

LIVE REEF FOOD FISH TRADE: UNDERVALUED, OVERFISHED AND OPPORTUNITIES FOR CHANGE

Yvonne SADOVY DE MITCHESON
University of Hong Kong
Science and Conservation of Fish Aggregations
IUCN Groupers and Wrasses Specialist Group



LIVE REEF FOOD FISH TRADE: UNDervalUED, OVERFISHED AND OPPORTUNITIES FOR CHANGE

Sadovy de Mitcheson, Y. 2019.
The Live Reef Food Fish Trade; Undervalued, Overfished and Opportunities for Change.
International Coral Reef Initiative.
44 pages.

Cover photo: «Camouflage grouper, *Epinephelus polyphekadion*, in a protected spawning aggregation. These are their only mating opportunities and many aggregations are now declining due to overfishing. This threatened species is valued in the live fish trade» / © Yvonne Sadovy de Mitcheson.



Sadly, it has become widely recognized that “Much of Southeast Asia’s economic success is based on the under-priced export of valuable natural resources. Nowhere is this more evident than in fisheries” (Mulekom et al. 2006)

The live reef food fish trade is a, if not the, prime example.

Time to change that!



EXECUTIVE SUMMARY

Background

The international live reef food fish trade (LRFFT) started over 4 decades ago. In the 1970s it emerged and over the following decades grew in volume and geographic extent across the Indo-Pacific region in response to rising interest in live seafood and increasing wealth. The growth was largely in response to demand according to a culinary tradition of southern China in which food is kept alive until immediately before cooking. The trade in reef fish is small by global fishery standards, estimated to be in the order of 20,000-30,000 metric tonnes (t), annually (after accounting for underreporting), but it is disproportionately valuable because it supplies a luxury restaurant market in which retail values per fish or kg charged can be extremely high. The annual retail value of live seafood is estimated to exceed US\$1 billion, with wild fish far more valuable than cultured fish and sometimes attaining many hundreds of USD per kg or per fish at retail (Sadovy de Mitcheson et al., 2017). To put this live fish trade in the broader context of the regional seafood trade in Southeast Asia, a major consumption region globally, when both live and dead reef fish, are included, the average annual production for 2008-2012 was about 90,000 t (Klinsukhon 2014). There is also an additional invertebrate component which is not considered here. This puts the live fish trade at between roughly a quarter and a third of all reef fish trade in the region.

Twenty years ago ICRI Partners set a goal to reduce adverse ecological and socio-economic impacts of trade in coral and coral reef species, eliminate unsustainable fishing practices and protect coral reefs and related ecosystems. They also recognized that international trade in corals and coral reef species is contributing to stresses on these systems including from extraction for, inter alia, the LRFFT, and is also associated with destructive fishing practices. The current study recognizes the ongoing need to focus on sustainability in coral reef systems in general, and the LRFFT in particular, and arose as an initiative of the former Fishery Minister of Indonesia, Susi Pudjiastuti, with ICRI. This report recognizes that most of the earlier long-term targets to manage this trade have not yet been addressed, generates a profile of the trade today and identifies drivers for ongoing problems and opportunities for positive change. The report recognizes that much of the high worth of the lucrative live reef export trade is leaving source countries undeclared (in terms of value), or unrecognized and much may be sometimes under-reported (in terms of volume). Unchecked, the trade leaves behind it a trail of overfished resources with long-term negative implications for local fisheries, reefs and fishing communities.

The Study

This study focused on groupers and on **the wild capture fishery** aspect of the LRFFT, which accounts for almost all the species in trade and a significant proportion of the volume. The trade also includes a growing proportion of hatchery-reared fish. The wild capture part of the trade, however, is particularly important because of concerns over biological sustainability, degraded fisheries, and threats to several species (four species in trade are considered to be threatened), to spawning aggregations (see cover photo) from overfishing, and to damage to reefs from destructive fishing and loss of important high trophic levels predators, amongst other concerns. The most highly valued species today (per unit fish) include the leopard coral trout, *P. leopardus*, and the Napoleon wrasse, *Cheilinus undulatus*.

The study was conducted using questionnaires sent to ICRI members and supplemented by literature review, personal communications and databases. It develops an overview of the trade as currently practiced, participating countries, volumes, values and species, fishing gears used, management in place and needed and other related issues. It also identifies the need for management of several elements of the trade chain to bring activities under control and to improve the economic value gained by source countries without further compromising the resources. Study findings are briefly summarized as follows.

The LRFFT today mainly operates out of Indonesia, followed by the Philippines and Malaysia, with lower volumes of exports of wild fish also coming from Australia and the Maldives and a few other countries. Indonesia is the biggest exporter of groupers overall, whether wild, live or chilled, or cultured. Thailand and Taiwan also export live fish but these are mostly or heavily from hatchery production. Although live groupers are the major target group, by value and volume, other reef fishes are also involved in small volumes annually less than 100-200 t; wrasses, parrotfish, snappers, and emperors, among others. The leopard coral trout is currently the single most important wild sourced species, by volume, as well as being particularly valuable. While a growing proportion of the trade is comprised of hatchery-produced fish, this is not likely to reduce pressure on wild-captured fish because these are the highest in value and the most important for fishers (see Box 'The mariculture myth').

Key findings highlight several ongoing and some emerging concerns around the exploitation of reef resources, including overfishing, illegal, unregulated and unmonitored fishing and trade, and threats to several

species and to coral habitat. Most major exporters (Australia excluded) may not fully recognize the potentially higher value that live reef resources could bring to their country than they do today. This is because of sparse documentation of volumes and values and is associated with opaqueness in export trade chains. For example, under-declaring by exporters, by at least 3 to 5 times the correct estimated export value per tonne substantially reduces potential income to source countries. Limited declaring of exports and imports (for example by Hong Kong-registered vessels) obscures the true value, volume and composition of the trade. A limited understanding of correct species identification and of the large price differentials among species on the part of fishery or enforcement officers or other government officials, means that such irregularities go undetected or overlooked. Chilled/frozen reef fish have become more acceptable to consumers in China, and demand for these is rapidly increasing elsewhere which will put further pressures on reefs. Dead fish are exported to a larger number of countries than live food fish according to questionnaire responses.

Given ongoing concerns, it is promising and encouraging that some progress has been made over the last two decades and several examples now show what can be achieved in LRFFT management. Australia has successfully sustained its leopard coral trout fishery by management; Australia monitors its exports and capture, the Maldives carries out some monitoring and there are laws for size limits that are species-specific in the Maldives, Australia and the Philippines, although the level of enforcement is not known for the Maldives and the Philippines. Gear controls in many countries prohibit the use of cyanide or compressed air for fishing although enforcement trails regulation. A major Indonesian trader has implemented his own minimum size limits and demonstrated that this is feasible from a business perspective. He also monitors catches which provides important insight into species-specific trends over time. The Philippines, Maldives, Indonesia and Australia have some seasonal and/or spatial protection of spawning aggregations either in place or (for the Maldives) planned. The CITES-listed Napoleon wrasse, *Cheilinus undulatus*, receives some protection in the only legal exporter country (Indonesia) although abundance of the species remains low in the country; both Indonesia and the Philippines have National Plans of Action for the species. Finally, many guidelines, methodologies, studies, best practice guides and protocols now exist for data-poor fisheries and to guide complex multi-species fishery management.

The Mariculture Myth and some Truths

During the course of this project it was several times suggested or implied that since mariculture will ultimately solve the supply of groupers for the live fish trade (and other seafood demands), it is not so important to commit heavily to managing these natural resources. This perspective is seriously misplaced for several reasons: (1) mariculture does not address the main driver of overfishing which is too much fishing effort. When mariculture starts or increases, fishing does not decrease, both are done and fishing pressure can actually increase (see item (4)); (2) since fishermen need to fish and most fishermen will not be culturists, natural wild populations need to be sustained long into the future from human welfare and equity perspectives, (3) in the LRFFT most species are wild-caught and only a few (about 4) are regularly hatchery-produced; (4) much of what is classified as 'cultured or ranched fish' today actually involves the capture and grow-out of juvenile wild groupers – this is still a fishing activity that needs to be managed as it adds fishing pressure and removes many fish before they can reproduce; (5) many consumers want to continue eating wild fish which are often considered more tasty and safer, and (6) wild-only sourced fish are the most highly valued economically and yield the best profit margins to traders. Since some desirable species may get higher prices the rarer they are, even when a species is threatened or very uncommon, there will still be interest to find, capture and trade it.

In the LRFFT almost all species and very approximately 50% of the production comes from the wild (see Table 1). Although hatchery production is increasing for a few species, the wild-caught component will continue to be important for the trade and for the region's fishers. These species, particularly the vulnerable grouper species and Napoleon wrasse, will need careful management by the governments of countries exporting LRFF.

Also on the positive side, multiple international and regional commitments and promises have been made within the last decade, or so, directly or indirectly relevant to the LRFT and provide excellent guidance and agendas. These now need to be fulfilled, honoured and advanced. Among the most important regional initiatives are the SEAFDEC vision for sustainable management and development of fisheries and aquaculture to contribute to food security, poverty alleviation and livelihoods for people in the Southeast

Asian region, and the Coral Triangle Initiative (CTI) on coral reefs, fisheries and food which has yet to be implemented. The CITES listing of the Napoleon wrasse helped to better control the trade in this species and may have slowed declines. Attention to reef-associated resources is growing with the noteworthy formalization of collaboration between the CTI and SEAFDEC that includes strong biological sustainability components and multi-government, multi-stakeholder engagement.



Figure 1. Variety of species in the LRFFT; mainly groupers but the Napoleon fish (upper left) is one of the highest value species. Species traded are a mixture of wild-caught and cultured fish. Photos show fish (at least 6 species, most wild-caught) on display for customers to select just prior to preparation in a Hong Kong restaurant.

Challenges, Recommendations and Opportunities

The outcomes of this and other studies on reef fisheries appear to converge on seven actions, ideally developed in parallel, that are achievable, and have precedents or available materials that can provide guidance and support. Fishery Management Plans (FMPs) relevant to the LRFFT are already variously developed, for example, in the Philippines and Australia, or being planned (the Maldives), while Indonesia has management plans for lobster and swimming crab, that could perhaps be used as reference, although not for reef fishes. Certification/traceability practices are increasing with some retailers in Hong Kong keen to access certified luxury seafood but largely unable to due to opaque trade structure and lack of traceability along the trade chain. Source countries are becoming more interested in certification initiatives, improving traceability or in Fishery Improvement Projects.

The crux of the matter, then, is that dedicated government action, political will and commitment, at the highest levels, is needed by the major LRFFT exporting countries, to address commitments and obligations already made at regional and international levels as well as to develop or strengthen the necessary national level regulations. Such measures could also make significant progress towards ensuring the long-term health and value of reef fisheries, and safeguarding reef ecosystems and the many important benefits these generate. Ten issues and 7 key recommendations are identified in this report to move the LRFT towards a more sustainable footing, improve transparency, protect reefs and retain the many priceless benefits of reef ecosystems to source countries. Several assumptions that may be impeding progress may need to be considered.

- **Governments to honour and advance existing agreements and commitments** made both regionally and internationally, such as those under CBD, CITES, SEAFDEC-CTI (especially the 2015 MoU Tables 3 & 4). Inter-government cooperation and communication could help to standardize and share practices and address IUU fishing and sustainability issues, amongst others.

- **Reduce heavy dependence on single export markets;** the growth in chilled fish trade will help diversification and reduce controls by and risks from having a single major export market.

History of the LRFFT

The history of the LRFFT from the 1980s or so to the present is depicted in the infographic. It shows how foreign traders working with local partners typically enter an area, fish for or initially purchase preferred species and sizes for live export and may move on as resources dwindle. The various possible stages of this process have occurred in several countries and may

have different time-sequences or durations (e.g. Fiji, Indonesia, the Philippines, Maldives, Palau, Solomon Is., Papua New Guinea, Malaysia, among others). Trends are moving towards the right hand side of the graph and will continue to do so without management as demand rises for live and especially dead fish.

Undervalued and Overfished

It is undisputed that reef-associated fisheries play a crucial role for millions of small-scale fishers around the world for income and food security and are of critical importance in Asia (Teh et al., 2013). Yet, while there is increasing focus on understanding the importance of coral reef habitat and reef ecosystems, including in relation to climate change and from the perspective of coral reef habitat conservation, far less attention is being paid to the state of the coral reef fish

and invertebrate populations of reef ecosystems and the fisheries these support. While fish need healthy reef habitat to survive and preservation of coral habitat is essential, it is also the case that the main value of coral reefs to most fisheries and to millions of people around the tropics is the food and income they generate, calling for improved management.

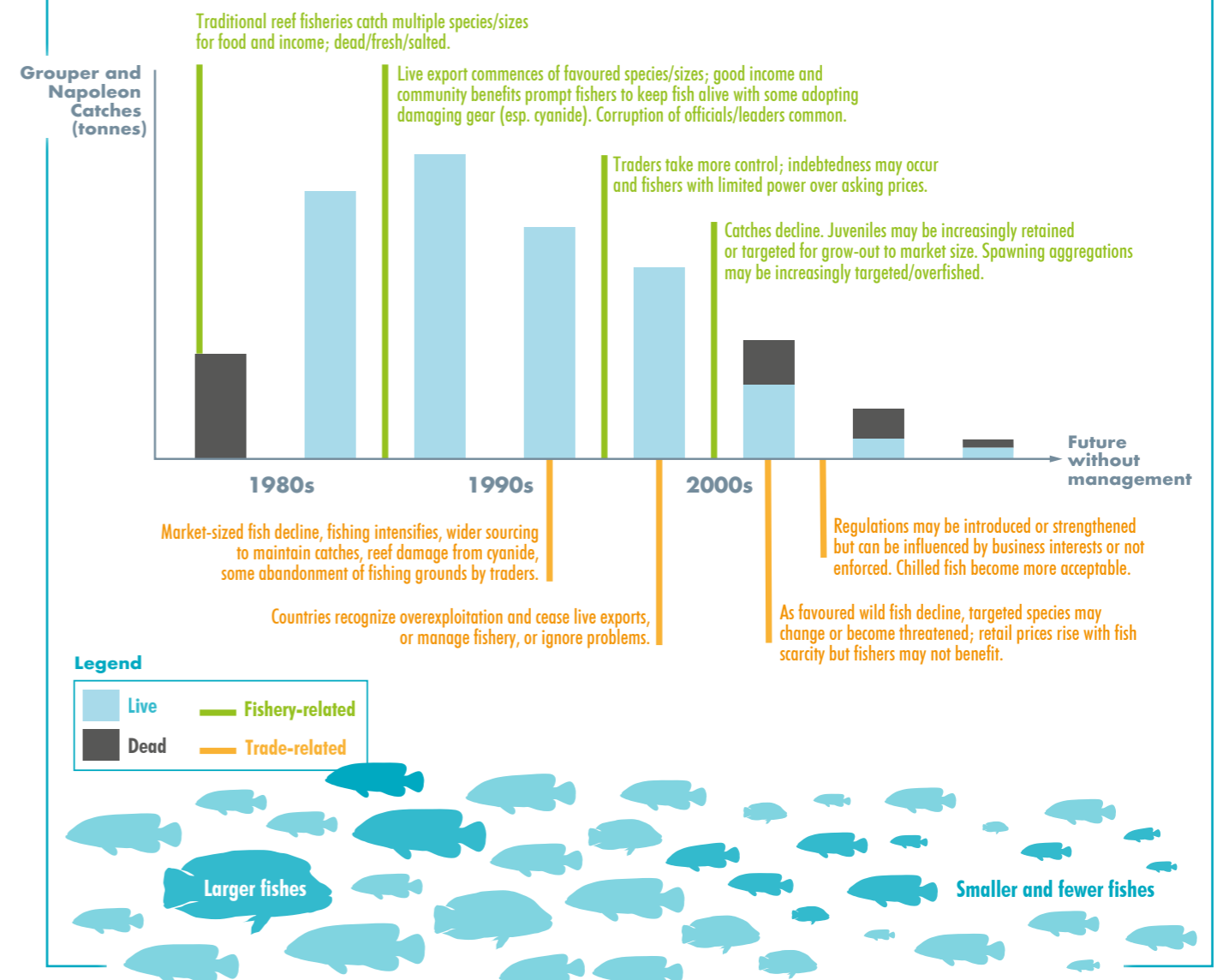
Recommendations for action at national and regional levels

- **Improve government understanding, oversight and control of coral reef fisheries and trade to within biologically sustainable levels.** A **Coral Reef Fishery Management Plan** could focus primarily on longer-term benefits of fishery resources to coastal fisher communities, for food and livelihoods.
- **Establish clear operational, regulatory and administrative distinctions between hatchery-based mariculture and wild capture fisheries** in terms of objectives and management and specifically recognize juvenile capture as a wild capture fishery.
- **Reduce/eliminate illegal, unregulated and unmonitored fishing and trade** by better monitoring and controlling exports conducted at airports, the use of cyanide and particularly the activities of foreign

vessels. Ensure that export values and volumes are correctly reported.

- **Ensure protection of spawning biomass of key target/threatened species** by safeguarding juveniles (minimum sizes) and/or managing juvenile fisheries (e.g. for grow-out). Spawning aggregation management will be necessary for some species, and all threatened species need better protection.
- **Develop certification and/or traceability systems** by establishing closer links with consumer centres, and analyzing trade chains. Consider the introduction of export duties/tariffs for luxury seafood. Value chain analysis would help to identify opportunities to retain value in-country.

HISTORY OF THE LIVE REEF FOOD-FISH TRADE



INTRO- DUCTION

International trade in live seafood took off in the 1980s and by the mid-1990s concerns were being raised about elements of it considered to be destructive, illegal, unregulated and undocumented leading to damage to coral habitat and heavy fishing in some areas (Johannes and Riepen 1995). There have also long been concerns about corruption and undue political influence associated with traders seeking new sources, gaining access to community fishing grounds or compromising fishery regulations in their favour (e.g. case study, Lowe 2002). As more attention was paid to this trade, other workers also documented overfishing, illegal trade, destructive fishing (particularly the use of cyanide which was typically supplied to fishers by trader/exporters, and the use of explosives to catch reef fish to feed cultured fish) and corruption. The recognition that many of the fish involved in the trade had life histories that make them easy to overfish was also recognized early highlighting the need for management (e.g. Lau and Parry-Jones 1999; Sadovy et al., 2003). See above Infographic for approximate timelines of the LRFFT.

As a result of these concerns projects were initiated to improve fishing and mariculture practices, document the trade and seek ways to address possible threats to species and habitats. Workshops were held and standards of good practice developed. In 2009 (seeded in 2007) the Coral Triangle Initiative was launched, in recognition of a critical need to safeguard the region's marine and coastal resources, as a cross-governmental grouping in association with major NGOs and others. Many publications were produced to summarize the trade as well as the experiences of many countries that opted to enter the trade in the 1990s and early 2000s and allow exports of live fish. This history is quite well documented in a range of reports and publications including issues of Live Reef Fish Bulletin (as of 1996) of the Secretariat for the Pacific Community and various reviews among many others (e.g. Muldoon et al., 2009; Klinsukhon 2014; Sadovy de Mitcheson et al. 2017).

The government of Hong Kong (Customs and Statistics Department) introduced several harmonized codes for trade declarations of the most frequently traded species. The government (Agriculture Fisheries and Conservation Department) also developed an informal system to collect data from some (it is a voluntary system) Hong Kong-registered vessels which, at the time, did not have to declare their imports to the government (that changed in 2009). These initiatives have proven very useful for documenting a substantial proportion of the total LRFFT trade, with species-level data for the key species, and occasional updates to incorporate changes, such as the introduction of hybrid grouper in 2016. Data can be assessed according to mode of transport (sea or air).

Today, two decades on and despite multiple initiatives undertaken, workshops and forums conducted, trade documented and ongoing concerns raised by intergovernmental agencies, non-governmental organizations (NGOs), aid agencies, academics, and in an extensive literature, many of the same problems persist, some have worsened and solutions to move the industry in a more sustainably practiced direction seem little nearer. Overfishing appears to be more widespread as traders move into ever-new fishing grounds, demand for exports is growing to supply an expanding and wealthier consumer base, several more species are now considered to be threatened, partly due to the trade and the loss of their spawning aggregations, cyanide fishing persists, spawning aggregations may be disappearing, juveniles are increasingly the target of fishing (usually captured to grow to adult size in the absence of sufficient adults), and illegal practices continue largely unabated in several exporting countries. The role of foreign vessels in illegal trade is particularly highlighted (Sadovy de Mitcheson et al., 2017). The gaps between policies and practice around the control of the trade can also be large (Fabinyi and Dalabajan 2011).

The trade supplies a growing demand for live seafood and often involves a complex and sometimes opaque trade chain. While there are economic benefits associated with this trade for many people along this chain, from reef to restaurant, the trade undeniably has a murky side with most accrual of benefits occurring downstream rather than within source countries. If source areas do not recognize the value or the trade or cannot benefit substantially there may be little incentive to consider managing exploited populations.

While mariculture (hatchery-production) is producing an ever-larger percentage of live groupers for the LRFFT, interest in wild-caught fish remains high for their perceived safety and taste qualities, while the majority of species in the trade, including all those that are most valuable economically, are wild-sourced. Wild fish populations and healthy coral reef ecosystems are also important for fishing communities across the region.

Fishes in the LRFFT and their importance for coral reef ecosystems

The LRFFT mainly targets groupers (family Epinephelidae), with much smaller volumes of other coral reef fish species of wrasses and parrotfishes (Labridae), particularly the Napoleon wrasse and snappers (Lutjanidae) among several others of 100-200 t at most, annually (Bloom Association 2017; Sadovy de Mitcheson et al., 2017) (Fig. 1, 2). These taxa are important for coral reef ecosystems and the benefits that humans derive from reef systems. The groupers, for example, are top-level reef fish predators and an important part of the biomass and biodiversity of coral reefs and, as such, may help keep reef ecosystems in biological balance. Because of their life histories (long life, slow maturation, aggregation-spawning, slow reproduction rates) many groupers and the Napoleon wrasse are easy to overfish. On the other hand, one of

the most popular species, *P. leopardus*, is relatively fast-growing and early maturing suggesting it can sustain greater pressure than some of the other groupers traded.

Loss from heavy removals of large volumes of reef predators, like groupers, is of concern not only for fishing communities but also for reef ecosystems. In terms of biomass, groupers count among the larger species in reef fish assemblages and, at natural levels, can occur in significant numbers in reef environments (Craig et al. 2011). Groupers are apex predators likely to be important in shaping coral reef assemblages because the top-down effect of grouper predation could influence community structure in highly diverse systems (Bellwood et al. 2004, Boaden and Kingsford 2015).



Figure 2. New, valuable, species becoming prominent in the live fish trade include the tomato hind I (two reddish fish on left of photo) *Cephalopholis sonnerati*. The light colour/brownish species with blue dots (two fish lower and left) is *Plectropomus areolatus*. Photo: Stanley Shea.

Predators can influence lower trophic levels through their interactions with prey, helping to preserve top-down trophic interactions in ecological systems (e.g. Ruttenberg et al. 2011, Walsh et al. 2012, Boaden and Kingsford 2015). Their loss, or reduction in their biomass, can affect reef ecosystems, both directly and indirectly (e.g. Thrush 1999, Heithaus et al. 2008). Specific examples range from an inverse relation between grouper density and that of the coral-eating, crown-of-thorns starfish, *Acanthaster planci*, in Fiji, with reduction of predators by fishing correlated to higher densities of the starfish, which, in turn, can damage living coral (Dulvy et al. 2004). The Napoleon wrasse is one of the few predators to feed on crown of thorns starfish, a species that can devastate coral reefs when populations explode (Randall et al. 1978).

In addition to reduced abundances of groupers and Napoleon fish taken for the LRFFT, four species are now threatened according to the categories and criteria used for assessing species for the IUCN Red List (Sadovy de Mitcheson et al., 2020), while several fishing methods can degrade coral reef habitat. Threatened species (IUCN Red List Vulnerable category) include several species important in the trade. *E. fuscoguttatus*, *E. polyphkadion* and *P. areolatus*. The endangered Napoleon wrasse was listed on the Convention on International Trade in Endangered Species of Flora and Fauna (CITES) Appendix II in 2004 largely as a result of the LRFFT. Damage to living corals can be caused in areas where the poison cyanide is repeatedly used (Jones et al. 1999). Explosives are used to catch reef fish used as food for groupers held in captivity as they wait to be exported or during many months, sometimes years, of grow-out of small fish to market size. Multiple reports and assessments have been produced over many years by many workers on the trade or for species assessments from Indonesia, Maldives, the Philippines, Australia and by international bodies (e.g. Koeshendrajana and

Hartono, 2006; Fabinyi and Dalabajan 2011; Sattar et al. 2012; 2014; Frisch et al., 2016; USAID 2013; Khasanah et al., 2020).

In light of ongoing sustainability concerns, the focus of the present study is on the wild-capture component of the Asian-based LRFFT, in terms of volumes, values, impacts, practices opportunities and challenges for major source countries. The impacts of international trade on coral reef ecosystems were recognized by ICRI over 20 years ago and the current initiative reflects the ongoing interest and concerns around the trade for reef ecosystems.

In recognition of the ongoing problem with the LRFFT and its implications for coral reef ecosystems and recalling the 33rd International Coral Reef Initiative (ICRI) Meeting adopted Plan of Action 2018 – 2020 to this study seeks:

- Improve understanding of the LRFFT by, collecting information on the extent and impacts of the LRFFT on coral reef species and ecosystems, including compiling a list of species impacted by the LRFFT, particularly in Southeast Asia, and collecting information on the socio-economic impacts of the LRFFT.
- Improve management measures related to the LRFFT based on an understanding of existing measures and collecting information on management measures being used to address the LRFFT, including the role of species and habitat protection and MPAs.
- Compile policies that address illegal trade in reef fish, including existing policies to combat the illegal extraction of and trade in other fauna and flora, with a particular emphasis on marine species, in order to identify where ICRI can contribute to and improve the management of LRFFT.

The present study was designed to address the following specific objectives:

- Develop an understanding of the live fish export trade at the national level (with some coverage of dead reef fish);
- Provide a summary of international trade data;
- Identify national and regional issues and challenges around live reef fish exploitation and export trade and possible solutions;
- Produce recommendations at the regional and national levels for consideration by countries exporting live reef fish, including Napoleon (humphead) wrasse and other threatened species.

METHODS



The Napoleon wrasse, *Cheilinus undulatus*, is threatened by the LRFFT. Photo: ©Allen To.

A questionnaire was developed to improve the understanding of and actions needed in relation to the LRFFT to produce a profile of the trade and better understand the experiences and perspectives of live reef fish exporters. The questionnaire was circulated to 40 ICRI country focal points and follow-up communications conducted, as needed. A review of the literature identified key regional initiatives and voluntary commitments relevant to the LRFFT, in particular, and to reef fisheries in general, over the last 15 years. Literature review also covered recent studies on the status of the trade and of traded species. International instruments relevant to reef fisheries management, reef ecosystems and species conservation were also reviewed. Import data recorded by the Hong Kong Census and Statistics Department (CSD) and Agriculture, Fisheries and Conservation Department of the Special Administrative Region of Hong Kong (AFCD-SAR) provide an overview of the import trade, by the major importing LRFFT hub, since 1999. The main species in trade with English and Latin names, and their IUCN conservation status are given in Table 1.

While the focus of this study is on wild-caught fish due to concerns over biological sustainability and threats to biodiversity and reef ecosystems posed by the LRFFT, a significant proportion of the trade includes hatchery-produced fish or involves fish produced by wild-fish grow-out operations, an activity sometimes referred to as 'ranching' or 'capture-based aquaculture' (or CBA). This activity is important because of its possible implications (i.e. uncontrolled juvenile capture can contribute to fishery depletion, if unmanaged, by removing reproductive potential) for wild populations. Moreover, considering a recent increase in the acceptability and prices of chilled/dead reef fish in major consumer markets, this aspect is also briefly covered. The results were used to develop recommendations and identify challenges faced and opportunities for moving towards more sustainable fishing and trade practices. The study was conducted in close collaboration with the Ministry of Marine Affairs and Fisheries of Indonesia.

Species: Latin name	Species: English common name(s)	Major production method	IUCN Red List (2018) CITES
<i>Plectropomus leopardus</i>	Leopard coral trout	Mostly wild-caught; some hatchery production occurring, mainly in China (though red colour not strong)	LC
<i>Plectropomus areolatus</i>	Squaretailed coral grouper	All wild-caught	Vulnerable
<i>Plectropomus maculatus</i>	Spotted coral trout,	All wild-caught	LC
<i>Epinephelus polyphkadion</i>	Camouflage or flowery grouper	All wild-caught	Vulnerable
<i>Epinephelus fuscoguttatus</i>	Tiger or brown-marbled grouper	Mix of wild-caught fish and hatchery- production	Vulnerable
<i>Epinephelus coioides</i>	Green grouper	Mix of wild-caught fish and hatchery production	LC
<i>Epinephelus lanceolatus</i>	Giant grouper	Mix of hatchery caught fish (smaller ones) some wild capture (large fish)	DD
<i>Cromileptes altivelis</i>	Mouse, high-finned grouper	Mixture of wild-caught, larger, adults and hatchery production of young (smaller fish)	DD
<i>Cephalopholis sonnerati</i>	Tomato hind, melon hind	All wild-caught	LC
<i>Cheilinus undulatus</i>	Napoleon or humphead wrasse, Maori wrasse	All wild-caught	CITES App II & Endangered
HYBRID (e.g. <i>E. lanceolatus</i> x <i>E. fucoguttatus</i> or <i>C. altivelis</i>); other hybrids also	Most typically hybrid or Sabah grouper- other market names may apply depending on species involved.	All hatchery-produced	
Other groupers	<i>Aetheloperca rogae</i> , <i>Anyperodon leucogrammicus</i> , <i>Cephalopholis miniata</i> , <i>C. argus</i> , <i>C. aurantia</i> , <i>Epinephelus trimaculatus</i> , <i>E. bleekeri</i> , <i>E. malabaricus</i> , <i>E. maculatus</i> , <i>E. caeruleopunctatus</i> , <i>E. cyanopodus</i> , <i>E. tukula</i> , <i>E. undulosus</i> , <i>E. flavocaeruleus</i> , <i>E. corallicola</i> , <i>Plectropomus pessuliferus</i> , <i>P. laevis</i> , <i>P. oligacanthus</i> , <i>Variola albimarginata</i> , and <i>V. louti</i>		All of these species are all wild-sourced

Table 1. Grouper species Latin and English common names and IUCN Red List conservation status: LC=least concern, DD=data deficient. DD species currently have insufficient information to determine their status. Major production source (wild or hatchery production) indicated.

RESULTS AND DISCUSSION

International trade volumes and values are patchily recorded for reef fishes traded for food, whether live or dead, including in the FAO database. For key species, volumes and values in the LRFFT, the most useful, longer-term, database is that of Hong Kong, the major known importer of live reef fish globally. Hong Kong was also the major export destination identified by source countries with other importers including mainland China, Taiwan and Singapore; however, similarly detailed databases were not available for these countries. Valuable insights into export volumes and values were also gained from questionnaire response, national databases and literature review on species, values and volumes from the perspectives of source countries. Twenty ICRI member countries responded to questionnaires and almost all those countries that export live reef fish for food provided responses.

Overall, the available information appears to allow for a useful profile of international trade in live fish, while is less detailed for chilled/fresh fish, although this was not unexpected because live fish was the major focus on this study.

This section variously summarizes, discusses and integrates trade data, feedback from questionnaires, pricing at different stages of the trade chain, management concerns, action and options, fishery production, pricing, fishing methods, management in place and needs, stock condition and relevant international and regional agreements, activities and commitments. Although the focus is on live wild-capture reef fish, it also briefly addresses the dead fish trade and the role of mariculture.

LRFFT scale and trends: Two decades of Hong Kong import data

To provide an indication of trends in and composition of live fish imported to Hong Kong, Hong Kong government data over 2 decades were summarized (Fig. 3). This dataset, although an incomplete coverage of the entire international LRFFT (other centres importing live fish are Singapore, mainland China and Taiwan) nonetheless provides useful information on a significant proportion of this trade, with information on trading partners (i.e. source countries), key species, volumes and trends over

time (e.g. Fig. 4). The focus of the data extracted from the dataset is the groupers which account for by far the great majority by weight and most of the value of imports to Hong Kong by taxon (Sadovy de Mitcheson et al. 2017). Other taxa include snappers, wrasses, parrotfish, sweetlips, emperors, morays and stonefish but data from these were not included in this analysis.

The Hong Kong government database for the LRFFT was introduced in 1999 following concerns expressed about the trade (Lau and Parry-Jones 1999). It includes CSD trade data (mainly mandatory declarations from air and foreign vessel imports) as well as AFCD data (information from some Hong-Kong registered live carrier vessels collected on a voluntary basis from cooperating traders; this represents a subset, estimated by AFCD to be about 50%, of all live carrier vessels). Some of the trade categorized (documented using international harmonized codes) are at the species level, some at higher taxonomic level. [For full details of data for 1999-2016 by species, country and transport mode see Sadovy de Mitcheson et al., 2017.]

Hong Kong import data record that trade (uncorrected for underreporting, particularly live fish cargo on vessels) in the last few years into the city of live groupers, was in the order of 13,000 t (Fig. 3) (Sadovy de Mitcheson et al., 2017). Over the 20-year period of the Hong Kong databases and according to personal communications with traders, several species are increasingly being supplied by hatcheries (most notably *E. fuscoguttatus*, *E. coioides*, *Cromileptes altivelis*, *E. lanceolatus* as well as the Sabah grouper hybrid). Hatchery production is now estimated to make up at least 50% of the trade, by weight.



Figure 3. Imports in tonnes (t) of live groupers reported entering Hong Kong from 1999-2018 (not corrected for underreporting). Red bars show all grouper imports, including Sabah grouper. Green bars indicate wild-caught fish only as estimated by assuming that several hatchery-produced species (*E. coioides*, *E. fuscoguttatus*, *Cromileptes altivelis*, *E. lanceolatus*) are supplying an increasing proportion of trade (increasing from 2-80% hatchery produced depending on the species and year over timeframe of the dataset). Source HKCSD and AFCD data.

The major species in the Hong Kong database, by weight (and value) is *Plectropomus leopardus*, with significant volumes of *E. coioides*, *E. fuscoguttatus*, *E. lanceolatus* and the Sabah grouper hybrid (as of 2016-not shown in Fig. 4) among the groupers identified to species level in the database. Low volumes of *P. areolatus* and *E. polyphemadion* remain in trade (Fig. 4); these were once more important but have declined over the last two decades and both species were listed as threatened in 2018 (IUCN Red List: www.iucn.org). These listings were partly attributed to overfishing of their spawning aggregations, with *E. polyphemadion*, in particular now substantially reduced from former levels (see IUCN Red List accounts; www.iucnredlist.org and cover photo).

A range of 'other groupers' are wild-caught groupers, most notably *Cephalopholis sonnerati* and *Anypserodon leucogrammicus* and are also regularly traded according to questionnaires and to surveys of retail outlets in Hong Kong. *Cephalopholis sonnerati*, in particular, has newly become important in the trade, popular due to its red coloration, and is seen as frequently in display tanks in Hong Kong (Sadovy de Mitcheson et al., 2017; F. Chan, AFCD, pers. comm.).

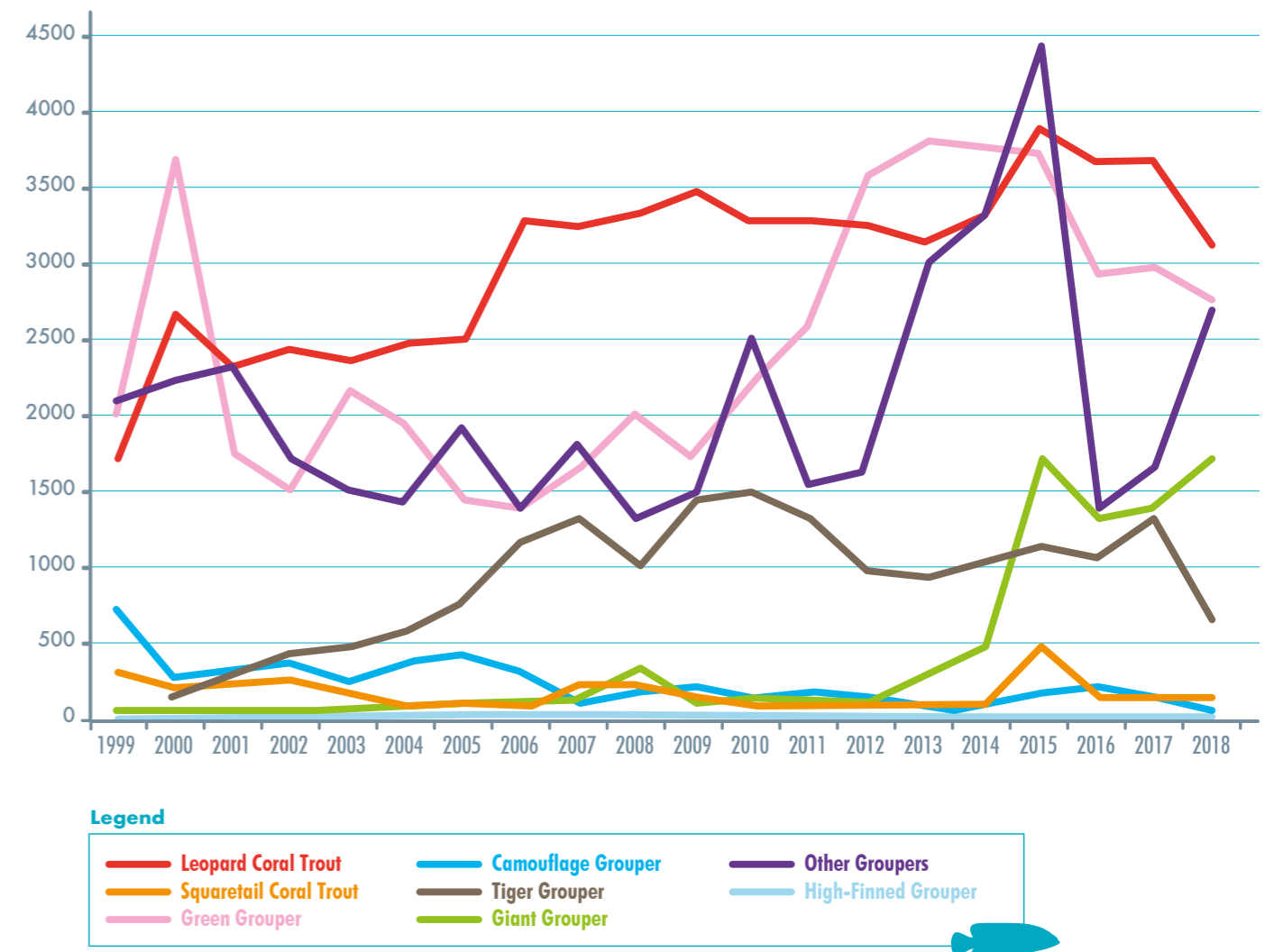


Figure 4. Grouper imports in tonnes (t) to Hong Kong by major species that are fully or partially wild-sourced (1999-2018); Hybrid/Sabah grouper is not included, because it is solely hatchery produced, but the species became a major component of the trade after 2015 (Sabah grouper 2016-2018 annual data=1,500 – 1832 t). For the 'Other Grouper' category and Latin names, see Table 1.

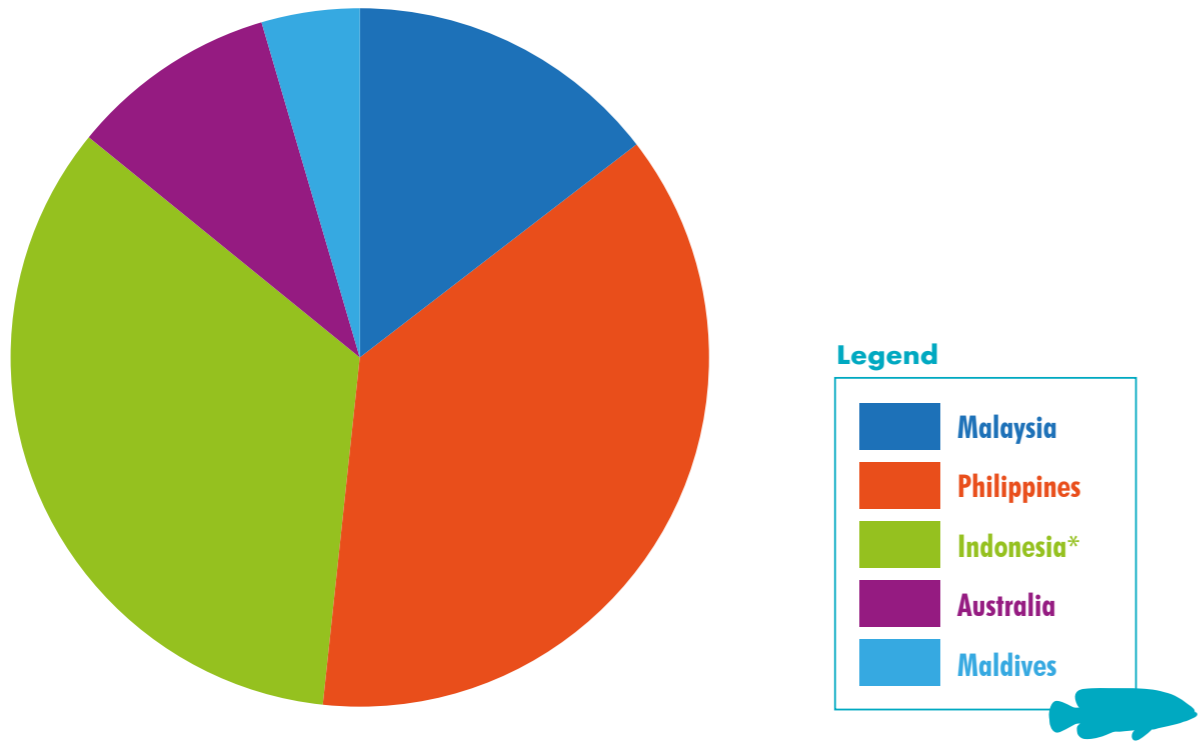


Figure 5a For 2018 Hong Kong **IMPORT** data about 60% of the total volume of live groupers entering Hong Kong, mostly wild-sourced groupers, came from 5 countries. While Taiwan and Thailand also produce significant volumes of groupers, much of this is likely hatchery production. Note that only about 50% of HK vessel imports are recorded and Hong Kong does not import all LRFF; given the importance of sea transport for Indonesia imports from this country, in particular, are likely underestimated by HK vessels (see Fig 5b). Species included in the wild-caught category were, leopard coral trout, tiger, flowery, squaretail, mouse and camouflage groupers and 'other groupers' (see Table 1). Source: AFCD+ CSD data. [Total volume in graph is 6,209 t.]

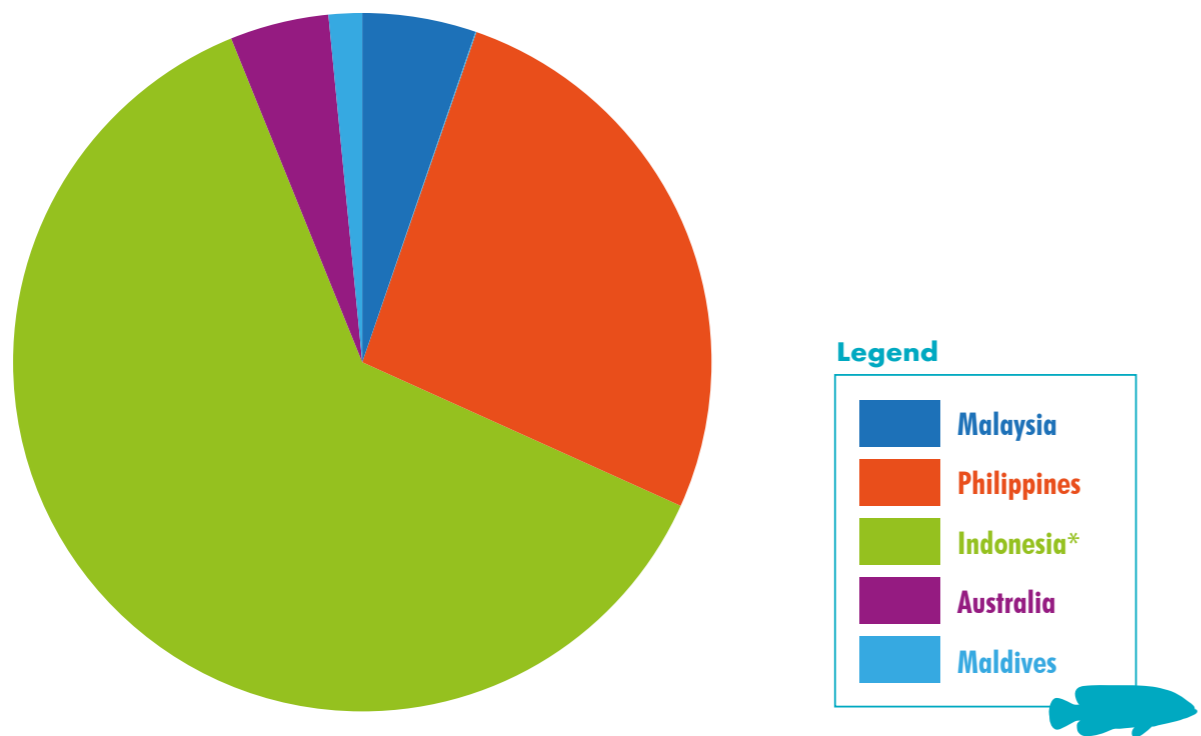


Figure 5b For 2014-2019 based on live grouper exports (sea and/or air) reported in questionnaires and from national export data. Total annual **EXPORTS** officially documented from the 5 main exporting countries show that Indonesia is the major exporter overall (62% of total). Data predominantly reflect wild-caught fish (no hybrids). Note that different countries reported over different time frames within the 2014-2019 window [Total volume in graph is 14,328 t.]



Figure 6. Two of the most common species in the LRFT currently, wild-caught *P. leopardus*, one of the highest priced fish, and a hatchery-produced hybrid (*E. lanceolatus* x *C. altivelis*), one of the lowest priced (Fig. 7 and 9, for pricing along trade chain for five species).

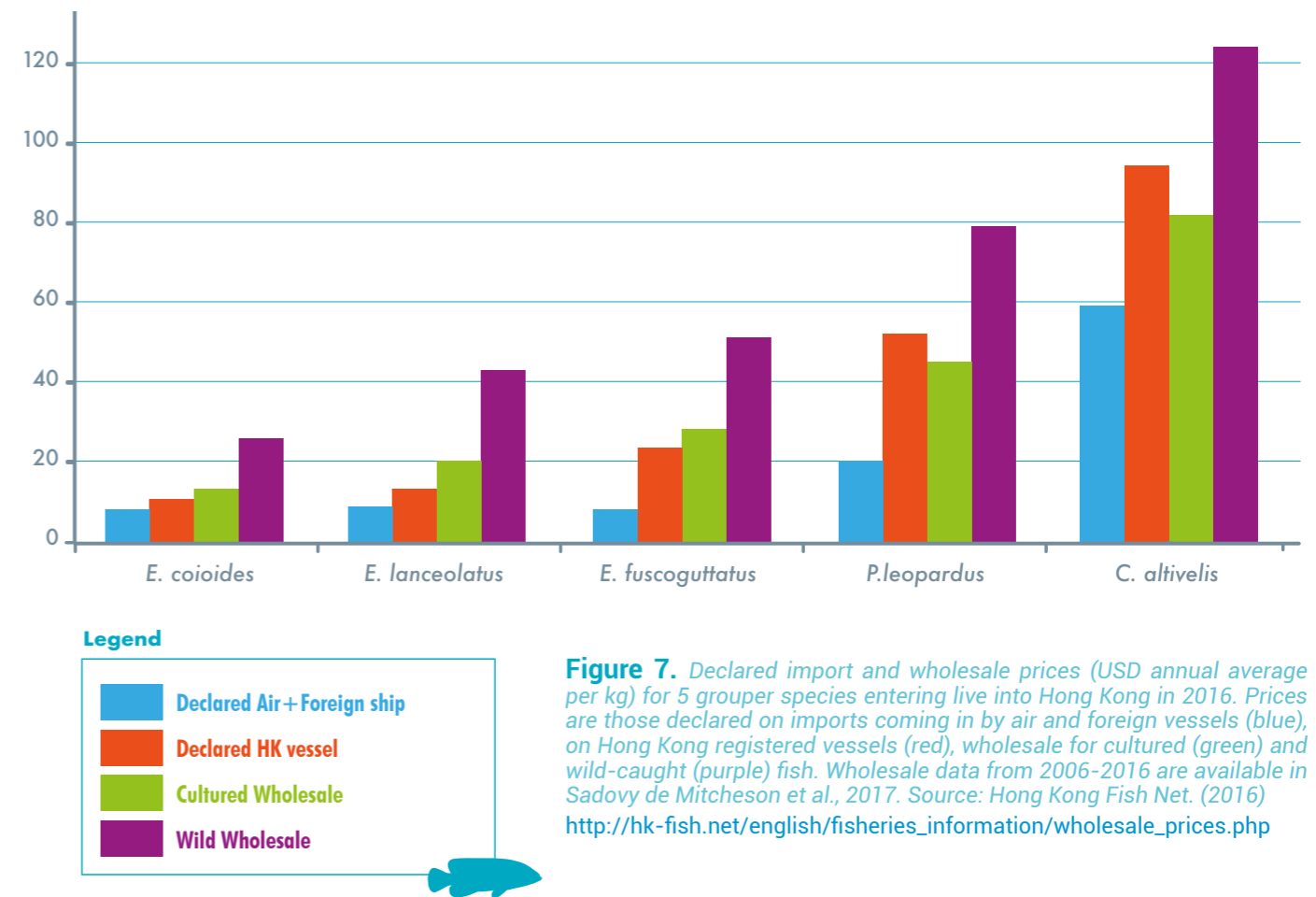


Figure 7. Declared import and wholesale prices (USD annual average per kg) for 5 grouper species entering live into Hong Kong in 2016. Prices are those declared on imports coming in by air and foreign vessels (blue), on Hong Kong registered vessels (red), wholesale for cultured (green) and wild-caught (purple) fish. Wholesale data from 2006-2016 are available in Sadovy de Mitcheson et al., 2017. Source: Hong Kong Fish Net. (2016) http://hk-fish.net/english/fisheries_information/wholesale_prices.php

Completed source country questionnaires: LRFFT

Twenty countries provided responses on the ICRI questionnaires which focused on live reef fish exports but also included questions on the chilled/fresh fish trade due to recognition of its growth. Of these, six (the Philippines, Indonesia, Malaysia, Thailand, the Maldives and Australia) account for most of the international trade in live coral reef fishes to the China market, dominated by Indonesia (about 62% of the exports documented - Fig. 5b). An additional four (Vietnam, Sri Lanka, Japan and Myanmar) have some live fish exports but these appear to be low. Grouper export data from these countries were not available but imports from these countries into Hong Kong in 2018 were: Vietnam-79t of 'other grouper' and 'tiger grouper'. Frozen grouper fillets marked as being of Vietnamese origin are being sold in Hong Kong

supermarkets (pers. obs. 2020); Sri Lanka-almost 7 to by air, mainly 'tiger', 'flowery' and 'other groupers'; Japan- 26 t or 'tiger' and 'other groupers'; Myanmar-8.5 t declared as *P. leopardus* at import but likely to be *C. sonnerati*. Several countries reported exports of both dead and live fish; Indonesia, the Philippines, Maldives, Thailand and Malaysia.

Management in effect and options identified to improve management

Management in place of some relevance to the LRFFT, as reported for the six live fish source countries, is shown in Table 2. Measures were few but include minimum sizes, protection of threatened species, gear and spatial controls, some protection of fish spawning aggregations and several stock assessments. Shortcomings identified by countries were for enforcement (limited capacity, problems with species identification), lack of export quotas, and poor controls or inspections of exports. All but one country had no limit on fishing effort (licences) or monitoring of reef fisheries, and none had certification, traceability or accreditation systems for live fish. The one implementation exception was Australia where enforcement was considered to be strong.

Additional measures identified in questionnaires to improve management include;

- monitoring of the fishery,
- best practices for fishing and mariculture,
- promotion of full-cycle mariculture,
- spawning aggregation protection,
- minimum sizes catch/export,
- improved oversight of traders/exports,
- no sale of species taken with destructive gear,
- no threatened species traded,
- develop FMPs for reef fish fisheries,
- provide alternative livelihoods,
- increase public/fisher awareness,
- reduce corruption,
- substantial improvement in enforcement,
- suitable penalties for non-compliance.

Management /Control measure	Thailand	Indonesia	Philippines	Malaysia	Maldives	Australia
Fishery condition	Overfished	Overfished	Overfished	Overfished	Overfished	Good
Minimum size control by species	No	<i>Cheilinus undulatus</i> ; no catch/export of 100 to 1,000 g or over 3,000 g	250 g <i>P. leopardus</i>	No	Capture/export size limits for 20 grouper species	38 cm min capture size
Catch quota by species	No	No	No	No	No	Catch quotas (ITQ)/ log books required
Export quota by species	No	Reviewed annually for <i>C. undulatus</i>	No	No	No	No
Threatened LRFFT species management (see also Box - <i>Cheilinus undulatus</i>)	No	<i>Cheilinus undulatus</i>	<i>Cheilinus undulatus</i> , although illegal exports	<i>Cheilinus undulatus</i> , no export	<i>Cheilinus undulatus</i> , no export	<i>Cheilinus undulatus</i> , <i>C. altivelis</i> , <i>E. lanceolatus</i>
Other controls	Gear controls	- No cyanide or compressed air for fishing - Foreign fish carriers control - Air-only exports for wild fish	- Partial protection of <i>P. leopardus</i> in spawning season	Gear controls	Some FSA protection planned	Some protection of reef fish in spawning season
Export/trade inspections on declared volume/value	No	No	No	No	No	Oversight of trade
Export tariffs/taxes	No	Yes	No	Yes	No	No
Limits on numbers of fishers or traders	No	No	No	No	No	Fisher licences
Extensive wild-capture juvenile grow out	Yes	Yes	Yes	Yes	None	None
Stock/fishery assessment/monitoring	Yes	<i>Cheilinus undulatus</i> assessed	<i>Plectropomus leopardus</i> assessed	Yes	Under review/development	Yes
Certification (trade)	No	No	No	No	No	No
MPAs	NA	Yes	Yes	Yes	Yes	Extensive
Enforcement effectiveness	Some	Weak	Very limited capacity	Only legal exit points policed	Limited capacity	High

Table 2: Fishery condition and control/management measures in effect in relation to LRFFT species (groupers/Napoleon wrasse)

Exports: Trade, mode, volumes and prices

Live groupers are typically taken by hook and line and fish trap, and also by cyanide in some areas of Indonesia and the Philippines. The total number of fishers and traders estimated to contribute to this trade in the 6 key exporting countries (Thailand, Indonesia, Malaysia, Philippines, Maldives and Australia) exceeds 30,000 fishers with fewer than 100 trader/exporters reported.

Volumes of live fish exported annually in recent years, based on export figures provided from all 10 exporting countries, were about 13,000 t, in line with the indicated government import volumes to Hong Kong in recent years (see above and Fig. 3). The largest volumes exported by individual countries of predominantly wild-sourced groupers are Indonesia, followed by the Philippines (Fig. 5a, b; Sadovy de Mitcheson et al., 2017).

Although it is a low volume trade when compared to many recognized fisheries globally, the high unit value of the LRFT, reflecting its luxury nature, is distinctive and can bring considerable economic gain to source countries. However, this value may not always be well or widely recognized outside of the trade due to apparent underreporting by traders in the declared export value of live fish shipments, as well as suspected under-declaring of volumes carried by Hong Kong live fish carrier vessels.

To better understand the relative value of the LRFT it is instructive to look at declared export values per t and compare them with import values (which should differ only by including insurance and transport costs), as well as compare export values with another, better known, export commodity, tuna. Highest values apply to the most expensive species such as the red *P. leopardus*, somewhere in the middle of the range for wild-caught *E. fuscoguttatus*, *E. polyphkadion*, *P. areolatus*, and lowest values are for green grouper (*E. coioides*) and hybrid groupers (Fig. 6 for high and low priced species). Moreover, prices are higher for wild-caught fish compared to cultured fish of the same species (Fig. 7).

Using government recorded wholesale prices for potential Hong Kong imports (Fig. 7) and considering estimated mark-ups along the trade chain of 60-65% of the final value of a fish in SE Asia goes to Hong Kong importer/wholesalers (20-25%) and retailers (40%) (Fig. 3.42 in Sadovy de Mitcheson et al., 2017), lowest and highest export prices for different types of grouper should range between approximately 5,000 and about 30,000 USD/t depending on the species (also confirmed by anonymous trader) (Fig. 7). By comparison tuna declared export value from Indonesia was 3,300-4,200 USD/t from 2016-2018 while swimming crab, also exported from Indonesia, was declared at 6,173 USD/t in 2018.

A quick analysis of trader export value declarations for live groupers compared to estimates of corrected values, strongly suggests that official declared export data from several countries are substantially lower than they should be, thereby undervaluing these exports. For example, mean declared exports from Malaysia (6,900USD/t), Indonesia (5,416USD/t by air and 6,688 USD/t by sea) and the Maldives (2,579USD/t) from government data, mainly or exclusively by air and in recent years (Fig. 8), were 2 to 5 times lower than the estimated export value should be. This roughly estimated 'corrected' export value per tonne (approximately 12,000-15,000 USD/t) was calculated based (a) on information of the species composition typically being exported (species vary markedly by

value), as determined by available trade data, (b) the fact that air exports are typically used for the more valuable species, and (c) by cross-referencing to declared import values in Hong Kong for several commonly traded species (Fig. 7, 8). A recent independent study in Indonesia calculated a similar value for these exports 16,000 USD/t using detailed trader data (Anon academic, 2019). Hence, although both tuna and crab are exported at much higher volumes, the higher value, lower volume live reef fish approaches the total annual export values of the cheaper exports more closely once declared values are 'corrected'.

The high unit values of exported LRFF show the high value to the country, especially in the case wild fish and undervaluing of export declarations is important to understand for two reasons. (1) In some countries income or other taxes are payable on declared export values (e.g. Indonesia and Malaysia) so lower export declarations will result in less tax payable and lower economic benefit to the source country. (2) Low official value reflected in trade data may give the wrong impression regarding true economic value to governments in exporting countries. This, in turn, could dampen government interest to manage the fishery or control the trade. Tighter controls on exports in both declared values and species reported, as done in Australia, could help correct this situation and bring more money from the LRFF trade to source countries. Moreover, value chain analyses could help to highlight the high potential value of some of the more desirable species, such as *P. leopardus* (Fig. 9) (and *C. sonnerati*), and perhaps be an incentive to manage these. Such high profit margin species are particularly appealing to traders.

Cheilinus undulatus, NAPOLEON (HUMPHEAD) WRASSE, grow-out and exports from Indonesia

The Napoleon, or humphead, wrasse, *Cheilinus undulatus*, is endangered (IUCN Red List) and was listed on CITES App II in 2004. All production is from the wild. The CITES listing means that any country exporting the species must do so with permits and after demonstrating that exports will not be detrimental to the species. Indonesia is the only legal exporter of the species and has a scientifically based export limit of 2,000 wild fish ('W' code under CITES) fish annually (Sadovy et al. 2007; Wu and Sadovy de Mitcheson 2016).

This species is important in the LRFT despite its relatively low volume in trade. It was one of the first major target species coming out of Indonesia in the 1980s (Khasanah et al., 2020) and fetches some of the highest prices among all reef fish, many hundreds of USD per kg in top end restaurants and yielding particularly high profit margins for traders. Heavy declines have occurred in Indonesia since it was first exploited in both size and catch rates: mean capture weight dropped from 70 kg in 1995 to 20 kg in 2000 to a few kg or less in 2017 (Khasanah 2019).

In 2018, Indonesia introduced an additional export quota for the species of 40,000 ranched ('R' code under CITES) fish without scientific justification (Hau and Sadovy de Mitcheson 2019). Given the poor condition of the species in most parts of Indonesia (low natural abundances and few adult fish, with very few large males) and little indication of recovery (with one exception) the ranched quota may be adding to overfishing and further threatening the species (Sadovy de Mitcheson et al., 2019). This is another example where CBA could be contributing to overexploitation, but could also be managed. Moreover from an enforcement perspective (e.g. in Hong Kong) it is impossible to distinguish between 'wild' and 'ranched' fish for enforcement purposes once fish leave Indonesia. Going forwards it will be necessary to tag one of the two forms to differentiate them. Given the very high prices that some consumers are prepared to pay, it is likely that the species will be exploited even as it becomes very rare.

The species is exported illegally from the Philippines as well as between Hong Kong and mainland China. Both the Philippines and Indonesia have developed National Plans of Action for the species.

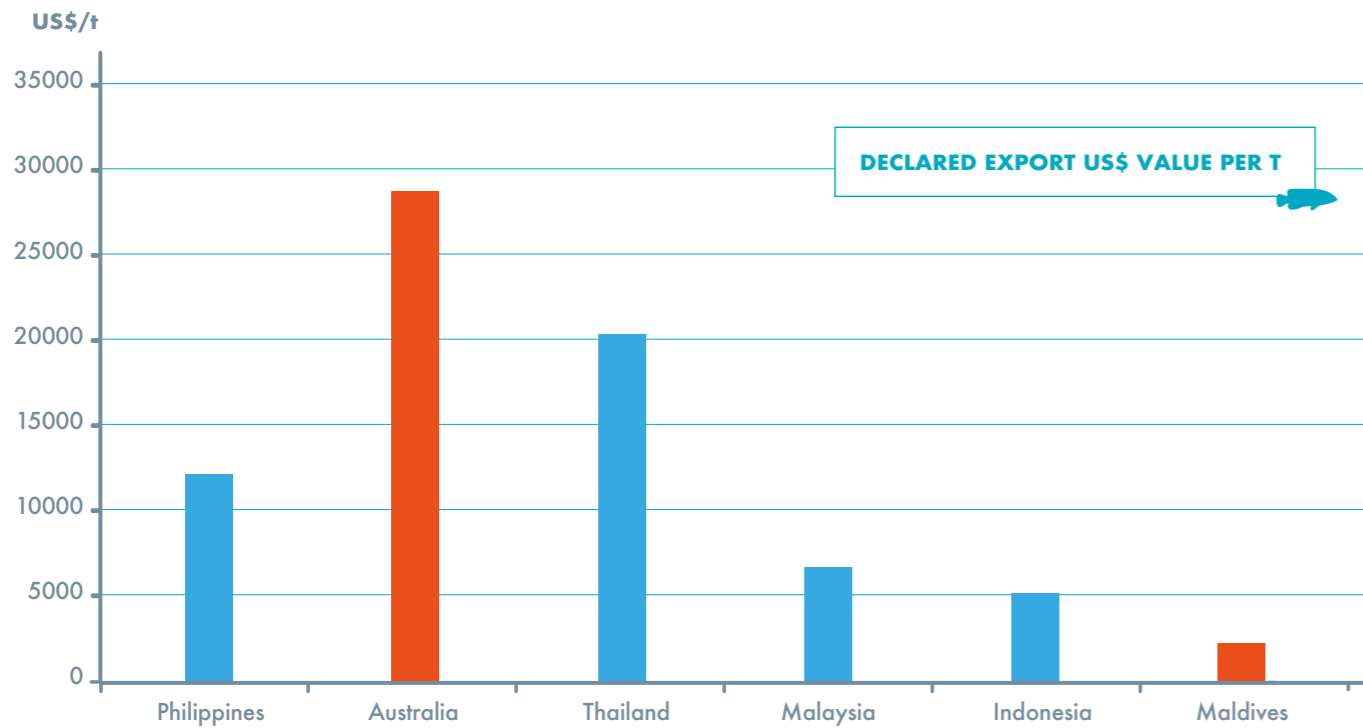


Figure 8. Declared annual export prices (USD/t) from government data (quarantine; export commodity clearance data) provided with questionnaires and related personal communications for major countries exporting live reef fish for several time periods. Philippines (2015-2019), Australia (estimated 2010-2011 and assumed no changes since), Thailand (2015-2017—prices include ornamental fish), Maldives (2014-2018) Indonesia (2016-2018 air export data; sea exports for 2019 were declared at 6,688 USD/t), Malaysia (2018). See text for further details. Red bars are for wild-caught fish and air exports only. Price for Australia reflects one high price species *P. leopardus*. Blue bars a mix of wild- and hatchery-produced (country-dependent) fish, predominantly wild (except for Thailand) and mainly air exports.

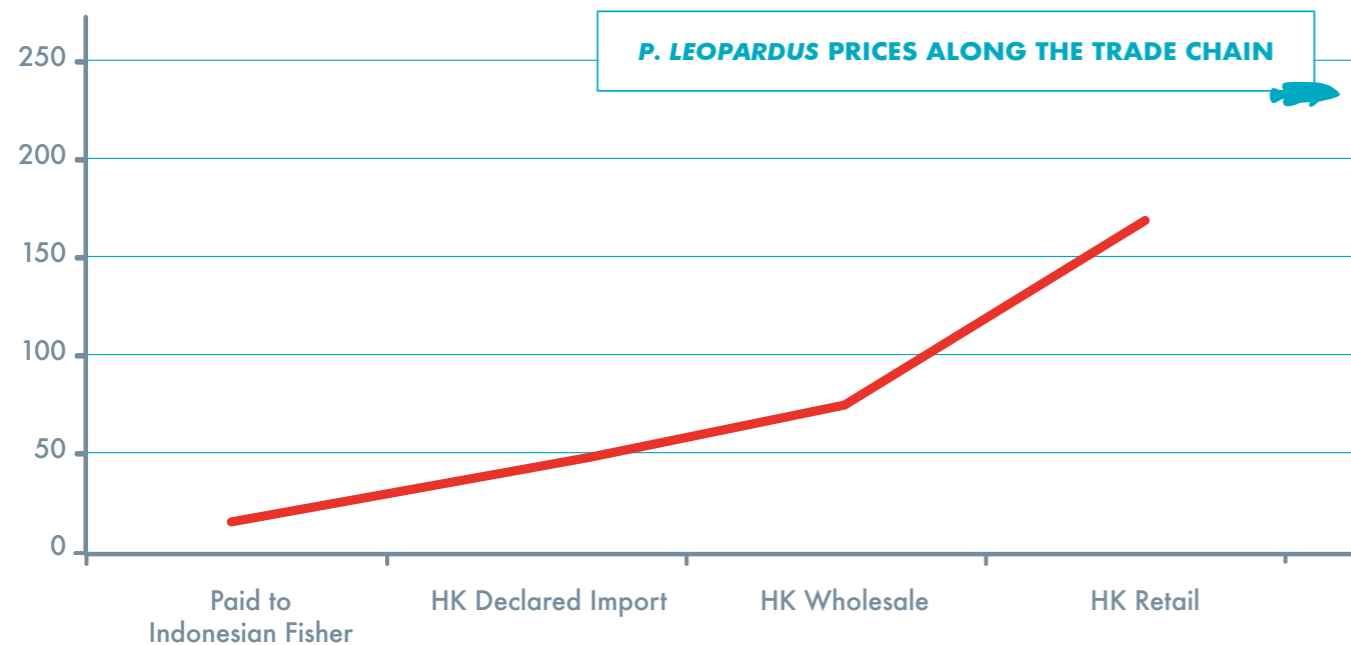


Figure 9 *P. leopardus* prices along the trade chain from fisher to restaurant. Paid to Indonesian fisher (M. Khasanah, pers. comm. 2018), declared at import and wholesale in Hong Kong (Fig. 7, 2016), and very approximate retail price in Hong Kong (2018). The latter is highly variable according to season and venue but is often at least 50% higher than wholesale prices and can be substantially higher. This value curve is also likely to apply to *Cephalopholis sonnerati* which is also high-priced. Note that *P. leopardus* is reported as being imported from the Maldives, where the species does not occur and hence is likely to reflect *C. sonnerati* exports.

Resource condition and assessment

Multiple signs of overfishing were identified by questionnaire responses and in five of the 6 (not Australia) major LRFFT suppliers as determined by;

- declining size of capture
- declining catch rates
- fishers moving to more distant fishing grounds or spending longer fishing to maintain catch rates
- threatened/declining species;

Several studies and stock assessments provide indications of the status of several species. For groupers, the IUCN Red List includes *P. areolatus*, *E. polyphkadion* and *E. fuscoguttatus* as vulnerable; recent reviews of all groupers can be found in species assessments of the IUCN Red List (www.iucn.org) with some declines attributed to the LRFFT. The camouflage grouper, *E. polyphkadion*, a regular but low volume species which fetches good prices, is now in such depleted condition in many places that it could be considered for a possible CITES Appendix II listing. The Napoleon wrasse, *Cheilinus undulatus*, is listed as endangered and is on CITES App II (since 2004). Indonesia is the only legal exporter of the species and imposed an export quota for 'wild' fish supported by a scientific study (Sadovy et al., 2007). A new and much larger quota for 'rancher' Napoleon fish introduced in 2018 has no scientific justification; the threat that this could pose to this still-depleted species in Indonesia is unknown and an assessment is needed (Sadovy de Mitcheson et al, 2019). In both Indonesia and the Philippines there are National Plans of Action (NPOA) in place for this species (Sadili et al. 2017; BFAR., 2017) (see also Box '*Cheilinus undulatus*').

Several assessments conducted in exporting countries are strongly suggestive of overexploitation. In the Philippines (Palawan) and Indonesia, surveys and stock assessments of *P. leopardus* indicated overfishing of the species and variously recommended reduction of

fishing effort, export quotas and protection of spawning biomass (Salao et al., 2013; Yin 2014). In Palawan this finding was subsequently corroborated by declines in live reef fish export shipments after 2014, dropping from 668 t in 2013 to 303 t in 2018 for this species (Palawan Council for Sustainable Development data). In eastern Indonesia fisher interviews documented marked declines in the mean capture sizes of several species since the 1980s, including *E. fuscoguttatus*, *E. polyphkadion*, *P. leopardus*, *P. oligacanthus* and *C. undulatus* as well as in average catch rates experienced by fishers taking live fish (Khasanah, 2019). In the Maldives there are concerns about declining catches and declining sizes of some target species and a Management Plan for Groupers was established in 2011; species-specific size limits for groupers are in place with some protection of spawning aggregations planned. There was a marked shift in exports from mainly live to mainly chilled fish from 2005 onwards (Sattar et al. 2012).

For those valued species with indications of overfishing (reduced sizes, substantial reduction in catch rates, etc.) several possible responses by fisher/traders are noted in questionnaire responses. Fishers sometimes strive to compensate by fishing longer or by travelling further to expand their fishing grounds and maintain catches. These responses are indications of overfishing and can increase the costs of fishing (so fishers need to catch more to maintain income) and/or the time spent away from their homes and families. Traders may simply move on from one area to another once catch rates in preferred species get too low. Another response is to continue to catch ever-smaller fish and grow these to market size, which could further push population levels downwards see above Infographic. Almost all *C. undulatus* are now grown out from the juvenile/post-larval stage to market size.

Fishery and mariculture production

Mariculture is an activity defined by FAO as the maintaining of fish in captivity in some form until they reach market size. During the grow-out phase they may be fed or may feed themselves from the natural environment. For groupers two variations of mariculture are practiced: one depends on the production of small fish by hatcheries followed by fed grow-out, termed hatchery-based aquaculture (HBA); the other depends on the capture of juveniles of a wide range of sizes from the wild for subsequent grow-out, termed capture-based aquaculture (CBA) (see also Box '*Cheilinus*

undulatus'). This latter is also sometimes referred to as 'ranching'. Four groupers typically undergo both forms of production (*E. fuscoguttatus*, *E. lanceolatus*, *E. coioides*, *Cromileptes altivelis*), while the great majority of species in the south and southeast Asian trade is exclusively wild-caught. CBA or ranching are capture-fishery based and need management.

It is difficult to know the relative contribution of CBA versus HBA in the live fish trade but approximately 50% of groupers, by weight, are currently estimated

to come from each of these two production methods, with a rapidly increasing proportion of fish coming from hatcheries (Fig. 3). Nonetheless, the high value of wild fish and the greater diversity of wild-sourced species are expected to sustain interest in wild sourcing even if fish populations decline. This is partly because consumers like a choice of different species and may consider wild fish to be more tasty and safer (no chemicals, like antibiotics). It is also because many more fishers catch live fish from the wild relative than culture them. Hence, while mariculture may come to produce an ever larger proportion of the LRFFT, this is unlikely to replace wild capture; both production modes are expected to continue.

The distinction between the two production modes is important because excessive juvenile capture fisheries (for grow out) could readily erode the reproductive capacity of species since juveniles removed from the wild cannot reproduce. CBA is a growing challenge for the LRFT because, as adult size fish decline in number (see below) juveniles are increasingly retained or sought

by fishers, and grown out for marketing. In Malaysia, Indonesia and the Philippines the practice of grow-out of wild-caught juveniles to supply the LRFFT is extensive and growing. In the Philippines, for example, 60-80% of the catch of *P. leopardus* is as juveniles (Palla 2012, John Pontillas, unpubl. doc.; PCSD 2019) which are grown to market size in captivity (although there is a minimum size in place-Table 2). On the other hand, grow-out is not practiced in the Maldives and Australia where juveniles are protected from capture by minimum size limits. There is a clearly a need to evaluate the sustainability of CBA within the LRFT (see Lovatelli and Holthus, 2008).

Countries that export dead reef fish

Questionnaires and other feedback returned from 20 ICRI member countries regarding dead reef fish trade showed that 5 do not export reef fish at all (Palau, Colombia, Bermuda, French Polynesia and New Caledonia) for commercial use. Countries that do variously export dead/chilled fish (but not live) are Egypt, Caribbean Netherlands, Belize and Seychelles (deep reef species). Countries exporting both dead and live reef fish are Myanmar, Thailand, Indonesia, the Philippines, Malaysia, Maldives and Vietnam. Chilled/dead fish exports were not reported for Japan or Sri Lanka and not conducted by Australia. Exports of chilled fish went to a larger number of countries than live fish, variously to Taiwan, Hong Kong, Peninsular Malaysia and China, Japan, Vietnam, Caribbean, Saudi Arabia, Jordan, USA, UK, Germany, Mauritius, Mauritius Reunion and Thailand.

Few data were available on chilled/dead reef fish exports with relatively low volumes noted in most cases for which information was available. Export volumes ranged from tens (Egypt, Netherlands Caribbean) to a few hundred tonnes (Belize), to hundreds (Maldives, Malaysia), several thousand tonnes in 2015-2019 for the Philippines (groupers only) and 2015-2019 for Indonesia (groupers only). Data on grouper exports to FAO are also very low and appear to be largely under-reported, with the Maldives being a noteworthy exception (ICRI questionnaires; Sadovy de Mitcheson and Yin 2015; Khasanah et al. 2020).

Export value data were particularly sparse. Several million dollars each annually were indicated for Thailand, Malaysia and Maldives and up to 14.3 million (in 2018) from the Philippines. However, overall, documentation in export trade value of dead/chilled reef fishes was not widely available suggesting that this is not well understood.

The main species involved in chilled reef fish exports include a range of species of groupers, snappers (some deepwater species), parrotfishes and several other families such as jacks, grunts and mackerel. Invertebrates were also noted, including sea cucumber, chiton squilla and octopus. Lobster exports, in particular were noted to be increasing. Examples of chilled groupers from the region on sale in Hong Kong are shown in Fig. 10: labelling is improving and sources may be indicated along with species names.

Reported gears used to take dead/chilled fish include hook and line and nets, spears and fish traps with some use of destructive gears such as cyanide and fish bombing noted by Indonesia, Philippines and Malaysia, as well as concerns about overfishing. While little information is available on the population status of most exploited reef fish species, some protection of threatened species and various management measures are in place. However, enforcement is variable and inspection or oversight of exports is, in general, limited.

Management regulations vary widely across countries, ranging from gear and seasonal controls, no fishing of parrotfish or threatened species, minimum capture and mesh sizes, no live export, and some protection of spawning aggregations of threatened species. The CITES listing for *C. undulatus* appears to be generally well-applied with the species only legally exported by Indonesia under export quotas, although ranched and

wild fish cannot be distinguished which is a serious implementation challenge. Responses reflected the need for more resources to enforce regulations and to assess fisheries, with shortfalls identified in manpower and funding and the need for training of officers, for example in species recognition.



Figure 10. Chilled frozen whole fish and fillets in Hong Kong supermarkets in 2019/20. Right-parrotfish, red snapper and grouper fillets from Indonesia. Centre-grouper fillets marked origin China. Left – whole groupers chilled (box length 15 cm) marked 'Origin China' but likely imported to China and reexported. Other frozen reef fish observed in Hong Kong 2020 were groupers labelled from Vietnam.

International and regional, binding and voluntary, instruments relevant to the LRFFT

Multiple international commitments, agreements and instruments include elements that are variously relevant to the conduct of the LRFFT (Table 3, 4) and are associated with most or all of the countries exporting reef fish for food. Some are binding and others are voluntary. Collectively these address; destructive fishing, IUU fishing and control and conduct of fishing vessels, sustainable fisheries of and trade in renewable natural resources, marine protected areas, equity and small-scale fisheries, poverty alleviation, food security, small

island developing states interests, threatened species, reef ecosystem health and biodiversity.

Important binding examples are Convention on Biological Diversity (CBD) (especially sustainable development goals [SDGs] 12 and 14), several 2016 United National Environment Programme (UNEP) resolutions, Convention on International Trade in Endangered Species of Flora and Fauna (CITES), and United Nations Convention on the Law of the Sea (UNCLOS), among others (Table 3).

Important voluntary agreements or commitments, many of which cover conservation/management of living resources, regional data gathering and collaboration, poverty alleviation, marine ecosystem management, traceability and biodiversity preservation, include Coral Triangle Initiative-Coral Reefs Fisheries (CTI-CFF) and many under the Southeast Asian Fisheries Development Center (SEAFDEC), Association of Southeast Asian Nations (ASEAN), Asia-Pacific Fishery Commission (APFIC) and Asia-Pacific Economic Cooperation (APEC) (Table 4).

Overall, few of these instruments and agreements have been advanced in relation to coral reef fisheries in general, and for the LRFFT in particular, despite the fact that many countries that export their reef fish are signatories or partners to many of the agreements. This is perhaps surprising considering the binding nature of several commitments (Table 3), some of which date back decades, and their importance for fisheries in the region. The need for governments to act is growing stronger given that exploitation rates and impacts are intensifying in many areas around coral reefs, including for reef fishes, and particularly in Asia.

For example, as highlighted by questionnaire responses, most coral reef fisheries are not regularly monitored, little is known of the economics of the LRFFT from the perspective of fisher communities, very few stock assessments have been carried out, and transboundary discussions do not appear to apply to reef species despite the fact that many are transboundary in nature (pelagic egg or larval phase). No coral reef fish (other than the CITES-listed *Cheilinus undulatus*) is protected despite several groupers considered to be globally threatened, according to the IUCN Red List (i.e. *E. polyphkadion*, *E. fuscoguttatus*, *P. areolatus*).

A particularly important commitment in SE Asia is the CTI-CFF to pursue national, intergovernmental and regional actions for sustainable LRFFT in the region which is well suited to addressing several important issues in the LRFFT. Targets include the need for "more effective management and more sustainable trade in live reef fish

and reef-based ornamentals", and include two priority actions. The aim is to develop a collaborative work programme on the management of and international trade in coral reef-based fish and ornamentals and to establish an informal CTI-CFF Forum on management of and international trade in coral-reef based organisms. Some of the work proposed includes the establishment of Marine Protected Areas (MPAs) that include fish refugia and spawning aggregation areas and other trans-boundary ecosystems that may be included in the Coral Triangle Marine Protected Area System. A second priority action is to develop an Accreditation System that includes incentives and disincentives designed to encourage LRFF suppliers/traders to follow sustainable and fair trade practices, involve independent bodies to monitor and check LRFF exports, complement the government's regulatory system, and designate export hubs for shipment of LRFF to simplify trade and streamline regulation.

ISSUE	UNCLOS (1994)	UN-PSMA (2001)	UNEP RESOLUTIONS (2016)	WTO (1995)	CBD (1993); esp. SDGs 12 and 14	CITES (1975)
Conservation of living resources	X				X	X
Management of fish stocks	X					
Sustainable use/ consumption of fisheries resources	X		X	Allows for safeguarding exhaustible natural resources	X	X
Enforcement of laws/regulations	X					
Science; catch and effort data	X				X	
Addressing IUU vessels		X				
Address illegal trade in wildlife and its products			x			
Regional and national data collection/sharing	X				X	
Biodiversity preservation			X		X	X
Poverty eradication/ human well-being (esp. developing countries)			X		X	
Marine ecosystem management (includes coral reefs)			X	Allows for environmental protection		
Equitable use (resource and/or market access)				X	X	
Avoid transboundary harm					X	
Collaboration/ cooperation between source and destination countries	X				X	
MPAs/spatial protection	X		X		X	

Table 3: Selected issues relevant to the LRFFT in global binding instruments and accords associated with most live reef fish exporting countries.

ISSUE RELEVANT TO THE LRFFT	APFIC (FAO) ¹	APEC ²	FAO (COC + IUU) ³	CTI-CFF ⁴	SEAFDEC ⁵	ASEAN ⁶
Conservation of living resources	X	X	X		X	
Management of fish stocks/natural resources	X		X		X	X
Sustainable use/ consumption of fisheries resources (proper utilization)	X	X	X		X	X
Enforcement of laws/regulations			X		X	
Catch and effort data collection/ stock assessment			X		X	
Addressing IUU fishing		Ratification of PMSA	X			X
Address illegal trade in wildlife and its products		X				
Regional and national data collection/sharing	X	X	X		X	X
Biodiversity preservation (includes threatened species)		X	X		X	
Poverty eradication/ alleviation/ human well-being (esp. developing countries) inc. food security		X	X		X	X
Marine ecosystem management/ protection (include coral reefs and ecosystem approach to management)		X	X		Specifically includes LRFF	X
Equitable use in source countries (resource and/or market access)	X	x			X	X
Threatened reef species						

ISSUE RELEVANT TO THE LRFFT	APFIC (FAO) ¹	APEC ²	FAO (COC + IUU) ³	CTI-CFF ⁴	SEAFDEC ⁵	ASEAN ⁶
Collaboration/ cooperation between governments	X	X	X		x	X
Research and development	X	X	X			
Training and capacity building	X	X	X		X	X
Partnering with others (e.g. working groups, international organizations, private sector)	X	X				
MPAs/spatial protection		X	X		X	
Traceability/ Certification		X			X	X
Promote resilience, for example considering climate change					X	X

Table 4. Selected issues relevant to the LRFFT in global and regional voluntary agreements associated with most live reef fish exporting countries (key website links are given below table).

¹ - <http://www.fao.org/apfic/background/about-asia-pacific-fishery-commission/function-apfic/en/>

² - <https://www.apec.org/Groups/SOM-Steering-Committee-on-Economic-and-Technical-Cooperation/Working-Groups/Ocean-and-Fisheries>
- https://www.apec.org/Meeting-Papers/Annual-Ministerial-Meetings/2015/2015_amm/annexb

³ - <http://www.fao.org/3/v9878e/v9878e00.htm>
- <http://www.fao.org/3/a-y1224e.pdf>

⁴ - [http://www.coraltriangleinitiative.org/sites/default/files/resources/15_Managing%20the%20Live%20Reef%20Fish%20Trade%20in%20Sabah%20\(factsheet\).pdf](http://www.coraltriangleinitiative.org/sites/default/files/resources/15_Managing%20the%20Live%20Reef%20Fish%20Trade%20in%20Sabah%20(factsheet).pdf)

- <https://d2ouvy59p0dg6k.cloudfront.net/downloads/towardsustainablelrfftworkshopcoraltriangle2009.pdf>

(see also: related WWF Workshop)

- [http://www.coraltriangleinitiative.org/sites/default/files/resources/10.%20Attachment%2010.4%20\(CTI-CFF%20SEAFDEC\).pdf](http://www.coraltriangleinitiative.org/sites/default/files/resources/10.%20Attachment%2010.4%20(CTI-CFF%20SEAFDEC).pdf)

⁵ - <http://www.seafdec.org/download/report-of-45th-meeting-of-seafdec-council/>

- <http://www.seafdec.org/strategies/>.

⁶ - <http://aseanregionalforum.asean.org/wp-content/uploads/2019/01/ARF-Statement-on-Cooperation-to-Prevent-Deter-and-Eliminate-Illegal-Unreported-and-Unregulated-Fishing-Manila-the-Philippines-7-August-2017.pdf>

- <https://asean.org/wp-content/uploads/2016/10/Strategic-Plan-of-Action-on-ASEAN-Cooperation-in-Fisheries-2016-2020.pdf>

SUMMARY

Based on questionnaires and responses from 20 ICRI country representatives, selected recent literature and reports, government data and a review and consideration of relevant instruments and agreements, 10 major issues are identified (Table 5) and 7 key recommendations are made. Not given in order of priority but in combination these, collectively, could sustain the LRFF trade and the fisheries they exploit, bring greater benefits to source countries, and help to improve stewardship of coral reef fisheries and coral reef ecosystems.

Seven recommendations for action at national and regional levels

- **Improve government understanding, oversight and control of coral reef fisheries and trade to within biologically sustainable levels. A Coral Reef Fishery Management Plan could focus primarily on longer-term benefits of fishery resources to coastal fisher communities, for food and livelihoods.** This involves surveys/stock assessments of key species, understanding how the trade chains work and the values, volumes and species of fish involved. Management should be driven primarily by expert government staff and academics. A Coral Reef Fishery Management Plan for reef species should be developed and limit take of threatened species if there is no management plan. Training of customs/quarantine/enforcement staff in species identification to ensure correct reporting/documentation by species and value is needed.
- **Establish clear operational, regulatory and administrative distinctions between mariculture and capture fisheries, in terms of objectives and management. From both operational and developmental perspectives, the distinction is necessary to encourage a move towards separating hatchery-based production from wild fisheries, which can be managed.** Currently there is a confusing 'hybrid' system that continues to contribute to overfishing through the wild-capture of juveniles for grow-out. Hatchery production should be operated according to established codes of good practice, to minimize pollution and reduce the use of fish-based feed in diets. The capture of juveniles for grow-out should be entirely phased out, unless this is part of a managed fishery under a Coral Reef Fishery

Management Plan (see first bullet). A management plan for 'ranching' Napoleon fish is needed (under CITES) and labelling is needed to distinguish wild-caught Napoleons from 'ranching' fish.

- **Reduce/eliminate illegal fishing, trade and seafood fraud by better monitoring and controlling exports conducted at airports and particularly on foreign vessels, and increasing oversight of trade practices.** Illegal fishing and trade undermine management actions and incentives and can damage resources. Illegal fishing continues in the use of cyanide, and exports may not be legal (e.g. Napoleons reported as groupers and without permits; declared export value per metric ton far below actual worth). Stronger oversight could involve more detailed registering of vessels (requiring owner name, vessel IMO/MMSI identifier numbers) to improve tracking of and accountability of vessels. Some systems may already be in place (such as export monitoring for quarantine) or VMS tracking at the national level but may need tightening and adapting. Regional collaborations under present agreements, and the wider application of vessel tracking technologies could assist in this goal. PSMA measures could be tightened with special attention to transshipments. Tighten export control of Napoleon fish to reduce illegal trade in wild fish and mark 'ranching' fish to distinguish that source from wild-sourced fish. Efforts to improve reporting of export values and volumes are needed. Consider a ban on export of wild-caught Napoleon since cyanide is heavily used for its capture and its populations are generally not recovering.

- **Ensure protection of biodiversity by conserving threatened species and safeguard spawning biomass of key target species by reducing juvenile catch (through imposing minimum sizes for catch and export) and managing juvenile fisheries. Spawning aggregation management will also be necessary for some species.** Develop regulations, such as minimum size of capture/export, for reef fishes to protect juveniles or, alternatively, manage juvenile fisheries for grow-out as CBA. Spawning aggregations either should be protected from fishing or managed. Species that are considered threatened call for conservation actions, while greater protection is needed for *C. undulatus* which is illegally exported in some cases and is generally in poor condition in Indonesia, the only legal exporter; condition may be poor in the Philippines.
- **Develop certification and/or traceability systems, analyze trade chains, improve oversight of exporters of live fish and consider introducing an export duty for luxury seafood, for sustainability considerations.** The growth in certification/eco-labelling systems or improved traceability and an increasing interest from the retail sector in Hong Kong to source seafood sustainably is an opportunity that should encourage improving traceability and transparency in trade chains. In this respect live reef fish is proving to be a major challenge because the trade chain is, in places, too complex/opaque to follow specific fish from reef to restaurant. Closer connections could be established between producers in source countries and retailers along transparent trade chains to increase accountability and develop high-value branded products that countries can take pride in (e.g. line-caught tuna in Maldives). An export duty/tariff could be charged for luxury seafood (mainland China has a tariff for import of luxury seafood). A value chain analysis could highlight opportunities to improve income for fishers.
- **Governments to honour and follow through on existing agreements and commitments made both regionally and internationally, such as those under CBD, CITES, SEAFDEC-CTI, among many others.** Collaboration, communication and cooperation to be increased within the region to advance work towards sustainable reef fisheries as identified in multiple forums and commitments and according to existing obligations. In particular, advance the SEAFDEC-CTI 2015 MOU planning.
- **Reduce heavy dependence on single/limited choice of export markets.** The growth in chilled fish trade, which is now equaling or surpassing live fish in some LRFF exporters, should help diversification and reduce controls by, and risks from having, a single major export market for reef fish. Currently, reliance on China as the major export market for reef fish can limit source country's ability to control prices and trade practices, and brings vulnerabilities to the trade chain from events such as the recent coronavirus outbreak during which much LRFF closed down.

ACKNOWLEDGEMENTS

Many people have contributed to this study and report. I am particularly grateful to Jaya Wijaya and Hanif San Emy Khonifah of the Ministry of Marine Affairs and Fisheries, Firdaus Agung of the Directorate General for Marine Spatial Management, Heru Perumu of UD. Pulau Mas, Dr. Miftah Chazanah, Hasanuddin University and Francis Staub of ICRI. Thanks also to Sophie LeClue and ADM Capital Foundation (Hong Kong) for access to information. I am also particularly grateful to all who responded to the questionnaires. I recognize and gratefully acknowledge the former fishery Minister of the Government of Indonesia, Susi Pudjiastuti for initiating this project and the Government of Sweden for funding. Bloom Association and Stanley Shea assisted with artwork, photo and data. Rachel Wong assisted with data compilation. Graphic design by Piknetart. Photos by author unless indicated otherwise.

Questionnaires and other information were provided by:
Australia: Darren Cameron, Great Barrier Reef Marine Park Authority and Tom Roberts, Queensland Fisheries.
Maldives: Ahmed Najeeb and Aishath Sarah Hashim, Maldives Marine Research Institute; Ministry of Fisheries, Marine Resources and Agriculture.
Malaysia: Lawrence Kissol, Department of Fisheries Sabah, and CITES manager.
Philippines: Mavic Matillano WWF, John Francisco Pontillas, Palawan Council for Sustainable Development, Acer Joseph Cubangbang, Bureau of Fisheries and Aquatic Resources.
Indonesia: Machmud, Ministry of Marine Affairs and Fisheries (MMAF), Hanif San EmyKhonifah, Kementrian Kelautandan Perikanan (KKP).
Thailand: Thamasak Yeemin and Makamas SutthacheepRamkhamhaeng University.
Palau: Yimnang Golbu, Palau International Coral Reef Centre.
Colombia: Andrea Ramirez Martinez, Ministry of Environment and Sustainable Development; National Aquaculture and Fisheries.

Egypt: Tamer Monir Attalla, Red Sea Protectorates, Natural Conservation Sector- Egyptian Environmental Affairs Agency- Ministry of Environment.
Caribbean Netherlands: Paul Hoetjes, Ministry of Agriculture, Nature and Food Quality National Office for the Caribbean Netherlands.
Bermuda: Joanna Pitt, Bermuda government.
Belize: Vivian Ramnarace, Kenneth Esquivel, Belize fisheries department.
French Polynesia: Serge Planes, CNRS - EPHE – UPVD (CRIOBE).
New Caledonia: Anne-Claire Goarant, Gouvernement de la Nouvelle-Calédonie.
Seychelles: Kevin Moumou and Rosabella Mangroo.
Myanmar: Cherry Aung, Marine Science Department, Patheingyi University.

Table 5: Ten major issues, situations and challenges identified, and opportunities and possible solutions for national-level action by major source countries based on responses and comments on questionnaires returned by the countries that export live reef fish for food and published literature and incorporating chilled/fresh fish components.

N°	ISSUE	SITUATIONS AND CHALLENGES	OPPORTUNITIES
1a.	Overfished status of reef fish fisheries including some that supply LRFT urgently need fishery management by capture fishery departments	<ul style="list-style-type: none"> - Overfishing indicated in most countries as suggested by: <ul style="list-style-type: none"> • Declining sizes • Declining catches and catch rates • Fishers moving further and fishing longer to maintain catches (increased costs of fishing, time away from community etc.). • Many fish caught/exported below size of sexual maturation so cannot help replenish populations; this situation intensifies and ranching increases as fisheries decline (e.g. Philippines and <i>P. leopardus</i>). - Juveniles comprise a large part of fisheries reported in Philippines, Indonesia and Malaysia. - Spawning aggregations targeted in some countries. - Loss of large predators and keystone species could negatively affect coral reef ecosystems - Reef fisheries rarely managed in region to sustain it for fishers -As pressures to exploit/export increase, and new trade routes/markets are established, other resources are targeted 	<ul style="list-style-type: none"> - Exporting countries can identify/track fishery status by regular and standardized monitoring, using simple methods to detect signs of overfishing which prompt management response. - Monitoring should take a holistic approach as new markets develop for more reef species (especially for export), e.g. fish swim bladder, and a range of chilled fresh fish including many herbivores which are important for reef ecosystem health. - Develop/implement national Fishery Management Plans for reef fishes to sustain the fisheries and safeguard the local livelihoods these support and the reef ecosystem. Focus on live reef fish/targeted species is an initially excellent opportunity to improve reef fishing practices; long term focus should be broader. - Protect reproductive capacity by reduction of catch/export of wild-caught juveniles and protection of spawning aggregations. This could involve quotas for juvenile capture or no ranching at all (see Issue No. 9). - Introduce species-specific size limits (catch and export) for major species to protect juveniles and, for some species, the largest breeders (highest fecundity). - Capture Fishery Departments need to include reef fisheries more deeply within their purview and to recognize possible transboundary nature of some stocks. - Particular management attention should be paid to the more valuable wild-caught species such as <i>P. leopardus</i>, <i>E. polyphemkadion</i>, etc. - Many methods and techniques to monitor fisheries readily available; most important is the commitment to apply them and to identify survey objectives.

N°	ISSUE	SITUATIONS AND CHALLENGES	OPPORTUNITIES
1b.	Several important traded species are threatened	<ul style="list-style-type: none"> - Several common groupers in trade are listed as threatened globally according to IUCN Red List (<i>P. areolatus</i>, <i>E. polyphekadion</i>, <i>E. fuscoguttatus</i>) and will decline further without management. - <i>Cheilinus undulatus</i> (CITES App II) is legally exported by Indonesia. Wild (W Code) fish have a scientifically based export quota but ranched (R code) fish do not. Since it is not possible to distinguish ranched from wild fish at import enforcement is seriously undermined. - <i>C. undulatus</i> is severely depleted in Indonesia with very few large adults and very low abundance. - The Philippines allows illegal exports of <i>Cheilinus undulatus</i>. 	<ul style="list-style-type: none"> - Conservation/management measures needed for all wild-caught species/stocks listed as threatened on the IUCN Red List. - Exports of 'ranched' <i>Cheilinus undulatus</i> from Indonesia should be at sustainable levels as scientifically demonstrated. - For CITES obligations, need to tag 'R' coded <i>C. undulatus</i> exported to distinguish them from 'W' coded exports. Alternatively could ban 'W' coded exports to allow for population recovery and only export 'ranched' fish which would not, therefore, need to be tagged to distinguish them. - The Philippines needs a sustainable export quota to export <i>Cheilinus undulatus</i> legally. - Fisheries Departments need to work with Conservation-related government Departments to coordinate responses for threatened species. - Consider a CITES App II listing for <i>E. polyphekadion</i> - Implement existing NPOAs for <i>C. undulatus</i>.

N°	ISSUE	SITUATIONS AND CHALLENGES	OPPORTUNITIES
2.	Limited understanding of volumes and values exported of live fish and values to fisher communities and source countries	<ul style="list-style-type: none"> - Only 6 countries export significant volumes of live wild-caught fish (Thailand, Indonesia, Philippines, Maldives, Australia, Malaysia) with Vietnam, Sri Lanka, Myanmar and Japan exporting small quantities. Reef fisheries in these countries, however, with few exceptions such as for <i>C. undulatus</i> (CITES-listed) and in Australia, are poorly understood and little managed. - Due to poor understanding of volumes and values of the trade, their economic and biological importance are not well recognized or widely appreciated. For example wild caught fish exports on vessels leaving Indonesia are not documented. - Major consumer markets (mainly Hong Kong and China) are not much interested in sustainable consumption practices and hence unlikely to drive demand for such products in the near future (as for example EU requirements for some fish species). Hence exporting countries need to be proactive in safeguarding their own resources. - Priority to safeguard fisheries for fishing communities is low while most emphasis appears to be on exports for economic development. 	<ul style="list-style-type: none"> - Can improve documentation of values and volumes exported and seek ways for more of the value of the LRFT to accrue to source countries. Special attention should be paid to exports on foreign vessels. - Could conduct socio-economic analysis of the fishery and comparisons with other major fisheries to highlight the importance of coral reef ecosystem productivity to fishers. - The relatively small number of trading partners and largely regional focus of the LRFT provide opportunities to use existing regional instruments and existing multi-lateral collaborations to help control the trade for sustainability by source countries (see Tables 3 & 4). For example, these could help to improve traceability and transparency of trade networks. - Countries exporting reef fish have the main responsibility to ensure sustainable practices to sustain their reef fisheries for food security and those fishing communities that rely and will continue to rely heavily on them. - Australia's approaches to management of <i>P. leopardus</i> and Indonesia's management of 'W' code (but not 'R' Code) <i>C. undulatus</i> could be referenced as management models - Several Codes of Good Practice are already available for application to wild-capture fisheries and mariculture, including for the LRFT
3. & 4.	Some fishing gear(s)/ capture methods for live fish are damaging to coral reefs	<ul style="list-style-type: none"> - Big concern is the use of cyanide to catch live fish (SE Asia). Some concern about fish traps damaging coral and taking high bycatch; compressors can more quickly drive overfishing and access to deeper refugia; bombing is sometimes use to get dead fish to feed consolidated live fish prior to export. - Cyanide can kill living coral and also makes overfishing more easy (because it is very efficient); it can also kill a lot of other unwanted bycatch during fishing operations. 	<ul style="list-style-type: none"> - Need to ensure enforcement of laws prohibiting cyanide fishing, bombing and use of compressors and other means that damage coral reefs. - Could prohibit sale or trade in species largely caught using destructive gears.

N°	ISSUE	SITUATIONS AND CHALLENGES	OPPORTUNITIES
5.	Large number of fishers (tens of thousands) benefit from income from LRFFT/reef fisheries but have little voice or power	<ul style="list-style-type: none"> - Many fishers gain benefits from reef fishes (high price for live ones; food security; increasing interest in dead fish/invertebrates exports) but this importance and the incomes are not well documented - Fishers generally have poor control over the prices they get for the live fish they sell; due to poor bargaining power or insufficient knowledge of market prices. - Healthy coral reef ecosystems and managed fisheries will provide income into the long-term but economic value to fishers is poorly understood - Short-term gains with intensive fisheries such as the high value LRFFT could lead to long-term pain if fisheries and ecosystem become degraded. 	<ul style="list-style-type: none"> - Conduct value chain analyses to examine money flows and seek ways to increase income to fishers and source countries - Could seek higher prices for fishers and retain more value in source countries. One way would be to form fisher cooperatives and make pricing widely available to improve fisher bargaining power. Government support would be needed. - Explore certification/traceability options to serve wealthy markets with certified fish with potentially higher prices. Would call for more direct linkages between producers and retailers (like 'fair-trade' practices). - Need to ensure that overfishing in the live fish trade does not otherwise compromise livelihoods and food security into the future (see also Issue 1). - The retail value of dead reef fish is also increasing with a wider range of species being taken. It is not apparent that these prices are trickling down to fishers.
6.	Small number of major or powerful exporter/traders can influence policy or policy-makers	<ul style="list-style-type: none"> - Some major trader/exporters are politically and economically powerful. This could enable disproportionate influence on regulations by the trade which already has strong control over pricing. - A disproportionately high proportion of the overall income from live fish goes to exporter/traders and importers which is a heavy driver for the trade (see also No. 7 below) and from illegal activities. 	<ul style="list-style-type: none"> - The small number of exporters provides an opportunity for better oversight through management, licensing and certification/traceability to improve control and monitoring of their activities. - (Higher) Export tariffs should be charged to ensure more economic benefits accrue to source countries and to help fund enforcement of regulations. - The regulation of reef fish fisheries should be driven by good science and priority given to sustaining and improving fisher income rather than accommodating influential major traders.

7.	Generally low capacity, priority or incentive/interest to manage reef fisheries and coral reef ecosystems among reef fish exporting countries	<ul style="list-style-type: none"> - Damage to ecosystems in one country can harm neighbouring countries' resources in the region. - Multiple international and regional commitments (both binding and voluntary – see text) have been made that are relevant to reef fish fisheries and trade and coral ecosystems-little action in last decade. - Sales in live/chilled/fresh reef fish trade is increasing, including for export, which will further compromise reef fisheries - Insufficient fully protected MPAs have been implemented (in terms of total area closed to fishing) - Few countries have government personnel who specialize in the LRFFT- hence official capacity for research and developing regulations is low. 	<ul style="list-style-type: none"> - Source countries and regional forums need to act on/honour commitments on LRFFT made over many years. These provide clear and useful guidance and approaches. Of particular importance is the SEAFDEC-CTI Memorandum of Understanding 2015 (Table 4). - Principles of biological sustainability should be applied by governments which need to prioritize source country fisher interests, for both short and long term, and condition of coral reef ecosystems. - Commitments on transboundary reef fish stocks are important at the regional level and hence multi-national cooperation among source countries is needed. - Management (including monitoring) of reef fisheries could be improved with dedicated expert staff located in fisheries departments - More MPAs could be designated in key habitats. - Training could be provided to increase capacity among fishery and customs officials, including on species identification.
8.	Considerable illegal, unregulated and unmonitored trade	<ul style="list-style-type: none"> - Poor trader traceability/accountability regarding reporting - Threatened species exported without controls, including CITES listed <i>C. undulatus</i> - Some exporters (e.g. Indonesia, Malaysia and Maldives) evidently underreport export values (price per tonne declaration) depriving source countries of revenue. Such practice obscures the economic importance of the LRFFT to source countries (see Fig. 7). - Some exporters may mis-declare species traded (e.g. (1) claiming cheaper species like <i>E. coioides</i> to reduce declared shipment value; (2) mix <i>C. undulatus</i> in with 'mixed grouper' shipments) - Some countries have little record of live food fish exports (e.g. Myanmar, Japan, Sri Lanka) or only incomplete understanding (e.g Philippines; <i>P. leopardus</i> trade only) - Exports by sea involving foreign vessels (e.g. some Hong Kong registered vessels in Indonesia) regularly carry out illegal exports of wild-caught fish including <i>C. undulatus</i>, and are largely uncontrolled. 	<ul style="list-style-type: none"> - Tighten controls at points of export and improve inspections of export consignments (air and sea) and reporting of species, volumes and values. - Increase accountability and transparency in trade and money flows. - License and limit the number of exporters and collect license fees to support / management. License conditions to include regular reporting of species, values, volumes and destinations. License could be withdrawn or companies blacklisted for violations. - Stop all threatened species export (CITES and IUCN Red Listed), unless their fishery/trade is assessed and effectively managed/controlled. - Need to train inspectors to identify species and to know their value to improve export monitoring and ensure that export species and values are being properly reported. - Significantly improve oversight and monitoring of foreign vessel movements within and out of source countries; penalize transshipment. - Improve documentation generally of reef fish fisheries in terms of volumes by main species and focus, perhaps, on important groups such as carnivores or herbivores and on high value species. -Need to increase transparency and traceability. Can consider accreditation and certification.

N°	ISSUE	SITUATIONS AND CHALLENGES	OPPORTUNITIES
9.	Definitions of 'mariculture' and 'ranching' confusing and sometimes misleading. Some regulations can be confusing.	<ul style="list-style-type: none"> - Some regulations can be confusing or inconsistent leading to enforcement problems, e.g. no live wild-caught fish export is permitted from the Philippines but thousands of tonnes are exported including <i>C. undulatus</i> with no permits. - Definition of 'mariculture' is outdated in some countries and currently includes both wild-caught and hatchery-produced fish, blurring the line between the two. - This confusing distinction means that wild-caught fish can be considered cultured (or 'ranching') if they are caught and then used for grow-out; this practice can lead to overfishing but is not treated as a fishery (CBA). 	<ul style="list-style-type: none"> - Clarify, simplify and align regulations for well-indicated objectives. - Most species in the LRFT by volume is of wild-caught fish and hence these should be clearly distinguished from hatchery-produced fish in respect of management. - Use of the FAO distinction between Hatchery-based Aquaculture (HBA) and Capture-Based Aquaculture (CBA) (i.e. i.e. involving wild caught juvenile growout) should be applied for clarity, with the latter calling for fishery management and monitoring (Lovatelli and Holthus 2008). - Different departments may need to manage different components of production; for example fisheries for wild-capture, including CBA and ranching and mariculture for HBA. - Distinguishing CBA and HBA will be increasingly important as HBA is further actively developed. HBA should be treated as an alternative and distinct mode of production.
10.	Poor political will for regulation and enforcement at national or regional levels of coral reef associated fisheries and safeguard ecosystems, fisher well-being and biodiversity	<ul style="list-style-type: none"> - A major problem identified is the lack of political will to manage reef ecosystems while prioritizing fisher benefits and good scientific practice. - While some source countries have many relevant regulations and some have very few; enforcement is poor with Australia an exception. - Enforcement capacity is widely recognized as a major challenge 	<ul style="list-style-type: none"> - If the LRFFT value were more widely acknowledged for its value and tariffs and income to source countries were greater, this could help increase commitment and funding to enforcement. Parallels could be found in tuna fisheries (for guidance). - A focus on fisher benefits, poverty alleviation access to markets, other economic drivers and international reputation should help to improve commitment to management. - A wider acknowledgement of vested interests and rooting out corruption could reduce resistance to management. - Collaborative (multi-lateral) management is important to improve effectiveness of certain measures (such as control of illegal vessels) and needed due to transboundary nature of many stocks.

REFERENCES

- AFCD. Report on Live Marine Fish Trade. Liaison & Special Duties Section, Fisheries Supporting Services Division: 2009-2018 issued annual (includes CSD data summaries).
- BFAR 2017 Bureau of Fisheries and Aquatic Resources - National Fisheries Research and Development Institute. 2017. Napoleon Wrasse (*Cheilinus undulatus*) "Mameng" Philippine Status Report and National Plan of Action 2017-2022, Bureau of Fisheries and Aquatic Resources - National Fisheries Research and Development Institute - Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety. Quezon City, Philippines. 43 pp. Editors: Mudjekeewis Santos Francisco Torres Jr. Victor Marius Tumilba Franca Sprong
- Bellwood, D.R., T.P. Hughes, C. Folke and M. Nystrom. 2004. Confronting the coral reef crisis. Nature 429: 827–833. Bloom Association, 2017. Live reef food fish wet market survey live reef food fish guide. Final Report Sept. 2017 pp. 21. <https://www.admcf.org/research-reports/live-reef-food-fish-wet-market-report-survey/>
- Boaden, A.E. and M.J. Kingsford. 2015. Predators drive community structure in coral reef fish assemblages. Ecosphere 6: 1–33
- Craig, M.T., Y.J. Sadovy de Mitcheson and P.C. Heemstra. 2011. Groupers of the World: A Field and Market Guide. Grahamstown: National Inquiry Services Center (NISC) Ltd.
- Dulvy, N.K., R.P. Freckleton and N.V.C. Polunin. 2004. Coral reef cascades and the indirect effects of predator removal by exploitation. Ecology Letters 7: 410–416.
- Fabinyi, M., and Dalabajan, D. 2011. Policy and practice in the live reef fish for food trade: A case study from Palawan, Philippines. Marine Policy Volume 35, Issue 3: 371–378
- Frisch, A., Cameron, D. S., Pratchett, M. S., Williamson, D. H., Williams, A. J., Reynolds, A. D., Hoey, A. S., Rizzari, J. R., Evans L., Kerrigan, B., Muldoon G., Welch D. J. and Hobbs, J-P A., 2016. Key aspects of the biology, fisheries and management of Coral grouper. Rev Fish Biol Fisheries (2016) 26:303–325 DOI 10.1007/s11160-016-9427-0 pp23
- Heithaus, M.R. A. Frid, A.J. Wirsing and B. Worm. 2008. Predicting ecological consequences of marine top predator declines. Trends in Ecology and Evolution 23: 202–210.
- HKCSD data. Hong Kong Government Census and Statistics Department import data 1999-2018
- Hau, C. Y. and Sadovy de Mitcheson, Y. 2019. A facial recognition tool and legislative changes for improved enforcement of the CITES Appendix II listing of the humphead wrasse, *Cheilinus undulatus*. Aquatic Conserv: Mar Freshw Ecosyst DOI: 10.1002/aqc.3199
- Johannes, R.E. & Riepen, M. 1995. Environmental, economic and social implications of the fishery for live coral reef food fish in Asia and the Western Pacific. The Nature Conservancy, Honolulu.
- Jones, R.J. and Hoegh-Guldberg, O. 1999. 'Effects of Cyanide on Coral Photosynthesis: Implications for Identifying the Cause of Coral Bleaching and for Assessing the Environmental Effects of Cyanide Fishing', Marine Ecological Progress Series, vol. 177, pp.83-91.

Khasanah, M., Sadovy de Mitcheson, Y., Kadir, N. N. and Jamaluddin J. 2020. Management of Grouper Export Trade in Indonesia Reviews in Fisheries Science & Aquaculture; 10.1080/23308249.2018.1542420

Khasanah, M., 2019. Sustainable Management of Live Reef Food Fish (Groupers) Trade in Coral Triangle, Eastern Indonesia. PhD Thesis Faculty of Marine Science and Fisheries, Hasanuddin University pp. 132

Koeshendrajana, S., and Hartono, T. T. 2006. Indonesian live reef fish industry: status, problems and possible future direction. Economics and marketing of the live reef fish trade in Asia–Pacific edited by Brian Johnston and Being Yeeting ACIAR Working Paper No. 60 (printed version published in 2006) pp. 74-163
<https://pdfs.semanticscholar.org/aeb2/e10dbf395158e205f0167aeacae9f84d8b7d.pdf>

Klinsukhon, S., 2014. Trading of Live Reef Food Fish from the Southeast Asian Region: Economic Boon or Bane? Volume 12 Number 3:15-19
<http://repository.seafdec.org/bitstream/handle/20.500.12066/947/SP12-3%20live%20reef%20food%20fish.pdf?sequence=1>

Lau, P. and Parry-Jones, R. 1999. The Hong Kong trade in live reef fish for food. WWF-Hong Kong, Traffic East Asia.

Lowe, C. 2002. Who is to blame? Logics of responsibility in the live reef food fish trade in Sulawesi, Indonesia. SPC Live Reef Fish Information Bulletin #10 June 2002 pp. 7-16
<https://spccfpstore1.blob.core.windows.net/digitallibrary-docs/files/1d/1de4ae86453743f4b57f8527a2911573.pdf>

Lovatelli, A. and Holthus, P.F. (eds). 2008. Capture-based aquaculture. Global overview. FAO Fisheries Technical Paper. No. 508. Rome, FAO. 2008. 298 p.
<http://www.fao.org/3/i0254e/i0254e00.htm>

Muldoon, G., Cola, R. and Soede, L.P. 2009. Towards A More Sustainable Live Reef Food Fish Trade In The Coral Triangle: First Regional Workshop. Coral Triangle Support Programme, WWF, p.53.

Mulekom, L., Axelsson, A, Batungbacal, E. P., Baxter, D., Siregar, R., de la Torre, I. and SEAFish for Justice. 2006. Trade and export orientation of fisheries in Southeast Asia: Under-priced export at the expense of domestic food security and local economies. Ocean & Coastal Management 49: 546-561

Palla, H. P. 2012. Seasonality of fecundity and spawning of Leopard Coral Grouper (Serranidae) in Quezon and Taytay, Palawan. Unpublished. Western Philippines University-Puerto Princesa Campus, Puerto Princesa City WWF- Philippines, Puerto Princesa City

PCSD 2019. Palawan Council for Sustainable Development Republic of the Philippines (Republic Act no. 7611). PCSD Resolution no. 19-688 pp 24

Randall, J. E., Head, S. and Sanders, A. P. L. 1978. Food habits of the giant humphead wrasse, *Cheilinus undulatus* (Labridae). Environmental Biology of Fishes 3(2):235-238

Ruttenberg, B.I., S.L. Hamilton, S.M. Walsh, M.K. Donovan, A. Friedlander, E. DeMartini, E. Sale and S.A. Sandin. 2011. Predator-induced demographic shifts in coral reef fish assemblages. PLOS ONE 6(6):e21062.

Sadili, D., Sarmintohadi, I., Ramli, S. R., Suharti, S. R., and Idrus, I. N. 2015. Rencana Aksi Nasional (RAN). Konservasi ikan Napoleon (*Cheilinus undulatus*). Periode I: 2016-2020. Direktorat Konservasi dan Keanekaragaman Hayati Laut. Dir Jen. Penegelolaan Ruang Laut. Kementerian Kelautandan Perikanan.
http://bpslpadang.kkp.go.id/pubs/uploads/files/Rencana_Aksi_Nasional_Konservasi_NAPOLEON.pdf

Sadovy, Y.J., T.J. Donaldson, T.R. Graham, F. McGilvray, G.J. Muldoon, M.J. Phillips, M.A. Rimmer, A. Smith, and B. Yeeting. 2003. The Live Reef Food Fish Trade While Stocks Last. Manila: Asian Development Bank. 147 pp.
<https://www.adb.org/sites/default/files/publication/28455/live-reef-complete.pdf>

Sadovy, Y., Punt, A.E., Cheung, W., Vasconcellos, M. and Suharti, S. 2007. Stock Assessment Approach for the Napoleon fish, *Cheilinus undulatus*, in Indonesia: a tool for quota-setting for data-poor fisheries under CITES Appendix II Non-Detriment Finding requirements. FAO Fisheries Circular. No. 1023 Rome, FAO, 71 p
<http://www.fao.org/3/a-a1237e.pdf>

Sadovy de Mitcheson, Y. and X. Yin. 2015. Cashing in on coral reefs: the implications of exporting reef fishes. pp. 166-179. In: C. Mora (ed.). Ecology of Fishes on Coral Reefs. Cambridge University Press.

Sadovy de Mitcheson, Y., Tam, I., Muldoon, G., le Clue, S., Botsford, E. and Shea, S. 2017. The Trade in Live Reef Food Fish – Going, Going, Gone. Volume 1: Main Report. Parts I, II & III, pp.1-288. ADM Capital Foundation and The University of Hong Kong
<https://www.admcf.org/research-reports/the-live-trade-in-live-reef-food-fish-going-going-gone/>

Sadovy de Mitcheson Y, Suharti S, and Colin PL. 2019. Quantifying the rare: Baselines for the endangered Napoleon Wrasse, *Cheilinus undulatus*, and implications for conservation. Aquatic Conserv: Mar Freshw Ecosyst. 2019;1-17.
<https://doi.org/10.1002/aqc.3124>.

Sadovy de Mitcheson, Y., Linardich, C., Barreiros, J, Ralph, G., Aguilar-Perera, A., Afonso, P., Erisman B., Pollard, D. Fennessy, Bertoncini, A, Nair, R. J. Rhodes, K. Francour, P., Brule, T., Samoily, M., Padovani, B., and Craig. M. 2020. Valuable but vulnerable: over-fishing and under-management continue to threaten groupers so what now? Marine Policy. In Press.
https://drive.google.com/file/d/1Jl_Byf7VWc1v5DVEqclOn_VpRx3dKBh-/view

Sattar, S. A., Najeeb, A., Islam, F., Shidha Afzal M. S., and Wood, E. 2012. Management of the grouper fishery of the Maldives. Proceedings of the 12th International Coral Reef Symposium, Cairns, Australia, 9-13 July 2012 13E Fisheries pp.5
<https://pdfs.semanticscholar.org/ef06/ac962aaf6ad2f64aef3267b401328e3d2bfe.pdf>

Sattar S.A., Wood E., Islam F. and Najeeb A. 2014. Current status of the reef fisheries of Maldives and recommendations for management. Darwin Reef

Fish Project Marine Research Centre/Marine Conservation Society (UK) pp.85

Salao, C., Cola, R., and Matillano, M. 2013. TAYTAY: Taking Charge of a Critical Resource: A case study on the Philippines. USAID Project Number: 486-A-00-08-00042-10
http://www.coraltriangleinitiative.org/sites/default/files/resources/40_Taytay%20Taking%20Charge%20of%20a%20Critical%20Resource_Philippines%20Case%20Study.pdf

Teh, L.S.L., Teh, L.C.L., and Sumaila, U.R. 2013. A Global Estimate of the Number of Coral Reef Fishers. PLoS ONE 8(6): e65397. doi:10.1371/journal.pone.0065397

Thrush, S.F. 1999. Complex role of predators in structuring soft-sediment macrobenthic communities: implications of changes in spatial scale for experimental studies. Australian Journal of Ecology 24: 344-354.

USAID 2013. Activity Report: Live Reef Food Fish Trade Intergovernmental Forum Bangkok, Thailand, January 31 and February 1, 2013 PP 69. US CTI Support Program Document No. 04-USCTI13
http://www.coraltriangleinitiative.org/sites/default/files/resources/LRFFIInter-GovernmentalForum31Jan-1Feb2013FullProceedingsReport_21Feb13_Final_V3.pdf

Walsh, S.M., S.L. Hamilton, B.I. Ruttenberg, M.K. Donovan, and S.A. Sandin. 2012. Fishing top predators indirectly affects condition and reproduction in a reef-fish community. Journal of Fish Biology 80(3): 519-537.

Wu, J. and Sadovy de Mitcheson, Y. 2016. Humphead (Napoleon) Wrasse *Cheilinus undulatus* trade into and through Hong Kong. TRAFFIC. Hong Kong, SAR pp. 42
<https://www.traffic.org/publications/reports/humphead-wrasse-trade-in-hong-kong/>

Yin, X. 2014. Sustainability of Coral Trout, *Plectropomus leopardus*, Fisheries in the Philippines and Indonesia. MPhil. University of Hong Kong. PP130

LIVE REEF FOOD FISH TRADE: UNDERVALUED, OVERFISHED AND OPPORTUNITIES FOR CHANGE

Yvonne SADOVY DE MITCHESON
University of Hong Kong
Science and Conservation of Fish Aggregations
IUCN Groupers and Wrasses Specialist Group