans in Samoa (King, Passfield and Ropeti, 2001)
- Buyer-enforced controls on crocodiles in the Solomon Islands and trochus in Palau (World Bank, 2000).
- Management of spearfishing and associated enforcement by residents of Kadavu, Fiji (Gillett and Moy, 2006)
- Co-management in Aitutaki trochus fishery of the Cook Islands (Nash *et al.*, 1995)

It should be noted that the above management schemes involve either a large degree of community involvement in management or point of export controls or both.

In dealing with management ideals and realities, an additional concept is worth bearing in mind. The process of satisfying the CITES requirements for the export of humphead wrasse could represent a catalyst for making general improvements in a country's fisheries management system, including incorporation of the desirable attributes mentioned in Section 6.2.

## 6. GUIDELINES

Establishing a management regime for humphead wrasse involves a number of steps – and it is expected to be differences in these steps between countries. In general, one of the first steps should be an analysis and discussion of the costs and benefits of the fishery and associated management prior to making management arrangements. This is covered in Section 6.3 above. A fundamental issue that needs to be resolved is whether humphead wrasse should be exported, or even harvested, given its natural lack of resilience to fishing.

Other steps are likely to involve identifying stocks, appropriate management units, management objectives, reference points, and indicators, as well as the actual management measures and associated enforcement. These are covered in the sections below.

### 6.1 Stock identification and management units

In a discussion of stock[27] identification and management units, it is important to note that the humphead wrasse is taken almost exclusively in small-scale fisheries and mostly in developing countries. In general, the management of those fisheries is associated with requirements and constraints that are very different from large-scale fisheries, especially those in developed countries. Box 9 contains a pragmatic discussion of stock identification and management units tailored for small-scale fisheries.

**Box 9**: Stock identification and management units in small-scale fisheries

Much has been written about the definition and identification of stocks. The ideas pertaining to stocks are closely related to definitions of population, subpopulations and the extent of interbreeding among these units. Concepts and research relating to the discreteness of stocks and populations are highly relevant to fishery management, but for small-scale fisheries, this type of information will frequently be unavailable, necessitating more practical definitions of the management unit.

Clearly, if management addresses only one part of a large resource that is being affected by heavy exploitation in other areas, its chances for success will be constrained by those outside forces. Consequently, there is a need to define management units within which there is the greatest chance for success. Here the precautionary principle has a role. In the absence of good information on the extent of a stock, it is precautionary to use the largest feasible management unit. In this context, management should not be confused with local efforts at fishery improvement in communities. The latter efforts can be successful for subunits of the management unit, provided they do not depend on a response from the entire resource. Ideally, the fishery management unit will encompass the entire resource and all of the vessel and gear combinations that exploit that resource.

For practical purposes, the management unit should be defined to include the resources, fishers, and communities that have the strongest interconnections. There will always be an element of subjectivity in assessing what interconnections are sufficiently strong that the elements must be incorporated in the definition. There are no strict rules for achieving the appropriate balance between inclusion of interactions and the simplicity that is essential for management to be feasible. In this regard, stakeholder perceptions and acceptance could be strong guiding factors.

*Source:* Adapted from Berkes *et al.*, 2001.

Little work has been done on humphead wrasse stock identification. Information on genetic aspects, including the presence of discrete populations, is not available in the literature. Adult humphead wrasse apparently do not move significant distances, so the presence of any discrete populations is likely to be related to the movement of eggs, larvae and sub-adults, which is again a subject that has not received much research attention. All that is apparently known is that the total length of newly hatched humphead wrasse larvae is 1.5 to 1.7 mm (Slamet and Hutapea, 2005) and these larvae settle out of the plankton at about 8 to 11 mm (Sadovy *et al.*, 2003b). The extent of egg/larval dispersal that could take place in the period from spawning to settling is unknown,[28] and therefore the recruitment linkages between reefs, island, or countries is unknown. This sentiment is expressed in a slightly different way by Sadovy *et al.* (2007): "Napoleon fish which, like many coral reef fishes, forms a metapopulation[29], in which populations are linked via larval advection and adult movement. The data for Napoleon fish do not currently allow detailed meta-population models to be developed".

As indicated by Berkes *et al. (*2001, Box 9), the lack of information on stocks/populations necessitates a different approach in identifying the appropriate management unit and it is precautionary to have such a unit as large as possible. This contention should be balanced with practicalities, including the present lack in the Indo-Pacific region of mechanisms for intercountry management of reef species. On the other hand, the free movement of fishers and catches within most range countries, would be ineffective should the humphead wrasse management unit be smaller than the national level. Considering the various factors, the most appropriate unit for managing the humphead wrasse appears to be the country.

[27] FAO (2002) gives a CITES-oriented definition of stock: "A unit stock in fisheries can be defined as all the individuals of fish in an area, which are part of the same reproductive process". Alternatively, Begg *et al. (*1999) state that fish stocks are "semi-discrete groups of fish with some definable attributes which are of interest to fishery managers".

[28] For comparison purposes, the duration of the planktonic stage of tropical reef fish ranges from 9 to well over 100 days, with size at settlement from 8 to 200 mm (Buchheim, 2006).

[29] A meta-population consists of a group of spatially separated populations of the same species.

## 6.2 Management objectives, reference points and indicators

### *6.2.1 Conceptual framework*

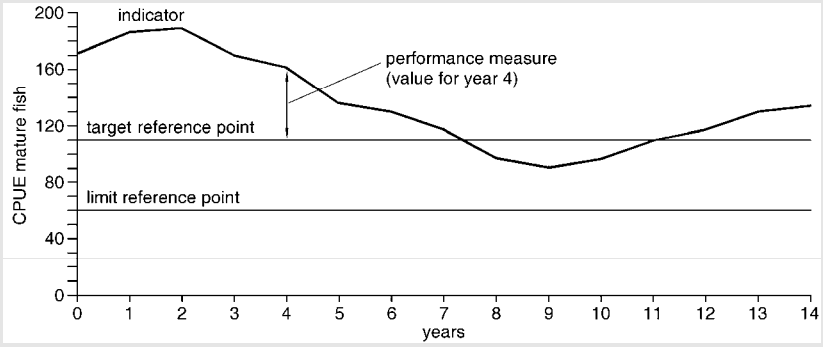
Fisheries can be managed for a wide variety of biological, economic, and social objectives. As different stakeholders often have very different expectations, many fisheries (including the live reef food fisheries) are managed for a variety of objectives. A clear statement of objectives is a fundamental prerequisite for effective fisheries management, especially in situations where there is a multiplicity of stakeholders and objectives.

Reference points and indicators are mechanisms that can help fishery managers determine whether the objectives are being attained. King (2007) contains a concise explanation of the relationship between objectives, reference points, and indicators (Box 10).

**Box 10**: Objectives, reference points and indicators

Reference points and indicators are an important part of the fisheries management process and can allow for an evaluation of the degree to which objectives are being met:

- Part of the management process involves translating an objective into a target for the exploitation of a fishery. A target or commonly "target reference point" can be defined in terms of stock size (say, a particular number of spawners) or fishing (say, a particular fishing mortality).
- After an objective has been translated into a target reference point, there is a need to evaluate and monitor how well, or otherwise, the management strategies are performing in relation to the objective. This involves the use of an appropriate indicator.
- If, for example, the single objective for a particular fishery was to maintain a certain level of spawning stock biomass, some estimate of this could be used as an indicator. The mean catch rate of sexually mature individuals, could be used.
- To avoid overexploitation there is a need to define a threshold or "limit reference point" that indicates the fishery is in an undesirable situation and immediate management action is needed.
- Management performance is measured as the vertical distance between the indicator and the target reference point – e.g. the indicator is about 45% above target in year 4 and 20% below in year 9 of the Figure below.




*Source:* King, 2007.

The importance of reference points specifically for the live reef food fish trade is emphasized in the International Standard for the Trade in Live Reef Food Fish.[30] The Standard states: "All live reef food fisheries shall have a formal procedure in place that details the action to be taken when certain pre-determined events occur. This procedure shall identify limit and target reference points, and the appropriate responses to be implemented if these reference points are breached".

It is generally recognized that when adequate quantitative information exists, the use of reference points is extremely important in improving the effectiveness of fisheries management. When such data is not available, which is often the case in the small-scale fisheries that capture the humphead wrasse, it is still important to have some means of verifying progress towards objectives, even though it may be less formal/quantitative than reference points (Caddy and Mahon, 1995; Berkes *et al.*, 2001).

[30] The International Standard for the Trade in Live Reef Food Fish was developed by regional organizations, national governments and non-government organizations at a workshop held in Honolulu in February 2001 (Kusumaatmadja *et al.*, 2003).

### *6.2.2 Management objectives, reference points, and indicators*

Various humphead wrasse management objectives are specified below. Although an export trade for this fish exists in only a few of the 48 range countries, many non-exporting countries also have an interest in humphead wrasse management. Accordingly, the objectives discussed in this section are oriented to both CITES and non-CITES purposes.

The most common objective in humphead wrasse management appearing in the literature concerns achieving a sustainable level of fishing. It is expressed in various ways, most often attaining a level of fishing that can be continued over the long-term or maintaining the population size at a certain percentage of the unfished level. These two specific objectives can be translated into reference points. Specifically, they could be the fishing mortality at maximum sustainable yield (or some fraction of maximum sustainable yield) and the fishing mortality that would result in a population at 20 percent of the unfished state, respectively. In situations where the species has been severely depleted, the recovery of biomass to pre-defined levels could also be a management objective. How well any management measures are performing with respect to the objectives is determined by the use of a measurable indicator. Useful indicators could be the densities of humphead wrasse in an area as determined by UVC (i.e. number of fish per 10 000 $m^2$), or the catch per unit effort (CPUE) of humphead wrasse.

With respect to objectives and indicators related to sustainable fishing levels for humphead wrasse, two aspects should be noted:

- By definition, the CITES objective of assuring that international trade is not detrimental to the survival of the humphead wrasse is closely related to the objective of achieving a sustainable level of fishing. This is because international trade is considered not detrimental when it is part of a harvest (for both domestic and export purposes) the sum of which is sustainable (Section 3.2 above).
- For indicators, there is considerable room for innovation – an intimate knowledge of a particular national fishery could enable the identification of improved indicators, such as easy to collect data related to the operations of live reef food fish collection vessels.

In addition to the management objective of achieving a sustainable level of fishing, humphead wrasse fisheries (and fisheries that catch humphead wrasse) are managed for other reasons. One important objective in many countries is to reduce destructive fishing associated with the capture of this species. Another is to increase the presence of humphead wrasse on reefs for viewing by dive tourists, as is the case in the Maldives. In Fiji the main management objective is to increase the abundance of the fish for cultural and subsistence purposes. In some Southeast Asian countries a *de facto* objective of government intervention in small-scale fisheries, including that for the humphead wrasse, is the generation of government income from licensing fees.

The reference points and indicators for these types of objectives are a bit more problematic – in small-scale fisheries there is often not enough data to establish them quantitatively. In this situation, the Berkes *et al. (*2001) concept of "reference directions" is useful – where the need to move in a direction is obvious, but the precise level is not able to be specified. This approach shifts the focus of management action from the exacting and difficult question of "where exactly do we want to be?" to the simpler and more manageable "how do we move from here in the desired direction?"

Another aspect of the objectives of management to be considered is simplicity: where appropriate, the use of simple biological objectives, such as increase the abundance by X percent the next Y years, is likely to be more easily understood by stakeholders, easier to monitor and are more likely to be achieved than model based reference points, such $F_{msy}$, of biomass at 20 percent of unfished stock.

Table 4 summarizes some examples of management objectives for humphead wrasse fisheries and means of ascertaining progress towards those objectives.

There are often difficulties in reconciling biological and socio-economic objectives, such as how to improve the status of the species (less fishing) and at the same time improve the situation of people (increase fisher's income, food security, etc.). It is usually easier to reconcile these objectives when resources are still unexploited than when the species is threatened such as for the humphead wrasse. This should be taken into

account when discussing the advantages and disadvantages of the various management measures discussed in the following section.

**Table 4:** Linking humphead wrasse management objectives to reference points and indicators

| Objectives | | Reference points and directions | Examples of indicators |
|---|---|---|---|
| **Achieve a sustainable level of fishing** | Maximum sustainable yield – or some specified fraction of MSY (numbers or weight) | • Fishing mortality at MSY (Fmsy) | • Fish density estimated by UVC<br>• Fisheries CPUE |
| | Maintenance of population size of 20% of the unfished level | • Fishing mortality when the population is 20 percent unfished level (F20%) | • Fish density estimated by UVC<br>• Fisheries CPUE |
| | Recovery of population to pre-defined levels of abundance/density | • Increase in fish density or abundance towards pre-defined levels | • Fish density estimated by UVC<br>• Fisheries CPUE |
| **Reduce destructive fishing** | | • Decline in perceptions of use<br>• Increase in awareness<br>• Decline in incidence in tested samples | • Community perceptions of use<br>• Level of community awareness of problem and implications<br>• Analysis for presence of cyanide |
| **Increase in humphead wrasse abundance for viewing on reefs by dive tourists** | | • Increase in sightings during UVC surveys<br>• Decrease in catch | • Number of individuals encountered in UVC on reef frequented by dive tourists<br>• Incidence in fish catch from areas frequented by dive tourists |
| **Increase abundance for cultural/subsistence purposes** | | • Decrease incidence in commercial catch<br>• Increase incidence in subsistence catch<br>• Decrease in exports | • Incidence in commercial catch<br>• Incidence in subsistence catch<br>• Exports |
| **Increase government revenue from the fishery** | | • Increase in revenue | • Revenue collected related to the capture of the fish |

## 6.3 Management measures

A fishery manager can use a number of measures to reach the various objectives that have been established for a fishery. These include input controls (e.g. gear restrictions, area/seasonal closures, restrictions on participation) and output controls (e.g. catch/export quotas, fish size limits). A manager can also use measures that are not controls, such as awareness/education programmes. Because a single management measure is not usually sufficient to reach a particular object and because most fisheries are managed for multiple objectives, nearly all fisheries are managed using several measures.

Sadovy *et al.* (2003a) gives management measures that apply to live reef food fisheries in general, along with their advantages and disadvantages. Specifically for humphead wrasse, Table 5 lists the common objectives in the management of humphead wrasse fisheries and for each objective, some of the more practical management measures are given. The list should be considered indicative rather than exhaustive.

Characteristic of some of the more important management measures in Table 5 are discussed immediate below and enforcement issues are covered in Section 6.5. In Section 6.6 the information requirements (including biological research) to support an effective humphead wrasse regime are discussed. Finally, Section 7 gives some practical considerations on single species management – which the present report may appear to promote.

**Table 5**: Example of management measures for attaining objectives.

| Objectives | Examples of measures |
|---|---|
| **Achieve a sustainable level of fishing** | Export quota<br>Export ban<br>Tax on exports<br>Commercial catch ban<br>MPAs<br>Limits on fish size, including those taken for grow-out<br>Ban on scuba spearfishing<br>Community ban on outsiders fishing<br>Closed seasons |
| **Reduce destructive fishing** | Export ban<br>Community awareness raising<br>Instruction in alternate techniques<br>Ban on cyanide presence in fish and associated testing in exporting country<br>Ban on cyanide presence in fish and associated testing in importing country<br>Ban on use of scuba/hookah gear for use in the live reef food fish trade |
| **Increase in humphead wrasse for viewing on reefs by dive tourists** | Bans on fishing for the species on specified reefs<br>Export quota<br>Export ban<br>Ban on scuba spearfishing<br>Tax on exports<br>Commercial sales ban<br>Complete catch ban<br>MPAs |
| **Increase abundance for cultural/subsistence purposes** | Export ban<br>Ban on scuba spearfishing<br>Tax on exports<br>Commercial sales ban<br>MPAs<br>Limits on fish size<br>Community awareness raising<br>Community ban on outsiders fishing |
| **Increase government revenue from the fishery** | Licensing collector/exporters and associated charging<br>Tax on exports<br>Sale of a portion of the export quota |

Export quotas

Currently there is much interest in using an export quota as a management measure to assure a sustainable level of humphead wrasse fishing. Because the preferred method of fishing for live export of humphead wrasse involves cyanide in many countries, restricting exports also has implications for reducing destructive fishing. A major advantage of an export quota system is that it can be applied at the level of the point of export, rather than at a lower level which may involve hundreds or thousands of locations. Quotas are also amenable to the development of incentives for cooperation/compliance, such as allocating rights to export between licensed companies and requiring in exchange reporting, compliance, or other concessions. Another advantage is that a quota system can be quite compatible with adaptive management – quota levels are characteristically easy to change with evolving circumstances. Despite these advantages, there are some significant difficulties associated with a humphead wrasse export quota system, including:

- There must be a good estimate of the other fates of captured humphead wrasse besides legal live exporting. This includes domestic use, mortality before live export, and exports that circumvent the quota. Presently, in many countries that export humphead wrasse, assigning quantities to these alternate fates is largely guesswork.
- Obtaining accurate estimates of stock densities is difficult. Even with appropriate methodologies (UVC) the uncertainties will be always substantial.
- A humphead wrasse export quota system would require a high degree of institutional cooperation, often involving the fisheries agency, CITES authority, and customs officials. In many developing countries the latter agency is primarily oriented to taxing imports, and is much less efficient at policing or even keeping track of exports, especially down to the species level.
- A humphead wrasse quota system is most effective when applied on fishing that is exclusively dedicated to catching this fish – operations that will curtail their activity when a quota is reached, with the idea that it is not worthwhile pursing this hard-to-catch fish unless they can access export market with high prices. In some countries there are fishing operations that take the humphead wrasse on a different basis – when the fish is encountered as part of (a) general live reef food fishery or (b) fishing for the non-live domestic market. In the case of (a), after reaching a quota, any

humphead wrasse capture can be simply diverted to domestic use, or in the case of (b) there would be no affect on fishing for humphead wrasse after reaching the quota.
- Because any fish captured after a quota has been reached could be held in a grow-out operation until a new quota period, some special arrangements are required.
- To be fully effective, there is a need for cooperation from destination countries.
- A national export quota could result in serial depletion of the humphead wrasse in particular areas of a country. The characteristically mobile live fish operations can sustain an overall catch level that is locally unsustainable by moving from area to area. Controls on the movements of collector vessels (Section 6.5 below) may be necessary.

In general, an export quota has major advantages as a humphead wrasse management measure. However, it would obviously be totally ineffective for countries that do not export the fish. For exporting countries, the difficulties identified above indicate that an export quota by itself would not be very effective at attaining a sustainable level of fishing or other objectives – it would need to be combined with other types of measures.

Export size limits

Export size limits are in place in Indonesia and Papua New Guinea and have been proposed for other countries. Limits on small size fish can be used to ensure that sufficient fish attain sexual maturity and can reproduce thereby enabling populations to persist. In addition, protection of the larger, rarer, males in this polygynous species could be important (Sadovy, 2005b). The principal difficulties with this management measure have been getting the size limits right. Indonesia's ban on exporting fish below 1 kg and above 3 kg appears to relate more to promoting value-adding through grow-out, rather than protecting pre-reproductive fish (fish become mature at about 3 kg). Although export size limits (like export quotas) have the advantage of application at the point of export, there is some degree of complexity: the required export monitoring entails both identifying fish to the species level and measuring fish, as well as dealing with issues related to fish fillets and aquarium fish. The recent studies by Choat *et al. (*2006) indicate that female humphead wrasse begin to become especially sexually active at 55 cm FL, a feature which should be taken into consideration in establishing any size limits. The major downfall of size limits as a management measure for humphead wrasse in many locations has been the exceptions for grow-out operations. Also to be considered is that the preferred market size is at the sub-adult to early adult stage. Fish below an established the size limit can be caught and placed in grow-out until a legal sized is reached. Experience seems to suggest that to be effective, size limits must be across the board and apply to all fishing and grow-out operations.

Export bans

A complete ban on exporting live (or all) humphead wrasse has the major advantage of simplicity: all exports are illegal, there is no opportunity for legally circumventing the ban, and export monitoring is relatively easy. Because there is no full-cycle aquaculture for this species, confusion would not exist between culture and captured fish. Some fisheries specialists with substantial field experience in important humphead wrasse range countries feel that a complete export ban is the *only* measure that has a reasonable chance of success for promoting sustainable fishing, reducing destructive fishing, and increasing abundance for domestic consumption or tourist purposes. Indeed, such vulnerable species probably cannot withstand a substantial export trade or uncontrolled local use into the long term without declines. On the other hand, an export ban reduces immediate benefits to fishers/exporters associated with the trade. The magnitude of those benefits, the numbers of fishers involved, and dependency on exports of humphead wrasse is unknown in most exporting countries.

In addition to complete export bans, a selective ban on certain export routes, such as by sea, could be an important management measure to facilitate enforcement.

Export taxes

To a certain degree, high prices for humphead wrasse in China and associated profits drive the fishery. Due to the rarity appeal, market forces often fail to curtail fishing operations even when the fish is quite rare in the fishing areas. Rising prosperity in China suggests that the demand for humphead wrasse will increase, allowing profitable fishing at progressively lower catch rates, which could have very serious consequences for the humphead wrasse. One way to break this "rarity cycle" that is less radical than a total export ban is to variably tax humphead wrasse exports. As the price of the fish (and associated profitability) rises, such an export tax would increase making continued fishing more difficult. A related scheme is to charge a variable amount for portion of a country's export quota. A possible difficulty with export taxes as a management

measure is that it favours the most profitable fishing operations, which in some areas could mean those that use cyanide.

Bans on scuba spearfishing

Scuba or hookah spearfishing (especially at night) diminishes or eliminates the positive effects of deep water acting as a sanctuary for fish. This is especially serious for the humphead wrasse adults, which often seeks refuge in deep water from diver and at night. For humphead wrasse range countries that do not participate in exporting the fish, a ban on scuba spearfishing is probably the single most important measure to protect the species from over-exploitation. Experience shows, however, that simply banning the use of scuba for spearfishing (or for all fishing) is insufficient because of difficulties in obtaining evidence for court prosecution. Banning the possession of scuba and fishing gear in same boat or car is much more effective (Gillett and Moy, 2006). Scuba/hookah use is also associated with another problem – much of the cyanide fishing is in conjunction with the use of compressed air, so there is justification for a complete scuba/hookah ban for the entire live reef food fishery.

Marine protected areas

Areas in which all fishing is prohibited provide some degree of protection to humphead wrasse from threats not addressed by many other measures, including habitat destruction and any targeting of spawning aggregations. The characteristically low density of the humphead wrasse, suggests that a marine protected area (MPA) would need to be large to have a significant effect. Not enough is known about humphead wrasse egg/larval dispersal and movement of adults to assess the effects of an MPA on stocks in neighbouring areas. If MPAs are intended to protect spawning aggregations, considerable planning must be undertaken to assure that appropriate geographical areas are selected. The enforcement considerations are quite different than for other measures, and maybe easier or more difficult, depending on local circumstances.

Awareness activities

Public awareness of certain features of the fishery for the humphead wrasse could lead to progress towards several of the objectives on Table 5. Knowledge that this charismatic giant reef fish is a threatened species can lead to less consumer demand, peer pressure to reduce harvesting, and greater enthusiasm for enforcement activities – similar to what has occurred for sea turtles. Awareness that destructive fishing practices are often used in the capture of humphead wrasse for the live fish trade, could galvanize the broader public to discourage their use. It would be overly-optimistic to believe that awareness alone could suffice in altering the behaviour of fishers to achieve the stated management objectives (especially in poor fishing communities), but awareness could be an important complement to other management measures. Awareness rising could also be considered as a facilitator of enforcement, in addition to being a management measure in itself.

Catch quotas and limited entry

These measures deserve special mention because they are often impractical to introduce for small-scale fisheries. They characteristically suffer from both being extremely difficult to enforce at the fishing locations, as well as being contrary to small-scale fishing traditions in many developing countries. The difficulty of introducing limited entry for humphead wrasse purposes is emphasized by a remark of a fisheries specialist in an important range country: “Utter nonsense of completely re-orienting national fisheries situation to cater for the management needs of a small fishery”. On the other hand, limited entry could be a feasible management option if applied at a higher level; that is, to humphead wrasse collectors and/or exporters. Collection or export rights could be granted to a limited number of companies, who in exchange are required to perform certain functions related to management.

Community ban on outsiders fishing

Many coastal communities in the Pacific Islands have a form of limited entry whereby community leaders restrict access by outsiders to coastal fisheries, and then apply various kinds of harvest bans for residents, most of which are oriented to prevent over-fishing. Unlike the limited entry mentioned above, these measures have generally not been “introduced”, but rather have been in place since traditional times. This form of management measure has had mixed results in dealing with the live reef food fisheries. It has resulted in the exclusion of live reef food fish operations perceived as being non-beneficial from community-controlled reefs in many countries (e.g. at Ontong Java atoll in the Solomon Islands [SPC 2000]) . However, their exclusion often comes after damage has been done or agreements broken. A key to the success of this

type of management is having communities fully aware of the costs, benefits, and risks of live reef food fisheries before an agreement is concluded with collecting companies. Awareness raising activities may also be required should community management be used to manage non-live fishing of humphead wrasse for the various objectives.

Ranching

Ranching is sometimes proposed as an easy alternative to restrictive management measures in a number of fisheries. Ranching is usually thought of as the enhancement of natural fisheries by artificially rearing young fish to be introduced to the wild. As applied to the humphead wrasse, ranching could be considered as allowing caged fish to spawn and release eggs into the wild. At best, ranching for most species of fish could supplement (not replace) other management measures. With specific reference to the management of humphead wrasse, CITES (2006) states that initiatives that aim to ranch this species need to be supported by scientific evidence of the advantage to natural populations of placing wild fish in captivity and allowing them to release eggs if ranching is to be used as a conservation measure. Presently, there is no evidence that any eggs released from cages survive to reproduction, while the current thinking is that the specific spawning sites used by the species are important or even critical for successful dispersal and propagation at the population level (Y. Sadovy, personal communication, August 2007).

In Table 5, 17 measures are given to obtain the objectives commonly associated with the management of the humphead wrasse. In examining the Table and points note above, several features are apparent:

- Each management measure is far from perfect. The effectiveness of each individual measure depends on several factors, including inherent characteristics of the measure, enforcement considerations, and local/national circumstances.
- All the identified measures have significant deficiencies, especially in the extremely challenging management environment that exists in most range countries (Section 5.2 above).
- To attain any of the humphead wrasse management objectives that are commonly put forward, it is likely that more than one management measure will be required.
- This leads to the contention that humphead wrasse management requires considerable effort to be effective. Some countries may therefore conclude that attaining certain objectives is not cost effective.
- Many of the measures on Table 5 are shown to be applicable to attaining more than one objective. This may suggest that certain measures are especially important in humphead wrasse management. Accordingly, special attention should be given to the various restrictions on exports, the ban on scuba spearfishing, and MPAs.

### 6.4 Enforcement issues

Enforcing management controls in small-scale fisheries is characteristically difficult. For humphead wrasse fishing activity, the situation is especially challenging due to the added complications of the high value of the catch and the international nature of the trade. Many of the very difficult or intractable problems dealing with the management of humphead wrasse noted in Section 5.2 relate to enforcement difficulties.

Some of the recent suggestions for improving humphead wrasse management consist of otherwise sensible measures that are predicated on remarkable progress in enforcement. In some cases it has been treated as an implementation detail ("Enforcement will need to be improved….") when actually the difficulty is much more profound. The reality is that national fishery enforcement arrangements are unlikely to undergo major transformation due to the requirements of the relatively small humphead wrasse fishery. An alternate approach to attaining management objectives for the humphead wrasse would be to favour those measures for which the required enforcement is likely to be practical and effective. This involves two main strategies: (a) focusing enforcement at a level higher than small-scale fishing activity, and (b) taking advantage of particular attributes of the humphead wrasse trade that may facilitate enforcement.

Enforcement conditions vary tremendously between the important humphead wrasse range countries. It is therefore difficult to come to detailed conclusions that have wide applicability. Nevertheless some generic suggestions can be made. These include:

- giving priority to management measures that are carried out at the point of export;
- using the collector level;
- using MPAs in appropriate situations;

- engineering enforcement cooperation at the two major overseas destination, China, Hong Kong SAR and Mainland China;
- creating incentives and constituencies for enforcement cooperation;
- using communities in enforcement in appropriate situations;
- identifying opportunities for using awareness to facilitate enforcement;
- promoting appropriate legislation.

Point of export management measures

Export quotas, total exports bans, and export taxes are associated with relative ease of enforcement. As an example, stationing agents at the seven international airports of Indonesia is obviously easier than doing the same along 55,000 km of coastline or 7 000 coastal villages. Factors that complicate point of export enforcement are misidentification of species (simple taxonomic guides need to be provided), exports by sea (a concurrent ban on sea exports is likely to be required) and inadequate checking of export shipments.

Using the collector level

Most live reef food fishing operations are associated with a substantial vessel that has circulating water in wells for keeping the fish alive during transport to the point of export or to the overseas destination. Although enforcement activity in the small-scale fisheries environment is plagued with problems, the live fish collection vessels operate on a higher level (fewer vessels, larger vessels, operated by relatively few commercial firms) and are more amenable to controls and associated enforcement. This opportunity could be developed by requiring such vessels to have a special licence, and making a limited number of licences available thereby creating scarcity/value (useful for another reason, below). Regulations could make the operators of collection vessels responsible for recording data (useful for another reason, Section 6.5), and for carrying illegal sizes of fish and fish with traces of cyanide. By doing so, collector vessels could be made *de facto* enforcement units through their ability to buy or reject fish. Depending on circumstances, additional requirements could be placed on collector vessels, including using a vessel monitoring transponder, requiring all transported fish to be exported by air, prohibiting transhipment, and carrying an observer.

Using MPAs in appropriate situations

Often enforcing controls related to marine protected areas are as difficult and expensive to enforce as other controls on the fishing grounds, but there are certain situations when enforcement is facilitated.

- If MPAs are large, situated in appropriate geographic areas, and all forms of fishing are banned, then any vessel seen operating in such an area would be a violator, tremendously facilitating detection of illegal activity.
- MPAs for humphead wrasse (or all live reef food fishes) could make use of existing conservation infrastructure. National parks and similar conservation areas could be charged with the additional responsibility of protecting humphead wrasse in such a way that any capture of the species is illegal. The enforcement advantage is that the ban is monitored by existing staff of the park, rather than additional fisheries enforcement staff. Reports in CITES (2006) and TRAFFIC (2006) suggests that many, if not most, of apprehensions related to the humphead wrasse in Indonesia were due to action of staff of national parks and conservation areas.
- If community interest in the conservation of humphead wrasse can be engineered, then enforcement of controls on an adjacent MPA is facilitated by the effect of "many eyes/ears" on fishing ground, as well as by peer pressure.
- MPAs are also consistent with ecosystem approach if properly placed and could bring substantial benefits to other components of the reef fishery and habitat

Enforcement cooperation in China, Hong Kong SAR

It appears that in recent years China, Hong Kong SAR officials have been quite cooperative in efforts to mitigate problems created by live reef food fish trade in source countries. This has included the joint sponsorship of international workshops, provision of trade data, and liaison with CITES and other international organizations. Because much, if not most, of the international trade in humphead wrasse is funnelled through China, Hong Kong SAR, advantage should be taken of the enforcement opportunities presented by such a situation. The obvious candidate (and one that is in the interest of China, Hong Kong SAR) is testing all humphead wrasse (or all live fish) on arrival for traces of cyanide – (though this is not yet possible. Another item concerns sorting out the difficulties associated with arrivals of live fish in China, Hong Kong SAR aboard Hong Kong registered fishing vessels (Section 2.3), which is especially important if the source countries follow the suggestion of banning sea exports of the fish. International forums which

involve the main humphead wrasse exporting countries (ASEAN, APEC) may be an effective channel to communicate to the China, Hong Kong SAR Government the importance to many countries of enforcement cooperation. Of particular concern is the lack of monitoring and enforcement into Mainland China, where at least half of all humphead wrasse imported to Hong Kong go and for which export permits from Hong Kong but no import permits to the Mainland are issued nor is there any record that imports are monitored.

Creating incentives and constituencies for enforcement

National opportunities for incentives and constituencies vary greatly across the range countries, but some examples can illustrate possibilities.

- If licensing of live fish collector vessels is made a requirement (section above) and a limited number of licences are made available, then the licence becomes valuable due to its utility and scarcity. Those that possess a valuable collecting licence are more inclined to comply with legal requirements (or else risk losing the valuable licence), report illegal collection operations (it reduces the competition), and to some degree be more oriented to the long-term future of the resource (with fewer collectors, the more chance that what is not harvested today is still available tomorrow).
- A constituency for improved enforcement could be a group that, due to its own self-interest, cooperates with enforcement agencies/personnel and facilitates compliance with regulations with such action as reporting or providing enforcement assets. Conversely, such a constituency could be in a position to generate much negative publicity when agencies/personnel underperform. The dive tourism industry, could become a constituency for improved enforcement due to its presence in the humphead wrasse fishing areas, clear interest in maximizing the abundance of one of the most spectacular coral reef fish, the dive industry's economic importance in some countries, and its organizational skills.

Using communities for enforcement

Management approaches in which communities and governments share management responsibilities, including enforcement, have proven effective where previous centrally-controlled attempts have failed. Like constituency creation above, some output of the management process must be tangibly beneficial to the community concerned. The amount of time required to convince a community of the need for, and benefits of, enforcing controls related to humphead wrasse management could be substantial, even in a single village. World Bank (2000) makes the point that Pacific Island communities are better at enforcing those national management controls that have been additionally adopted by communities as local controls. King, Passfield and Ropeti (2001) indicate that a community fishery management plan could facilitate the management process, including enforcement aspects. Community enforcement activities could include passing on information of illegal fishing, apprehensions where communities have this power, or (most often) simply making life difficult for contravening fishing operations.

Using awareness to facilitate enforcement

Awareness rising, in addition to being a management measure in itself, could facilitate compliance with other measures. This could occur at the level of the fisher, the general public or the consumer.

- At the fisher level, explaining the endangered status of the humphead wrasse, effects of destructive fishing, the relevant regulations, and associated penalties could easily have positive effects on compliance with those regulations.
- At the community level in source countries, an awareness campaign emphasizing the charismatic nature of the humphead wrasse together (and cultural value, if applicable) with its listing on CITES and the relevant fishing restrictions could motivate the general public to pressure fishers to comply with those restrictions, or report violations. Similar awareness activities for the CITES-listed sea turtles (through posters, car stickers, newspaper advertisements, and school programmes) have had a very positive effect on compliance.
- Awareness campaigns could be successful in the east Asian demand centres. Presently, there are awareness campaigns targeting consumers such as WWF's sustainable seafood guide in Chinese. While not disputing the value to humphead wrasse conservation of educating the Chinese public[31], another strategy would be to target a much smaller number of China, Hong Kong SAR distributors

[31] In many countries, consumer environmental awareness is high, and their collective purchasing power can force industry and stakeholders to change their practices for environmental good. However, Sadovy *et al. (*2003b) indicate that this cannot yet be said for China, Hong Kong SAR and mainland China where environmental awareness is as yet underdeveloped.

of humphead wrasse.[32] An awareness campaign could make the distributors aware of legal issues in source countries with the idea of obtaining their voluntary compliance in specific subjects, such as refusal to buy fish with traces of cyanide or fish that has not arrived by air freight.

Promotion of appropriate legislation

In small-scale fisheries, the compliance with regulations is related to both rule simplicity and clarity of the actual legislation (World Bank 2000). An example of a simple rule is a full ban on spearfishing, as in the Maldives. A more complex, harder to enforce rule would be a ban on spearfishing for the taking of humphead wrasse, except for non-commercial purposes. Clarity of the legislation is important – many countries have fisheries legislation that baffles both fishers and enforcement personnel. Concise and easy-to-understand legislation should be promoted to both encourage compliance and facilitate enforcement.

Grow-out operations create special enforcement problems, for which there may not be easy solutions. It has been said that the downfall of size limits as a management measure for humphead wrasse in many locations has been the exceptions for grow-out operations. In addition, there is the possibility that grow-out operations could circumvent an export quota – fish captured after a quota has been reached could conceivably be held in a grow-out operation until a new quota period. For countries such as Malaysia and Indonesia where growing-out is important, special arrangements may be required, such as specific licensing/monitoring of those operations.

### 6.5 Monitoring and data collection

Information is required for informed fishery management decisions. The Code of Conduct specifically addresses this subject. "Conservation and management decisions for fisheries should be based on the best scientific evidence available, also taking into account traditional knowledge of the resources and their habitat, as well as relevant environmental, economic and social factors".

In examining the information needs for humphead wrasse management, comments in Cochrane (2002) are especially relevant:

> *In many fisheries agencies, insufficient attention is given to the collection of data and information, and the attempts by these agencies to manage their fisheries are therefore flawed from the outset. Some other agencies go to considerable trouble and expense to collect information on their fisheries, but then do not process and store the information correctly and do not analyse it properly, or at all. Collection of fisheries data is not an end in itself, data stored in log books or on data collection sheets and collecting dust in a cupboard represents a wasted resource. For responsible fisheries management to occur, the required data must be collected and used to obtain information to assist in managing the fishery effectively and hence improving the long-term benefits derived from it.*

For humphead wrasse management (where there is some contention over whether proposed management efforts would be cost-effective), the information needs for the various management objectives should be made clear during the period when the regime is being formulated, as this will have a bearing on the cost, feasibility, and overall desirability of the management being contemplated.

The information required for humphead wrasse stock assessment purposes is covered in Section 6.6 below. The following concerns the data to be collected on a regular basis for monitoring fishing activity and related impacts.

Humphead wrasse fishing activities have some special characteristics with respect to the collection of information for monitoring purposes. The fish are captured from mainly small-scale fishing units, often in isolated locations. Depending on ultimate destination of the fish, the post-harvest handling is often small-scale for domestic use and large-scale for exports. Another feature affecting information collection is that there is much illegal activity associated with both the capture (nationally and internationally) and distribution of the fish. The capture of the humphead wrasse for grow-out is also a complication. These features have implications with respect to cost and accuracy of the data, as well as appropriate methodologies for its collection.

[32] An analogous situation exists in the shrimp trade. For instance, because just a few institutional buyers in the United States of America make decisions about which shrimp will be purchased by millions of consumers who subsequently eat in restaurants, the buyer level is the most efficient place to address many issues related to sustainability of shrimp fisheries.

Table 5 above lists five objectives commonly pursued in the management of humphead wrasse fishing activity along reference points and indicators. Each objective has its own requirements with respect to monitoring.

The monitoring necessary to achieve a sustainable level of humphead wrasse fishing requires information on the change in stock abundance over time.

- Assuming that the raw catch limit as determined by the method outlined in Section 6.6.2 below is valid, the important biomass monitoring would be total catch, CPUE, and/or density in the wild. Monitoring of total catch of humphead wrasse may be as simple as using information from the national fisheries statistical system – for countries that report this species individually. It is conceivable that there could be sampling programmes dedicated to collecting total catch and CPUE for humphead wrasse fishing, but there is little likelihood of such occurring the developing range countries. Underwater visual census (UVC) techniques (Figure 5) have been modified for surveying a large wide-ranging fish (CITES, 2006; Colin, 2006). Although UVC data can be reliable for determining density in the wild, its high cost makes it prohibitive for most countries to conduct UVCs on a regular basis (Sadovy *et al.,* 2007). There is justification for collecting fish size data, including that at the beginning and end of the grow-out process – but in many cases the priority for monitoring would remain to be total catch and CPUE. The possibility of having collection vessels gather the information important for monitoring changes in biomass is discussed below.
- When the humphead wrasse fishing is for both domestic and export purposes, an export quota could be the management measure selected for achieving a sustainable level of fishing. In that case, information is required on the use of harvested fish. Those fish could be exported legally, exported illegally, used domestically, or die before use/export. If there is reason to believe that the relative proportions in these four categories change over time, monitoring is required. The monitoring of legal exports has been tremendously facilitated by the documentation required by CITES.

Appropriate monitoring for reducing destructive fishing is likely to involve either a qualitative measure of use of cyanide as per community perceptions, or, should testing for traces of cyanide be possible, the changes in detection rate over time. Rapid appraisal[33] of a sampling of villages may be appropriate. Cyanide testing could occur at different stages of the distribution chain, but there are practical advantages at the level of collection vessel, point of export, or import into the destination country. Recent technical developments in cyanide testing may allow detection for a much longer period after use in the capture of fish (G. Muldoon, personal communication).

The increase in humphead wrasse for viewing on reefs by dive tourists could be monitored by doing UVCs at selected reefs in areas frequented by dive tourists. Although such work could be carried out by researchers from government agencies, there is the possibility of having the dive tour operators (or their clients) involved in the surveys. Fisheries statistics could be collected on areas fishing in the areas frequented by dive tourists, that data would also be important for monitoring purposes, and their could be a role for dive business in this process.

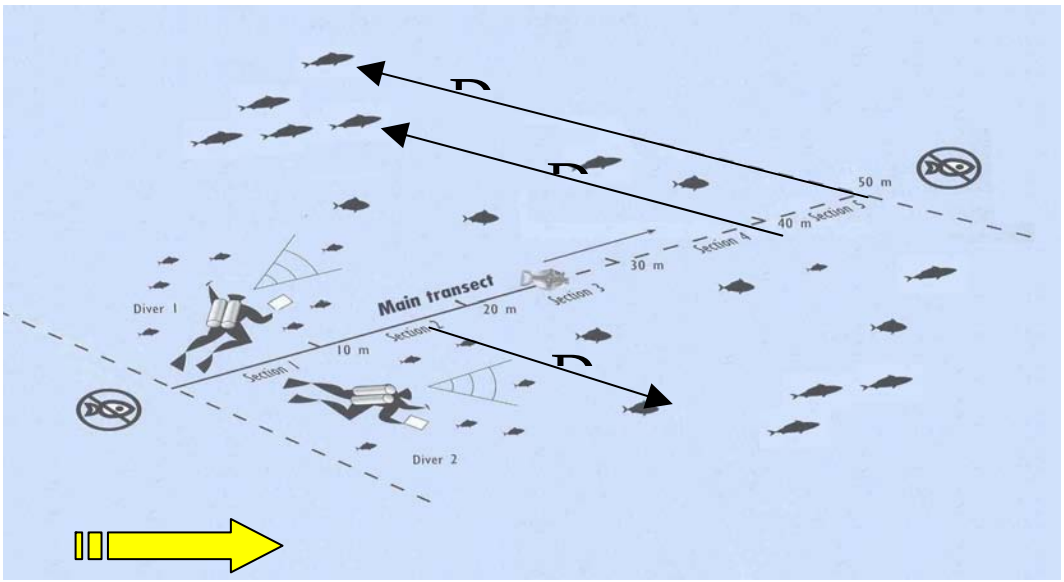
Monitoring associated with efforts to increase abundance of humphead wrasse for cultural or subsistence purposes could consist of noting amounts of the fish in markets, or amounts exported from the country – as determined by national export statistics, CITES documentation or import statistics at the destination country.

In some countries, the objective of much of the government intervention in small-scale fisheries is the generation of revenue, in which cases there are licensing systems in place. Any revenue obtained specifically from fishing for humphead wrasse (or live reef food fishes in general) could, in principle, be monitored.

[33] Rapid appraisal is a term has been used to describe approaches to information gathering that provide alternatives to the conventional sampling and census-based methodologies that dominate scientific research. Rapid appraisal techniques allow the quick acquisition of key information that is perceived as essential to management decision-making. One cannot draw a precise dividing line between conventional research methods and rapid appraisal methods, as the latter may often be adapted from the former. Rapid appraisal methods may range from interviews with key informants to scaled-down versions of conventional sampling (Berkes *et al.,* 2001).

There is also a spatial aspect to monitoring. It is especially important to know the geographic distribution of humphead wrasse fishing activity. The use of vessel monitoring systems by collection vessels could provide important information on the origin of the humphead wrasse and other fishes entering the live fish trade.

**Figure 5**: Underwater Visual Census methods are based on on-site visual counts of organisms. Census methods can be done in a variety of ways, the most common of which is by either snorkelling or scuba diving. Censuses are usually conducted in three ways: along random paths (chosen by chance), using quadrats (grids moved along a transect by divers) or transects, or from stationary points




*Sources*: Adapted from Yeeting (2006) and Labrosse, Kulbicki and Ferraris (2002).

The above considerations on humphead wrasse monitoring are largely oriented to those countries that have an export fishery. For countries that do not export the fish, the effective banning of scuba spearfishing is likely to be the most important measure to achieve many of the management objectives (Section 6.2.2). In such situations, the monitoring of any scuba fishing activity is important. This could include the perceptions of dive tour operators, fish sellers, and operators of air compressors used for filling scuba tanks.

Some observations can be made on the monitoring mentioned above:

- Rarely will all the desirable monitoring be possible, hence a necessity for prioritizing – something that depends on a hierarchy of objectives. In many range countries such a ranking is likely to result in the conclusion that collecting total catch and CPUE data is the most important.
- Should humphead wrasse data from a national fisheries statistical system be available, this could be valuable for monitoring purposes. This information could, however, be misleading. For at least two important range countries, the landings of humphead wrasse as given by the national fisheries statistical system are considered by knowledgeable individuals as being completely erroneous. Various factors could be responsible, including general laxity of the systems and incentives for fishers to underreport.
- Effective monitoring of the small-scale component of the humphead wrasse fishery in many countries is likely to be costly and/or time consuming and out of proportion with the size/benefits of the fishery. This suggests that, wherever possible, monitoring activities related to humphead wrasse take place at the level of the collector vessel or higher.
- By having some degree of control over the live reef food fish collection vessels (Section 6.4), it is conceivable that the important monitoring in the live fishery such as total catch and CPUE, can be integrated into the operations of those vessels.

### 6.6 Assessments

Sadovy *et al.* (2003b) state that assessment of the fishery or conservation status of tropical reef fishes, especially larger, wide-ranging ones like the humphead wrasse, is particularly challenging. Yet, assessment is essential for evaluating status and, if necessary, developing recovery, monitoring and management

responses and, for species such as these, calls for a creative approach that makes the best use of available data.

In the sections below, three assessment topics related to humphead wrasse are covered: trends in biological indicators, stock assessment models, and considerations on estimating the various fates of captured humphead wrasse.

### *6.6.1 Trends in simple biological indicators*

Assessment of the biological status of a stock of humphead wrasse can range in sophistication from trends in simple biological indicators to very complex stock assessment models. Trends have the advantage that they are simple, easy for developing country managers to use, and are readily understood by policy makers, fishers and the general public. The more sophisticated models are able to integrate many different types of information on the resource and can give important information, such as potential yields.

The simplest form of assessment of humphead wrasse consists of analysis of trends in basic biological indicators. Two indicators, total catch and CPUE, are likely to be most practical to collect. Data from UVC are less likely to be collected regularly, due to survey expense, but nevertheless useful when available – especially since they are independent of the fishery and the errors often associated with fishery-dependent data.

Accurate total catch data specifically on humphead wrasse are unlikely to be available from national fisheries statistical systems in many developing range countries, and for CPUE data even less so. A more workable arrangement could be requiring collection vessels to gather such data on their live reef food fishing activities for the array of species taken, including humphead wrasse.

Trends in the total catch of humphead wrasse may be the only indicator available, but could give advance warning of threats to the stock, especially if the area involved was relatively small. In Fiji the commercial catch of humphead wrasse from the two main islands dropped from 12.26 tonnes in 1998 to 3.13 tonnes in 2003 (Fisheries Division, 1999; Fisheries Department, 2004), and was one of the factors resulting in the commercial trade in this species being banned in 2004. A slightly more refined indicator than total catch is the total catch of humphead wrasse as compared to the total catch of other species caught concurrently (i.e. percentage composition). In Palau the percentage of humphead wrasse in a mixture of nine monitored species dropped from 1.38% in 1976 to 0.93% in 1990 (Kitalong and Dalzell, 1994).

Trends in CPUE can be much more informative than total catch as they take into consideration differences in fishing intensity, which might otherwise mask important changes. Richards (1993) examined data on catch per fishing day of a live reef food fish operation in the Hermit Islands of Manus Province, Papua New Guinea. The catch per day (in numbers of fish) showed no discernible trend in the period August 1991 to May 1992. In the same study, another simple indicator did, however, show some change over the same period. The average fish weight, declined between August and May (Figure 6). The relatively short period covered, less than one year, did not allow conclusions to be made but resulted in a recommendation that fish size monitoring be continued.

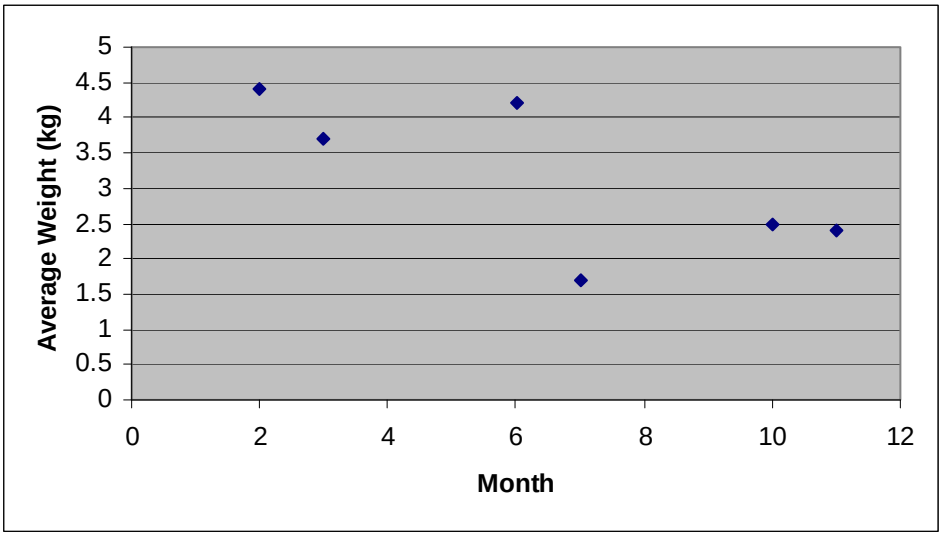
Simple analysis of data from underwater visual census (UVC) can be very important to elucidate important trends in the biomass of humphead wrasse. Repeated UVC surveys are able to reveal changes in fish density (fish/10 000 $m^2$) or biomass ($g/m^2$).

Simple analysis of UVC survey data provides some of the clearest indication of effects of fishing pressure on humphead wrasse stocks. Sadovy *et al.* (2003b) indicate that densities of adults appear to be naturally low, but drop rapidly to a few fish per unit area when fishing intensifies.

Although UVC monitoring is not likely to be carried out very often in most range countries due to its expense, the results are quite valuable because they are fishery independent, and can add to the credibility of any trends detected through regular fishery dependent means, such as changes in CPUE or fish weight. Another important attribute of UVC is that the methodology, results, and implications are readily

understandable by non-technical policy-makers. Also, there are a number of regular UVC reef monitoring programmes underway in many countries by various government and non-government agencies.

**Figure 6**: Average weight of humphead wrasse in a Papua New Guinea live reef food fish operation




*Source:* Richards (1993).

### *6.6.2 Stock assessment models*

Although fish stock assessment using basic trend indicators has the distinct advantage of simplicity, it has several major limitations. Simple assessment methods taken in isolation are rarely conclusive – when a change is noticed in one indicator, there are often several possible explanations of why that change is occurring. In addition, simple indicators typically fail to provide information on management quantities such as near-term potential yields from a fishery. Applying more complex analytical stock assessment methods (Box 11) can help address these and other issues.

**Box 11**: Stock assessment methods

In a fish stock, net production is composed of three basic processes: recruitment of new individuals to a population through reproduction; the sum of the individual growth of all the members of a population; and the total mortality, which can be divided into the individuals caught and killed or removed by the fishery (fishing mortality) and the members killed or dying by any other cause (natural mortality). All stock assessment methods attempt to determine those rates directly or indirectly, and to consider how they could change at different population sizes, under different management strategies and, where considered, under different environmental and ecological conditions. Stock assessment methods have been intensively studied and applied for decades and many different approaches now exist for different circumstances and different fish types. While there are different ways of categorizing the methods, they are classically listed under three categories:

- Surplus production or biomass dynamic models
- Size/age based models
- Stock/recruit models

*Source:* modified from Cochrane (2002).

For the assessment approaches categorized in Box 11, the applicability to humphead wrasse is relatively limited. Production models typically require a long time series of accurate catch and effort estimates with sufficient contrast in stock size (both increasing and decreasing) to ascertain reasonable estimates of the stock's underlying productivity. Classical size/age approaches also require complete sets of catch-at-age (or size) data in each year along with a relative abundance index in order to obtain reliable estimates. Stock recruit approaches require output typically from age-structured models and are used to evaluate the potential productivity characteristics of the stock. These approaches are likely to be inappropriate by themselves due to data restrictions.

In the various range countries few analytical assessment methods have been applied to the humphead wrasse. The CITES listing of the species in 2004 and the requirement for non-detriment findings for countries that

wish to export the fish prompted the development of a new stock assessment technique for the species. In 2006 CITES, IUCN, FAO and Indonesia agencies cooperated to formulate an assessment method for humphead wrasse in Indonesia. Sadovy *et al.* (2007) document this new stock assessment approach. The assessment approach used by Sadovy *et al.* (2007) effectively combines an age-, sex- and size-structured assessment method with the stock recruitment analysis in order to evaluate underlying stock productivity and biological reference points for humphead wrasse. Additionally, they population densities and size structure obtained from UVC to tune the population model and to estimate sustainable catch levels. The approach involves the following steps:

- Specifying an objective, such as maximum sustainable yield, or maintenance of a population size above some threshold level.
- Using the population model to determine the rate of fishing mortality that will on average achieve the above objective, and the associated uncertainty.
- Calculating the current size of the population.
- Multiplying the population size by the fishing mortality rate to give a raw catch limit.

The modelling and estimation framework is also tailored to the protogynous hermaphroditic nature of the humphead wrasse, as well as to the specifics of its fishery in Indonesia. Specifically, the number of males depends on the number of females and the rate of sex-change, while allowance is also made for size-specific fishing selectivity and grow-out of caged animals.

The major uncertainties that affect the accuracy of the catch limit are the relationship between stock and recruitment, the meta-population nature of the species and estimates of the area of the habitat suitable for the species.

Sadovy *et al.* (2007) suggest that the raw catch limit could be used as a basis for management by export quota, with the amount of allowable export being what remains after other avenues of disposal are accounted for, such as domestic consumption, illegal exports, and mortality prior to export. The intention is that the model will be adapted for estimating sustainable catch levels in other countries for which suitable estimates of reef area and fish densities are available. A very important intended component of this model is that it has a simplified front end (computer program) into which different countries can plug simple information, like the extent of reef areas suitable for humphead wrasse and the characteristics of the growout operation, to calculate quotas at the country level.

This model advances our ability to assess the status of humphead wrasse stocks with far fewer assumptions than was required in the past (e.g. assessments based on simple trend indicators). This provides a more rigorous scientific basis for the establishment of catch limits and/or exports quotas. Added advantages are that the model is relatively easy to use and does not require large amounts of data. A more thorough discussion of this stock assessment approach is given in Annex 2.

The development of the humphead wrasse model results in obvious benefits. Without disputing the utility of the approach, two issues deserve at least some mention. One is that there is a need to eventually progress from the single-species orientation of the model to a broader scope. Another concerns the realities of using the result of stock assessment in small-scale multi-species fisheries in developing countries.

Cochrane (2002) states that there is increasing realization that fisheries management must move from seeing fisheries as dealing with single-species to considering fisheries as the multispecies, ecosystem based activities that they invariably are. However, the amount of uncertainty is generally much higher as one attempts to include more factors. Furthermore, as one considers more and more issues and objectives, which is an inevitable consequence of considering the whole ecosystem, the number of potential conflicts and constraints increases dramatically. For these reasons, the necessary move from single-species to ecosystem-based management has barely started in most countries and fisheries. Nevertheless, there are some important analytical tools available for considering these interactions and they should be used to help inform managers in making decisions. The better developed and more commonly applied approaches are shown in Table 6.

It is important to distinguish between multispecies assessments (that may introduce, say trophic interactions) and multi-species management (e.g. where fisheries bycatch levels and habitat impacts are appropriately managed in addition to the target species). The former provides insight on potential outcomes of depleting some species more than others whereas the latter broadens the consideration on the impact of the fisheries.

Of the models presented in Table 6, none are strictly spatially explicit nor do they provide guidance for the design or implementation of marine protected areas (MPAs). However, the food-web and trophic level models would qualify as appropriate for evaluating the effects of establishing MPAs. For example, they could provide useful insight on changes in community structure in MPAs relative to areas that were open to fishing. The other methods apply to fisheries where a number of species are being taken concurrently. For example, the Aggregate Production Models consider all species combined as a single productive unit whereas the multispecies per recruit models consider the combined catch as the sum of (potentially) diverse species. The multispecies stock recruit approach requires extensive data on other species that potentially interact (prey upon during pre-recruit stages) with any particular target species. Similarly, multispecies VPA typically requires catch-at-age and consumption-at-age for closely interacting species and thus have extensive data requirements.

Clearly, the applicability of these stock assessment approaches above to humphead wrasse is limited without extensive information on other species that are caught concurrently. If such data are available, then for management purposes, the application of complex multispecies models is possible. Section 6.6.4 contains some thoughts on the application of the outputs of these models.

National authorities are best able to decide how appropriate the various approaches are in the context of the concerned country, but in making this determination there may be value in considering alternative perspectives.

- The FAO Technical Guidelines for Responsible Fisheries make a relevant comment: “For small fisheries and artisanal fisheries, computationally intensive management analyses are often not possible or cost-effective. In such cases, management measures will probably not depend on quantitative analyses, but rather on assessing the practicality of ensuring that the precautionary measures are accepted and observed by the fishing community” (FAO, 1995).
- In a recent study of the world’s shrimp fisheries the issue of stock assessment in small-scale fisheries was examined. “In many developing tropical nations, some sophisticated stock assessment has been carried out on shrimp resources by externally-funded projects using expatriate expertise. The degree to which that work is replicable after departure of project staff is an issue in some countries” (Gillett, 2007).
- The two previous comments largely concern the ability to carry out the stock assessment, but a more profound issue in some range countries is the ability to use the results of the stock assessment process. If it is not possible to halt or discourage the mainly small-scale humphead wrasse fishing activity when a catch limit is reached, some consideration should be given to alternate management approaches.

### *6.6.3 Estimating various disposal categories*

Several things can happen to a captured humphead wrasse. These include domestic use, legal exports (both live and non-live), illegal exports, holding for growth prior to export, and mortality prior to export.

An assessment of the important disposal categories is required for applying the humphead wrasse stock assessment results to an export quota – the amount of allowable export being what remains after other avenues of disposal are accounted for.

**Table 6**: Main categories of multispecies and ecosystem-based assessment methods and their characteristics

| Method | Main information requirements | Comment |
|---|---|---|
| Multispecies surplus production models | Same as for single-species + indices of abundance +, preferably, abundances of all species with important interactions with the "dependent" species. | In theory, enable consideration of biological interactions, but of little practical value because:<br>– if only indices of abundance are available for the species included, then enormous statistical problems will be encountered in estimating the parameters; and<br>– as for single-species, good data contrast is required for good estimates. |
| Aggregated production models | – Annual catch aggregated into appropriate species groups.<br>–Annual index of abundance, e.g. CPUE or biomass estimate for same aggregated groups. | –Has proven informative in some cases where tried.<br>–Provides a feasible source of information for ecosystems with high species diversity.<br>–Caution required as the selected reference point for the aggregation could lead to depletion of some vulnerable species while producing sustainable yield for the aggregation as a whole. |
| Multispecies per recruit models | – As for single-species per recruit analyses.<br>– The relative catchability of each species for a unit of fishing effort.<br>– The relative recruitments of the different species. | – Can be used for more than one fishery at a time as well as more than one species.<br>– Consider technical interactions, not biological interactions.<br>– Involve the same assumptions and limitations as single species per-recruit methods.<br>– A useful tool for assisting in setting reference points in multi-species fisheries. |
| Multispecies stock recruit models | – As for single-species method.<br>– Abundance estimates of other predators and competitors on the species of interest. | – Extends single-species stock recruit models to consider the effect of other species on a given species. |
| Multispecies VPA | – As for single-species method.<br>– Estimates of the number at age of individuals of the species of interest consumed by all other species. | – Has the potential to provide very useful information taking into account some biological interactions.<br>– Very data intensive and therefore probably not applicable in most circumstances. |
| Food web and trophic level models | – Estimates of biomass of all major species or species groups.<br>– Production per unit biomass for each group.<br>– Consumption per unit biomass per group.<br>– Average diet composition per species group. | – The requirements listed here are for a simple food web type model, models incorporating e.g. physical factors require more.<br>– In equilibrium form useful for gaining insight into trophic relationships and direct and indirect interactions.<br>– In dynamic form (e.g. Ecopath with Ecosim) can be used to explore multi-species implications of harvest policies.<br>– Invariably include substantial uncertainty which must be rigorously explored, reported and considered. |

*Source:* Cochrane (2002).

Information useful for estimating the amount of illegal humphead wrasse exports can be obtained from import statistics of the main destination countries. As China, Hong Kong SAR imports represent some 60 percent of the international trade in the humphead wrasse, data from there is important. Presently, the Hong Kong Census and Statistics Department obtains data on live fish imports by air and the Agriculture Fisheries and Conservation Department makes estimates of quantities of live fish arriving aboard China, Hong Kong SAR registered fishing vessels. Almost all of the difference between legal exports from a country and estimates of imports of that country into China, Hong Kong SAR and other destination countries consists of illegal exports.[34]

The mortality that should be accounted for has several components: mortality between capture and cage-culture, during cage culture, and during transit before export. There is likely to be a large difference in such mortality between the various exporting countries. Factors responsible for this include the proportion of fish undergoing grow-out, use of cyanide in capture, and the size of the country and associated amount of transit involved. Mortality during grow-out is likely to be the greatest. Sadovy *et al.* (2007) contains information on 23 humphead wrasse grow-out ventures in Indonesia. The operators stated that they held fish from 6 to 48

[34] Much of the mortality in transit is likely to occur just after the fish are handled during transfer onto the transport vessel.

months (mostly 12 to 24 months) and suffered from zero to 80 percent mortality (mostly 5 to 10 percent). Familiarity with the operations of collection vessels could lead to reasonable estimates of the mortality that is not associated with grow-out. Being aware of this mortality could also be an incentive to reduce it.

With regards to the estimates of legal exports (both live and non-live), these are tremendously facilitated by the accounting associated with the CITES listing of humphead wrasse. Some mis-identification at the point of export is inevitable, especially for filets, so an allowance must be made.

Estimating domestic use is important but can be difficult in some countries and is typically underestimated. Some of the considerations are:

- In the range countries that do not export the fish, domestic use could be the only significant disposal category, hence its estimation is very important.
- "Double counting" may be an issue in some countries. It is not always clear if national fisheries systems include the harvest for the live reef food fish trade. If so, the amount of live fish harvested for export must be subtracted from the total national harvest to obtain the amount of domestic use.
- Just because estimates of fish landings are the "official fisheries statistics" does not confer automatic credibility. Some important humphead wrasse range countries have national fisheries statistical systems that have been described as "dysfunctional".
- For many countries, the best estimate of domestic use of humphead wrasse could probably be made by obtaining national catch statistics in a geographically disaggregated form and selectively using a variety of sources (staff of government fisheries agency, fishers, fish dealers, retailers) to scrutinize those landings. Information on any bias in the national catch statistics could be useful.

### *6.6.4 Rules of thumb*

There is a need for a scientific basis for establishing the level of a quota and for other management measures. This must be reconciled with the reality that the capacity in fishery agencies of range countries to deal with the complexities of stock assessment is quite limited. Staff skills, work priorities, financial resources, and political will are often inadequate to enable even basic quantitative stock assessment models to have an effect on the fisheries management process.

In this difficult situation there are two very different types of thinking on how to proceed:

- In recognition that many humphead wrasse range countries do not have the capacity to use deal with quantitative stock assessment (with poor prospects for acquiring such capacity in the future), there could be considerable value in exploring the possibility of developing simple "rules of thumb" yield estimates based on models such as the one developed by Sadovy *et al.* (2007). This could consist of crude ranges in annual yields of humphead wrasse per linear or square kilometre of reef, under various conditions.
- Alternatively, there is the thinking that it is not wise to provide some idea of the annual yield, based on a set of assumptions about habitat area and fish densities. This is because it may encourage quota setting from information that is less accurate than that which could be obtained from the model – and doing little else to improve the information.

The choice between the two approaches would obviously depend on national circumstances. Where there is some degree of expertise in fisheries science and it is likely that this expertise could be focused on assessment of humphead wrasse resources, then clarifying the steps needed for national fisheries officers to estimate sustainable yield using stock assessment models is probably the best approach. By contrast, in countries where expertise in fisheries science is not available for humphead wrasse assessment, the use of rules of thumb may be considerably better than the alternative of arbitrarily setting a quota, or worse, carrying out no management of humphead wrasse due to lack of information.

In the Pacific Islands region, rules of thumb have been developed decades ago for three important fishery resources, deepwater snapper, trochus, and lobster. Adams and Chapman (2004) describe the situation for deepwater snapper:

> *In many cases a "rule of thumb" was developed based on a typical sustainable catch per nautical mile along a certain depth-contour of the outer reef-slope and seamounts, or the area between contours, and national total allowable catches were estimated…..the rules of thumb developed in the 1980s are still relevant – and the most cost-effective precautionary form of management for small-island states.*

It is no coincidence that some of the best managed inshore fisheries in the Pacific Islands are those for which rules of thumb have been developed. Despite a multitude of stock assessment exercises on dozens of resources, the rules of thumb are used much more often in the fisheries management process because they available, easy to use, and understandable by fisheries agency staff and policy-makers. An important point is that rules of thumb do not displace the results of specific stock assessment, but rather are they used when the more precise stock assessment results are not available.

### 6.7 Feedback and review

Any management regime instigated for the humphead wrasse needs to be able to accommodate change. Reasons why a system must change include:

- In establishing a new management regime it is not likely that all arrangements are appropriate from the beginning; the various measures require some testing and subsequent refining or discarding. Stakeholders may express legitimate concerns with aspects of a new system which may require adjustment.
- The management arrangements for humphead wrasse deal with a very dynamic situation and must constantly evolve as change occurs in fishing activity, resource levels, trade, legal regimes, and other factors.
- The underlying objectives of the management regime may change, or the relative importance of an objective in a mixture of objectives may change. The management objective of maximizing yield could change to protecting the survival of the species.

Adaptive management is an institutionalized system for continually making the required changes to management policies and practices based on learning from the outcomes of operational programs.

One convenient way of assuring that adaptive management arrangements are built into the fisheries management cycle is to have a specific section in the management plan dedicated to feedback and review. This section could all such requirements, including public comment, quantitative analysis of changes in indicators (e.g. CPUE, results of UVC), qualitative assessment of progress towards objectives, and/or an appraisal of the cost of management.

The result of such a mandatory review process in management planning could consist of a variety of actions: retaining present arrangements, altering limits within existing measures (e.g. export quota, allowable catch), using different measures (e.g. an MPA rather than a quota), or something more radical (e.g. a total ban on the export of humphead wrasse).

A persistent problem of fisheries management in developing countries concerns worthwhile requirements that are not acted upon. Of relevance to the adaptive management of humphead wrasse, experience has shown in many countries that a requirement in a fishery management plan does not necessarily get translated into action. Some countries take the extra step of having fisheries management plans adopted as regulations under the fisheries laws – in which case inactivity can result in penalties. Another approach is to have a "sundown clause" that stipulates that particular provisions in regime expires on a specific date (export quota goes to zero) unless certain action (in this case, a review) occurs. Finally, under the CITES requirements, there appears to be potential for encouraging periodic reviews of management effectiveness, for instance through the Significant Trade Review process, designed to examine problems with implementation of CITES listings.

An important point concerning the feedback/review of adaptive management was mentioned in Section 5.3 – rather than viewing "adaptive management" as a complexity or a component of an advanced management regime, it could be a mechanism for improving even very ineffective management schemes.

## 7. CONSIDERATIONS ON SINGLE SPECIES MANAGEMENT

In sections above, objectives for managing humphead wrasse fishing activity are identified along with measures to attain those objectives and associated considerations. The scheme presented, while useful for conveying concepts, is based largely on single species management, which could be criticized on the basis of being overly-simplistic and too narrow. Although the focus on a single species conforms to CITES

requirements, there are several difficulties in the larger context. The capture of humphead wrasse is not done in isolation from other fishing activities; it is often forms a component of a live reef food fishery, or on a larger scale, part of the entire fishing activities of a community or coastal region. Many of the management mechanisms described in earlier section (e.g. ban on scuba spearfishing) would actually have an effect much broader than on fishing for humphead wrasse. Ideally, fishing for humphead wrasse should be managed along with the entire array of small-scale fishing. On an even broader basis, there are numerous advantages of taking a comprehensive ecosystem approach to the management of humphead wrasse.

These logical contentions must be balanced with some hard realities in most of the important humphead wrasse range countries. Section 5.2 identifies some serious or intractable problems in dealing with humphead wrasse management. Sadovy *et al.* (2003a) summarize the situation: "In some countries and areas the capacity to manage a live reef food fish fishery is so limited and the prospects for strengthening that capacity are so bleak". In a larger context, Cochrane (2002) states that the necessary move from single-species to ecosystem-based management has barely started in most countries and fisheries.

One strategy for dealing with humphead wrasse in this challenging situation is to take advantage of a current opportunity afforded by combining three favourable elements: the iconic charismatic nature of a spectacular giant reef fish, the international publicity generated by its CITES listing, and the efforts of international organization such as FAO and IUCN to improve its management. Combining these positive features may enable some simple management measures to produce tangible benefits in an environment that has seen little management success – efforts which could conceivably be broadened in the future to include other species/fisheries or ecosystem considerations.

## 8. A MANAGEMENT REGIME FOR THE HUMPHEAD WRASSE

In the above sections various considerations on monitoring and management of humphead wrasse are presented. At this point it may be useful to describe a management regime for this species in a hypothetical country.

The Republic of Undulatia is an imaginary country in the Indo-Pacific that has an active live reef food fishery taking a variety of species, including the humphead wrasse, for export to Southeast Asia. The humphead wrasse is also taken for domestic consumption and there is a significant dive tourism industry in the country. In Undulatia there has never been a strong heritage of the national government intervening in the small-scale fisheries, so the CITES requirement for a non-detriment finding has presented a significant challenge to the Undulatia Government.

The Undulatia Fisheries Department consulted various stakeholders on issues related to the humphead wrasse. Those in the live reef food fish trade stressed the tremendous value of the live export of humphead wrasse and the benefits to impoverished fishers in the outer islands. Those fishers were also enthusiastic about the trade. Representatives of the dive tourism industry said the humphead wrasse is more valuable on the reefs for tourist viewing and they claim that the harvesting almost always involves the use of cyanide. Local and overseas NGOs stressed that no fishery for this species is sustainable, and certainly not one that involves extremely high prices in the destination markets. Staff of a regional fisheries organization stated that an effective management regime for humphead wrasse and associated monitoring would be extremely costly and may not be justified for such a small fishery, especially since much more economically important fishing activity is not currently managed.

After the stakeholder consultations, Fisheries Department staff carried out an economic analysis to put some of the stakeholder claims in context and give estimates on the total and net value of the trade, magnitude of benefits, main beneficiaries, and likely costs of management. That analysis showed the main domestic beneficiaries were the exporters (most of whom operated collection vessels), and that significant benefits accrued to participating rural fishers. The analysis also suggested high management costs would be associated with the fishery. Although there was some doubt over the net benefits, an Undulatia Government decision was made to continue the fishery for an initial period of five years, based primarily on the likelihood of cash benefits to rural communities.

In consultation with stakeholders a management plan was formulated and subsequently approved by the Minister of Fisheries with the following features:

- The plan gives the dual management objectives of maximizing economic benefits of live humphead wrasse exports (tentatively based on 80% of MSY) and maximizing the presence of the species on reefs close to resorts.
- The basic strategies adopted were: (a) refraining from attempts to directly regulate the activities of thousands of small-scale fishers all over the country; (b) using collection vessels to enforce management requirements and collect data; (c) implementing much of the required management from the two international airports of the country; and (d) adopting "user pays" policy for management cost recovery.
- In addition to general fisheries management arrangements in Undulatia (which include a full ban on all use of scuba in fishing activities), specific humphead wrasse management measures: (a) an export quota based on assessment using a yield per recruit model and in consideration of non-export uses of the fish; (b) a ban on fishing, collecting, transporting, farming, or exporting humphead wrasse that are less than 50 cm or which possess traces of cyanide; (c) a ban on any fishing or transport of this species with 10 km of a recognized resort area; and (d) a ban on all live reef food fish exports by sea transport.
- Operators of collector vessels are required to be licensed (limited to three licenses), carry fisheries observers or use vessel monitoring system (VMS), record basic fishery data, be responsible for any under-size or cyanide containing fish, refrain from fishing in resort areas, and pay the management costs associated with the live export fishery for humphead wrasse (deemed to be US$10 per individual fish covered by CITES permit).
- A joint working group is established which is composed of staff of the Fisheries Department, Environment Department, and Customs Department and a representative of the live fish collectors/exporters. Its purpose is to establish procedures related to humphead wrasse CITES non-detriment findings, CITES export authorizations, and export quotas.
- The Fisheries Department, using international assistance as available, is required to: (a) carry out research in support of the yield per recruit stock assessment; (b) analyse the catch data gathered by the collection vessels; (c) carry out UVC surveys in the major live reef food fish areas; (d) once per year produce a report on the management significance of this work and estimates of management costs and cost recovery; and (e) present the report (along with suggested management changes) at a meeting of stakeholders once per year.
- Compliance measures of the plan include heavy penalties for collection vessels and grow-out operations for buying, holding, or selling under-size fish, fish with traces of cyanide, or operation in resort areas. For both compliance and educational purposes, the Fisheries Department and the national CITES authorities will jointly produce and circulate a poster on the humphead wrasse, with information on the beauty of the fish, its threatened status, and management regulations.

The Government of Undulatia, subsequent to approving the humphead wrasse export fisheries management plan, issued a policy statement on the export of humphead wrasse. The Government affirms a zero tolerance policy for non-compliance with the requirements placed on collection vessels, a major management tool in this fishery. After a five-year period the costs and benefits of the export of humphead wrasse will be assessed. Unless the analysis can show that the export trade is clearly beneficial, all export trade in humphead wrasse will cease (the trade ban could be strengthened by trade sanctions imposed by CITES). If the analysis shows clear benefits of the export trade and success of the humphead wrasse management measures, the trade will be allowed to continue, and the Fisheries Department will be directed to extend a similar management approach to the entire live reef food fishery, and study the applicability to small-scale fishing activity in general.

## 9. CONCLUDING REMARKS

### 9.1 Monitoring and management

Because some particular features associated with humphead wrasse monitoring and management appear in several sections of this report, there could be some value in stressing their importance. Many important monitoring/management principles appear in the Code of Conduct for Responsible Fisheries and associated guidelines and therefore do not warrant repetition here – where the emphasis is on pragmatic aspects directly related to humphead wrasse.

An economic analysis of the costs and benefits associated with the fishery for humphead wrasse (including costs for effective management) is important for placing the situation in proper context. There is some chance that such an assessment could reveal large management costs associated with a fishery of very minor economic importance. In any case, an economic analysis could produce information on which to base fundamental decisions such as the degree to which fishing activity (if any) should be allowed and the appropriate level of management resources to focus on the humphead wrasse fishery.

In the humphead wrasse management process, the importance of a management plan should be stressed. Fishery management plans elucidate the management process, and in doing so, assure that there is indeed a process. Such plans could encourage many positive developments, including the establishment of clear objectives, transparency, stakeholder input, and review procedures. As the principles of fisheries management are not widely understood in many range countries, management plans can be an effective mechanism for creating an awareness of how management operates. Lastly, management plans are likely to be required for a CITES non-detriment finding.

In the formulation of humphead wrasse management measures, some important lessons learned should be noted. The especially important ones are:

- Predicating management on remarkable improvements in the effectiveness of current enforcement should be avoided.
- Management measures that involve the complexities associated with directly restricting fishing effort of multitudes of small-scale fishers are usually not successful: “attempting to manage the unmanageable”.
- Wherever possible, use should be made of collection vessels and airports for compliance and data collection purposes.
- No single management measure is likely to be successful; to attain any of the humphead wrasse management objectives that are commonly put forward, it is likely that more than one management measure will be required. In this context it is important that all sources of mortality be considered when defining which combination of measures will be most effective.
- Management measures taken in the destination country (such as limiting the modes of transport of fish into the country) could be complementary to the measures adopted in the source countries.

### 9.2 Is the humphead wrasse exportable?

Some of the recent documentation associated with the humphead wrasse seems to be oriented to finding a way the fish can be exported rather than determining if it should be exported. This seems to be implied in statements like: “Humphead wrasse cannot be sustainably traded without significant efforts from both range States and consumer countries”.

Nothing in this report should be taken as supporting the contention that exporting humphead wrasse is sustainable. Given that the fish is naturally rare, cannot sustain much fishing pressure and is mostly caught in fisheries that are notoriously difficult to regulate, the logical solution in many range countries would be to simply ban the export of humphead wrasse. Indeed, many countries have recognized the realities and have taken this course. Unfortunately, even when trade is banned, often other important sources of mortality such as those resulting from catching fish for growout and domestic use are not adequately accounted for by managers.

Other factors to consider when pondering the desirability of an export fishery for humphead wrasse are:

- To have effective management and be compliant with CITES, could involve considerable expense – which may not be justified for a fishery associated with small domestic benefits and significant costs of various types.
- There are indications that the future may be even more difficult for humphead wrasse management. Due to the rarity appeal, market forces may fail to curtail fishing operations even when the fish is quite rare in the fishing areas. Rising prosperity in China suggests that the demand for humphead wrasse will increase, allowing profitable fishing at progressively lower catch rates, which could have very serious consequences for the humphead wrasse.

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## ANNEX 1: TERMINOLOGY USED BY CITES AND OTHER SOURCES RELEVANT TO THE HUMPHEAD WRASSE

### CITES terminology

The following are official terms obtained from the CITES Web site www.cites.org that have special relevance to the humphead wrasse.

**Annual report** – A report submitted to the Secretariat by each Party every year on its implementation of the Convention and containing a summary of the following information: the number and type of permits and certificates granted to authorize trade in CITES specimens; the States with which such trade occurred; the numbers or quantities and types of specimens, names of species as included in Appendices I, II and III and, where applicable, the size and sex of the specimens in question.

**Bred in captivity –** Characteristic of animal specimens, applied only if:

- the parents mated or gametes were otherwise transferred in a controlled environment, if reproduction is sexual, or the parents were in a controlled environment when development of the offspring began, if reproduction is asexual; and
- the breeding stock, to the satisfaction of the competent government authorities of the exporting country:

  A. was established in accordance with the provisions of CITES and relevant national laws and in a manner not detrimental to the survival of the species in the wild;

  B. is maintained without the introduction of specimens from the wild, except for the occasional addition of animals, eggs or gametes, in accordance with the provisions of CITES and relevant national laws and in a manner not detrimental to the survival of the species in the wild as advised by the Scientific Authority.

**Certificate** – An official document issued by a Management Authority of a Party and used to authorize different types of trade in CITES specimens. The most important are the re-export certificate, certificate of origin, pre-Convention certificate, and certificate of captive-breeding or artificial propagation.

**Listing –** The inclusion of a species in Appendix I, II or III of CITES.

**Party –** A State that has consented to be bound by the Convention and for which the Convention is in force.

**Permit –** An official document issued by a Management Authority of a Party to authorize the export of a specimen of a species included in Appendices I or II, the export of a specimen of a species included in Appendix III from the State that included the species therein, or the import of a specimen of a species included in Appendix I.

**Population –** The total number of individuals of a species.

**Range State –** A State whose territory is within the natural range of distribution of a species.

**Re-export** – The export of any specimen that has previously been imported.

**Sustainable use –** The use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations.

**Trade –** Any export, re-export, import and introduction from the sea.

**Relevant terminology from other sources**

**Aquaculture** – The farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants. Farming implies some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated (FAO, 1997).

**Capture-based aquaculture –** The practice of collecting "seed" material – from early life stages to adults – from the wild, and its subsequent on-growing in captivity to marketable size, using aquaculture techniques (Ottolenghi *et al.,* 2004).

**Full-cycle culture** – Egg to adult aquaculture (McGilvray and Chan, 2003); Hatchery-based aquaculture (Sadovy *et al.,* 2003a).

**Growout** – The capture of juvenile fish and placement in cages until saleable size (Sadovy *et al.,* 2003a).

**Ranching** – The commercial raising of animals, mainly for human consumption, under extensive production systems, within controlled boundaries and paddocks (e.g. in agriculture), or in open space (oceans, lakes) where they grow using natural food supplies. In fisheries, animals may be released by national authorities and re-captured by fishermen as wild animals, either when they return to the release site (e.g. salmon) or elsewhere (seabreams, flatfish) (FAO Fisheries Glossary).

## ANNEX 2: A STOCK ASSESSMENT APPROACH FOR THE HUMPHEAD WRASSE IN INDONESIA[35]

Following the listing of humphead wrasse in CITES Appendix II, the CITES Authorities of Indonesia decided to establish an export quota of 8 000 fish per year as an interim measure pending further information. The initial quota was determined based on discussions with traders in Indonesia and export figures, and was 10-fold less than the previous quota of 70 000–80 000 fish. Since then, the Indonesian Institute of Oceanography, which is the CITES national scientific authority, became involved in collaborative work with the IUCN Groupers and Wrasses Specialist Group and the FAO to develop an approach for NDF to further refine an export quota for the species.

The general approach for calculating a sustainable level of harvest involves the following steps:

- use of a population dynamics model to select the rate of fishing mortality that achieves a user-specified management goal;
- calculation of the current size of the population based on fish densities estimated using UVC; and
- multiplication of the current population size by the exploitation rate, which leads to the catch limit.

The population dynamics model is used to determine three relationships: (1) between the rate of fishing mortality in the wild and the expected catch (in the wild and from caged animals); (2) between the rate of fishing mortality in the wild and the reduction in population size (measured by, for example, total female biomass, or egg production), and (3) between the rate of fishing mortality in the wild and the sex-ratio (M:F) of mature animals. These relationships can be used to calculate a variety of biological reference points. The following biological reference points can be computed using the model at present:

- $F_{MSY}$ – the fishing mortality rate at which the catch (in numbers and in mass) is maximized;
- $F_{20\%}$ – the fishing mortality rate at which the spawning biomass is reduced to 20% of its unfished level; and
- $F_{M:F}$ – the fishing mortality rate at which the sex ratio (M:F) is double that in an unfished state.

The modelling and estimation framework is tailored to a protogynous hermaphrodite as well as to the specifics of the fishery for humphead wrasse in Indonesia. Specifically, the number of males depends on the number of females and the rate of sex-change, while allowance is also made for size-specific fishing selectivity and grow-out of caged animals. The calculation of sustainable offtake (i.e. catch) allows for the allocation of the target catch level amongst various uses (domestic use, export use) and for adjustments to the export quota to account for losses due to mortalities in transit and illegal exports, to ensure a sustainable export quota in accordance with the NDF requirement.

Given the lack of data for humphead wrasse, both the population dynamics model and the estimate of the current population size are highly uncertain. Monte Carlo simulation is therefore used to quantify this uncertainty, which then allows the results (the level of harvest) to be expressed as a probability distribution. A precautionary approach to handling uncertainty is to base any export quota on a lower percentile of the probability distribution for the export quota, rather than the ”best” estimate, especially if there is an intention for population recovery.

In common with most coral reef fishes, the data for humphead wrasse are limited. Specifically, there is no long-term index of abundance for this species, either globally or locally, which could form the basis for a stock assessment based on fitting a population dynamics model. However, the yield model developed for humphead wrasse (which uses a conventional stock assessment modelling approach, adapted for a protogynous species) only requires the values of its parameters and the current absolute abundance (and its size-structure).

It should be noted, however, that, while there are a number of shortcomings in the analyses, these are characteristic of assessments and risk analyses for many coral reef fishes, and the ability exists within the assessment framework to examine the implications of alternative assumptions and parameters values. Areas in which the collection of additional data could further refine parameter estimates and improve the calculations are identified. When establishing a sustainable offtake (annual catch) it is clearly important to factor in all uses of the resource (for example mortality of live fish and estimates of illegal trade). This is

[35] Taken from Sadovy *et al.* (2007).

because it is the sum of all offtake that must be demonstrated to be sustainable to satisfy the NDF requirement under CITES Appendix II, which cannot be assessed just by the numbers of fish exported.

The sustainable offtake suggested by the model should be considered as part of an adaptive approach to managing the humphead wrasse. It assumes that any quota set will be effectively enforced and will be modified accordingly in response to periodically repeated monitoring of stock condition and assessments of enforcement effectiveness by both importing and exporting countries. The quota and/or level of enforcement may need to be adjusted according to whether subsequent monitoring of humphead wrasse indicates no recovery, further declines or increasing numbers.

The model, and the estimation of its parameters (see Table A below) are based on the best available scientific information and can be modified as more information becomes available. It can be adapted for use in different countries by minor modifications to parameter values and assumptions. One aspect of the model that needs further work is the estimation of reef area, which is important for abundance estimation. A satellite imagery approach to recalculate reef area for Indonesia is currently being developed (FAO, in prep.) and can be readily applied to other countries.

**Table A**: Parameter estimates in the humphead wrasse model

| Quantity | Males | Females |
|---|---|---|
| **Length-weight relationship** | | |
| Length-weight a, $\tilde{a}$ | 0.000023178 g / $m^2$ | |
| Length-weight b, $\tilde{b}$ | 2.9589 | |
| **Growth curve** | | |
| Von Bertalanffy $\ell_\infty$ | 91.5 cm | 168.4 cm |
| Von Bertalanffy $\kappa$ | 0.131 $yr^{-1}$ | 0.0675 $yr^{-1}$ |
| Variance in growth increment $\sigma$ | 19.5 $cm^2$ | 19.5 $cm^2$ |
| **Maturity-length relationship** | | |
| First length-at-maturity, $l^{\mathrm{f}}_{\mathrm{min}}$ | 35cm | |
| Length-at-50%-maturity, $l^{\mathrm{f}}_{50}$ | 35cm | |
| Length-at-95%-maturity, $l^{\mathrm{f}}_{95}$ | 68.2 cm | |
| **Gonad weight-length relationship** | | |
| Gonad weight-length a, $a^g$ | 12.816 | |
| Gonad weight-length b, $b^g$ | 0.0025 | |
| **Density-dependence** | | |
| Steepness, h | Logit(h) ~ N(0.891, $0.912^2$) | |
| Critical sex-ratio, $\chi_c$ | 50 | |
| **Parameters related to growout** | | |
| Natural mortality (cages), M' | 0.134$yr^{-1}$ (± 0.064) | |
| Fraction caged, $\beta_l$ | 1 for size < 25cm | |
| Length-at-export, G | Trapezoidal 30, 40, 50, 55 | |
| **Other parameters** | | |
| Natural mortality, M | 0.106 $yr^{-1}$ | |
| Selectivity (wild), $S_l$ | | |
| Constant term, $\phi$ | 0.0281 | |
| Length-at-modal selectivity | 34.261 | |
| Variance of selection function, $\sigma_S$ | 0.0838 | |
| Fishing mortality (wild), F | | |
| Rate of sex change, $\gamma$ | 0.04–0.27$yr^{-1}$ | |
| Length range for sex change | 55–75 cm | |

*Source:* Sadovy *et al.* (2007)

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