<u>Workshop Report on the Trade of *Cheilinus undulatus* (Humphead Wrasse / Napoleon Wrasse) & CITES implementation</u>

3rd and 4th June 2010

Bali, Indonesia

Index

Workshop Report

Annex

Sadovy *et al.* (2003) The humphead wrasse, *Cheilinus undulatus*: synopsis of a threatened and poorly known giant coral reef fish. Reviews in Fish Biology and Fisheries 13: 327–364

Sadovy *et al.* (2010) Gonadal development in a giant threatened reef fish, the humphead wrasse *Cheilinus undulatus*, and its relationship to international trade Journal of Fish Biology doi:10.1111/j.1095-8649.2010.02714.x

Executive Summary

The Humphead Wrasse (*Cheilinus undulatus*) (HHW), known also as the Napoleon wrasse, was listed on Appendix II of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) in October 2004. One of the highest commercially valued of all reef fishes in the line reef fish trade, HHW is traded internationally by air and sea. The major exporters are in South-east Asia, mainly Indonesia, Malaysia, and the Philippines while the major importers are the People's Republic of China (China), especially Guangdong province (Southern China) and Hong Kong; the latter two units are considered separate for trading purposes.

A major challenge to successful implementation of the CITES listing for this species is illegal, unreported and unmonitored trade (IUU). A workshop held in Bali, June 2010, identified the major issues of concern and made a number of recommendations. These include to: establish a capture fisheries data collection system, ban catches of small (immature) fish, establish protected areas and/or protected seasons for adult HHW, develop a cyanide testing procedure, establish a national HHW traders' association and certificate of good trade practices, strengthen inspection protocols especially in relation to Hong Kong licensed vessels operating in Indonesia, develop a coordinated approach to interagency inspection at international airports, step-up CITES enforcement through tagging and validating shipments, compile a list of currently active traders, improve prosecution capacity on the case of violations, and conduct biological and socio-economic assessments for the species.

Acknowledgements

To address this species issues, a workshop, supported by a project funded by the United States government agency NOAA (National Oceanographic and Atmospheric Administration) and organized by the IUCN (International Union for Conservation of Nature) Groupers and Wrasses Specialist Group was held in Bali, June 2010.

The Workshop – summary of issues identified and discussed

A workshop on the trade of Humphead Wrasse (HHW) and CITES implementation was held on 3rd and 4th June, 2010, in Bali. The workshop brought together representatives of CITES Management Authorities (MAs) from Indonesia and Malaysia (the major exporting countries of the species), researchers from Hong Kong, Indonesia, Taiwan, Philippines, Indonesian officials from different government departments including biodiversity, conservation, customs, fisheries, quarantine, and a representative of the international trade in live reef fish and former exporter of the HHW and NGO. Representatives of WWF were also present.

It was recognized that, as a result of the humphead wrasse being the first commercial reef food fish species listed on CITES, many challenges have arisen in the course of CITES implementation, and many lessons are being learned. Focusing on illegal, unregulated and unmonitored (IUU) trade, the workshop had the following six aims:

1. To identify and discuss issues related to IUU for HHW (international and national for major exporting countries) and to identify measures and actions to reduce IUU and improve implementation of the CITES listing for HHW;
2. To identify ongoing or planned work on IUU for HHW;
3. To consider HHW status and performance indicators for its sustainable use;
4. To discuss mariculture and other possible options for supplemental production of HHW;
5. To discuss key issues in relation to IUU and CITES and of relevance to the Decision on enforcement from CoP 15 at Doha and the Doha Task Force, and
6. To identify awareness and capacity building needs in relation to the implementation of the CITES listing for HHW.

Areas and issues identified directly associated with current and suspected IUU trade

1. **Transportation**: (1) IUU sea and air shipments of live fish that include mixed shipments of live fish (HHW hidden in amongst groupers, fishing vessels with secret compartment(s) concealing HHW), (2) Hong Kong licensed fishing vessels entering exporting countries to collect HHW (e.g. Banggai island), (3) Hong Kong or other fishing vessels getting licenses for aquaculture (in relation to government mariculture project) but actually catch juvenile fish from the wild and exports them with no hatchery culture or research involved in such activities. This includes suspected illegal exporters based in Makassar that are supposed to only ship out maricultured fish but in practice also take other live food fish in addition to wild-caught juvenile HHW, and (4) shipping of HHW directly from West Papua to Hong Kong or China (easier and cheaper for traders than going via international airports in Makassar etc), (4) illegal imports to Hong Kong by air, (5) illegal exports by sea from Philippines and Malaysia.

2. **Fishery**: extensive export trade of undersized (juvenile) fish from Indonesia (i.e. < 1 kg and some > 3 kg); the use of cyanide and other destructive fishing methods with a high proportion of small HHW apparently caught by cyanide (some suggested that cyanide caught fish are more than 90% of all small HHW taken) because this is the most efficient way to catch large numbers of the species for the live fish trade.

3. **Trade practices**: on the exporting side in Indonesia companies who have export licenses allocated to them can sell the license to other companies that actually conduct the trade, such that no one is held liable for exporting HHW illegally. This situation also means that traders can avoid paying taxes and that inspection of shipments by officials is compromised. On the importing side in Hong Kong, shipment (consignment) companies bringing in HHW illegally are difficult to prosecute if apprehended because they are not held accountable for illegal fish within mixed fish shipments in the same way as exporting companies could be.

4. **Inspection protocols**: current protocols do not include any inspections of Hong Kong licensed vessels entering Hong Kong by sea. This is a more enforcement shortcoming in Hong Kong and is relevant to trade in general in the city; Hong Kong vessels can land shipments at any time or place they wish and do not have to declare live fish cargo. At the airports, inspections of shipments may be random and based on intelligence. However, the large volume of shipments being traded make it logistically difficult to randomly inspect more than a very small proportion of shipments exiting Indonesia by air or entering Hong Kong. Inspection protocols for frozen/dead HHW are unclear but such exports are known to occur.

5. **CITES enforcement**: implementation of CITES in China on import is non-existent for marine species listed on CITES Appendix II or III. Imported and exported quantities of HHW do not match in some cases (i.e. between Singapore and Hong Kong). Singapore does not adequately monitor exports of HHW. In the Philippines, there is an active grow-out operation for HHW yet all of the fish that are exported as a result of this operation are illegally exported because there is a total ban currently in place in Philippines for all CITES listed marine species, and for live fish in general.

6. **Trade routing**: problems are identified with illegal trade in the following areas; re-export via Singapore, trade directly entering China from Hong Kong and Indonesia, and trade between Philippines and eastern Malaysia.

7. **Documented cases of illegal wildlife trade**: smuggling in the Philippines is very serious and includes drugs and arms, as well as live fishes – from Tawi-tawi to Sabah (mainly done by Filipinos). Even if there are successful interventions, such cases do not get support from judges or government in general. Several cases of local illegal trade reported in newspapers in Indonesia.

Identify ongoing or planned work on IUU for HHW

1 Malaysia has imposed an international ban on HHW trade since 2010, such ban may continue. They are planning to the control domestic market of HHW.

2 Workshop for Coral Triangle Initiative (CTI) held on 21st June in Jakarta.

3 Indonesia President has set up a task force to combat mafia in forestry/mining/fisheries. This is important for HHW since IUU in fisheries is a major problem for the species. On the other hand, there are high targets to attain for fisheries production which may put more pressure on coastal fishery resources. Plans for managing these resources are not clear.

4 Establishment of Indonesian Grouper Lobster Fishermen Foundation by the private company Pulau Mas includes around 5000 fishermen who have to agree not to catch HHW at all. The company is the first private company in Indonesia that has made this a company policy and demonstrates the power of action at the company level.

5 A proposal was made, as an outcome of the workshop, to convene a meeting among law enforcement and export inspection units (Forestry, Fisheries and Quarantine) to better coordinate/streamline inspections of fish being prepared and processed for export.

6 Existing Indonesian law is that HHW can only be fished by traditional methods by artisanal fishermen with environmentally friendly methods (such as hook & line and traps not industrial catching or using bombs and cyanide) and that fish should be exported at < 1 kg and > 3 kg. This law is a very good one for more sustainable use of this species if implemented and adequately enforced.

7 MMAF will become the new MA for CITES-listed aquatic species (corals, seahorse, arowana fish, HHW, etc.). Transition is still taking place in the transfer of responsibility for such species from Forestry to Fisheries as not all provinces have fisheries offices.

8 An informative website maintained by the IUCN specialist group www.humpheadwrasse.info contains up-to-date HHW fishery, trade, management, and educational information.

HHW status and performance indicators for sustainable use

1 Currently little is known about coral reef fisheries in Indonesia.

2 Non-Detriment Finding (NDF) work conducted in Sabah Malaysia, used the FAO NDF method (SEE: http://www.fao.org/docrep/012/a1237e/a1237e00.htm) and clearly demonstrated that the wild population is low and that most of the traded HHW must come from the Philippines. NDF in Indonesia provided an estimate for sustainable catches and international trade based on trader consultation and FAO NDF study, among other factors.

3 Further assessments of populations are needed to determine whether existing enforcement and regulative measures have resulted in increases in natural populations. It is suggested to hold a small meeting with the Scientific Authority to refine methodologies for assessing HHW populations in Indonesia and to discuss possible the development of possible indicators to assess sustainability in this species. The trade should be demonstrably sustainable under CITES so this work should be a priority.

Mariculture and other possible options for supplemental production of HHW

1 Closed-cycle mariculture production (i.e. hatchery) is potentially an additional form of production to the capture fishery. However, it will not address or solve the overfishing of HHW unless mariculture production directly results in reduced fishing pressure and replaces fishing in the wild. This seems unlikely given the very high demand for HHW. Moreover, if mariculture replaces capture fisheries for HHW then the current fishermen will lose livelihood opportunities due lowered demand for their wild caught HHW. The incentive and benefit for maintaining the natural environment for HHW would also be lost. On the other

hand, if wild capture of juveniles was to continue unmanaged, and populations decline, fishermen in Indonesia would lose benefit from the resource. Therefore, mariculture (hatchery) production of HHW should be seen as an entirely separate activity from wild capture of HHW and managed separately. Mariculture (hatchery) production does not solve overfishing (e.g. salmon). Currently, mariculture of HHW is practices as a wild fishery of juveniles (SEE: http://www.fao.org/docrep/011/i0254e/i0254e00.htm).

2 Successful mariculture production of HHW is currently not possible commercially and many years of development are necessary to reach commercial production. As currently practiced the ‘culture’ of HHW (i.e. grow-out / ranching) is a fishery of juveniles, a type of wild harvest fishery that is typically unsustainable if not carefully managed.

3 HHW is no longer a priority for mariculture (hatchery) development by the Indonesian government and little other research is being conducted on this aspect of the species. An example of research in China was presented at the meeting showing little success to date.

4 Restocking can only be conducted once there is successful hatchery production of HHW and initially would only be at experimental levels. It will take many years after hatchery production is successful to determine the appropriate places, times and fish sizes for successful restocking initiatives to occur; without such preparatory work, restocking is likely to be a waste of valuable resources; successful restocking, experience has shown, requires appropriate preparation and sufficient knowledge. Restocking also needs to be monitored to be able to demonstrate success. In almost all cases of restocking globally, there is no documentation of outcomes and wild fisheries have not been recovered as a result of restocking. Restocking without the appropriate scientific foundation and monitoring can be an enormous waste of public funds and efforts with little chance of success unless managed carefully.

Key issues in relation to IUU and CITES and of relevance to the Decision on enforcement from CoP 15 at Doha and the Doha Task Force

1 Trade Practices:

a. Trade within Indonesia (domestic trade): need to address the trade between capture and export, why are so many fish < 1 kg exported from Indonesia; when and where can inspections of catches be made most efficiently (i.e. at bottlenecks such as storage shipping points) This is a serious problem that needs to be addressed since protected the juveniles (<1 kg) and the larger fish (>3kg), which are more fecund, are very important fishery management measures.

b. No quotas are allocated for HHW in Bali so all the packaging and trading done in Bali involve fish coming from other provinces. Do the numbers add up? How are the exports from West Papua documented since these are suspected to leave Indonesia illegally by sea – are these fishes accounted for? If not, should there be no allocation of HHW to West Papua?

c. Who are the major economic beneficiaries in the trade for HHW? An economic analysis is strongly recommended to determine the real benefits to fishermen of catching the HHW, and, in particular, the losses they will incur if HHW populations declines and the species goes extinct economically.

d. Is there value in establishing a trader association for HHW to develop a code or standard of good practices and address the IUU problems? Are there lessons to be learned from the tuna industry regarding how better to manage the HHW, and other reef fish species that need management?

2 Inspection of catches and international shipments:

a. Hong Kong should inspect Hong Kong licensed vessels importing live fish into Hong Kong for CITES species. This lack of ability to enforce sea shipments seriously undermine the effectiveness of implementation for CITES listed species, including HHW in Hong Kong.

b. Are conservation officers involved in checking HHW export shipments from Indonesia? Customs, immigration and quarantine are the 3 institutions involved in inspection. Conservation team (BKSDA) can also actively join inspection in the cargo areas (air, sea, land) of all ports involved in shipment of HHW. There appears to be considerable scope to increase enforcement of export shipments of HHW. A meeting to improve coordination is suggested Particular issues to be addressed include: illegal air exports into HK coming from Indonesia; export shipments without CITES paperwork or by companies that are not held responsible for illegal shipments; many illegal sized fish exported from Indonesia i.e. , <1 kg. Inspections could be improved at packing facilities and consistency of labelling for species names could be addressed.

3 CITES enforcement:

a. Tighten both national and international enforcement activities and mechanisms for HHW.

b. Address the issue of what to do with confiscations of illegally imported or traded HHW (both at national and international levels); sent to zoos, auctioned, released, destroyed?

c. Address the issue of how to determine the export quotas allocated among different provinces in Indonesia. If illegal exports are suspected from some provinces, maybe permits should not be granted until the issue is satisfactorily addressed.

d. From the Hong Kong government's view point source countries should manage their own resources. However, as a CITES Party, Hong Kong is responsible for ensuring sufficient inspections of imports and this is not yet being done for imports by sea. Hong Kong has no authority to inspect Hong Kong registered vessels coming into Hong Kong for the purposes of HHW

e. Mainland China was reluctant to accept the air-only international trade condition proposed by Indonesia at the Doha CoP because it does not want other countries to influence internal policies, especially on CITES (commercially harvested) marine species.

f. Mainland China is not implementing or does not have the capacity to implement CITES for marine species. This is a major issue that needs to be addressed and is not just applicable to the HHW but for all marine species listed on CITES.

4 Trade Routing:

a. Trade in HHW between Singapore and Hong Kong and between Indonesia and Singapore is not fully documented.

b. Trade is evidently increasingly bypassing Hong Kong and going directly to China. This trade either enters Hong Kong illegally or goes straight over the border at several locations, or it goes directly into several cities in southern Mainland China. Involved in some cases are Chinese companies with a Hong Kong-based contact. A number of institutional challenges at the national level have been identified, including lengthy and costly procedures for traders to apply for export permits, the large number of various government departments involved in the process (See attached flow charts compiled by Joyce Wu), and limited inspection resources available (one boat patrol per province in Indonesia)

5 There is a need for more rapid information exchange on enforcement and trade issues.

6 A possible temporary measure to consider introducing until IUU has been reduced could be international trade bans.

a. **For:** 95% HHW are caught by cyanide; cyanide is illegal and mostly provided by collector/traders – since the HHW is the major target species for cyanide, then the incentive to introduce cyanide to fishing communities is reduced if HHW cannot be caught. Also, if all exporting countries ban HHW international trade then any HHW found on sale in Hong Kong and Mainland China are highly likely to be illegal. This would greatly assist in implementation of CITES in importing countries. The international trade in HHW is highly lucrative for a small number of traders and this represents a very high incentive to trade as much as possible, regardless of quota regulation. Given that the CITES quotas are too low relative to demand, some companies simply ignore the quotas and trade illegally. A temporary moratorium could assist in finding means to get the international trade under better control. The Indonesian government has a commitment to address fishery IUU and a temporary ban would send a strong message that it is serious. If the HHW declines further, then it is possible that it might be proposed for Appendix I which would mean no international trade.

b. **Against:** no clear information to support closing the trade. Would a ban defeat the intention of CITES Appendix II for sustainable trade? The Indonesia government has a mandate to increase fishery production generally so a moratorium would be difficult to justify. However, if this leads to loss of the commercial use of HHW, then lack of action is counterproductive. The HHW is a particularly vulnerable fish species in a low volume trade and appears to need special attention.

c. **Other:** Cyanide is also used to catch some groupers, such as the coral trout (*Plectropomus leopardus*), in some places; total export ban in 2010 in Malaysia –

because of NDF study, also because of those fish are actually coming from Philippines; Livelihood? Short term or long term needs

d. Suggest a meeting with LIPI to discuss various options for assessing population status for the HHW in Indonesia so that there is a consensus on estimation of population condition.

e. What would happen if the HHW is banned from export? Who are the losers and what is the loss? If banning international trade results in sustainable use of the HHW as food and for local trade, this might be an overwhelming advantage to source countries.

7 In the face of inaction, the economic extinction of HHW is likely and this would represent a loss of income for both traders and fishers as well reduction in food security.

8 What role can the ASEAN WEN network play?

Analyse gaps and identify next steps, research or actions needed to address the key issues, key players and priorities – develop workplan to improve CITES implementation

Gaps:

1. Additional HHW wild population assessment needed – research to be conducted by LIPI – suggest a workshop among workers on fish and fisheries to reach a consensus on best and most practical methodology to be applied in Indonesia and to determine where and when to do assessments.
2. Impact of CITES implementation should be determined by re-monitoring initially studied sites and additional sites could be surveyed for future reference. Remonitoring of surveyed sites could be conducted within 5-10 years of original surveys.
3. Economic study of the HHW trade needed – which level of trade is the biggest earner? Are exporters/importers gaining most of the profits or the fishing community, for example, Some workshop participants suggested that for 1 kg HHW, international traders can earn up to $150USD, because it is sold in Hong Kong/ China around $170 per kg. Bribes are reportedly paid to officials to allow illegal exports to occur.
4. Funding is needed for further studies and assessments. Indonesia, as a range state, could consider seeking funding from private sources or from the CITES Secretariat for studies related to NDF

Possible next steps

1. Assessment of wild HHW population abundances: LIPI and/or other research institution to explore options to assess population status of HHW in Indonesia so that there is a consensus on appropriate methods to estimate wild HHW. The FAO GPS transect method is an useful starting point for discussion.
2. Socio-economic study of HHW trade to look at the economic value at different trade levels, from fisher to retailer; who is the biggest beneficiary of HHW trade, and how stakeholders

would be affected by overfishing of the species or trade ban.

3. Transportation: would it assist enforcement efforts to only permit single species (i.e. HHW) export shipments out of international ports of exit?

4. Fishery:

    a. Establishment of capture fisheries data collection system -this could collect data from fishers or at major HHW consolidation points (bottlenecks) at the province level.

    b. Ban catches of small fish (i.e. < 1kg) to protect the juveniles – Indonesia has in place an excellent national law to prohibit export of fish below 1 kg, however this law is not enforced and widely and openly violated.

    c. Establish a minimum size of capture (sexual maturation?). In this case 1 kg would be an appropriate minimum size. Also consider a maximum size for capture (>3kg) to ensure that the larger fish, which are more fecund, are available for breeding and replenishing natural stocks.

    d. Establish protected areas and/or seasons where and when the HHW is known to spawn.

    e. Develop a cyanide testing procedure for HHW. Assist the development of a cyanide testing laboratory in Indonesia

5. Trade Practices:

    Good practice by traders should be encouraged, maybe by providing incentives like certification. Also to be considered the blacklisting of companies with record of illegal trade. Establish a HHW traders' association to encourage better trade practices, also useful for the government to obtain information about the trade.

6. Inspection:

    a. Strengthen inspections, especially stronger enforcement of sea transported fish within Indonesia and on Hong Kong (HK) licensed vessels-much of the financial benefit from HHW to Indonesia might be lost because of illegal activities by HK vessels. One approach would be not to permit any HK licensed/registered vessel to transport HHW within Indonesia. Are there lessons learned from other fisheries that could be positively applied to the fishery and trade in HHW? For example, shipments of tuna are inspected carefully, marking parameters like length, weight – could the same documentation procedures be adopted?

    b. Inspection for HHW at international airports with customs and conservation teams checking boxes of live fish HHW on a random and more coordinated basis. Every box containing HHW should be checked, this is considered practical as only a small volume of trade involved. Also, the labelling of boxes for CITES listed species needs to be consistent i.e. the same Latin and English or local names need to be used at all stages of inspection and documentation.

    c. Identify HHW using X-ray machine. A research project could be conducted to determine the X-ray signature of the HHW if this is considered to be useful. X-ray is currently used by security guards at airports to inspect whether there are explosive materials and whether the shipment is legal, so could the same approach be applied to HHW. Fish quarantine and conservation officers are responsible for opening boxes and checking what is inside shipments of live fish. Since there are time constraints when dealing with live fish, only a fraction of the boxes are checked so are there methods that could improve effectiveness?

d. Spot checks before loading in airport could be applied or facilities developed for inspection near the airport.

7. CITES enforcement:

   a. A meeting to be held among law enforcement and export inspection units (Customs, Forestry, Fisheries, and Quarantine) to better coordinate HHW inspection, while the species are being processed for export.

   b. It is important to ensure that quotas are adequately allocated to traders who actually export HHW and have no illegal trade records as well as taking into consideration areas/provinces with sufficient and healthy HHW populations.

   c. Tagging / validating could be conducted using lessons learned in the forestry and tuna industries. Tracing of HHW by tagging (like tuna), potential effective management tool at bottleneck in international trade (e.g. China, Hong Kong, Indonesia).

   d. Need to identify loopholes and bottlenecks to assess whether CITES is working for HHW and if not what the fundamental challenges are.

   e. Receiving countries should also be liable for illegal exports (e.g. like the United States LACEY Act to combat illegal logging) – resulting in co-operation between consumer and producer countries (e.g. as in the case of Ramin – wood)

   f. Certificate of quarantine – should have common name printed on the certificate so that customs officers can realize that the species is CITES-listed (e.g. HHW) and check

   g. Need a comprehensive list of actual exporters (same as importers) and records of trade violations.

   h. China needs to implement CITES Appendix II for marine fishes.

8. Illegal Cases: What to do with confiscated fish? Can these go to auction? Why is it difficult for the Hong Kong government to deal with confiscated HHW? There are clear standard steps within the CITES framework on how to deal with confiscations step by step (See Joy Lam presentation). At the moment, Hong Kong government contacts source countries in relation to HHW confiscated in Hong that are alive; outcomes depend on the source countries for their agreement on the return of confiscated HHW. The HK government has also sent HHW to Ocean Park in HK.

9. Consumer choice campaign in relation to HHW could be conducted. However, the huge

demand in China for HHW means that this approach could only make a small difference to overall demand, and alone consumer choice is likely to be insufficient.

10. Temporary moratorium of HHW export from Indonesia, upon the result of NDF study and assessment of wild populations

Discuss the Decision on enforcement from CoP 15 at Doha and the Doha Task Force

1 Air-only shipment mode: Hong Kong and China stated that they do not welcome this suggestion Information exchange to be improved- need for a confidential website to be accessed by CITES Management Authorities to assist in implementation?

2 Working group/ task force could be multi-stakeholder with international NGOs, standing committee, secretariat, exporting and importing countries, IUCN specialist group, others?

3 Effective management of HHW requires that all government departments involved (including transportation, customs, trade ministries) should work together to conserve HHW, to set up a management system to deal with livelihoods of fishers, pollution etc. HHW population data should be obtained and analysed, and practical sustainability indicators (i.e. easily measured) developed, using methods that have wide agreement/consensus within LIPI.

4 To address illegal trade by HK fishing vessels, clear and strong action is needed regarding HK fishing vessel activities within Indonesian waters and regarding inspections of fishing vessels entering Hong Kong and Mainland China.

Identify awareness and capacity building needs in relation to the implementation of the CITES listing for HHW

1 Effective management and capacity-building are strongly needed across government departments responsible for HHW management: inspection of every shipment is currently hard to conduct due to the large volume of shipments involved (estimated 40-50 boxes of live fish per shipment, and 30-40 shipments per day in airport occur) so more effective inspection protocols are needed.

2 Capacity for inspection of packaging facilities – customs, conservation and fisheries quarantine departments to visit trader packaging facilities and seal the shipment after inspection. This should be relatively straightforward as there are currently few exporters of HHW. Is it possible to finalize inspection at a packaging facility?

3 BKSDA and quarantine and customs and immigration to come together to seek ways to improve inspection protocols.

4 Training is needed to improve ability of officials for inspecting HHW. Need training to identify the species and to estimate fish sizes.

5 Educate fishers and traders not to use cyanide or to catch under-sized fish

6 IUCN GWSG can assist educational and outreach projects if invited.

List of presentations

Brief history of HHW fishery and management & Aims of Workshop and expected outcomes	Yvonne Sadovy
Napoleon Wrasse Trade in Indonesia	Joyce Wu
Humphead Wrasees IUU study in TAWI-TAWI	Filemon Romero
Napoleon / Humphead Wrasse (HHW) Trade in South China and Hong Kong	Joy Lam
HHW trade of Singapore	Joyce Wu
Challenges of HHW management in Sabah, Malaysia	Lawrence Kissol
Regulation/ legislation/ enforcement system of HHW Trade in exporting countries- Philippines	Filemon Romero
Cheilinus undulatus (Humphead Wrasse/HHW) : Major enforcement challenges at national level and in relation to CITES at export levels	Harry Santoso
CITES decision on HHW enforcement and the initiative to set up HHW working group	Harry Santoso
Fish quarantine regional office of Ngurah Rai and its role in HHW trade	G. Gatot Perdana
Indonesian customs in HHW trade regulations	Johanes Felix
Lesson learnt on Napoleon Wrasse trade in Indonesia	Heru Purnomo
The role of LIPI in HHW conservation and information needs	Sasanti Suharti
The Live Reef Food Fish Trade: “Coral Triangle” Programs	Geoffrey Muldoon
The role of directorate for conservation and marine national park on HHW Trade	Rofi Alhanif
The role of directorate of fisheries resources management (DFRM) in sustainable use of Humphead Wrasse (*Cheilinus undulatus*)	Agus Budhiman
The research progress for HHW mariculture – success and ongoing challenges	Jhon Hutapea
Discussion on measures to assist implementation: minimum sizes; training; education; information exchange; moratorium, MPAs, etc. – related to DOHA	Yvonne Sadovy
The role of mariculture and stock enhancement in the sustainable use of HHW and addressing overfishing	Yvonne Sadovy
IUCN / CITES policy on return in confiscated fish in illegal international trade	Joy Lam
The Role of BKSDA Bali on HHW trade regulation	Tamen Sitorus

AGENDA

Workshop on the Trade in *Cheilinus undulatus* (Napoleon Fish / Humphead Wrasse/HHW)

JUNE 3 & 4 2010

WWF – Indonesia, Bali

3 June 2010 AM

0900-0915	**Welcoming note & Introduction**	Lida Pet/Yvonne Sadovy
0915-0945	**History of HHW fishery and management, including CITES listing. Aims of Workshop and expected outcomes**	Yvonne Sadovy
0945-1230	**Updates on ongoing research and data collection in HHW legal and illegal, unregulated and unmonitored trade (IUU) in major exporting and importing countries**	
0945-1015	Indonesia	Joyce Wu
1015-1030	Philippines	Mon Romero
1030-1045	Singapore	Joyce Wu
1045-1115	**Tea / Coffee Break**	
1115-1145	South China/HK	Joy Lam
1145-1230	Discussion	All

LUNCH 1230 – 1400

3 June 2010 PM

1400-1730	**Discussion of regulation/ legislation and enforcement system of HHW trade in exporting countries** Identify major enforcement challenges at national level and in relation to CITES at export levels	
1400-1415	Malaysia	Lawrence Kissoll
1415-1430	Philippines	Mon Romero
1430-1500	Indonesia	Harry Santoso
1500-1515	The Role of BKSDA in Bali on HHW trade regulation, including cooperation with BKSDA in the provinces in relation to HHW harvest quota	Tamen Sitorus
1515-1545	Tea / Coffee Break	
1545-1600	Role of Fish Quarantine in the inspection of cultured HHW, packaging and regulation of legal exports: role and challenges.	Mohammed Ridwan (pending confirmation)
1600-1615	The role of Customs (in Bali) on HHW trade regulation - how to reduce illegal trade	SE Ariohadi (to be represented by Bambang Wahyudi)
1615-1645	Discussion: to identify future directions to improve enforcement in exporting countries	All
1645-1715	Summary of CITES decision on HHW enforcement and discussion on the initiative to set up HHW task force (related to CITES meeting at Doha)	Harry Santoso
1715-1730	Day close remark/introduce Day 2	Yvonne Sadovy

4 June 2010 AM

0900-0915	Summary of Day 1 and Introduction to Day 2	Yvonne Sadovy
0915-0930	IUU trade of HHW – A trader perspective	Heru Perumo
0930-1000	**Identify work on HHW trade, biology, etc. IUU being planned or ongoing, and possible synergies with other projects or initiatives**	
0930-0945	The Role of LIPI in HHW conservation and information needs	Santi Suharti
0945-1000	Discussion: ongoing and planned work & possible synergies	All
1000-1030	Discussion on management system of HHW trade including controlling and monitoring system in exporting and importing countries	All
1000-1015	The CTI, live reef fish trade and threatened reef fishes	Geoffrey Muldoon
1015-1030	The Role of Conservation and Ocean National Park/MOMAF in HHW trade, now and in the future)	Rofi Alhanif
1030-1100	Tea / Coffee Break	
	Identify information needs for improved management of the HHW	
1100-1130	Discussion on feasibility of measures to assist implementation, such as minimum sizes, a platform for information exchange and indicators for successful management	Yvonne Sadovy
1130-1230	**Further follow-up from the CoP decision in Doha, proposed by Indonesia, on improved enforcement for the HHW and related issues, such as capacity building, confiscations, etc**	
1130-1145	IUCN policy on returning confiscated fish in illegal international trade	Joy Lam
1145-1230	Discussion on matters related to CoP decision in Doha on improved enforcement	All

LUNCH 1230-1400

4 June 2010 PM

1400-1630	**Other sustainable use and production issues in relation to HHW and the live reef fish trade (food fish) in general**	
1400-1415	How the Department of Fisheries Resources manages HHW resources for sustainability and its role in relation to CITES listed marine species	Agus Budhiman
1415-1430	The role of mariculture and stock enhancement in the sustainable use of HHW and for addressing overfishing	Yvonne Sadovy
1430-1445	Research Progress for HHW mariculture - successes and challenges	Jhon H. Hutapea (representing Dr. Giri of Gondol Mariculture facility)
1445-1515	Tea / Coffee Break	
1515-1700	**Discussion on key issues arising, gaps and next steps**	All
1700-1730	**Concluding Remarks**	Yvonne Sadovy

Guestlist of the Workshop on the Trade of *Cheilinus undulatus* (Humphead Wrasse / Napoleon Wrasse) & CITES implementation

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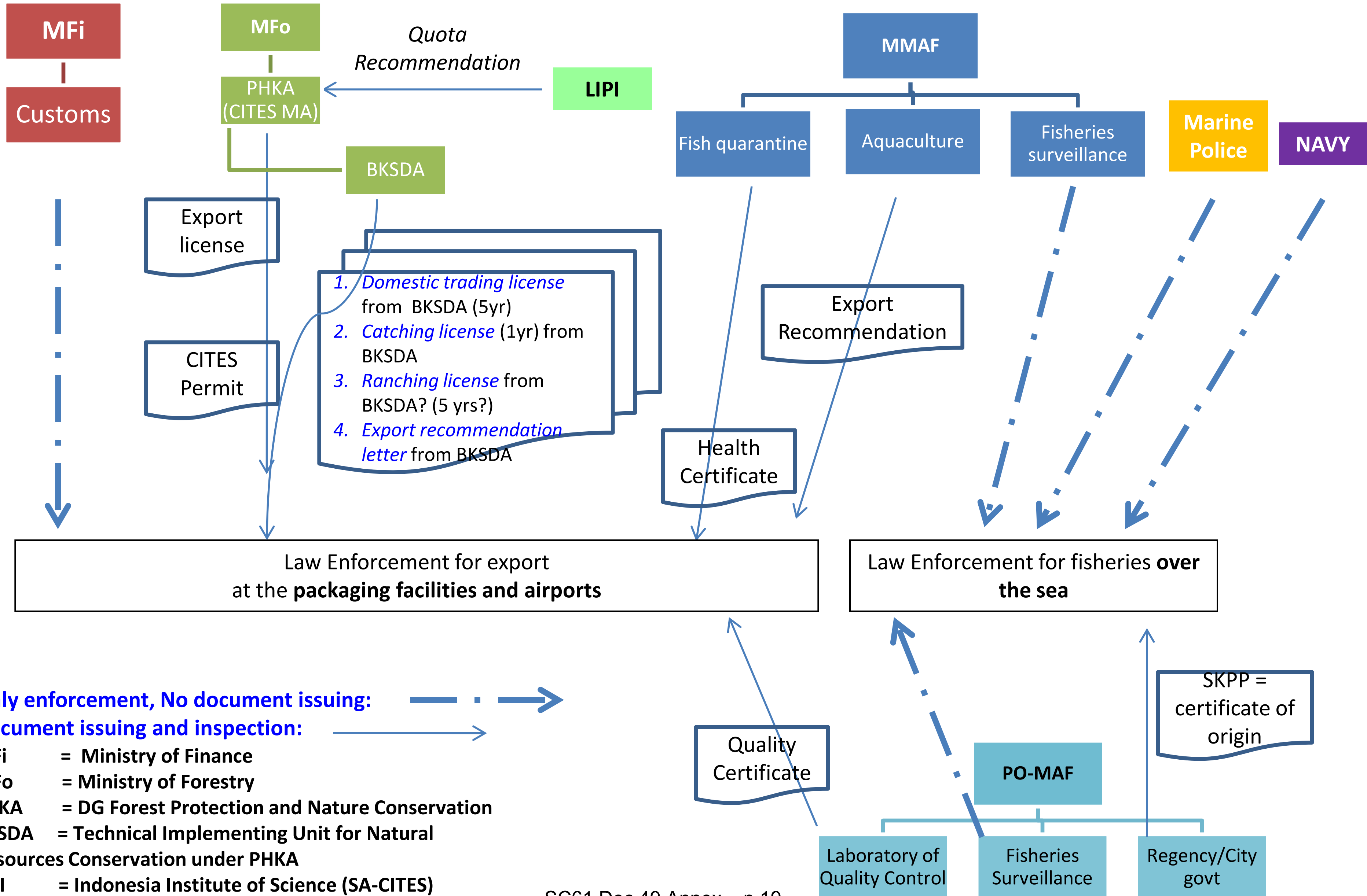
Flow Charts for HHW trade and regulation in Indonesia

Prepared by TRAFFIC
Joyce Wu

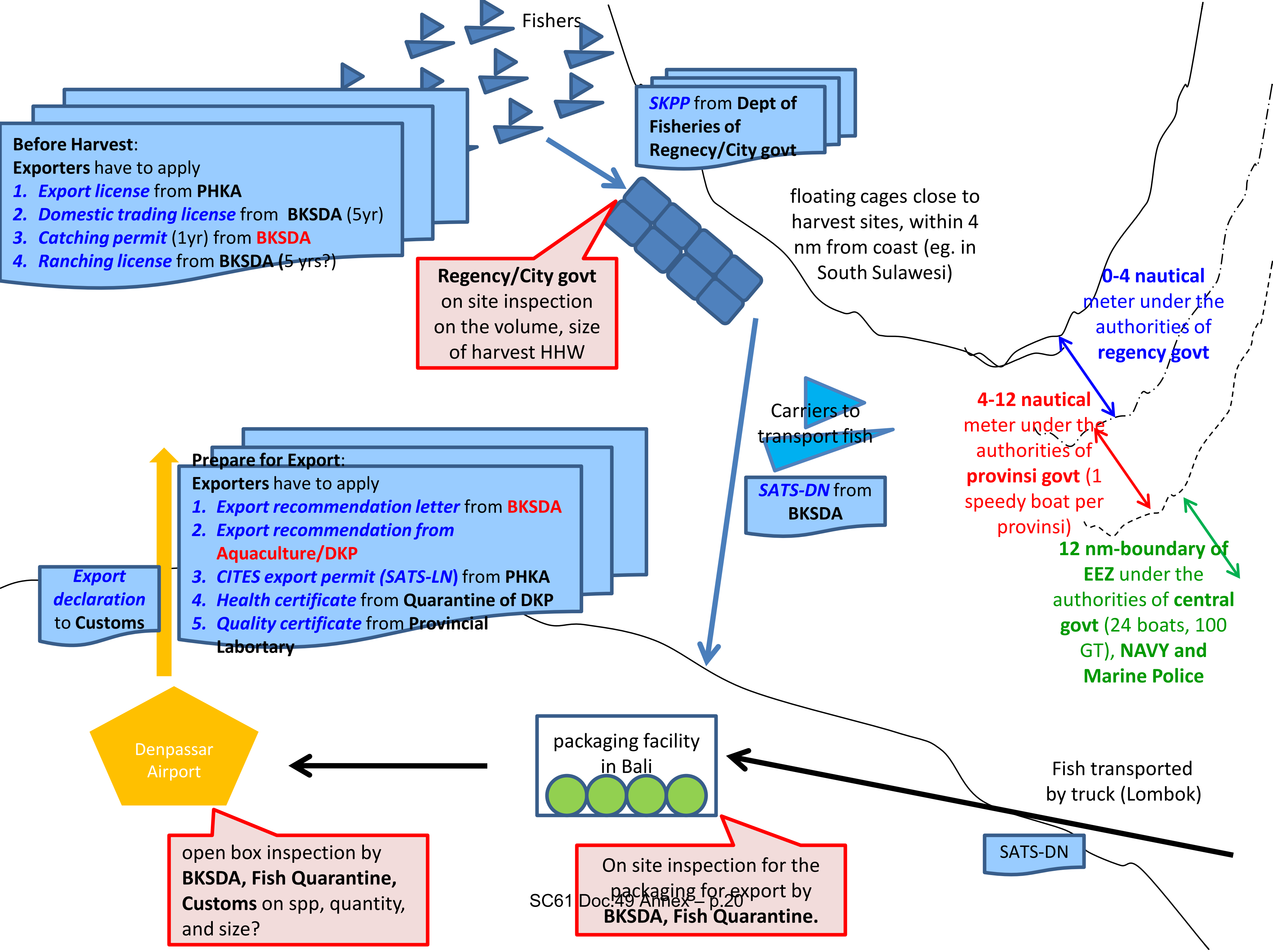
Mechanism for HHW Management in Indonesia



Only enforcement, No document issuing:

Document issuing and inspection:

MFi = Ministry of Finance
MFo = Ministry of Forestry
PHKA = DG Forest Protection and Nature Conservation
BKSDA = Technical Implementing Unit for Natural Resources Conservation under PHKA
LIPI = Indonesia Institute of Science (SA-CITES)
MMAF = Ministry of Marine Affairs and Fisheries
PO-MAF = Provincial Office of Marine Affairs and Fisheries



Fishers
Before Harvest:
Exporters have to apply
1. Export license from PHKA
2. Domestic trading license from BKSDA (5yr)
3. Catching permit (1yr) from BKSDA
4. Ranching license from BKSDA (5 yrs?)
SKPP from Dept of Fisheries of Regnecy/City govt
Regency/City govt on site inspection on the volume, size of harvest HHW
floating cages close to harvest sites, within 4 nm from coast (eg. in South Sulawesi)
0-4 nautical meter under the authorities of regency govt
4-12 nautical meter under the authorities of provinsi govt (1 speedy boat per provinsi)
12 nm-boundary of EEZ under the authorities of central govt (24 boats, 100 GT), NAVY and Marine Police
Carriers to transport fish
SATS-DN from BKSDA
Prepare for Export:
Exporters have to apply
1. Export recommendation letter from BKSDA
2. Export recommendation from Aquaculture/DKP
3. CITES export permit (SATS-LN) from PHKA
4. Health certificate from Quarantine of DKP
5. Quality certificate from Provincial Labortary
Export declaration to Customs
Denpassar Airport
packaging facility in Bali
Fish transported by truck (Lombok)
SATS-DN
open box inspection by BKSDA, Fish Quarantine, Customs on spp, quantity, and size?
On site inspection for the packaging for export by BKSDA, Fish Quarantine.

Documents required for HHW fishery and trade – before harvesting

Export License

- issued by **PHKA**

Domestic Trading License

- issued by **BKSDA** at provinsi the company has catching quota
- valid for 5 yrs

Ranching License

- in order to grow up HHW
- issued by **Aquaculture of DKP? Or provinsi govt?** where the floating cage located
- valid for 5 yr?

Fishery business license??

- Issued by **Fisheries Service under Regency**?

Recommendation for collecting/cultivating (Catching license?)

- issued by **BKSDA**
- specified the cooperated fishermen, fishing groud, harvest quota for the company
- valid for 1 year

Documents required for HHW export – after harvesting

Notification Letter for collecting/cultivating (Certificate of Origin)(SKPP)

- issued by **fishery service under regency/city**
- name, address of fishermen?, catching permit, fishing gear

Recommentation for domestinc transportation (SAT-DN)

- issued by **BKSDA** at the catching province
- valid for 1 shipment

Export inspction reporting letter

- after checking at the packaging site
- issued by **BKSDA** at export province, section office where the **floating cage located??**
- valid for 1 shipmint

Export Recommendation Letter

- based on the export inspction reporting letter
- issued by **BKSDA in provinsi with export quota**
- valid 6 mos, for 1 shipment

Export Recommendation

- Issued by **Aquaculture/DKP**
- Based on the export recommendation letter from BKSDA

CITES Export Permit (SAT-LN)

- based on the Export Recommendation Letter AND **SAT-DN**
- issued by **PHKA** (DG of Forestry Protection & Nature Rescourse Conservation) in Jakarta
- valid for 1 shipment

Fish Health Certificat

- prove fish is free of bacteria
- issued by **Fish Quaratine** under DKP (MMAF)
- valid for 1 shipment

Fish Quality Certificate

- demand by HK to provde fish free from E coli, salmonan
- issued by **Provincial Laborary for Fish Inspection & Quality**
- valid for 1 shipment

Customs Export Declaration

- valid for 1 shipment

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The humphead wrasse, *Cheilinus undulatus*: synopsis of a threatened and poorly known giant coral reef fish

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Contents

Key words: high value, live fish trade, reef fish fishery, vulnerable

Abstract

The humphead wrasse, *Cheilinus undulatus,* is the largest living member of the family Labridae, with a maximum size exceeding 2 m and 190 kg. Its geographic range covers much of the Indo-Pacific. The species is not common, recorded maximum adult densities rarely exceeding 20 fish/10,000 m^2. Small individuals are typically associated with high coral cover; larger fish are found mainly on outer or deep reefs, steep slopes and passes, singly or in small groups and seagrasses. However, for reproduction the species forms small spawning aggregations of tens to more than one hundred fish. The diet of the humphead wrasse includes large invertebrates and small fishes. The species attains at least 30 years and reaches sexual maturation at about 35–50 cm total length and <5 years of age. Most small adults are female while mainly males exceed 1 m and there is evidence of female to male sex change. The humphead wrasse is of considerable cultural value in some Pacific countries and is among the most prized in the live reef food fish export trade, for which it is often taken in its juvenile size range, either directly for sale or, increasingly, for grow-out to market size. It is also marketed chilled. The species is particularly sensitive to fishing pressure. In most fished areas, density and body size have dropped substantially. It appears to be particularly heavily targeted and depleted in SE Asia and in some places faces extirpation. The humphead wrasse is often taken by night spearfishing and by cyanide, with protection typically weak or non-existent, despite regulations and a 'vulnerable' assessment on the 1996 IUCN Red List. The humphead wrasse has not been reared successfully

in hatcheries. Other giant reef fish share many similar problems and detailed study of the humphead wrasse contributes to a better understanding and conservation of all such species. This review examines and evaluates published and gray literature, original unpublished research and correspondence with almost 50 knowledgeable workers. It examines the value of such sources for quickly, but adequately, assessing the conservation and management status and key data gaps in species that are little known, vulnerable, difficult and expensive to study and may require urgent management or conservation action.

Introduction

The humphead wrasse, *Cheilinus undulatus* (Rüppell, 1835), also commonly known in English as the Maori or Napoleon wrasse, is the biggest member of the family Labridae and a giant among reef fishes, capable of attaining over two meters in length. The more commonly used names for this species derive variously from the prominent bulbous hump that appears on the forehead in larger adults, the intricate markings around its eyes, its large body size and, reportedly, because it was the trophy fish of a Mr. Napoleon, fisher and farmer in New Caledonia (Fourmanoir and Laboute, 1976).

A distinct and readily recognizable species, it is of considerable traditional customary significance in many Pacific islands and is much appreciated by divers, spearfishers and seafood gourmets alike. There are increasing reports, however, of substantial declines due to exploitation, in particular related to its susceptibility to spearfishing and the growth of the live reef food fish trade (LRFFT) in which *C. undulatus*, traded live, fetches top prices. The LRFFT has expanded rapidly since the early 1990s, placing heavy pressure on larger preferred reef fishes, with the humphead wrasse in recent years fetching as much as US$130/kg at retail.

In 1996, the humphead wrasse was listed as vulnerable on the IUCN (World Conservation Union) Red List, the first to focus specifically on the status of marine fishes. This species was listed because of concerns over rapidly declining numbers in many areas, particularly within the last decade, as well as projected future demand in the growing LRFFT. Traders themselves have reported that large individuals are becoming scarcer and the retail market in Hong Kong, the biggest LRFFT centre globally, includes a high proportion of juvenile sized fish (Sadovy and Vincent, 2002). While little is published on the natural history of this species, these apparent trends and a likely natural vulnerability to over-fishing due to large body size and longevity, mean that we cannot wait for the completion of much-needed long-term studies, or detailed trade or fishery assessments, to develop management or conservation action (Donaldson and Sadovy, 2001). Therefore, an alternative approach was adopted to evaluate its biology, trade and fishery status.

Assessment of the fishery or conservation status of tropical reef fishes, especially larger, wide-ranging ones like the humphead wrasse, is particularly challenging, whether by fishery dependent or independent means. Reef fishes are rarely managed or monitored in the tropics, with large species that move over wide areas difficult to assess by fishery independent methods such as underwater visual census (UVC), at least at the spatial scale most typically practiced for UVC. For valuable or large species, moreover, obtaining samples can be expensive and large individuals difficult to sample. 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. While there is little published literature on the life history, trade or fishery of the humphead wrasse, there is a wealth of gray literature, including unpublished studies and reports, trade data, traditional knowledge, anecdotal observations and lifetime experiences of field biologists, fishers, traders and divers from which to draw. Combined and carefully assessed, these can contribute significantly to an overall understanding of this species, particularly regarding changes within living memory. This is especially important because concern often arises once a system is already compromised and the lack of long-term records for most reef fishes makes it impossible to otherwise reconstruct possible past conditions for particular species. It is also important to establish a baseline of information on little known species against which future work can be assessed.

The purpose of this paper is multifold. As a synopsis it draws together qualitative and quantitative, fishery dependent and independent information summarizing our present knowledge of the biology, fishery and international trade of this little-known species. It also allows an evaluation of the extent to which concerns over conservation status might be justified, while identifying areas for further research and possible management and recovery options. We do not suggest that this approach should replace more rigorous and conventional assessments or studies of exploited species. Rather, we advocate that, for particularly vulnerable or uncommon species subjected to small but intensive fisheries and in the absence of available data, wide consultation and careful compilation of information provide essential background for identifying problems and areas in need of attention. Indeed, there may be no other means of obtaining the necessary understanding in time for effective conservation and management.

Specifically, we wanted to address the following questions: What information is available on the trade, biology and fishery of the humphead wrasse and what is its quality? What are the volumes and fish sizes in trade and fisheries? What are the natural densities and habitats of the humphead wrasse? What data gaps need to be addressed? What is the evidence that fishing influences abundance? Is the humphead wrasse threatened by fishing, international trade and/or certain fishing practices and if so, is this species adequately protected by existing regulations and what recommendations can be made to better protect and manage this species? Finally, to what extent can a combination of published and informal data sources, from a range of fishery dependent and independent sources, provide useful information for conservation and management?

Methodology

Data and other information were gathered from a wide range of sources and cross-validated whenever possible, to provide a background of the past and present fishery of this species, its biology and its trade. In addition, almost 50 biologists, fishers, divers and traders with extensive field experience or other relevant knowledge of this species were consulted or interviewed directly (hence the personal communications and unpublished data citations; those of the authors are given as initials only). Most workers on this species and others likely to be able to provide information were consulted. Ongoing or unpublished studies were also accessed and are provided here in summary or in their entirety. Government trade data and non-governmental organization (NGO) reports were summarized and market surveys conducted or consulted.

Previously unpublished studies are presented from underwater surveys and histological analyses of gonads. A series of detailed surveys, carried out using standardized methodology, was conducted between 1985 and 1997 in New Caledonia, Chesterfield Islands, Uvea Atoll and the Tuamoru Archipelago by M.K., P.L. and Y.L. These unpublished studies provide information on densities, habitat type (including percentage coral cover), fishing pressure, fish size and are compared with other UVC surveys. To gain some insight into reproductive biology, histological preparations of gonads from 142 individuals, ranging from 22 to 115 cm total length (TL) were made by embedding ovaries and testes in paraffin, staining them in eosin and haematoxylin and classifying them according to germ cell type and stage of maturation.

Based on these data, the distribution, biology, habitat and abundance of humphead wrasse in both fished and unfished areas are described as well as fishery and trade volumes, value and mariculture potential. Current regulations and conservation status are reviewed and data compiled by country. The information is then synthesized to provide an overview of the current and projected status of this species, with recommendations for its protection and management and for further work.

Results

Distribution, habitat and abundance

Distribution

The humphead wrasse is widely distributed on coral reefs and inshore habitats throughout much of the tropical Indo-Pacific (Fowler and Bean, 1928; Schultz et al, 1960; Bagnis et al., 1972; Vivien, 1973; Dor, 1984; Masuda et al., 1984; Wass, 1984;

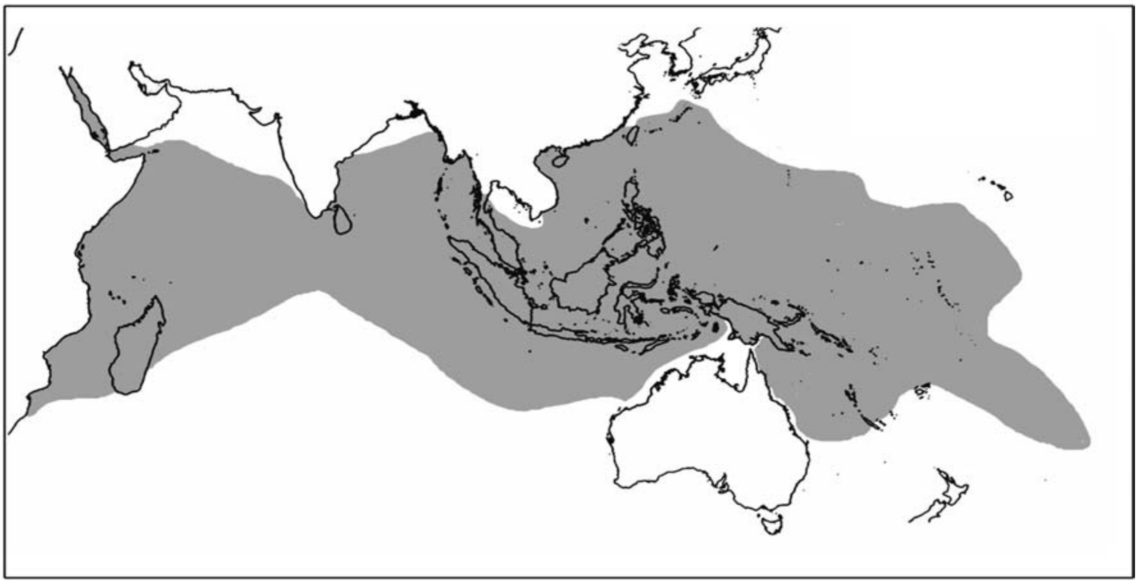

Figure 1. The humphead wrasse has been recorded from the following locations: Israel, Egypt, Somalia, Sudan, Eritrea, Saudi Arabia, Tanzania, Djibouti, Somalia, Mozambique, Madagascar, Seychelles, Chagos Archipelago, southern India including Laccadive Islands (Alien and Steene, 1987; Dorairaj, 1998; B. Sluka and R.F. Myers, personal communication), Sri Lanka, Myanmar, the Maldives (Dor, 1984; Randall and Anderson, 1995), Myanmar, Christmas Island (Alien and Steene, 1979), Indonesia (Kuiter, 1992), offshore atoll reefs Rowley Shoals, Scott Reef, Seringapatam Reef, Ashmore Reef and Carrier Island of northwestern Australia (Alien and Russell, 1986; Grant, 1999). In the Pacific, it ranges from Indonesia (Kuiter, 1992) and the Philippines east through Melanesia and Polynesia to the Tuamotu Archipelago and Henderson Island of the Pitcairn Group (Irving et al., 1995; Randall, 1999), north to the Ryukyu Islands of Japan (Masuda et al., 1984), and from the Mariana and Line islands east to the Marshall Islands including Fiji, Gilbert Islands, Palau, Malaysia, Solomon Islands, Vanuatu, Tonga, Cook Islands , Tokelau, Western and American Samoa, Guam, Kiribati, Gambier Islands (Randall, 1955; Randall and Randall, 1987; Williams and Ayling, 1990; Myers, 1991, 1999, personal communication; Donaldson, 1996) and Wake Atoll (Lobel and Lobel, 2004). Papua New Guinea, the Great Barrier Reef in Australia (Russell, 1983; Randall et al., 1996; Alien, 1997), down to Elizabeth reef (rare; also rare in the Capricorn-Bunker Group, Middleton Reef and Cocos-Keeling Island) and east to New Caledonia (Fourmanoir and Laboute, 1976), and the Chesterfield Islands (Kulbicki et al., 1990). The humphead wrasse is found throughout Southeast Asia and has been reported from China, including Hainan Island and Hong Kong (Sadovy and Cornish, 2000; Huang, 2001), Thailand, Vietnam, Taiwan (Shen, 1988), including the Pescadores Islands and southern offshore islands, including Orchid and Green Islands and the disputed Pratas and Spratly Islands (Chen et al., 1991).

Smith and Heemstra, 1986; Myers, 1991, 1999; Alien, 1993; Figure 1). This species appears to occur predominantly at depths of less than 100 m. It is not known from the Hawaiian Islands, Johnston Island, Easter Island, Pitcairn Islands, Rapa or Lord Howe Islands, Kermadec or Australes Islands, and evidently does not occur in the Gulf of Oman, the Persian Gulf, Reunion Islands, Mauritius or Rodrigues Islands (Randall et al., 1985; Francis, 1993; Randall, 1995, 1996; Fricke, 1999).

Habitat and abundance

This section examines the habitat and abundance of the humphead wrasse based upon literature accounts and unpublished underwater surveys. UVC surveys were carried out by one, or several, of the authors and the results of standardized unpublished surveys from New Caledonia are presented.

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 (P.L. Colin, unpublished data). 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 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. (branching form; M.A. Tupper, personal communication). 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 (Myers, 1999).

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 (Randall, 1955; Randall et al., 1978; Myers, 1999; J.H. Choat, personal communication). Recruitment patterns may vary considerably between years (M.A. Tupper, unpublished data). 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 (Palau Fisheries Report, 1992). UVC surveys (see details below) 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; C.M. Roberts (personal communication) noted that despite extensive diving in the Red Sea, he had never seen small (i.e., < 40 cm TL) humphead wrasse, leading him, also, to suggest that this species may recruit only episodically in some areas.

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 (Vivien, 1973; Randall et al., 1978; Winterbottom et al., 1989; Allen and Swainston, 1992; Sluka, 2000). Typically they are solitary or paired, but have also been noted in groups of 3–7 individuals (Donaldson, 1995; unpublished data). They appear to be somewhat sedentary in that the same individuals, indentifiable 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. Natural densities are evidently never high, even in presumed preferred habitats. For example, in unfished or lightly fished areas, densities may range from 2 to 27, rarely more, individuals per 10,000 m^2 of reef (see below). In fished areas, however, densities are typically lower by tenfold or more (see below) and in some places fish no longer appear to be present (see Fishery and Traditional Use).

The most detailed and standardized survey results come from New Caledonia where UVC was

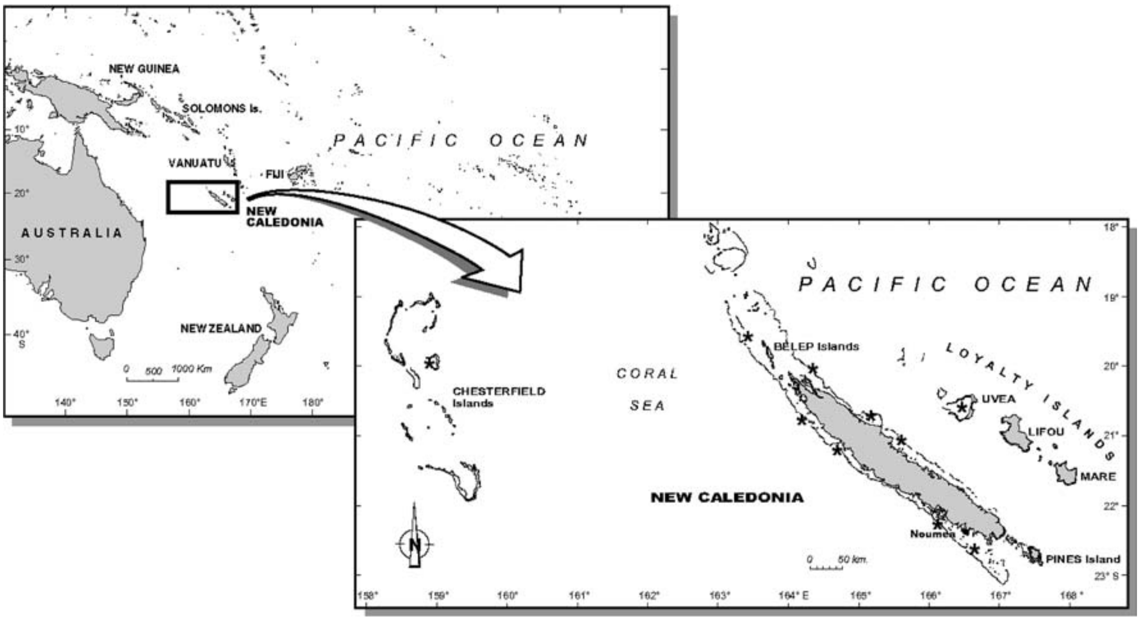

Figure 2. Map of New Caledonia showing study sites (asterisks) for series of standardized underwater visual census surveys.

Table 1. Sampling effort (in standardized transects 50 m × 10 m) for five habitat types between 1985 and 1997 (F.P.: French Polynesia)

	New Caledonia						F.P.		
	Northern lagoon	North-Western lagoon	North-Eastern lagoon	South-West lagoon	Uvea Atoll	Chester-field Islands	Tuamotu	Tonga-Niue	Total
Barrier	98	109	126	310	118	30	478	210	1479
Middle	76	110	127	492				45	850
Coast		74	196	280				62	612
Lagoon				466	76		36	15	593
Pass		2	3				16		21
Total	174	295	452	1548	194	30	530	332	3555

carried out at six regions, with comparable surveys conducted at the Tuamotu Archipelago (French Polynesia; Figure 2). New Caledonia was the most intensively surveyed location with the equivalent of 2693 transects of 50 m × 10 m. At the Tuamotu Archipelago, 530 transects were conducted at 10 different atolls of increasing size (Table 1).

All surveys in the New Caledonia study were carried out in areas where *C. undulatus* might reasonably be expected to occur and data were collected by fish size class (total length), water depth, habitat type, degree of exposure (leeward or windward side of the reef) and coral and hard substrate cover. An index of fishing pressure was also assigned based on the population density in each area. Live coral and hard substrate cover (i.e., any substrate not consisting of mud, sand, gravel or debris) were evaluated as a percentage according to one of two methods: (1) the transects were divided into 20 areas of 25 m^2 each and the percentage cover in each area was estimated by sight and (2) at each metre mark along the transect, the type of cover present was noted (50 marks per transect). Method 1 was used in the southwest lagoon of New Caledonia and the Chesterfield Islands, whereas method 2 was used elsewhere. The methods were found to be directly comparable.

Methods for determining fish size, density and biomass were consistent across regions. Sample stations in each region were classified into five general habitat types: 'barrier' – barrier reefs in lagoons or around atolls; 'middle' – reefs in the middle of lagoons; 'coast' – coastal reefs; 'lagoon' – submerged or patch reefs away from the barrier reef and 'pass' – passes (channels) of atolls. All habitats had at least 500 transects, with the exception of passes that were not well sampled because of unsafe diving conditions. Sampling effort was greatest in the shallowest (0–5 m and 2196 dives) depth range with 615 dives from >5–10 m and 457 dives at >10 m. Fish TL was estimated to the nearest 1–20 cm depending on the absolute size of the animal, i.e., for fish <10 cm, 1 cm size classes were used; from 10–30 cm, 2 cm size classes; for fish of 30–50 cm, 5 cm size classes; for fish of 50–100 cm, 10 cm size classes and for fish >100 cm, 20 cm size classes. Biomass was calculated from fish lengths using the length (TL)–weight (W) relationship $W = 0.0123\ \mathrm{TL}^{3.115}$, for *C. undulatus* ($W$ in g and TL in cm; Letourneur et al, 1998). For all surveys, census transects were either 50 or 100 m in length and all results were standardized to unit transects of 50 m long by 10 m wide.

Results were analyzed for both size and abundance of humphead wrasse. A multiple regression with indicator variables (Neter and Wasserman, 1974) was performed to determine whether the size of *C. undulatus* observed depended upon the following continuous or indicator variables. Continuous variables included, hard substrate cover, depth and coral cover. Indicator variables included, wind exposure, fishing pressure index and habitat. Variables were introduced into the multiple regression using a stepwise procedure. The independence of the variables was tested. Independent variables were excluded from the model if their correlation with variables already in the model was above $r = 0.2$. Thus, size was better correlated to hard substrate cover (cover by all hard substrates, including dead or live coral) than to live coral cover and as the latter variable was strongly correlated to hard substrate cover, coral

Table 2. Size distribution of *Cheilinus undulatus* according to locality (New Caledonia, Tonga-Niue, and Tuamotu Archipelago, Polynesia). Chesterfield Islands datum is not included (M.K., Y.L. and P.L., unpublished data)

	Total length (mm)															
	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	Total
SW lagoon	5	16	15	22	1	7	1	2		1						79
Uvea					3	6	9	8	2	9		2	1			40
N. lagoon		3	2	3	18	23	22	21	15	8	5	2	2	1	1	126
E. lagoon	4	4	6	10	7	9	9	11	1	3	1	2				67
W. lagoon	1	3	4	6	11	7	8	5	2	4	0	1				52
Tuamotus	2	1	4	6	5	6	4	2	3	2	1					36
Tongatapu	1	3														4
Ha'apai	2	1		2			2			2						9
Vavau	1		1	5	1		1		1	3						13
Niue								2								2

cover could not be kept in the analysis. Depth and wind exposure did not contribute significantly to the model when the level of fishing pressure was taken into account. Only one humphead wrasse was observed in the Chesterfield Islands, even though transects were run in suitable habitats for this species and so this location was excluded from statistical analyses. For fish size, the only significant factors were, in decreasing order of significance, habitat, fishing level and hard substrate cover, while in unfished areas, water depth was also significant ($p = 0.043$).

Across regions, fish measured between 20 and 90 cm TL, few exceeding 100 cm, with smaller fish generally found in the southwest lagoon, in New Caledonia and largest fish in the eastern and western lagoons and at Uvea atoll (Table 2).

Across different habitat types, humphead wrasses were largest on barrier reefs and passes in unexploited areas (Figure 3). In coastal, middle reefs and lagoon areas, fish were typically < 50 cm TL, occurring with branched staghorn, type coral, *Acropora* spp.

Fish density (fish/10,000 m^2) and biomass (g/m^2) varied by region, habitat type, percent of substrate cover and with fishing intensity. In particular, the density increased with hard cover ($r = 0.64$, $p < 0.05$). The smallest fish were found in areas with high live coral cover and the largest individuals in places where coral cover was low

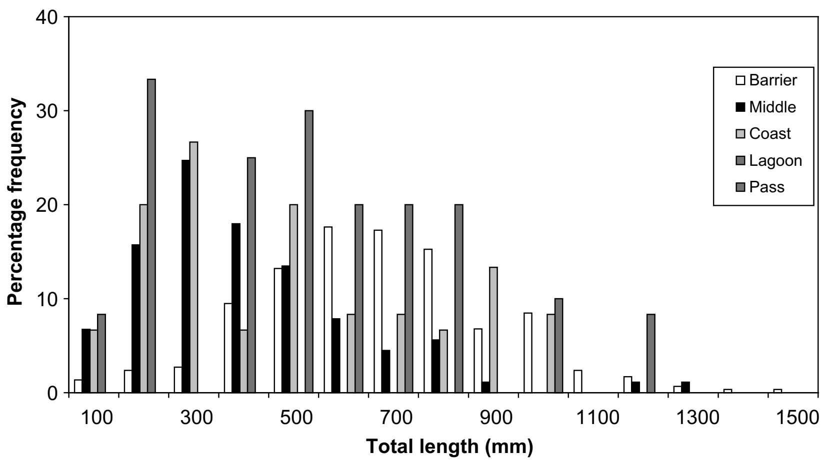

Figure 3. Size (total length in mm) distribution of *Cheilinus undulatus* by habitat type in New Caledonia and Tuamotu Archipelago. Distributions are given as frequencies (cumulative frequencies for each habitat is 100%) to allow for comparisons across habitats.

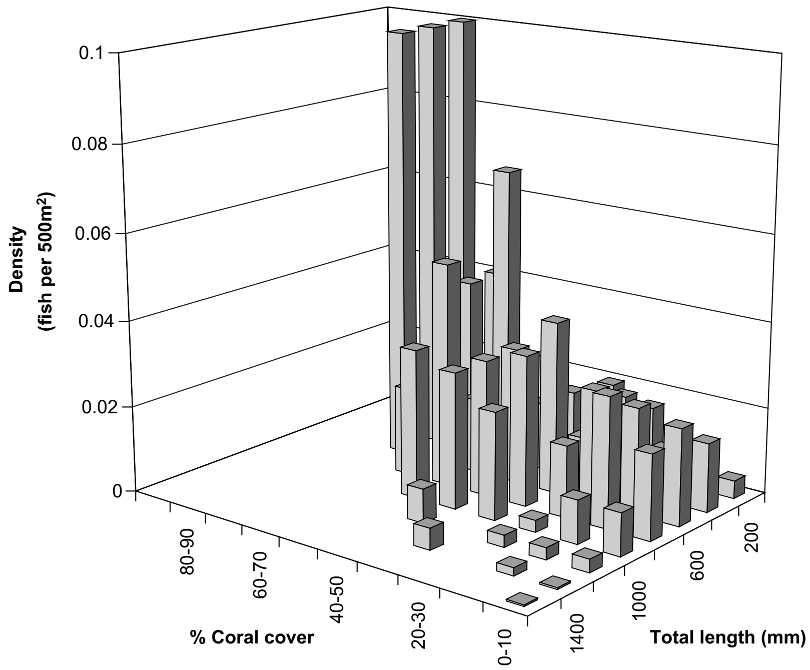

Figure 4. Relationship between density (fish per 50 × 10 m transect), coral cover and fish size, in New Caledonia and Tuamotu Archipelago.

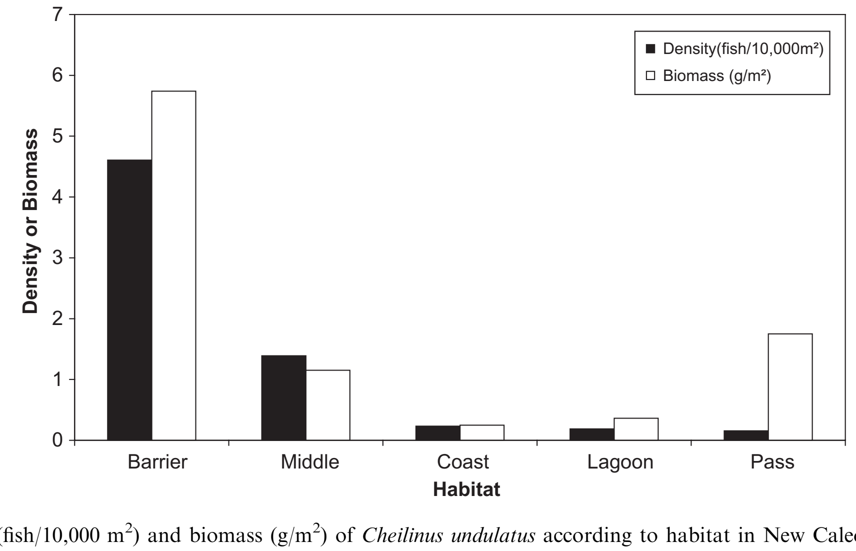

Figure 5. Density (fish/10,000 m^2) and biomass (g/m^2) of *Cheilinus undulatus* according to habitat in New Caledonia and Tuamotu Archipelago.

(Figure 4). Density and biomass levels (Figure 5) were highest around barrier reefs (note, however, that passes were relatively under-sampled) and in unfished areas (see also Letourneur et al., 2000). Density and total length were lower in areas of higher fishing index (Figure 6).

Quantitative estimates of abundance by UVC of this species in 24 locations scattered widely throughout its geographic range and provided to us by at least 12 different workers, strongly suggest that lower abundances occur where fishing pressure is higher, although densities in presumed

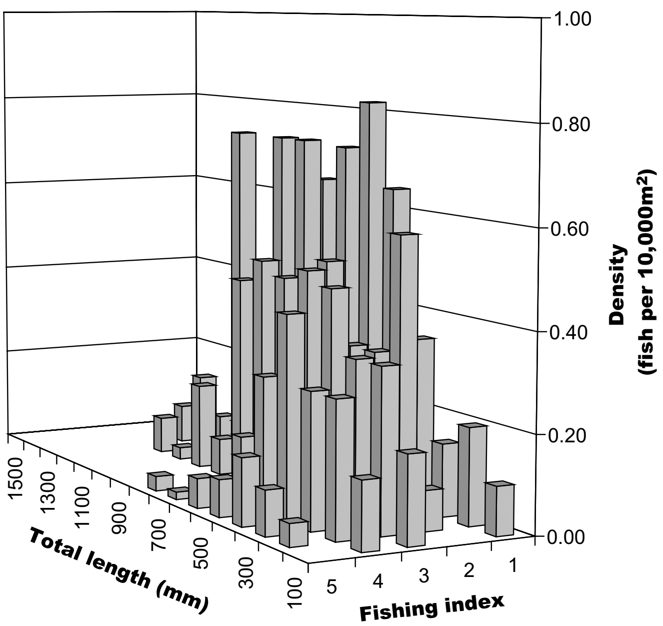

Figure 6. Density and body sizes (in mm TL) of *Cheilinus undulatus* in New Caledonia and Tuamotu Archipelago, from 17 areas surveyed between 1987 and 1995, by underwater visual census surveys and standardized methodology in relation to a crude measure of fishing index (index of 1: low to 5: high; M.K., P.L. and Y.L., unpublished data).

preferred habitats are variable (Table 3, Figure 7). In consultation with each biologist, data sets were standardized for area surveyed, with degree of fishing pressure from 1 (low) to 5 (high), subjectively determined by those working in the area. Only surveys conducted in habitat typical for this species are included and all were standardized to 10,000 m^2.

Biology

Morphology
The maximum size attained by the humphead wrasse exceeds 2 m and the species passes through several colour and shape changes as it grows (Figure 8a–d) that account for its multiple names in some places. The forehead becomes increasingly enlarged and, in larger adults, can reach anterior to the level of the eye, while the lips become particularly fleshy (Figure 8d). Scales can exceed 10 cm in diameter in medium-sized fishes. Small juveniles have large dark spots on some of the scales that produce a series of broad dark bands, interspersed with narrower white bands along the length of the body (Figure 8a), changing to pale green with elongate dark spots on scales tending to form bars as the animal grows (Figure 8b). All sizes have a distinctive pair of lines running through the eye, the lines being more distinct posterior to the eye and in juveniles, making the species unmistakable. There is no apparent sexual dichromatism. Larger fish become olive to green and scales have vertical dark lines; the head is blue-green to blue with irregular wavy yellowish lines, while the posterior dorsal and anal fins of adults are highly pointed and the rounded caudal fin develops a yellow margin (Randall et al., 1978; Myers, 1991; Figure 8c,d). Phylogenetic relationships within the monophyletic tribe Cheilinini (5 genera and 21 species) are described by Westneat (1993). The species has 9 dorsal fin spines 10 dorsal fin rays 3 anal fin spines and 8 anal fin rays.

Food and feeding
Humphead wrasses feed primarily upon molluscs and a wide variety of invertebrates, including crustaceans, echinoids, brittle stars and starfish; heavy shells of *Trochus* and *Turbo* spp. are crushed with its pharyngeal teeth and larger individuals also take small fishes (Myers, 1991). It appears to be one of the few predators of toxic animals such as the crown of thorns starfish (*Acanthaster*

Table 3. Results of 24 underwater visual census surveys around the Pacific (for fishing pressure, 0 represents none; 1 = low; 5 = high) by different workers; methods are not standardized across studies, except for those from New Caledonia (marked with an asterisk; for methodology see text). Size range given is that most typically noted during surveys

Location[1]	Fish/10,000 m^2 (range and/or mean and standard deviation)	Fishing pressure	Typical size range (cm TL)	Source
Australia (GBR)[2]	3.2–4.4	2	40–60 (few >90 cm)	J.H. Choat (personal communication); Pogonoski et al. (2002)
Fiji (Lau)[3] (1999–2000)	0.7–4.78 (2.6)	1	45–140	N.K. Dulvy
Fiji (Nauluv)	(0.8)	1	47 & 6	S. Jennings
Fiji (Ko Ono)	0–0.8	2	63–67	S. Jennings
Fiji (Moala)	(0.4)	4	63	S. Jennings
Fiji (Nakuta)	0	3	n.a.	S. Jennings
Fiji (Yadua and Yadua-Taba)	0–8.4 (2.6)	1	50–120	Taylor et al. (2002)
Fiji (Cokov)	0	5	n.a.	S. Jennings
French Polynesia	< 0.2	5	n.a.	Galzin (1985)
Maldives (1996–1997)	4–20	1	60–110	Sluka (2000)
New Caledonia*[7]	(10.9)	1	10–150	M. Kulbicki, P. Labrosse and Y. Letourneur
New Caledonia*	(4.3)	2	20–130	M. Kulbicki, P. Labrosse and Y. Letourneur
New Caledonia*	(3.6)	3	10–120	M. Kulbicki, P. Labrosse and Y. Letourneur
New Caledonia*	(1.5)	4	10–60	M. Kulbicki, P. Labrosse and Y. Letourneur
New Caledonia*	(0.51)	5	20–80	M. Kulbicki, P. Labrosse and Y. Letourneur
Niue	(1.67)	2	80	P. Labrosse
Palau SW Islands (1999–2000)	0–6(1.72, s.d. = 1.85)	2	35–185	T.J. Donaldson (personal communication)
Palau Islands (1999–2000)	0–8.3 (0.3, s.d. = 0.96)	3	24–170	T.J.D. (personal communication)
Papua New Guinea (Kavieng)[4]	5.6–9.2	1	n.a.	J.H. Choat (personal communication)
Solomon Islands (2000)	0–4	3	12–150	T.J. Donaldson

Tonga (Tongatapu) (2001–2002)	0–0.8	5	15–27	Secretariat of the Pacific Community (SPC) and the Institut de Recherche pour le Developpement (IRD)[5]
Tonga (Ha'apai) (2001–2002)	(1.69)	4	8–110	SPC and IRD
Tonga (Vavau) (2001–2002)	(3.17)	3	15–100	SPC and IRD
Wake Atoll[6]	13–27	0	n.a.	P.S. Lobel (personal communication), Lobel and Lobel (2000)

[1] Other countries with more limited information include: (1) American Samoa with an average of 2 fish per 10,000 m^2 in the lesser-fished Manu'a Islands and absent in heavily fished Tutuila (Green, 2003); (2) Christmas Islands, Kiribati survey in 2001 showed 5 fish in 30,000 m^2, between 60 and 120 cm TL (T.J.D., unpublished data), while at the Phoenix Islands, with little fishing pressure, the species is considered to be abundant (G. Allen, unpublished data); (3) Malaysia – the species is rarely seen by divers in much of eastern Malaysia, where most of the country's coral reefs (and hence suitable habitat) is located – exceptions are Pulau Layang Layang where about 350 fish measuring 60–120 cm TL were noted in the late 1990s and the area is protected by the Royal Malaysia Navy. Elsewhere fish were rare and mostly immature (TRACC, 2002); (4) in Indonesia, anecdotal accounts from experienced ichthyologists and divers indicate severely reduced numbers of humphead wrasse in many areas (J.E. Randall and M. Erdmann, personal communication); (5) in the Philippines, during a UVC of the Calamianes Islands, Palawan Province, the humphead wrasse was rare and all but one fish surveyed a juvenile (Werner and Allen, 2000); (6) in Tuvalu, humpheads are reasonably common even above 100 cm TL (R.E. Johannes, personal communication); (7) in the Seychelles, the species is relatively abundant and not specifically targeted – surveys yield between 1.4 and 16 fish per 10,000 m^2 (J.H. Choat and L. Beckley, personal communication); (8) in Tanzania, the species is moderately common in the Mafia Islands, a relatively unfished area (N.K. Dulvy, personal communication); (9) in Vanuatu, a survey determined that insufficient Napoleon wrasse were present for export in a live fishery (Naviti and Hickey, 2001).
[2] Cocos Keeling Islands and Rowley Shoals have many fish and low fishing pressure (J.H. Choat, personal communication).
[3] In Fiji, several surveys have been conducted. In addition to those in this table, six fishing grounds with varying levels of fishing pressure were surveyed in southern and eastern Fiji over 162,000 m^2 and 100 diver hours. Out of 10,000 reef fishes of >15 cm TL noted, only five humphead wrasses were noted in suitable habitat (Jennings and Polunin, 1996, 1997). In a 1995–96 survey of northwest Kadavu Islands, of 126,000 m^2 surveyed and 150 diver hours, not one humphead was seen, with villagers noting declines and attributing these to the arrival of outside spearfishermen (S. Jennings, personal communication). Extirpation was noted from one of the Lau islands (Dulvy et al., 2003).
[4] Off northern East New Britain Province, underwater cenuses determined the species to be rare in 1997 (A. Mobiha, unpublished data).
[5] No humphead wrasses were seen near Tongatapu in 1996 (Matoto et al., 1997).
[6] The area is fully protected by the United States Department of Defence. The species is abundant, especially the juveniles, and particularly between 5 and 30 m.
[7] New Caledonia data were all collected using a standardized methodology (see Methods section) and are represented by the open squares in Figure 7. The remaining 19 surveys are all from independent studies and are represented by closed diamonds in Figure 7.

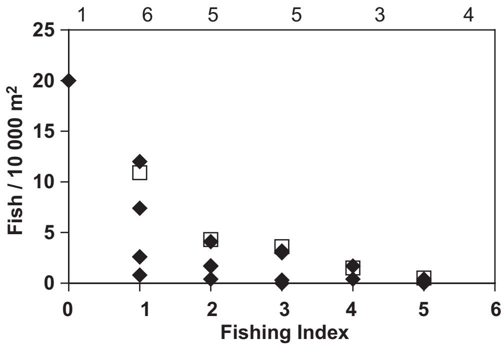

Figure 7. Densities *of Cheilinus undulatus* determined from underwater visual census surveys observed at 24 different locations (details in Table 3 and at top of graph) according to fishing pressure (index of 1: low to 5: high), as determined by workers in each location. When a range was given the median value is represented on this figure.

planci), boxfishes (Ostraciidae) and sea hares and is also known to eat *Arca*, *Barbati* and *Striarca* spp. (Fourmanoir and Laboute, 1976; Randall et al., 1978; Laboute and Grandperrin, 2000). Stomach contents from 72 specimens mainly contained molluscs, especially gastropods, pelecypods, echinoids and crustaceans, as well as fishes ranging from sand-dwelling gobies to morays (Randall et al., 1978). Humphead wrasses have been observed to turn over rubble to reach the animals beneath (P.S. Lobel, personal communication) and crush large chunks of dead coral rubble to feed on burrowing mussels and worms (Pogonoski et al., 2002). Large individuals are reported to be ciguatoxic in Tahiti, Tuvalu, New Caledonia and the Tuamotu Archipelago (Lewis, 1986; Dalzell, 1992).

Behaviour

Despite its size, the humphead wrasse is a naturally wary fish, occurring singly or in small social units outside of the reproductive season and aggregating in larger groups temporarily to spawn (P.L. Colin, J.H. Choat and S. Oakley, personal communication). Individuals appear to be relatively site-attached, with larger fish occupying

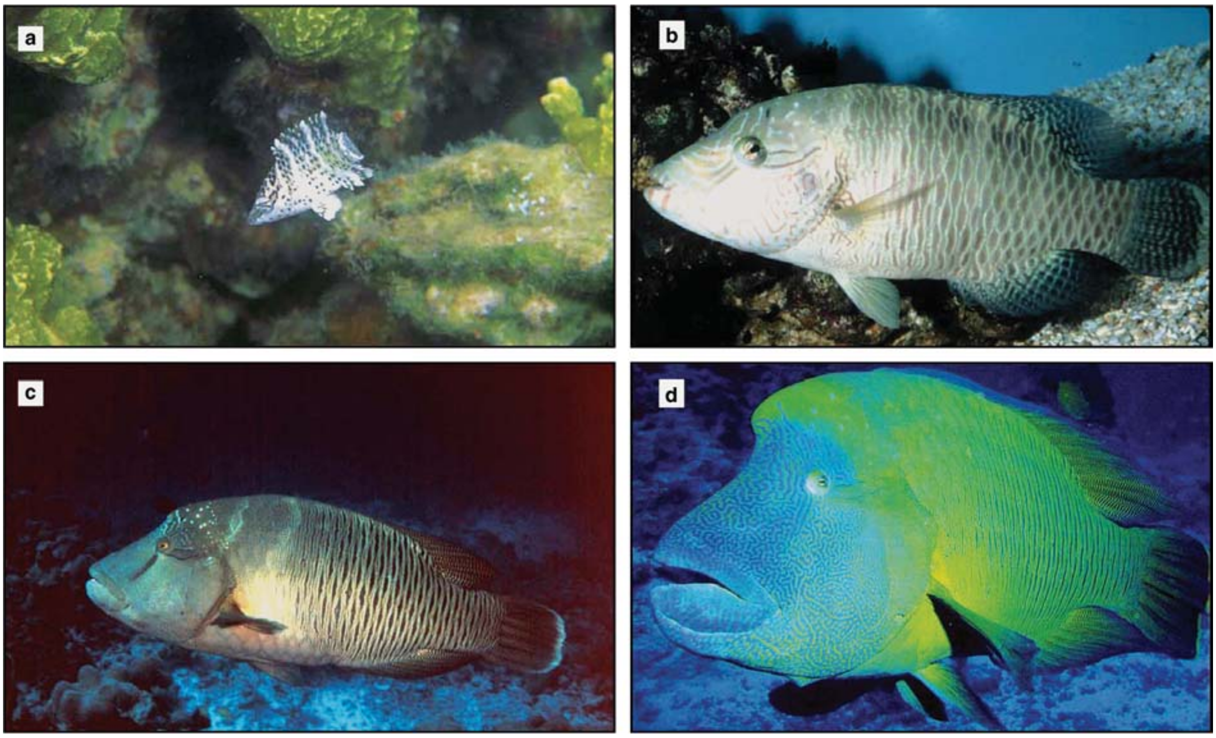

Figure 8. Morphological and colour changes in *Cheilinus undulatus* with growth. All phases have a pair of distinctive lines running through the eye: (a) small juveniles are light with dark bands; (b) larger juveniles (25 cm TL) are pale green; (c) adults are more olive to green and (d) the largest fish have a pronounced forehead and are more blue-green to blue. (Photographs by kind courtesy of J.E. Randall [a, b, c] and R.F. Myers [d].)

Table 4. Underwater visual census data on humphead wrasse giving percentage of positive sightings for this species as either singles, or small or large groupings, along with an estimate of the probable degree of fishing pressure in the area(s) surveyed

Number of fish seen on positive sighting	Fiji[1] (%)	New Caledonia[2] (%)	Tonga[2]	Palau[3] (%)
Single	60	52	96	15
2–3 fish	28	24	4	70
≥3 fish	12	19		15
≥3 fish		5		In spawning season
Fishing pressure	High	Various	High	Medium

[1] N.K. Dulvy (personal observation).
[2] M.K., Y.L. and P.L. (personal observation).
[3] T.J.D. (personal observation. Units of 2 large and 2 small humpheads were also reported from popular dive sites in Palau. Larger groups of spawning fish have been noted by P.L. Colin.

home ranges of at least 1000 m^2 and smaller members of a social group generally utilizing only a portion of this area (T.J.D., unpublished data). Larger fish may be less wary in protected areas, where attracted to tourists by the promise of food, or where spearfishing is banned, although divers

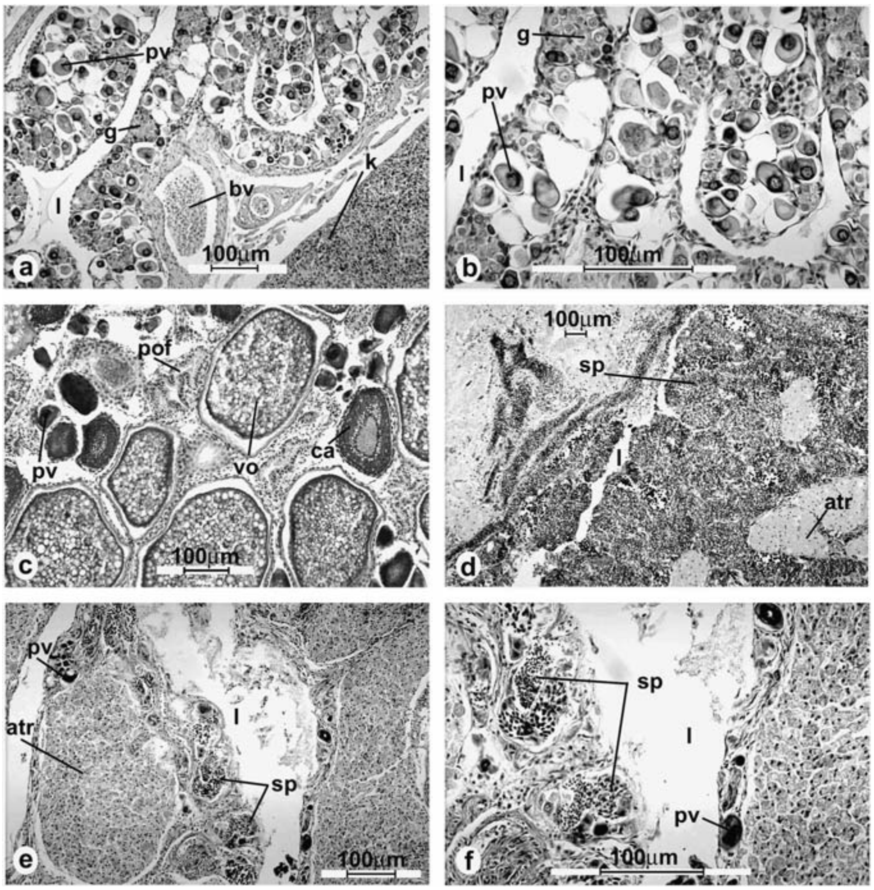

Figure 9. Gonadal stages *of Cheilinus undulatus*. (a) immature; (b) detail of (a); (c) mature ripe female; (d) mature ripe male; (e) sexual transition; (f) detail of (e). Atr = atretic oocyte; bv = blood vessel; ca = cortical alveolus; g = gonia; k = kidney; l = lumen; pof = post-ovulatory follicle; pv = previtellogenic oocyte; sp = spermatogenic tissue and vo = vitellogenic oocyte.

may disturb fish if they approach spawning aggregations too closely (J.H. Choat, personal communication). They may rest at night in a home cave or crevice (Thaman, 1998; Lieske and Myers, 2001). Quantitative data on group size are few, but are consistent with UVC reports of small social units moving together in less heavily fished areas, while in more heavily fished areas, lone individuals are more often noted (Table 4).

Reproduction

Summaries of unpublished studies, behavioural observations, anecdotal accounts and gonad samples provide a preliminary understanding of the reproductive biology of this species. The gonads examined microscopically came variously from a live fish operation in Milne Bay Province, Papua New Guinea (PNG) ($N = 111$) and from fish markets in New Caledonia ($N = 2$), Palau ($N = 7$), Pohnpei ($N = 8$), Hong Kong (origin unknown but most likely Indonesia, $N = 12$) and the Philippines ($N = 2$). Inactive females had previtellogenic oocytes and included immature (Figure 9a, b) and resting or developing females; the latter may or may not have spawned previously. Mature, ripe, females were those with vitellogenic (i.e., yolky) 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 (Figure 9c). Individuals undergoing sexual transition from mature female to male had vitellogenic or degenerating vitellogenic oocytes and developing spermatogenic tissue (Figures 9 e, f). Males were identified as inactive, or mature, ripe (Figure 9d); mature, ripe males had a significant proportion of the gonad filled with sperm (i.e., spermatozoa or spermatids). Inactive males had a range of stages of spermatogenesis with few spermatids or sperm.

Sexual pattern, sex ratio and approximate size of sexual maturation were determined from this limited sample (Figure 10), as well as field observations of reproductive behaviour. Gonads of both sexes were paired and contained a lumen surrounded by lamellae, except for an alamellar medio-lateral section. Gonad morphology is similar to that of other labrids. The smallest female (immature) sampled was 22 cm and the smallest mature, ripe female was 52 cm TL. The smallest male was 29.5 cm TL, while the smallest mature, ripe male was 59.5 cm TL. Two transitional fish were found (67 and 76 cm TL), indicating that the species is protogynous (Pogonoski et al., 2002). The size and sex data also suggest that some males develop directly from the juvenile phase and, therefore, that males have two pathways of development (directly from the juvenile phase or via sex change from an adult female). Further sampling is needed however, to confirm diandric protogyny, as well as sizes of sexual maturation, in this species because few fish below 60 cm TL were sampled. The presence of small males is further discussed in relation to 'sneaking' and mating (below). Few large fish were sampled, partly for practical and economic reasons (i.e., hard to catch or expensive), but also because they were rarely available; if larger fish are more likely to be male, then the apparent heavy female bias in our samples

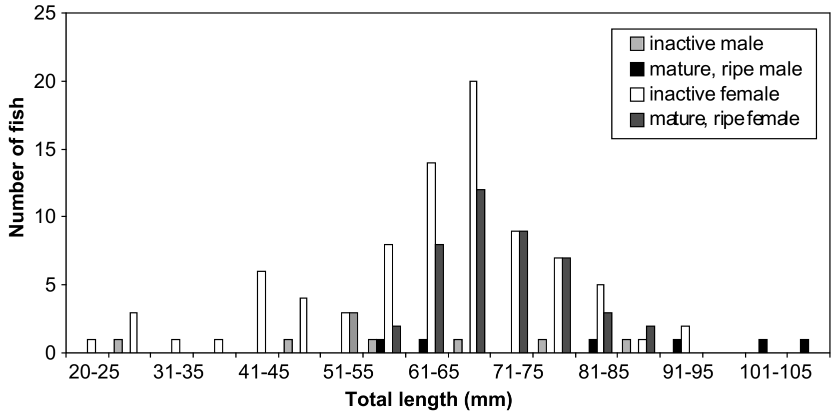

Figure 10. Size, sex and stage of sexual development of *Cheilinus undulatus* gonads prepared histologically ($N = 142$).

(1 male: 11 females) was at least partly due to the greater difficulties of sampling larger fish.

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 (unspecified) reefs (P.L. Colin, J.H. Choat, R. Hamilton and S. Oakley, personal communication). 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 (Domeier and Colin, 1997; P.L. Colin, personal communication). 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 (P.L.Colin, unpublished data). 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 (P.L. Colin, unpublished data). 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 (TRACC, 2002; S. Oakley, personal communication).

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. Although spawning was not confirmed, some females had hydrated oocytes and rising pairs were noted with peak numbers before the falling tide (J.H. Choat, personal communication). 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 (Johannes and Squire, 1988; L. Squire, personal communication). 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 (M.K., personal communication). Around Yadua, Fiji, groupings of the species have been noted in a couple of places that may represent spawning aggregations (Taylor et al., 2002). Groupings have also been noted in the Solomon Islands (R. Hamilton, personal communication).

Age, growth, size and mortality

Maximum sizes recorded are from Queensland, Australia, at 229 cm and 190.5 kg (Marshall, 1964) and 250 cm and 191 kg (Choat and Bellwood, 1994). In the Marshall Islands, Schultz et al. (1960) reported fish exceeding 200 cm. Similar-sized individuals have also been noted from PNG, Kwajelain and Wake Atoll (P.S. Lobel and S. Johnson, personal communication). In general, however, fish considerably larger than 100 cm are not often recorded. Randall et al. (1978) sampled 72 fish, ranging from 38–111 cm, in a feeding survey, while in the unpublished visual census surveys, lengths observed rarely exceeded 150 cm TL and were usually considerably less. We conclude 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 (J.H. Choat, unpublished data). On the GBR, fish attain about 100 cm TL in 28 years and sexual maturity in 5–7 years (Pogonoski et al., 2002). In a separate study, 27 fish were aged at 3–23 years, the largest one measuring 135 cm TL (G. McPherson, personal communication). In public aquaria in

Hong Kong and New Caledonia, three fish were known to live at least 16, 20 and 21 years (M. Stewart and M.K., personal communication).

Length–weight and length–length relationships were 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; $r^2 = 0.99$). For 18 fish sampled by us, both standard length (SL) and TL measurements were available from fish ranging from 22 to 115 cm TL and yielded the following equation: $TL = 1.8498 + 1.2013 \times SL$ ($N = 18$; $r^2 = 0.997$).

Nothing is known about the natural mortality rates of the humphead wrasse. The longevity of the species, however and our limited knowledge of reef fish biology would suggest that adult mortality is low.

Fishery and traditional use

Traditional use

In the western Pacific, notably Palau, Guam, Fiji, Cook Islands, Yap, Pohnpei and parts of PNG, the humphead wrasse has, or had, strong cultural significance. This may account partially for the many different names by which this species is known, with often several in one location according to colour phase and size of the fish (Table 5). In Palau, it is one of the most highly regarded of fishes, especially appreciated for its large adult size and special taste and may be used to commemorate special occasions (Johannes, 1991). In the Cook Islands, this species was formerly only eaten by royalty and fishing spots were coveted by experienced divers (Sims, 1989). In Fiji, its flesh and liver are considered a delicacy and it is traditionally cooked in earthen ovens, sometimes presented to chiefs at feasts (Thaman, 1998). In Guam, the taking of this species by spear was once associated with manhood (T.J.D., personal observation), while in Pohnpei, large humphead wrasses were appreciated highly and could only be eaten by royalty (K.L. Rhodes, personal communication). In the Cateret Islands, Bougainville, PNG, the flesh of humphead wrasse is only consumed by elders. Whomsoever catches one must prepare it for the elders and women are forbidden to eat this species (P.L., personal communication).

Fishery

The humphead wrasse is caught in low volume fisheries in different ways according to its size, whether it is needed alive or dead, or depending on local traditions (Table 6). It is used both domestically or exported as food or for aquaria. Smaller individuals may be attracted by bait consisting of cut or living fish, crabs on hook and line, although the species is not easily taken with hook and line, or caught in fish traps (Figure 11). In Palau, Guam, Tahiti, Tonga and Fiji, larger fish may be speared, often at night in their resting crevices, where they are easy victims, by divers using compressed air (using SCUBA or hookah), or by free divers working in shallower water (Bagnis et al., 1972; Johannes, 1981; Thaman, 1998; T. Pitlek and T.J.D., personal observation). If fish are to be exported alive for food, once caught they are held in floating cages until air-shipped or sent by sea to Hong Kong, Singapore and Taiwan, or to Chinese communities elsewhere. For domestic consumption, chilled fish are generally marketed in low volumes, ranging from less than 1 mt (metric ton, or tonne = 1000 kg), up to 30 mt in a year recorded for Fiji, mainly for local Chinese restaurants and tourist sectors (N.K. Dulvy, personal communication; Y.S., personal observation; Table 6). For export, Indonesia, Malaysia and Philippines are major producer countries (Table 7).

There appears to be an increasing take of juvenile fishes, both because of market demand for certain fish sizes (preferred sizes are currently 0.5–1 kg [about 30–40 cm TL]; Sadovy et al. 2003) and, according to anecdotal accounts, because of declines in the numbers of larger fish in source areas. Although protected in some countries, regulations are often circumvented by allowing the capture of smaller fishes (<0.5 kg) for grow-out in mariculture cages (e.g., Indonesia and Palawan, Philippines). These fish are maintained in captivity and fed until they attain market size. In key export countries for this species, indications are that most fish are now being caught below market size and grown out in this way.

Fisheries of this species are often associated with illegal activities, such as night fishing on compressed air, cyanide and fishing without permits, because it is hard to catch with hook and line. Cyanide or derris is used sometimes to extract individuals from among corals or caves, if they are

Table 5. Some common names of *Cheilinus undulatus* within the Indo-West Pacific region. (FSM = Federated States of Micronesia)

Language	Locality	Name	Source
Afrikaans	South Africa	Ramkop-lipvis	Smith and Heemstra (1986)
Belauan	Palau	Mamel	Froese and Pauly (2002), Myers and Donaldson (unpublished data)
Cqntonese	Hong Kong and southern China	So-mei	Myers and Donaldson (unpublished data)
Carolinian	Northern Mariana Islands	Mem	Froese and Pauly (2002), Myers and Donaldson (unpublished data)
Chamorro	Guam and Northern Mariana Islands	Tanguisson	Myers and Donaldson (unpublished data)
Chuukese	Chuuk, FSM	Merer	Myers and Donaldson (unpublished data)
English	Widespread	Humphead, Maori, Napoleon, double-head, giant, truck, or undulate wrasse	Myers (1999), Smith and Heemstra (1986), Froese and Pauly (2002)
Fijian	Fiji	Variivoce, dagava, tagava, draudrau	Morgan (1999), Froese and Pauly (2002), Myers and Donaldson (unpublished data)
French	French Polynesia, New Caledonia, Vanuatu	Napoleon	Bagris et al. (1972), Froese and Pauly (2002), Myers and Donaldson (unpublished data)
Gilbertese	Fanning Atoll	Te karon	Lobel (1978)
	Ellice Islands	Te tangafu	Lobel (1978)
Indonesian	Indonesia	Angke, ikan napoleon or maming	Myers and Donaldson (unpublished data)
Japanese	Japan	Megane-mochino-no	Masuda et al. (1984)
Malay	Malaysia	Batu, bechak, mameng tetarap	Chin (1998), Froese and Pauly (2002), Myers and Donaldson (unpublished data)
Mandarin	Taiwan	So-mei	Myers and Donaldson (unpublished data)
Polynesian	French Polynesia	Mara	Bagnis et al. (1972), Froese and Pauly (2002)
Ponapean	Pohnpei, FSM	Phoros, moaroar, pian-pokon and podar-takai, mameng	Myers and Donaldson (unpublished data)
Rotuman	Rotuma, Fiji	Mem	Myers and Donaldson (unpublished data)
Samoan	Samoa	Lalafi	Froese and Pauly (2002)
Swahili	East Africa	Ponomchriwi, pono-ngombe	Froese and Pauly (2002)
Tagalog	Philippines (and other dialects)	Buntogan, ipus-ipus, or mameng	Froese and Pauly (2002), Myers and Donaldson (unpublished data)
Thai	Thailand	Pla napoleon tua-miasu	Myers and Donaldson (unpublished data)
Tongan	Tonga	Lalafi (small), tangafa (large)	Morgan (1999), Froese and Pauly (2002)
Tuvaluan	Tuvalu	Te tangfu	Lobel (1978)
Ulithian	Ulithi, FSM	Man	Myers and Donaldson (unpublished data)
Vietnamese	Vietnam	A mo soc gon song	Myers and Donaldson (unpublished data)
Yapese	Yap, FSM	Namen	Myers and Donaldson (unpublished data)

Additional names may be found in Froese and Pauly (2002).

Table 6. Fishery, export and landings data for *Cheilinus undulatus* compiled from a range of published and unpublished, including personal communications, sources. The information reflects what is known of fishing methods, domestic and export activities and landings trends, of humphead wrasse, and should be referred to in conjunction with Table 7 which shows imports of this species into Hong Kong

	Fishery/export trade	Landings/export volume	Trend	Source
Australia[1] (GBR)	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	10–15 mt annually (1989–1998); catch rates 0.1–0.25 mt/year per boat for 40–90 boats. Exports grew from 0.55 mt in 1996 to 5.2 mt in 2000 due to the live fish trade and 25% of importers in Hong Kong sourced this species from Australia	Stable local catches, exports increased from 1996–2000	Lau and Parry-Jones (1999), Pogonoski et al. (2002), Williams (2002), M. Samoilys and M. Elmer (personal communication)
Fiji	Night spearfishing and poison (derris) widely used; considered difficult to catch using other means; some export both live and chilled. One live fish operation exports fillets taken from humphead wrasse considered too large to export live, and about 4 mt live annually. Only two live reef fish exporters currently active	Since 1998 annual fishery landings for chilled humphead wrasse were highly variable but always < 30 mt from municipal and non-municipal sources combined. Interviews (Oct/Nov 2003) with 22 fishermen who sometimes take humphead wrasse all indicated catches of up to several fish a month at low fishing pressure, 10–20 years ago (20–30 kg/fish), with low or zero catches nowadays. Villagers note declines that they attribute to outside spearfishers in NW Kadavu Islands	Declines from late 1960s attributed to increase in night spearing; severely reduced in Viti Levu. Scarcer and smaller in areas where taken for the live fish trade	Bagnis et al. (1972), Fiji Annual Fisheries reports (1993, 1995, 1998, 1999, 2000, 2002), Thaman (1998), Yeeting et al. (2001), Dulvy et al. (2003), A. Leewai, B. Yeeting and S. Jennings (personal communications), Y.S. (unpublished)[3]
French Polynesia (Society Islands)	Spearfishing for domestic use, more recently involving taking larger fish from sleeping holes at night. No known export.	No landings data known	Decline in large fish with advent of spearing humpheads at night in sleeping holes	Bagnis et al. (1972), Galzin (1985), Galzin et al. (1990)
Guam	Night spearfishing on SCUBA No known export	No landings data	Declines indicated in sizes/catches	T. Pitlik (personal communication)

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	No official landings or export data available despite reporting requirements (see Regulations). Anecdotal accounts strongly indicate that catch rates have declined for live humphead wrasses during the 1990s in many areas and that fishers continually extend fishing grounds for the species. Spawning aggregations are targeted and larger fish are now only found in deep water. By the late 1990s, catch volume and fish size declined and fishers had to travel increasingly far to maintain catch rates. In western Sumatra, catch rates of 50–70 kg per month per fisher (1992–1994) declined to 10–50 kg by the late 1990s for live fish. Where long targeted, species is considered rare and knowledgeable traders estimate annual live humphead exports to be at least 10–20 mt. Individual businesses can export 100 kg monthly. For April/May 2000, direct monitoring of fishing vessels arriving in Hong yielded noted 3.35 mt from Indonesia	Declines in CPUE, sizes and volumes, strongly implicated in many areas. Prices paid to fishers almost doubled in 1995–1997 as exports, declined	Erdmann and Pet-Soede (1998), Bentley (1999), Lau and Parry-Jones (1999), Lowe (2002), D. Trakakis, P. Chan, J.S. Pet, C. Chu and M. Erdmann (personal communication)
Japan	Unknown capture method. Some aquarium trade. No known export for food	A few mt are landed each year for at least a decade in Okinawa Prefecture	Stable	K. Tanaka and A. Nakazono (personal communication)
Kiribati, Christmas Islands	The species is considered to be particularly vulnerable to fishing. Exported live	Recorded exports less than 0.5 mt annually between 1996 and 1998	No trend data	Awira (1999)

Table 6. (Continued)

	Fishery/export trade	Landings/export volume	Trend	Source
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	Monthly purchases of 100 kg of humphead wrasse (200 g fish; hence 500 fish) per operator in Kudat; from 1996–2001, 10–16 operators in business. During 1995–2002, monthly mean weight of fish caught per fishing trip and sold in Kudat declined from 4.13–1.21 kg for fish between 0.5 and 3 kg, and declined from 1.19–0.13 kg for fish of < 0.5 kg each with no apparent changes in fishing effort. Moreover, the proportion, by weight, of humphead wrasse among all live fish in catches of artisanal fishermen in Malawali, Sabah, dropped from 10% to 2% between 1995 and 2002 despite continuing demand. No official data on exports or landings were available for this species	Interviewed fishers and cage owners (2002) reported declines in size and CPUE between 1995/6 and 2000/1. Prices have doubled. Fisheries Department is concerned	Bentley (1999), Biusing et al. (1999), Lauand Parry-Jones (1999), Sadovy (2000), TRACC (2002), A. Cabanban, T. Daw, S. Oakley, H. Hendry and A. Manica (personal communication)
Marshall Islands	The species is sought for live export and transported by sea to Hong Kong	50 mt taken from Enewetak atoll during 1999 and shipped live to Hong Kong; high mortality during shipment was reported	No trend data	International Marinelife Alliance (unpublished data)
Mayotte (Comoro Archipelago) and Madagascar	Spearfishing and handlining of small numbers of humphead for local use. No known export	Approx. 10–30 fish reported taken annually; may be relatively common in marine reserves in Mayotte. Numbers have declined in southern Madagascar but the species was common in the 1970s in all size classes in Madagascar	Declines noted between 1970s and 1980s in Madagascar possibly in response to increasing human population and presumed fishing pressures	Harmelin-Vivien (1979), Vasseur et al. (1988), Letourneur (1996), B. Wendling and M. Harmelin-Vivien (personal communication)

New Caledonia, Tuamotu Archipelago	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	Standardized UVC surveys from 17 areas from 1987–1995 (see Methods section) showed density per 10,000 m^2 ranging from 0.67 to 15.9 under low fishing intensity to tenfold less in heavily fished areas. The effect of fishing on biomass (g/m^2) indicated a strong effect of fishing (ANOVA: $F_{(1,418)} = 7.52$)	Declines indicated: lower body size and density in areas with higher fishing pressure	M.K., P.L. and Y.L. (unpublished data)
Palau[1]	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	0.5–3.5 mt annually (1976–1990); 0 mt in 1996[2]; landings data no longer collected. 1990–1991, a total of 142 fish; mainly 40–60 cm TL, went through the Palau Federation of Fishing Associations; in the mid 1990s, of 9,000 fish sampled from night-spearing, 6 were humphead wrasse, measuring 60–150 cm TL	Declining since 1970s due to nighttime spearfishing, and in mid 1980s due to live fish export trade	Johannes (1981, 1991), Palau Fisheries Report (1992), Kitalong and Dalzell (1994), T.R. Graham (personal communication), Y.S. (unpublished data[3])
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	A live fish export fishery developed in the early 1990s. Declines over the short term noted although reason is unclear (i.e. fishing ‘down’ or fishing ‘out’). Annual exports to Hong Kong, the major export market, were 8 mt (1997) and 3.3 mt (1998) for fish weighing 5-7 kg. Trial fisheries are currently being conducted to assess the impact of live reef fisheries generally	No trend data. Live reef fish export undeveloped to date with few operations	Richards (1993), P. Lokani, S. Why, (personal communications), Anas et al. (n.d.)

Table 6. (Continued)

	Fishery/export trade	Landings/export volume	Trend	Source
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	No catch or export data available. Unofficially, 60–100 boxes per month, at 3–5 fish per box of 1–3 kg fish are exported to sum 6–18 mt annually (late 1990s). From 40 interviews with reef fishermen in Palawan, Guimaras and Guian, older fishers report that large fish became very uncommon after divers with cyanide starting fishing for them. They occasionally encounter smaller fish up to 0.5 kg in some coral areas species. There is illegal movement of humphead wrasse out of Palawan where certain size restrictions have been in place	General impression by fishers of declines in sizes and availability. Large fish (>3 kg) are now rare and species not common generally	Barber and Pratt (1997), Y.S. (unpublished data[3]), J.C. Alban (personal communication), International Marinelife Alliance, (unpublished data)
Seychelles	Not traditionally taken but targeted briefly for export of live fish; shipments transported by sea	Trial export fishery for live fish established in the mid 1990s with export volumes of humphead wrasse unknown. It was concluded that the trial resulted in depletions of live fish and a moratorium placed on live fish exports	No trend data	Seychelles Fishing Authority (2000), J. Robinson, E. Grandcourt and L. Beckley (personal communication),
Solomon Islands	Ths species is sought for live export with some domestic sale. Int the Western Province, fish are taken with traditional traps (Figure 11) that are baited and closed by hand when the fish enters and with hook and line or spear. Export by sea only, when permitted	There are no landings data available for this species. Only about 3% of all live fish exported from the Solomons in 1997 were humphead wrasse, likely to be less than 10 mt, based on total live fish trade for the year	No trend data	Oreihaka (1999), R. Hamilton, M. Lam and P.S.W. Chan (personal communication)

South China Sea	Small numbers taken in the past from Hong Kong, Hainan Islands, and especially from offshore reefs (Pratas Reef, Paracel and Dangan Islands), and Pescador Islands of Taiwan, largely by spear or cyanide	No landings data but reportedly once more abundant on offshore reefs. Small numbers of live humphead wrasse come into Hong Kong on Hong Kong vessels. Only limited numbers of small fish are reported from Orchid and Green Islands, Taiwan	Severe declines indicated. The species is now rare in the South China Sea where once it was abundant	Sadovy and Cornish (2000), Huang (2001) P. Chan, J. Wong and K.-T. Shao (personal communication), C. Chu (unpublished data)
Tuvalu	No known export. Occasionally taken by spear, or by hook and line baited with land crabs. Not a prized fish	No known landings data	No trend data	R.E. Johannes (personal communication)

[1] Export not permitted.
[2] True market numbers may not be reflected after 1994 when a minimum size regulation was imposed (see Regulations); also, it is likely that some fish go directly to restaurants, private functions or for local customs or feasts without passing through markets.
[3] 30 (Palau), 40 (Philippines) and 52 (Fiji) standardized interviews were conducted in 2003 by YS on reef fish fisheries as part of a regional study on reef fish spawning aggregations for the Society for the Conservation of Reef Fish Aggregations.

to be maintained alive, especially in areas where they have not been fished traditionally or where no traditional fishing method has developed previously (Barber and Pratt, 1997). Cyanide is used widely in some areas, such as eastern Indonesia, eastern Malaysia and the Philippines and has been introduced elsewhere by traders as the method of choice for live fish.

Humphead wrasse populations evidently cannot withstand anything other than light fishing pressure, as indicated by both qualitative and quantitative data from broadly throughout its geographic range (Figure 7, Tables 3 and 6). 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 LRFFT, export 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, Wake Atoll; Tables 3 and 6).

Trade, value and mariculture

While there is some capture for local use, the humphead wrasse is primarily taken for export as part of the valuable LRFFT; all animals in trade are wild-caught because commercial-level hatchery production of this species is not yet possible. The major importing countries are China (especially Hong Kong), Taiwan and Singapore, while exports originate throughout much of the geographic range of this species, especially Indonesia, Malaysia and the Philippines (Johannes and Riepen, 1995; Chan, 2001a, b; Sadovy and Vincent, 2002; Tables 6 and 7). Consumption of a wide variety of seafood, including live seafood, is traditionally important to people of the southeast

Figure 11. In the Solomon Islands *Cheilinus undulatus* is traditionally taken by woven traps made of wild betelnut twine, amongst other gears. This 'kura habili' trap is about 60 cm long. The trap is baited, sunk and watched; once a fish enters, fishers close the trap by hand and haul it to the surface. (Photograph by kind courtesy of R. Hamilton.)

coast of China, with interest growing in other areas of mainland China.

International trade

A wide range of countries trade in live reef fish with many exporting and few importing, countries involved. Importers mainly include Taiwan, Singapore, mainland China and Hong Kong, although by far the largest and the only one for which we have import figures for humphead wrasse, is Hong Kong. Hong Kong is the biggest consumer/trans-shipment centre for the live seafood market, handling an estimated 60% of the total international trade (Johannes and Riepen, 1995). It also re-exports considerable volumes of live fish to mainland China which charges a 14% duty on live fish; Hong Kong is duty free (Johannes and Riepen, 1995; Chan, 2001b). In Hong Kong, the government Census and Statistics Department (CSD) recorded 647 kg (1999) and 12 kg (2000) re-exported to Macau but do not reflect the estimated 80% or so of this species imported into Hong Kong which is re-exported to mainland China, mainly by sea (Johannes and Riepen, 1995; Lau and Parry-Jones 1999; Chan 2001b; McGilvray and Chan, 2001). Receiving ports in mainland China include Yantien, Guangzhou and Shekou in Guangdong Province, with air connections to Shanghai, Beijing, Xiamen and other cities from Yantien and Shekou.

The current official monitoring system (CSD) in Hong Kong records all imports that arrive by air and all imports by sea on those vessels (ships) not licensed in Hong Kong; vessels licensed in Hong Kong are considered to be fishing vessels (although they actually include both fishing and cargo vessels) and are exempted from declaring live seafood (Sadovy, 2001). Live fish recorded in CSD includes almost all come in by air, since only a couple of vessels not licensed in Hong Kong import live fish. Hong Kong has about six unloading sites for live reef fish that come in by sea. Because of concern about the live reef fish trade, in January 1997 and 1999, commodity codes (Harmonized System: Hong Kong import and export classification system based on the Harmonized Commodity Description and Coding System design by the World Customs Organization) were

Table 7. Imports of humphead wrasse into Hong Kong from 1997–2002 based on Census and Statistics Department (CSD), and the Agriculture, Fisheries and Conservation Department (AFCD) of the Hong Kong government. An unknown volume of imports to Hong Kong is re-exported to mainland China. Data for 2003 are January to September only.

CSD	1997 (kg)	1998 (kg)	1999 (kg)	2000 (kg)	2001 (kg)	2002 (kg)	2003 (kg)
Australia					2651	49	
Cambodia				1479			
Indonesia	1500	200	1583	1375	499	5344	16,508
Kiribati		1000					
Mainland China		458[1]					
Malaysia			2402	4503	3438	2497	9951
Philippines	296	1616	602	5055	5343	28,642[2]	40,492
Thailand[3]				30,483			
Vietnam		1000		4	360		96
CSD totals	1796	4274	4587	42,899	12,291	28,642	67,047[4]
AFCD[5] (HK-licensed vessels)	187,020	127,500	99,542	38,673	24,660	20,031	12,159[6]
TOTALS	188,816	131,774	104,129	81,572	36,951	48,673	
% attributed to HK-licensed vessels	99	97	96	47	67	41	15

[1]includes disputed islands in the South China Sea: Pratas, Paracel, Spratly and Dangan.
[2]Humphead wrasse caught elsewhere in the western Pacific have been shipped through the Philippines and claimed as being of Philippine origin. This tactic has been evidently used by operators to circumvent laws and regulations (for example a temporary moratorium in the Solomon Islands), but possibly also to mask the potential presence of ciguatera in fishes harvested from localities where the toxin is known to occur (G.P. Reyes, personal communication).
[3]This source country may well be an error since this species is not known to be taken, or occur, in Thailand in appreciable numbers. Trade contacts suggest that the true origin is likely to be Indonesia because most humphead wrasse in recent years come from Indonesia, and because much of the export from Indonesia is of illegal sized fish and so the source country is often hidden: humphead wrasse from Indonesia often are shipped by sea and sea imports are less well documented than air shipments into Hong Kong. Another possibility is illegal trade from the Maldives, Andaman Islands, or Myanmar.
[4]January to September, inclusive, only.
[5]Hong Kong-licensed vessels (HK vessels) are exempted from declaring live fish, so AFCD introduced a voluntary data collection program in 1997 whereby imports by major importers are recorded and compiled monthly. The data in the table are double those provided to AFCD because AFCD estimate that they obtain only about 50% of the actual landings in Hong Kong from the data collection program. This program includes data from eight major exporters using Hong Kong-licensed vessels. An independent survey of Hong Kong-licensed vessel imports noted fish source to be overwhelmingly Indonesia over the 3-month study period (C. Chu, unpublished data).
[6]January to September, inclusive, only.

introduced for key species in the LRFFT. These included the humphead wrasse (commodity code number 0301 9931), for volume, value and country for imports and exports/re-exports. To address the data shortfall from Hong Kong-licensed vessels, a voluntary data collection scheme was also introduced by the Agriculture, Fisheries and Conservation Department (AFCD) of the Hong Kong Special Administrative Region government, in January 1997. In 2000, the AFCD estimated that there was a total of 150 vessels in the LRFFT operating out of Hong Kong and ranging in capacity from 10 to >20 t capacity; most are Hong Kong-licensed and hence, exempted from formally declaring live imports.

Independent checks of official CSD and voluntary AFCD data collection schemes in Hong Kong and comparisons of imports with exports from source countries, suggest under- and mis-reporting of live reef fish in general, including for humphead wrasse (Sadovy, 2001; Tables 6 and 7). A project was undertaken in April and May 2001, whereby a subset of Hong Kong-licensed vessels was directly monitored for live cargo. This survey recorded 6701 kg of humphead wrasse in the 2 month period while, for the same period, the

AFCD voluntary programme noted 3270 kg humphead wrasse (C. Chu, unpublished data; also noted in this study was Myanmar as a source country, otherwise not recorded). Single shipments included 2.5 mt of humphead, ranging in size from 20 to 125 cm TL, with almost all coming from Indonesia and a small proportion from islands in the South China Sea. Cross-checks of source country exports destined for Hong Kong show exports reported from the Solomon Islands, Marshall Islands, Fiji and PNG not recorded in CSD as source countries, possibly because all imports came in by sea, while exports from Kiribati, Philippines and Australia were only sporadically reported or mis-reported in Hong Kong import figures.

The total annual volume of catch and international trade in humphead wrasse is difficult to determine but Hong Kong (the major importer) import figures suggest that total international trade (assuming that Hong Kong imports of 37–189 mt account for 60% of the total) is about 60–315 mt annually (Tables 6 and 7). Total domestic trade in source countries is likely to be at least 50 mt or so all countries combined, based on the limited information available and discounting domestic use in Indonesia, Philippines and Malaysia for which data are unavailable (Table 6). A minimum estimate of domestically marketed catch and international trade, combined, therefore, is likely to be in the order of 100–400 mt annually, the great majority of which is international trade. An increasing proportion of this species is arriving in Hong Kong by air, as evidenced by the declining proportion attributed to Hong Kong licensed vessels (Table 7) and information from traders; air shipments are better suited to transporting smaller animals.

Overall, there are several shortcomings with estimates of trade and landings volumes resulting in an under-estimate of overall production (Johannes and Riepen, 1995; Bentley, 1999; Chan 2001a, b; Sadovy, 2001; Sadovy and Vincent, 2002, Leung Siu Fai, personal communication). (1) There appears to be significant under- and mis-reporting of the trade in live reef fish, as well as illegal trade, especially in key exporting countries – Indonesia, Malaysia and Philippines. (2) Mortality rates of live reef fish between capture and consumer can be considerable and may go unrecorded entirely. (3) There are no customs inspections at import into Hong Kong to verify species noted on import forms (e.g., the species has been mis-labelled as grouper in Indonesia). (4) Some source countries are not recorded in AFCD's voluntary data collection scheme. (5) There are no re-export data between Hong Kong and mainland China. While significant improvements to the monitoring of trade, with the introduction of additional commodity codes (Harmonized System) and the voluntary data collection scheme, were made in Hong Kong in 1997 and 1999, these have yet to be

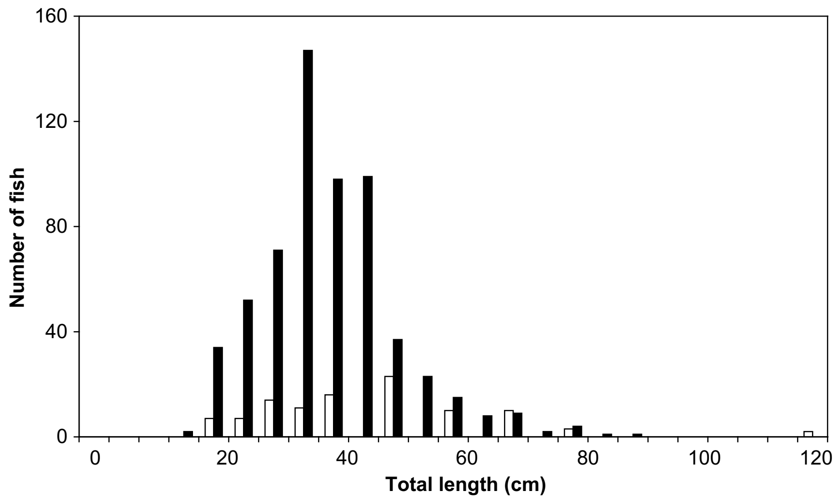

Figure 12. Lengths (cm TL) of live *Cheilinus undulatus* on retail sale in Hong Kong markets in 2000–2001 (white bars $N = 80$) and 2002 (black bars N = 607). Data were taken over a total of approximately 3 months, spread throughout the year and all fish seen were measured by holding a ruler against them outside the tank. The fish were sampled randomly.

adopted elsewhere or fully applied in Hong Kong and re-export data are not collected.

Surveys of Hong Kong retail markets provide information on sizes of humphead wrasse for retail sale; many are in the juvenile size range (Figure 12). There are reports by Hong Kong traders that humphead wrasse and large individuals in particular are becoming increasingly difficult to procure; are only available in deeper waters in some areas and that fishers keep changing areas to maintain catches (Johannes and Riepen, 1995; P.S.W. Chan and D. Trakakis, personal communication). Although the occasional large humphead wrasse is still seen in tanks in Hong Kong, these animals are not as commonly observed as they were a few years ago (Y.S., personal observation). How much this relates to availability or to market demand is not clear; the economic downturn since 1997 has reduced consumer spending on luxury live fish in Hong Kong, while growing wealth in mainland China is stimulating interest in live reef food fish (Sadovy, 2001; P.S.W. Chan and L. Min, personal communication).

Value

The complex and lucrative trade in live reef fish is reflected in the changing value of this species up the trade chain from captor to consumer (Table 8). Prices paid to fishers for live humpheads in some countries are high compared to most other reef fishes, ranging from US$3–60/kg depending on the size of the fish and country, the most valuable fish per kg now being in the range of 0.5–1 kg and the lowest prices to fishers being in Fiji in recent years (Table 8). This species is the most highly valued of all species in the live reef fish trade per kg, similar only to the highfin grouper, *Cromileptes altivelis,* with smaller fish fetching higher prices per kg than larger fish because of a preference for serving up whole fish in restaurants (Sadovy and Vincent, 2002). Prices paid to fishers vary widely, while mark-ups from the price paid to the fisher to that paid by the consumer can be 10 times or more (Table 8). The high costs of transport and other risks of the business, such as mortality rates at capture and in transit or holding, fees, bribes, etc., are among the reasons stated for the high mark-ups given by traders (Chan, 2001b). In Hong Kong, for the live fish trade in general (i.e., across all species), retailers take a profit of 25–35%, wholesalers sell to retailers with 8–14% profit, while restaurants mark up an additional 100–150%, or more (Chan, 2001b). Mean monthly retail prices for humphead wrasse in southern mainland China in 2002 were higher than those in Hong Kong in 2002, with a peak monthly value of US$130 in February in Shenzhen (International Marinelife Alliance, unpublished data).

Mariculture

Multiple attempts to culture the humphead wrasse, by induced spawning of adults and raising the eggs and larvae, have met with little success, although there are occasional unsubstantiated claims to the contrary. Closed system (or hatchery) culture (e.g., no reliance on wild broodstock) appears to be particularly difficult because of small larval sizes, rare broodstock and feeding regimen problems (M. Rimmer, personal communication). In Indonesia, this species has been induced to spawn in captivity, the eggs hatched and the larvae raised to day 15; in 13 trials, hatching success was 30–80% and survivorship to day 16 was very low (Murdjani, 1999). All apparent hatchery 'successes' to date claimed for this species involve, instead, the grow-out of wild-caught juveniles; it is important, therefore, that any claim of hatchery success be independently and rigorously evaluated. Should measures be introduced to protect the species in the wild and, if hatchery production becomes possible, it will be necessary to devise means of distinguishing wild-caught from cultured fish.

The 'grow-out' of small, wild-caught, humphead wrasse is commonly practiced in Indonesia and Malaysia and also occurs in the Philippines, where it is one of the most highly valued fish cultured, with unknown impacts on adult stocks. Small individuals, typically 20–40 cm TL and mostly juveniles, are regularly taken from the wild and raised in floating net cages until 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 – see Regulations and Conservation Status). In Guiuan, Philippines, fish of 300 g or smaller are put in holding cages and grown to 400 g (Bentley, 1999). In Riau and west Java, Indonesia, grow-out of this species is common (Ahmad and Sunyoto, 1990),

Table 8. Price data for live humphead wrasse at different levels of the trade, from fisher to retail. All prices are in US$ and are either given per kg or quoted per individual fish. Prices are those paid to fishers or dealer in source country, and wholesale or retail in consumer destination. For this species price varies according to body size. Prices in the tables are averaged over all sizes; in general, more expensive fish weigh roughly between 0.5–1 kg because these tend to be preferred by restaurants and in the consumer market, with smaller fish more common in retail markets in the last few years. Years are in bold type

Country	Paid to fisher/dealer	Wholesale/kg US$ (mean prices: monthly or annual)	Retail/kg US$ (mean prices: monthly or annual)	Source
Australia	**2002**: 8–10/kg			G. Muldoon (unpublished data)
Fiji	**2003**: 3–6/kg			Fiji-based export company, communication to Y. Sadovy
Hong Kong		**1990–1994**: 62–76 **1997**: 54 **1999–2000**: 46–71 **2001**: 50–63 **2002**: 51–69	**1997**: 131 **1999–2000**: 93–120 **2001**: 87–123 **2002**: 87–121	Lau and Parry-Jones (1999) International Marinelife Alliance, Hong Kong (unpublished data)
Indonesia	**1999–2001**: 8–15/kg (all fish sizes; depends on area)			Indrawan (1999), Sadovy et al. (2003)
Malaysia	**2000–2001**: 55–60 (lower prices <0.5 kg for grow-out, upper prices for 0.5–1.0 kg)			Bentley (1999), Sadovy et al. (2003)
Southern mainland China (Guanghzou and Shenzhen)		**2001**: 51–76 **2002**: 51–85	**2001**: 74–130 **2002**: 78–130	International Marinelife Alliance, Hong Kong (unpublished data)
Philippines	**1997**: 3 kg fish $50 each; big fish $83 each; 0.5–1 kg $33/kg; >1 kg $43/fish **1999–2001**: 45–60 per fish			Bentley (1999), Sadovy et al. (2003)
Singapore		**1994–1995**: 50–70	**1997**: 120–160	Johannes and Riepen (1995), Lau and Parry-Jones (1999)

Table 9. Fishery and export regulations for capture and trade in *Cheilinus undulatus*

Country	Regulation	Implementation date/source
Australia	Western Australia – complete protection since May 1998 because stocks determined to be insufficient and susceptible to overfishing. From December 1st, 2003, Coral Reef Fin Fish Management Plan (for Queensland waters, including the Great Barrier Reef Marine Park) prohibits all take and possession of humphead wrasse, other than for limited educational purposes and public display	Implemented. Pogonoski et al. (2002), Fish Resources Management Act, 1994. (http://www.dpi.qld.gov.au/fis hweb/1 3510.html)
Indonesia	Fishing permitted if • done by researcher (with research permit) for the purpose of scientific and mariculture development, as well as by artisanal fishers (with specific fishing permit); • allowable weights are 1–3 kg. Fish with weight less than 1 kg and more than 3 kg should be used for mariculture and/or freed to nature; • allowable fishing methods for catching humphead wrasse are hook and line, fish trap and gill net; • with regards to artisanal fishers involved in fisheries business partnership, the fishers should sell the fish to its collector partners; • collector and exporters should develop a rearing and culturing facility in the collection site which is equipped with staff knowledgeable in reef fish culture; • provincial fisheries Services must monitor, control and report on permits and volumes 3-monthly	Directorate General of Fisheries No: HK.330/S3.6631/96 amending HK.330/DJ.8259/95. There is no implementation, data could no be obtained and there is widespread use of the mariculture exemption to take juveniles from the wild and hold them until sale
Maldives	All exports of humphead wrasse were banned in 1995, largely due to concern for recreational diving, a sector that values this species	Anderson and Waheed (1997), H. Shakeel (unpublished manuscript)
New Caledonia	Catch of humphead wrasse not permitted during spearfishing competitions. Occasional poaching may occur in marine protected areas. Not exported	M. Kulbicki (personal communication)
Niue	The interference, take, kill or bringing to shore of the humphead wrasse is prohibited without written approval	Niue Domestic Fishing Regulations, 1996
Palau	Illegal to fish, buy or sell humphead wrasse <64 cm TL. Illegal to export humphead wrasse irrespective of size	Appears to be implemented. Palau, Domestic Fishing Laws 1998 (27 PNCA 1204)
Papua New Guinea	There is a 65 cm minimum size limit for exporting humphead wrasse but this does not prevent fishers from catching and holding smaller humphead wrasse in cages (culturing) until they attain 65 cm TL. All live fish operators are required to obtain licences	Implementation unknown. National Gazette No. G99, June 17, 2002; Anas et al. (n.d.), P. Lokani (personal communication)
Philippines	Exports of all live fish are technically prohibited from throughout the Philippines but this part of the code is evidently not implemented. Until recently humphead wrasse could not be exported from Palawan with an exemption for the taking of small fish for mariculture. The Palawan regulation is pending reconsideration. There was much illegal movement of this species outside of Palawan for subsequent export	No implementation. Philippine Fisheries Code of 1998 – Republic Act 8550. February 25, 1998; Barber and Pratt (1997). Exemption for wild caught fish (50–300g) to be cultured 8–10 months

although by 2002, many fish cages were no longer operational due to lack of fish (M. Erdmann, personal communication). Grow-out is also practiced in both peninsular and Sabah Malaysia (Kudat, Semporna; Darvel Bay; Lahad Datu and Tuaran) where small fish are available (Biusing et al., 1999; Mat Ali and AH, 1999; A. Cabanban, personal communication). In Kudat, survival was 60–80% after 12 months of culture. The impact of juvenile grow-out on adult stocks depends on the sizes and numbers of fish taken and their likelihood of reaching adulthood and reproduction. Given the advanced age of many fish taken from the wild for mariculture grow-out, the impact is likely to be considerable if most would have survived to adulthood.

Regulations and conservation status

Concern over the conservation status of this species and its natural vulnerability to unregulated fishing, in particular to the high demand generated by the LRFFT, resulted in it being listed as 'vulnerable' in the 1996 IUCN Red List of marine fishes. Several countries have implemented, or are considering, conservation action or fisheries management for this species (Table 9). Fiji is considering protection for the humphead wrasse and there are, or have been, size limits in place in Indonesia, Palawan in the Philippines, PNG and Palau. Sales of this species must be under permit in Guangzhou, China. In Australia, a prohibition on take and possession is in place and Palau and the Maldives do not permit export. A recent conservation overview and action plan for marine and estuarine fishes of Australia (Pogonoski et al., 2002) lists the humphead wrasse as 'conservation dependent' Australia-wide and susceptible to overfishing. There are campaigns in progress to collect information on the species from recreational divers and promote its conservation for such use, citing its value in the non-consumptive versus consumptive markets (e.g., www.divesociety.com/napwatch.htm [website of Ocean Environment). In American waters of the Pacific, the Western Pacific Regional Management Fishery Council included the humphead wrasse as a harvestable species, arguing that there were no data to show declines in abundance and that the species is naturally uncommon (C. Birkeland, personal communication).

In commercial and recreational fisheries, the humphead wrasse is variously protected through size (mainly) or bag limits, or from export, either explicitly or as a component of the live fish trade (Table 9), although there appears to be little effective implementation or compliance in general. Several regulations were prompted following concerns over the impacts of the export component of the LRFFT. Other, earlier, measures were introduced specifically to protect the humphead wrasse due to declines noted in local (i.e., non-export) fisheries, often following the introduction of spearfishing and especially if SCUBA or hookah was involved. Because few reef fishes are explicitly protected at the level of the species, the growing number of regulations that single out this species is noteworthy. However, there persists illegal, unregulated and unmonitored trade and little capacity to enforce regulations (Sadovy et al., 2003). There is no regional level management of this species.

In Indonesia, although on paper there are controls on catch and export of this species, it is still being exported to Hong Kong by air, sometimes labelled as 'groupers' and by sea in unregistered live reef fish transport/cargo vessels, while exemptions for mariculture effectively circumvent regulations (Erdmann and Pet-Soede, 1996; Thaman, 1998). There appears to be no enforcement of the laws protecting this species or monitoring of culture, capture or export, despite the fact that monitoring is required under the law (Table 9); insufficient funding and human resources apparently preclude control and monitoring in provinces or at export. In northwestern Java in 2000, Y.S. visited a large raft of floating net mariculture cages where, according to the raft guard, hundreds of illegal sized juveniles were being stored ready for shipment to Hong Kong. At the import end, Hong Kong customs do not inspect shipments (Leung Siu Fai, personal communication). There are no laws restricting the import of reef fish into Hong Kong. AFCD have publicly stated, however, that protection for species of conservation concern in the LRFFT is best implemented under CITES (Sham, 1998).

Discussion

Our aim was to better understand the conservation status of the humphead wrasse, given the dearth of published or available information on its trade, fishery and biology and concerns over recent declines in many parts of its range. In the absence of comprehensive studies, the compilation and evaluation of quantitative, semi-quantitative and qualitative information from a wide range of sources and both fishery-dependent and fishery-independent data, offered the only means of assessing this large and relatively uncommon species. Moreover, by examining biology, trade and fisheries together, a better appreciation of the relationships of demand and supply is possible. As just one example, the demand for small live fish in the retail sector results in selective targeting of juveniles of larger species (for marketing or grow-out to market size) and may not necessarily reflect size availability in the field.

To ensure sufficient rigour, we used and cross-validated a wide and diverse range of formal and informal data sources to identify possible actions and key data gaps. We evaluated this approach as a general one for assessing species, like the humphead wrasse, for which little information is available or likely to be forthcoming in the near term, but which may be particularly vulnerable or threatened. Such species might be difficult to study, naturally vulnerable to intensive fishing and/or subjected to small fisheries of little economic value and little managed or monitored. We identified shortcomings and their implications, in the application of techniques, such as UVC, to large far-ranging fish, highlighted the paucity of landings data for this species, determined gaps in understanding its biology and examined the nature and problems associated with trade (import/export) data. Although variable in quality, the wide range of information sources we used were consistent in affirming the concerns for this species and, we argue, provided a valuable approach for meaningfully assessing conservation status in data-poor situations. The data also represent a powerful argument for conservation action for the humphead wrasse.

The prognosis for the persistence of exploited populations of *C. undulatus,* under current conditions and given the biology of the species is poor. Conservation and management are needed to ensure that it persists in viable numbers wherever exploited. There is clear and strong direct and inferential evidence that, despite considerable variation in natural densities across a wide range of locations and studies, the higher the fishing pressure the lower the density and biomass per unit area and the smaller the body size. This was evident from UVC data, fishery-dependent data, as well as from multiple anecdotes from fishermen, divers and biologists. Reduced numbers alone, of course, are typical of most fisheries and expected within limits, but in the case of the humphead wrasse, reductions were also associated with several more worrying trends. (1) Negative population impacts are implicated despite the relatively low numbers of fishes involved in fisheries and trade. (2) Marked reductions in adults are suggested for many locations. (3) Heavy focus on juveniles, both for mariculture grow-out for the live fish export market and because of the preferred fish size in the live fish retail sector, will likely compromise reproductive potential and population persistence of targeted populations. (4) Probable extirpations at edge of range sites signal the start of range reduction, an early step towards extinction. (5) The introduction of particularly efficient or destructive fishing methods, night-spearing and poisons, as well as access to the species even in previously unfished locations, may leave populations little in the way of remaining refuges. (6) Moreover, indications are that, for adults at least, their habitat is relatively limited to outer reef slopes and the fact that they are known to spawn in aggregations and sleep in caves at night makes them particularly predictable and easy to find. (7) The species is taken in fisheries and in areas where there is typically uncontrolled fishing and little monitoring. (8) With few exceptions, protective legislation is largely ineffective as there is little or no enforcement capacity. Importantly, even where protective legislation exists for specific size classes, there are exemptions (such as in Indonesia and Palawan, Philippines) permitting the capture of juveniles if destined for mariculture grow-out. Since the species cannot yet be hatchery-reared, this places even greater pressure on stocks by removing animals before they have been able to reproduce. In this concluding section, we evaluate the data quality and utility of the mixed approach we used in this synopsis, summarize our results and make recommendations for further research and the better conservation and management of the species.

The humphead wrasse is a large, relatively uncommon and particularly vulnerable reef fish of commercial importance, being depleted in parts of its extensive geographic range by both domestic fisheries, involving night diving and by export of live fish. Moreover, key coral habitat is becoming degraded, representing a double threat to the species; population declines in fishes are well documented resulting from loss of coral reef habitat (Maragos et al., 1996). Formerly of considerable cultural and traditional significance in some Pacific countries and only taken for special occasions, heavy spearfishing, especially at night and the live reef fish export trade have resulted in severe declines in many countries. It is clear that this species cannot withstand anything other than low levels of fishing pressure. And this pressure increased dramatically in the 1990s due largely to demand from the live food fish trade centred in Hong Kong, southern China and SE Asia. Evidence indicates that, wherever an export fishery has developed, abundance, mean sizes and catch rates decline shortly thereafter, fishers have to seek ever further to maintain catches and adults become rare. There is also a preference for juvenile and small adult sized fish in the consumer market for live fish and heavy grow-out of juveniles, driving a size-selective fishery for pre-reproductive fish. The species is unlikely to be able to sustain the fishing levels required for export and the apparent increasing demand from mainland China that has occurred in recent years for the higher value species of live food fish (Sadovy et al., 2003) or uncontrolled night spearfishing.

The natural history of the humphead wrasse renders it particularly vulnerable to disturbance and fishing pressure, because of its longevity, late sexual maturation, aggregation spawning and sex change habits, ready accessibility and generally low natural abundance. It is long-lived and late maturing, characteristics typically associated with low natural rates of replacement, little capacity to support fishing and poor ability to recover from over-fishing (e.g., Dulvy et al., 2003). Several accounts suggest strongly that recruitment is sporadic, a pattern common to long-lived fishes in which populations tend to be dominated by relatively few year classes (Roberts, 1996). This means that heavy pressure on pulses of recruits during infrequent productive years could have particularly severe long-term impacts, that standard stock assessment approaches cannot be applied (among other things they assume constant recruitment) and that serious over-fishing may take many years to detect. The species is protogynous (female to male sex change), a sexual pattern that renders it susceptible to size-selective fishing, as occurs in the LRFFT (Bannerot et al., 1987; Sadovy and Vincent, 2002). The humphead wrasse can be predictable in its spawning areas and therefore easy to re-locate, as are adults in their sleeping places, from which spearfishers can readily extract them at night. UVC data strongly suggest that, in heavily fished areas, social groupings are smaller, more solitary fish are seen and spawning aggregations may no longer form. Finally, densities of adults, in protected and relatively undisturbed habitats, appear to be naturally low, rarely exceeding 20 fish per 10,000 m^2; densities drop rapidly to a few fish per unit area when fishing intensifies, with extirpations already indicated in some countries.

The humphead wrasse is particularly vulnerable to exploitation at anything other than the lowest levels of fishing pressure. While exploitation for local use, particularly once night-spearing was introduced, had already led to concerns resulting in regulations on local fisheries in some areas, it was the expanding LRFFT that pushed this species high up the conservation agenda and into a CITES Appendix II proposal (rejected by a narrow margin in 2002). Although the risk of global extinction in the near term (50 years or so) seems unlikely given the broad geographic distribution of this species, there is clearly need for concern: the 1996 IUCN listing was timely, if not conservative. The greatest pressure is in the centre of the geographic range, particularly Indonesia, the Philippines and Malaysia, of the humphead wrasse and regional extirpations or near-extirpations are indicated at edge of range locations in the South China Sea and the southwestern Indian Ocean, as well as parts of Fiji.

These problems have emerged even though current international trade, mainly of live humphead wrasse as far as can be determined, is unlikely to exceed more than a few hundred mt annually, with local (i.e., national levels of) consumption evidently much lower. Such volumes are tiny for a commercially important species and represent a very small percentage (AFCD, unpublished data) of live reef fish imports into Hong Kong, by both volume and value. The fact that problems are encountered despite such low volumes is testimony to the vulnerability of this species and a clear signal that this and most probably similar giant fishes, cannot withstand uncontrolled international trade or heavy fishing for local use. Although comprising a small fraction of the overall live food fish trade, the humphead wrasse is one of the most valuable species on a per fish basis. Mean monthly retails prices can exceed US$130 per kg, a high price that makes it a lucrative species and provides strong incentive to continue fishing even as populations decline. Indeed, for this luxury species, traders suggest that its value over the long term may increase with its rarity. And, demand is predicted to grow: imports into Hong Kong, for example, of high-priced live fish have increased in recent years relative to those of lower price and shipments into mainland China are increasing and imports of humphead wrasse for 2003 exceed those of the last three years (Sadovy et al., 2003; Table 7)

The LRRFT not only poses a threat to this species in terms of current trade volume and projected growth in demand, particularly in mainland China, but also because of practices associated with its capture. Of greatest concern is the growing demand for plate-size fish in the consumer market that puts pressure on juveniles and small adults; these are either caught at market size or taken at sub-market size and grown-out to market size. The resulting heavy take of juveniles for 'grow-out' mariculture, especially in Malaysia and Indonesia, is a worrying trend since these individuals are taken at sizes large enough to suggest that they would probably survive to adulthood in the wild, yet are marketed before attaining sexual maturation. Their removal represents a juvenile fishery likely to severely compromise population recovery from fishing.

Fishing practices and market demand are not the only problems, for if this species were protected by the persistence of unreachable refuges throughout its broad geographic range, there would be less cause for concern. Unfortunately, the humphead wrasse is relatively easy to locate, both as adults along limited outer and deep inner, reef habitat and as juveniles inshore in coral rich, mangrove or seagrass areas. Even remote regions, once assumed to be unassailable, are now accessible to the wide-ranging live fish transporter vessels that ply the remotest areas of the Indo-Pacific. Johannes cited one industry representative he interviewed as saying, "we prefer the remoter areas because they are away from prying eyes" (Johannes and Riepen, 1995). In addition to the direct impacts of removals on populations, indirect pressures are likely also taking a toll on populations, most notably from destruction of coral habitat; the species is generally associated with areas of high cover of living corals. Given the rate of reef degradation in the Indo-Pacific (Burke et al., 2002) and the use of cyanide to capture this species in some places (cyanide can kill corals), the condition of coral reef habitat must also be a major consideration in the conservation and management of the humphead wrasse.

We have evaluated the natural abundance, fishery, trade and status of humphead wrasse by referring to and soliciting, data from both formal and informal sources, so it is important to consider possible errors inherent in applying this approach and consider how they might affect our conclusions. It is clear that estimates of catches and trade under-represent true extraction figures of fish from the wild: there is an unknown volume of illegal trade; chilled fish exports and domestic trade are largely unknown; mortality between capture and consumer for live fish occurs but at unknown levels; cargo is sometimes mis-labelled; international trade is under-reported or not reported from some countries; fishery monitoring data are few, imports into Hong Kong are not verified to species level by Customs and the size of the mariculture sector is undocumented. On the other hand, estimates of natural densities using UVC likely give biased and lower estimates of true natural densities in the wild. This is because of the very real difficulties in assessing abundance of large wide-ranging, and often wary, species using UVC approaches. Such species do not lend themselves well to the UVC methods so valuable for smaller reef species because low fish density (and therefore low encounter rates) requires particularly long transects (or bottom time) and the fish tend to be naturally wary of divers, especially in areas where spearfishing occurs. Habitats where adults often occur, such as steep slopes, deep waters or where currents are strong, often do not lend themselves well to dive transects. There is also a likely tendency for a sampling bias (i.e., procuring specimens for histology or fish seen in the field) towards smaller rather than larger individuals of such valuable (i.e., expensive) and uncommon species, almost certainly affecting information on sex ratios (especially in the case of sequential hermaphrodites) and estimates of mature adults. Nonetheless, patterns in the data and other information, as inferred from importing and exporting countries, traders and biologists and coming from much of the geographic range of the species, were consistent and compelling.

The challenge, then, is to find practical solutions to these problems, through legislation, education, monitoring, management and biological and socio-economic research. More widespread introduction of protective legislation at the national level and a greater awareness of the status of this species, might encourage better fishery monitoring (especially in key supply countries of live fish where landings data are so poor), while national protection, such as allowing air-only exports, could control international trade. Adoption by all trading countries of the harmonized codes introduced by Hong Kong would improve trade monitoring for several live reef fish traded and we also need information at both national and international levels on trade in chilled humphead wrasse. Re-export data between Hong Kong and mainland China are needed. Consideration of the economic and cultural importance of this species to source countries is important, given that demand for exports appears to be growing. For example, its value alive and in the water for diving tourism, or for traditional use, might be higher in the long term than its possible export value. The capture of this species by night-diving, especially using SCUBA, could be banned and the use of cyanide more heavily policed. The take of juveniles for mariculture grow-out is a capture fishery and needs to be managed accordingly, with the numbers taken added to any overall capture quota determined to be sustainable: awareness of this issue could be enhanced. Protected areas might be appropriate to preserve important habitat, or for diving tourism. Serious and urgent consideration must be given to the protection of spawning aggregation sites, or otherwise to spawning fish during the reproductive season which needs special attention; spawning aggregations are particularly vulnerable to heavy fishing in general. The use of international instruments such as CITES would appear to be particularly appropriate for this species, given its current status, the role of international trade in its demise, the absence of any regional management authority overseeing its management, the relatively few demand centres involved, as well as its distinctive appearance; these characteristics also mean that cooperation between major producers and importers might be necessary to reduce trade in illegally caught fish. If sold chilled as fillets it can be distinguished by maintaining a piece of the skin attached, as is practiced in New Caledonia. The role of consumers is also important for addressing the demand side of the LRFFT. For example, young consumers of seafood in Hong Kong claimed to be willing to change eating habits given conservation considerations (Chan, 2000).

Research is needed to address key biological, socio-economic, trade management and conservation questions and education would foster support for protective initiatives in both consumer and producer countries. Specific biological issues include the natural mortality of pre-maturational fish, population structuring and timing and location of reproduction, minimum spawning densities and the need to adapt UVC or other fishery-independent sampling methods to better assess the density of large, widely ranging, wary and uncommon reef fishes. For mariculture, research on early larval development is needed and a method developed to distinguish hatchery-reared fish from wild-caught (if hatchery rearing becomes possible) for conservation purposes. We need a better appreciation of the roles of politics and socio-economics in the institutionalized use of cyanide and the social factors that lead to destructive and wasteful fishing practices. Finally, many problems with this species are common to other large coral reef-associated fishes and solutions could advance broader reef fishery agendas.

The humphead wrasse shares several characteristics in common (or converging) with a number of other particularly large reef fish species, such as the bigger serranids (*Epinephelus lanceolatus*, *E. tukula*, *E. marginatus*, *E. nigritus*, *E. fuscoguttatus*, *E. itajara*, *E. malabaricus* and *E. coioides*) and the largest scarid, *Bolbometopon muricatum*. All of these species have low natural densities and biomasses, slow recovery potential, take many years to mature and hence are often targeted as juveniles, are subjected to heavy fishing pressure in little managed fisheries and many have high market value or are particularly easy to catch. Like the humphead wrasse, our information on most of these species is rudimentary at best, despite their economic importance. Moreover, the ecological role of such large fishes is not well understood and it could turn out that they are key species for long-term ecosystem stability. All 'virgin' systems have such large species that tend to be the first to disappear, as we have seen on land, and they are likely to be particularly at risk. In many respects, therefore, the humphead wrasse could be a 'flagship' species for reef fish giants and for coral reef ecosystems in general, representing many of the questions relevant to species that have specialized in attaining giant size in complex ecosystems.

Like the humphead wrasse, many of these reef fish giants are considered to be vulnerable and some might be endangered (e.g., Dulvy et al., 2003). There are considerable difficulties inherent in obtaining biological and fishery data on low volume fisheries of widely dispersed and long-lived species, especially in fisheries with little monitoring or management, sporadic information on trade and the expense of detailed studies. We suggest, therefore, that the present approach adopted to collect such information represents a valuable and important tool for documenting changes in sizes, numbers, catches, distribution, trade and exploitation patterns. Although we do not suggest that the approach replaces more quantitative studies and research, or should be viewed as an 'easy alternative', we do advocate that, for some species, *C. undulatus* and similar reef fish giants being good examples, judicious use of qualitative and quantitative information is warranted. Indeed, for such species, given our current state of knowledge, the speed with which coral reef-associated fisheries are being developed and poor prospects for collecting more rigorous data in the near future, it is probably one of the only ways whereby sufficient data can be collected, quickly enough, for timely management and conservation action.

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Gonadal development in a giant threatened reef fish, the humphead wrasse *Cheilinus undulatus*, and its relationship to international trade

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An opportunity arose to obtain humphead wrasse *Cheilinus undulatus* specimens between 2006 and 2009 from Indonesia, the major source and exporting country of this species, making study on its early gonad development possible for the first time. Protogynous hermaphroditism, previously proposed for this species, was confirmed in this study. Based on histological examination of 178 specimens, mainly <500 mm total length (L_T) and ranging from 208 to 1290 mm L_T (119·1 g to 43·0 kg whole body mass), the minimum body sizes for female and male sexual maturation were determined to be 650 and 845 mm L_T, respectively. Primary male development through juvenile sexual differentiation was not detected. A unique blind pouch, with a possible sperm storage function and associated with the testis, was reported for the first time in the Labridae. In Hong Kong retail markets, the global trading centre for this valuable species, live *C. undulatus* on sale for food were dominated by body sizes <500 mm L_T between 1995 and 2009, reflecting an international trade largely focused on juveniles. In consideration of these findings, and given the threatened status of this species, management for *C. undulatus* capture and trade nationally and internationally are discussed with recommendations for ensuring sufficient spawning biomass in exploited populations and for sustainable trade.

Key words: CITES Appendix II; hermaphroditism; juvenile fishery; Labridae; live reef food fish trade; management.

INTRODUCTION

The humphead, or Napoleon, wrasse *Cheilinus undulatus* Rüppell is the largest living member of the family Labridae with a reliable record for maximum body size of *c*. 1500 mm total length (L_T) and reported to exceed 2000 mm L_T (Sadovy *et al*., 2003*a*; Choat *et al*., 2006). Protogynous hermaphroditism was proposed for *C. undulatus* through histological examination, with males derived from adult females through sex change (through a transitional phase to functionally secondary

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males) and a suggestion of diandry due to the presence of two males smaller than the smallest mature female (520 mm L_T) sampled (Sadovy *et al.*, 2003*a*). A study on age and size distributions of females and males likewise suggested protogyny for the species (Choat *et al.*, 2006). Insufficient availability of small specimens, particularly <500 mm L_T, however, has precluded a more detailed assessment of early gonadal development of *C. undulatus* and further assessment of its sexual pattern, *i.e.* diandry or monandry.

Because of the biological characteristics of long life (exceeding three decades) and because it is naturally uncommon and has a particularly high retail live value, *C. undulatus* is susceptible to overexploitation in unregulated fisheries (Sadovy *et al.*, 2003*a*). In 2004, *C. undulatus* was listed on the International Union for Conservation of Nature (IUCN) Red List as 'Endangered' and on Appendix II of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Hong Kong is the hub of the international live reef food-fish trade (LRFFT) and the major global importer of *C. undulatus*; the species has the highest price among all fishes in the trade and is imported both for local consumption as well as for transshipment to mainland China (Sadovy *et al.*, 2003*a*, *b*). The major export countries of *C. undulatus* are Indonesia, Malaysia and the Philippines according to import records in Hong Kong (Sadovy *et al.*, 2003*a*, *b*). The total estimated annual import volume of *C. undulatus* into Hong Kong based on government figures by all transportation modes (including air, non-Hong Kong and Hong Kong-licensed vessels) was *c*. 9 to 189 t between 1997 and 2008 with a peak volume in 1997 and declining to <10 t in both 2007 and 2008 (Sadovy *et al.*, 2003*a*, *b*; AFCD, 1997–2008) (Fig. 1). These are believed to be substantial underestimates because much of the trade is evidently unmonitored and illegal as indicated by personal communications

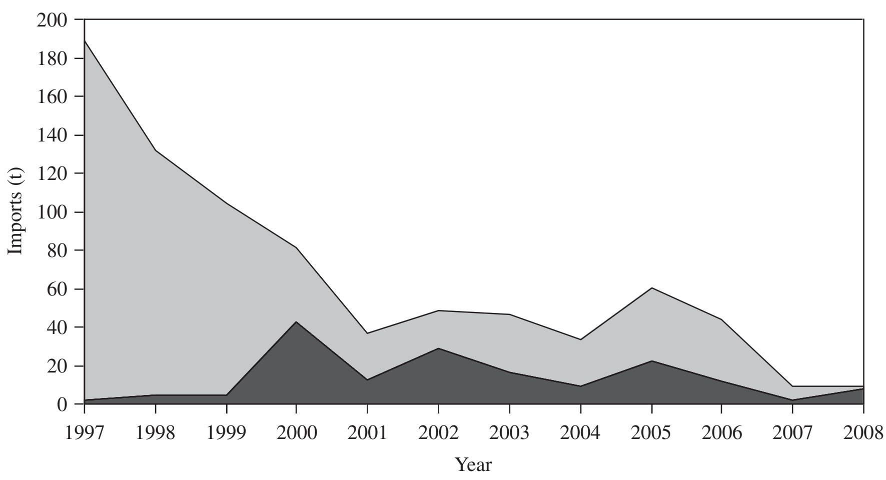

FIG. 1. Estimated total annual imports (tonnes) of *Cheilinus undulatus* into Hong Kong by all modes of transport (air and HK-licensed and non-HK-licensed vessels) between 1997 and 2008. Data from the Agriculture, Fisheries and Conservation Department (AFCD) of Hong Kong through a monthly questionnaire submitted voluntarily by traders who use Hong Kong-licensed vessels for live marine-fish imports (▢) and from the Census and Statistic Department (CSD) of Hong Kong through the trade declaration forms and by air and non-Hong Kong-licensed vessels for live marine-fish imports (■).

from traders, biologists and government officials and based on regular confiscations of imports in Hong Kong. The species is also sold chilled in many countries but likewise is scarce in local markets.

Study on gonadal development is particularly challenging in the case of *C. undulatus* because of its low natural availability, low catchability and high price. Donations of confiscated *C. undulatus* captured in, or exported illegally from, Indonesia to the University of Hong Kong (HKU) provided a unique opportunity to examine sexual development of the species, especially among smaller specimens. Examination of small size classes prior to first sexual maturation is particularly important for determining the type of protogyny in teleosts (Sadovy de Mitcheson & Liu, 2008). An understanding of body sizes of *C. undulatus* marketed in the LRFFT reflects market preference and availability in the fishery and is important to document for management planning. The aims of this study were: (1) to describe gonadal development from the juvenile to adult phases of *C. undulatus* to specifically determine the type of protogyny and the size of sexual maturation, (2) to examine the body sizes of *C. undulatus* imported into and on retail sale in Hong Kong and in relation to sexual maturation, and (3) to consider the possible management implications of (1) and (2) for *C. undulatus*.

MATERIALS AND METHODS

SPECIMEN COLLECTION AND MEASUREMENT

One hundred and seventy-eight specimens of *C. undulatus* from Indonesian waters were confiscated by the Indonesian and Hong Kong authorities and donated to HKU between 2006 and 2009. All specimens were captured or traded illegally following the CITES listing; 58 were caught in Selayar waters (7° S; 121° E) without the necessary permits for capture, and the rest entered Hong Kong by air with exact capture locations in Indonesia unknown but also without CITES import permits. All specimens were preserved in −20° C freezers for >6 months prior to measurement and dissection. The month of capture was not known nor whether the fish had been kept in captivity for grow out prior to export.

Specimens were measured in the laboratory for L_T (to the nearest 1 mm), standard length (L_S, to the nearest 1 mm), whole body mass (M, to the nearest 0·1 g) and whole gonad mass (M_G, to the nearest 0·1 g). The gonado-somatic index (I_G) was calculated only in mature females and males from $I_G = 100\ M_G(M - M_G)^{-1}$. Otoliths were initially removed from specimens, but growth lines were not evident and they were not considered readable for ageing.

HISTOLOGY

Gonads and associated tissues were cut into several pieces of *c*. 10 mm in length each, fixed in Dietrich's fixative and stored at room temperature for at least 14 days. In preparation for histology, the tissues were dehydrated in ascending grades of alcohol from 75 to 95%, embedded in paraffin wax and sectioned transversely at 6–7 μm thickness. The sections were stained with haematoxylin and eosin and mounted on slides. Depending on gonad size, the tissues were sectioned for their entire length or at short regular intervals throughout their length and the resulting sections examined under light microscopy.

SEXUAL DEFINITION

All gonads of *C. undulatus* had an ovarian structure with a lumen and numerous lamellae, irrespective of sex. Each gonad was assigned to one of six developmental phases based on the degree of egg and sperm cell development, the appearance of sperm sinuses and the presence of sperm in sperm sinuses; sexual maturation stages were defined as immature, mature inactive and mature active (Grier, 1981; Selman & Wallace, 1989; Liu & Sadovy, 2004) (Table I). Adult females were classified as mature inactive or mature active with vitellogenic stage oocytes or later stages (hydrated oocytes, atretic vitellogenic oocytes or postovulatory follicles). Adult males were either mature inactive or mature active with sperm sinuses and with or without sperm. Sexual transition was identified by the concomitant appearance of degenerating vitellogenic stage oocytes (often in the form of late stage, large, atretic vitellogenic oocytes) and proliferating spermatogenic cysts (Sadovy & Shapiro, 1987; Sadovy *et al*., 2003*a*; Sadovy de Mitcheson & Liu, 2008).

BODY SIZES ON RETAIL SALE IN HONG KONG

The four major retail markets in Hong Kong (Lei Yue Mun, Sai Kung, Sham Shiu Po and Tsun Mun) for the LRFFT, including *C. undulatus*, were visited two to four times each year between 1995 and 2009 at different times, including major celebrations when seafood sales are particularly high. Since fishes are typically sold within a short time (a week) of arriving, there was no double counting. All shops in these retail markets were visited during each trip, and all live *C. undulatus* observed on sale in tanks were estimated for L_T (to the nearest 50 mm) by holding a tape against them outside the tank.

RESULTS

BODY SIZES ON RETAIL SALE IN HONG KONG

Two thousand three hundred and ten live *C. undulatus* were measured (L_T) between 1995 and 2009 (Fig. 6). Body size distributions showed that the international trade sector was dominated by juveniles and small adults; fish < 650 mm L_T contributed to 894% of the total number measured and < 500 mm L_T to 762%.

GONADAL MORPHOLOGY AND BIOLOGICAL VARIABLES

Gonads of all *C. undulatus* specimens lie in the posterior dorsal part of the body cavity and consist of a pair of elongate lobes separated anteriorly but united posteriorly before reaching the urogenital opening (Fig. 2). Two unique gonadal features were found in *C. undulatus* previously unreported in other labrids. First, in all gonads, paired kidney heads were located at the point where the two gonad lobes united posteriorly [Fig. 2(a)]. Second, a single blind pouch (male accessory structure) was present in the testes [Fig. 2(b)]. It did not occur in any of the ovaries from immature to mature females, indicating secondary development. The male accessory structure was located in the posterior portion of the testes where the two gonad lobes united and opened to the common duct.

One hundred and seventy-eight *C. undulatus* specimens processed histologically ranged in body sizes from 208 to 1290 mm L_T and from 119·1 g to 43·0 kg M. The relationship between L_T and M was presented: $M = 1 \times 10^{-5}\ L_T^{3\cdot0554}$ ($n = 178$, $r^2 = 0\cdot9745$, $P < 0\cdot05$). The relationship between L_S and L_T was presented: $L_T = 0\cdot9514 + 1\cdot2261\ L_S$ ($n = 178$, $r^2 = 0\cdot9972$, $P < 0\cdot05$).

SEXUAL MATURATION

Numbers of females and males and their sexual maturation stages with body size classes were summarized (Table II). Of the 178 specimens, 145 were immature

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TABLE I. Sexual maturation stages of *Cheilinus undulatus* according to gonad histological criteria. All gonads had a lumen and lamellar structure

	Gonad structure and germ-cell type								
Sexual maturation stage	L	LA	O1	O2	O3	AO	SC	SS	Description
Immature female	+	+	+	−	−	−	−	−	Gonads consisted of only O1 and did not exhibit any signs of previous female function such as AO. There were no signs of SC
Mature inactive female	+	+	+	+/−	−	+	−	−	Gonads consisted of O1; O2 may or may not occur. AO were prominent. There were no signs of SC
Mature active female	+	+	+	+	+	+	−	−	Gonads consisted of O1, O2 and O3, indicating female maturation. AO were found not prominent. There were no signs of SC
Sexual transition	+	+	+	−	−	+	+	+/−	Gonads consisted of O1 and AO. SC proliferated along the germinal epithelia of lamellae. SS may not form
Mature inactive male	+	+	+/−	−	−	+	+	+*	Gonads consisted of different stages of SC except sperm. SS ran within the gonadal wall and were empty with occasionally sperm residual. AO were found but not prominent. O1 may or may not occur
Mature active male	+	+	+/−	−	−	+	+	+**	Gonads were dominated by sperm. SS converged into some chambers within the wall of the common duct and were full of sperm. AO were found but not prominent. O1 may or may not occur

AO, atretic vitellogenic oocyte; L, lumen; LA, lamellae; O1, primary-growth stage oocyte; O2, cortical-alveolus stage oocyte; O3, vitellogenic stage oocyte; SC, spermatogenic cyst; SS, sperm sinus. +, present; −, absent; *, without sperm or sperm residual in sperm sinuses; **, with sperm filled fully in sperm sinuses.

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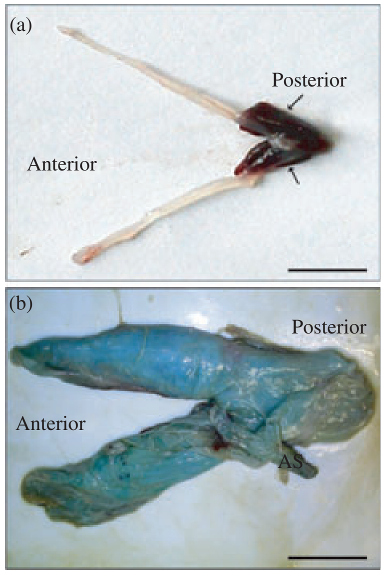

FIG. 2. Gonadal morphology of *Cheilinus undulatus*. (a) Pair of elongate gonad lobes and adhering paired kidney heads (⟶) where the two lobes unite (a 245 mm total length). (b) Pair of elongate gonad lobes in a testis and a single blind pouch (AS) extended from where the two lobes united, with the paired kidney head removed (a 1000 mm L_T specimen). AS, male accessory structure. Bar = (a) 10 mm and (b) 25 mm.

females and 15 were mature inactive or active females [Fig. 3(a)–(f)]. The I_G in immature females and mature inactive females ranged from <0·10 to 1·12% and from 0·60 to 1·89% in mature active females. Seventeen were mature active or inactive males with I_G not exceeding 0·15% [Fig. 4(a)–(d)]. The minimum sizes for mature female and male were 650 and 845 mm L_T, respectively. No sexually transitional specimens were found. Among the 178 *C. undulatus* specimens, 81·5% were <650 mm L_T (the minimum size of female sexual maturation according to this study) and 77·5% were <500 mm L_T (*i.e.* less than the minimum size of female sexual maturation in Sadovy *et al*., 2003*a*) (Table II).

In all specimens, the gonad and kidneys were in close contact [Fig. 3(a), (b)], and the male accessory structure was surrounded by connective tissue in the outer epithelium [Fig. 5(a)–(c)]. Within the wall, there were chamber-like structures filled with sperm. The inner epithelium has folds protruding into the duct connected to the common duct with sperm sinuses within the wall [Fig. 4(d)].

DISCUSSION

Protogynous hermaphroditism is confirmed for *C. undulatus* based on evidence of sexual transition, indicating sex change from functional females to males (Sadovy *et al*., 2003*a*), in combination with histological examination of the juvenile phase (this study) and age and size distributions of females and males (Choat *et al*., 2006). The presence of two small males (295 and 480 mm L_T, *i.e.* smaller than or similar to the size of female sexual maturation) in an earlier study led to a suggestion of

TABLE II. Numbers of *Cheilinus undulatus* specimens from Indonesia in 50 mm total length (L_T) classes by sexual maturation stage ($n = 178$) (see Table I for gonad histological criteria)

L_T classes (mm)	Immature female	Mature inactive female	Mature active female	Mature inactive male	Mature active male
200–249	14				
250–299	39				
300–349	44				
350–399	25				
400–449	10				
450–499	6				
500–549	3				
550–599	3				
600–649	1				
650–699		1	2		
700–749		1	2		
750–799	1		2		
800–849			3	1	
850–899			2	3	1
900–949		2		1	
950–999				1	
1000–1049				1	1
1050–1099					
1100–1149					2
1150–1199				1	2
1200–1249					2
1250–1299					1
Subtotal	146	4	11	8	9
Minimum L_T	208	690	650	845	850
Maximum L_T	765	930	885	1198	1290

possible diandry (Sadovy *et al*., 2003*a*). The low sample size of small specimens in the 2003 study, particularly <500 mm L_T, however, precluded a comprehensive assessment of early sexual development. This study, made possible through the fortuitous availability of small specimens particularly, provided an opportunity to further examine the type of protogyny and better understand early sexual development.

In this study, all *C. undulatus* testes had a secondarily derived morphology, with a lumen and lamellar configuration, and all specimens <650 mm L_T ($n = 145$), *i.e.* smaller than the size of female sexual maturation, had an ovarian structure with no sign of spermatogenic cysts. This suggests that *C. undulatus* is a monandric protogynous hermaphrodite. In terms of function, it appears that a few small males may develop directly from the juvenile phase (Sadovy *et al*., 2003*a*). In certain labrids, males likewise have secondary testes irrespective of whether or not they are gonochoristic or sequential hermaphrodites (Hoffman, 1980; Kobayashi & Suzuki, 1990; Coulson *et al*., 2009), highlighting the need for detailed examination of gonadal development, especially of juveniles, to assess functional sexual pattern in this family (Shapiro & Rasotto, 1993; Sadovy de Mitcheson & Liu, 2008). Moreover, two large mature females of *C. undulatus* with body sizes of 905 and 930 mm L_T were found

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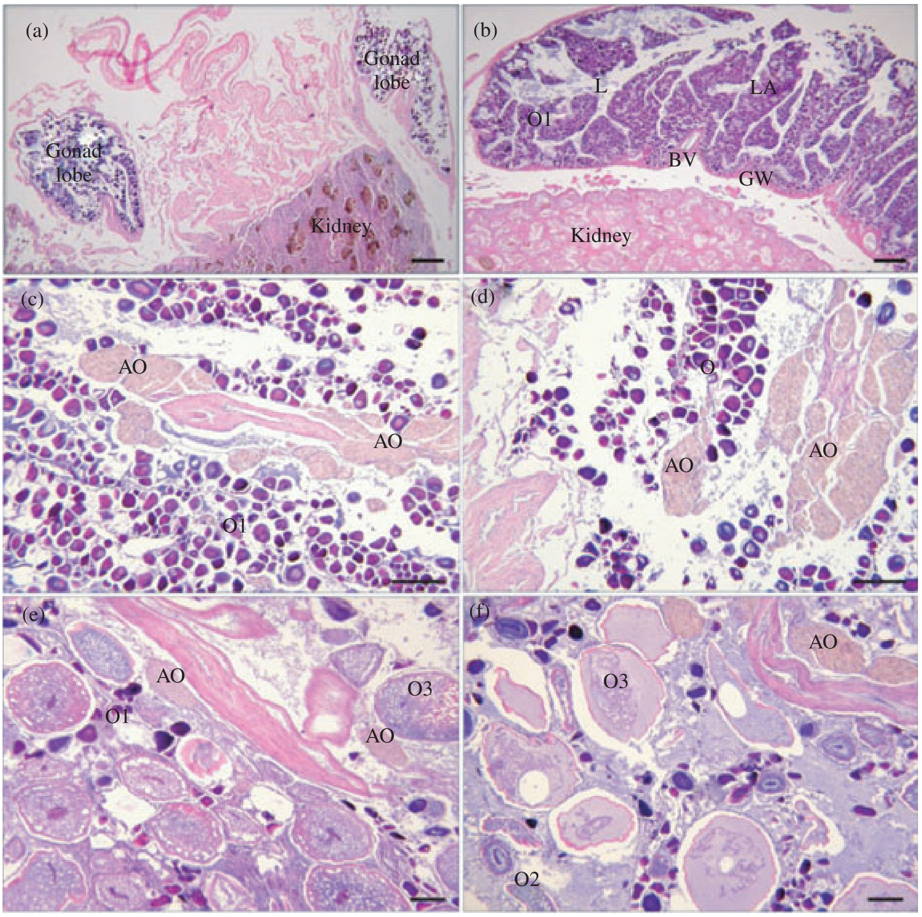

FIG. 3. Female *Cheilinus undulatus*. Immature females of (a) 208 mm total length (L_T) and (b) 365 mm L_T with gonad lobes associated with kidney. Mature inactive females of (c) 690 mm L_T and (d) 905 mm L_T showing presence of atretic vitellogenic oocyte (AO) in the intralamellae. Mature active females of (e) 725 mm L_T and (f) 800 mm L_T showing presence of AO in the intralamellae. BV, blood vessel; GW, gonadal wall; L, lumen; LA, lamellae; O1, primary-growth stage oocyte; O2, cortical-alveolus stage oocyte; O3, vitellogenic stage oocyte. Bars = 100 µm.

supporting the suggestion, based on ageing data, that some females never undergo adult sex change (Choat *et al*., 2006). These various findings reflect the considerable sexual plasticity exhibited by the Labridae.

No specimens were undergoing sexual transition in this study, possibly due to the small sample size of large fish, while the earlier study on the same species identified two sexually transitional individuals at 670 and 750 mm L_T, respectively (Sadovy *et al*., 2003*a*). Moreover, in this study of Indonesian-sourced specimens, minimum sizes of mature female and male were 650 and 845 mm L_T, respectively, while from the Great Barrier Reef, Australia, the smallest male was 700 mm L_T (Choat *et al*., 2006). Based on the three studies, it is suggested that adult sex change for *C. undulatus* probably occurs at *c*. 650–800 mm L_T.

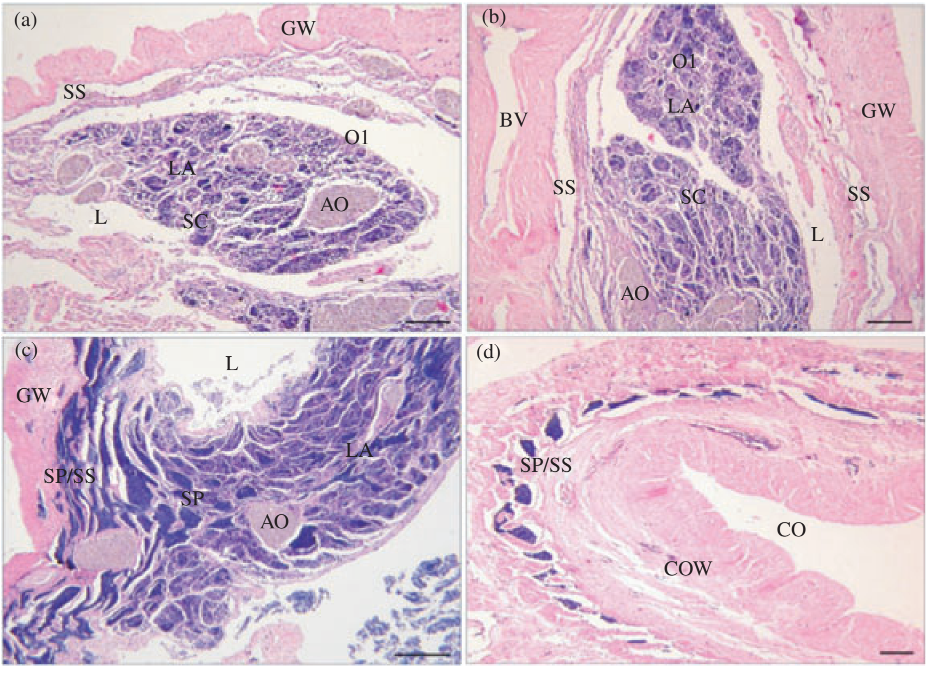

FIG. 4. Male *Cheilinus undulatus*. Mature inactive males of (a) 875 mm total length (L_T) and (b) 1000 mm L_T with empty sperm sinuses or residual sperm in sperm sinuses and presence of atretic vitellogenic oocyte (AO) and primary-growth stage oocyte (O1). Mature active males of (c) 1245 mm L_T and (d) 1125 mm L_T with sperm sinuses filled with sperm. BV, blood vessel; CO, common duct; COW, common duct wall; GW, gonadal wall; L, lumen; LA, lamellae; SC, spermatogenic cyst; SP, sperm; SS, sperm sinus; SP/SS, sperm in sperm sinuses. Bars = 100 µm.

The apparent differences in estimated minimum size of female sexual maturation among the different studies and locations merit comment to enable a recommendation on female maturation size for *C. undulatus*. In Indonesia and Papua New Guinea (PNG), minimum sizes were 650 and 520 mm L_T, respectively, based on measured samples and gonad histology and applying the same criteria of sexual maturation (Sadovy *et al*., 2003*a*; this study). Minimum size for females to spawn in captivity was reported at *c*. 500 mm L_T at grow-out facilities in Indonesia. In Palau, Micronesia, and Layang Layang, Malaysia, the minimum sizes of female sexual maturation were estimated visually at *c*. 350–450 mm L_T, based on observations of female spawning underwater (TRACC, 2004; Colin, 2010). Specimens from Indonesia and PNG included few specimens of the size range of 450–550 mm L_T, most were either much larger (PNG; Sadovy *et al*., 2003*a*) or smaller (Indonesia, this study). While more information is needed to determine minimum size of female sexual maturation more precisely by assessing more fish in the range of 450–550 mm L_T, based on available information, it is suggested that the typical size of female sexual maturation for *C. undulatus* be considered, for practical purposes, to occur at *c*. 400–500 mm L_T.

Various male gonad accessory structures are described in several teleost perciform families, such as Labridae, Gobiidae and Blennioidei (*e.g.* Blenniidae) (Fishelson,

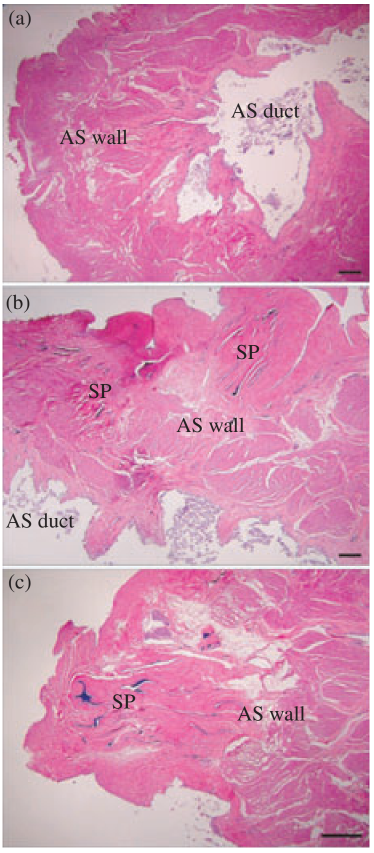

FIG. 5. Male accessory structure in *Cheilinus undulatus*. (a) The wall with chamber-like structure. (b), (c) Sperm in chambers. AS, accessory structure; SP, sperm. Bars = 100 μm.

1991; Rasotto, 1995; Rasotto & Shapiro, 1998; Richtarski & Patzner, 2000; this study); the phylogenetic pattern in their appearance merits further investigation. The possible functions of male accessory structures in Gobiidae and Blennioidei include the nutrition and storage of sperm and production of seminal fluid. Intraspecific variations in male accessory structure development are suggested to be associated with male mating systems and sperm competition (Rasotto, 1995). In labrids, male accessory structures have been described with a suggested role in controlling gamete release. In the protogynous wrasse, *Thalassoma bifasciatum* (Bloch), for example, testes associated with the sphincter and ligament muscular structures were considered to play a role in sperm release with ligament muscles possibly associated with the number of sperm released in males (Rasotto & Shapiro, 1998).

Gonad morphology of *C. undulatus* in this study revealed a previously undescribed single blind pouch associated with testes in males. This male accessory structure did not occur in any ovarian stages, indicating its secondary development. The chamber-like structure within the wall of the accessory structure contained sperm, indicating a possible sperm storage function in *C. undulatus* males. The species spawns between several and all months of the year and a male can spawn in pairs

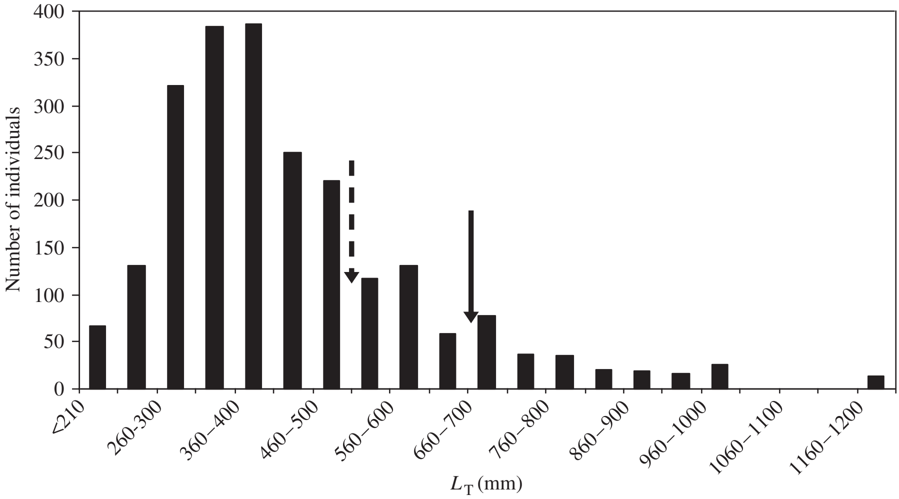

FIG. 6. Total length (L_T) distribution for live *Cheilinus undulatus* on sale in all major Hong Kong retail markets between 1995 and 2009 ($n = 2310$). The minimum sizes of female sexual maturation were indicated based on gonad histology and same criteria for female sexual maturation (650 mm L_T, ↓, this study; 520 mm L_T, ⇣; Sadovy *et al*., 2003*a*).

with multiple females in a single day; spawning behaviour is associated with lunar phase (Sadovy *et al*., 2003*a*; Colin, 2010). In mature females of *C. undulatus*, the I_G was <2%, indicating that females release small amounts of eggs during each mating episode. The development of an accessory structure in *C. undulatus* testes may assist in sperm accumulation and delivery.

Body size distribution of *C. undulatus* on sale in Hong Kong major retail markets showed a strong skewed pattern, with most fish juveniles <500 mm L_T. According to Hong Kong government data, the major exporting country for the species over the last decade or so is Indonesia, followed by Malaysia and the Philippines with most fish recorded from Malaysia coming from the southern Philippines even though export of live fish from the Philippines is illegal. Given that a high proportion of *C. undulatus* entering Hong Kong come from Indonesia and that *c*. 77·5% of the confiscated fish in this study from Indonesia are <500 mm L_T with 68·5% <400 mm L_T, it is clear that a significant proportion of captures and exports from Indonesia are of immature juveniles. This finding is important because the country has the national regulation that *C. undulatus* <1 kg (*c*. 420 mm L_T) should not be exported.

Subsequent to the CITES listing for *C. undulatus* in 2004, Indonesia and Malaysia set annual trade quotas of 8000 and 26 600 individuals since 2005 and between 2007 and 2009, respectively, with a zero quota introduced in Malaysia in 2010. The non-detriment findings (NDF) of CITES (*i.e.* the sustainable management plan for export) were developed and introduced into Indonesia and Malaysia in 2007 and 2008, respectively, partially supported by a fishery model (Sadovy *et al*., 2007).

Due to concerns for *C. undulatus*, a number of source countries that do not have significant international trade for this species, regulations are in place. In Palau and PNG, the minimum size for capture is *c*. 650 mm L_T (*c*. 3·9 kg *M*) (Sadovy *et al*., 2003*a*). The species has been fully protected in West Australia and Queensland since

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1998 and 2003, respectively (Pogonoski *et al*., 2002; Sadovy *et al*., 2003*a*). Export of *C. undulatus* has been prohibited from Maldives, New Caledonia, Niue, Palau and Philippines (*e.g*. Palawan) for about ten years (Sadovy *et al*., 2003*a*), and Fiji and Palau prohibited capture in 2004; PNG no longer allows the species to be exported.

For a species susceptible to fishing pressure due to its biological characteristics and international trade such as *C. undulatus*, minimum size regulations and quota setting may not be sufficient to ensure its sustainable use. Based on results of this and other studies, threatened status of this species (www.IUCNredlist.org), illegal capture in source countries and illegal imports into Hong Kong from Indonesia and enforcement of the national regulation in Indonesia regarding minimum body size for export are needed, and the international trade in the species requires considerably tighter enforcement. The air-only export for this species is now required for *C. undulatus*, reinforced by additional measures in Hong Kong, the major importer, with more comprehensive inspection of air exports, and the recent CITES decision to tighten enforcement of sea shipments should assist in enforcement. Additional actions could include marine protected areas to protect spawning biomass, especially for preserving large males, which are now considered rare wherever the species is heavily exploited. Size regulation for *C. undulatus* should take into account both the size of sexual maturation of females and the size of sexual transition (between 650 and 800 mm L_T) (Sadovy *et al*., 2003*a*; Choat *et al*., 2006; this study) as well as incorporating spawning areas into marine protected areas to ensure sufficient spawning biomass for population persistence.

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