

LITERATURE REVIEW

THE BENEFITS OF WILD CAUGHT ORNAMENTAL AQUATIC ORGANISMS



**Submitted to the
ORNAMENTAL AQUATIC TRADE ASSOCIATION**

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by

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Acronyms Used In This Report

Acronym	Meaning
APHA	Animal and Plant Health Agency, UK
ARC	Animal Reception Centre
AWB	Air waybill
BIS	Department for Business, Innovation and Skills, UK
CBD	Convention on Biological Diversity
cif	Cost, insurance and freight
CIPS	China International Pet Show
CITES	Convention on International Trade in Endangered Species
DAA	Dead after arrival (i.e. deaths which occur during quarantine)
DEFRA	Department for Environment, Food and Rural Affairs (England)
DOA	Dead on arrival
DTI	Department for Trade and Industry (UK)
EMS	Environmental Management System (Queensland, AUS)
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
FHI	Fish Health Inspectorate (UK)
fob	Free on board
FRA	Fish Replenishment Area
GBP	UK pounds sterling
GWG	Goodeid Working Group
HK SAR	Hong Kong Special Administration Region
IBAMA	Brazilian Institute of Environment and Renewable Natural Resources (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis)
IDR	Indonesian Rupiah
INPA	National Institute of Amazonian Research (Instituto Nacional de Pesquisas da Amazônia)
IPCC	International Panel on Climate Change
ISO	International Standards Organisation
LHR	London Heathrow airport
LINI	Yayasan Alam Indonesia Lestari (LINI), Indonesia Nature Foundation
LGW	London Gatwick airport
MAFF	Marine Aquarium Fish Fishery (Queensland), AUS
MPA	Marine Protected Area

MWK	Malawi Kwacha
nei	Not elsewhere indicated – a catchall category used in FAO statistics
NGO	Non-governmental organisation
OIE	World Organisation for Animal Health
PICT	Pacific Island Countries and Territories
PDO	Protected Designation of Origin (a form of Geographical Indication used to protect a product)
QCF	Queensland Coral Fishery, AUS
SAP	Stewardship Action Plan (Queensland, AUS)
SPC	Secretariat of the Pacific Community
UNCTAD	United Nations Conference on Trade and Development
UNESCO	United Nations Educational, Scientific and Cultural Organization
USD	United States Dollar
VAT	Value Added Tax
WATO	The Welfare of Animals (Transport) (England) Order 2006 (and equivalent legislation for Scotland and Northern Ireland)
WTO	World Trade Organisation

Executive Summary

The trade in wild-caught ornamental aquatic organisms provides benefits to many people. There are very strong indications of the importance of the trade in wild-caught ornamental aquatic organisms to remote communities and it can bring environmental benefits by ensuring that communities value and care for the resources on which they rely. One key aspect of the trade is that it brings cash and/or trade benefits to remote areas which can make all the difference between a livelihood being sustainable or not. Too few studies are available to enable the quantification of benefits and there is little published data that would allow anything other than a qualitative assessment of the benefits to be made in most cases. This applies at all levels from the collectors up to the global value of the trade. It is clear that many people rely on the trade for their livelihoods although to put it in perspective, the industry is far smaller than, for example, the food fish industry. The industry is also unusual in that there is no added value in the same sense as, for example the food fish industry where substantial product transformation may take place; what ends up in the hobbyists' aquaria is essentially the same product as was harvested by the collector inasmuch as the product does not undergo substantial transformation. However, the product does undergo a number of processes in the country of origin and at the importer to quarantine the fishes, clean up parasites and so on. They are therefore adapted to life in the aquarium before they go on sale. In this respect, the industry is hard to compare with similar activities that rely on harvesting of wild products as so many of these have to undergo transformation and/or added value before being sold.

Reliable statistics on the trade are also hard to come by and the more a set of statistics is examined, the more anomalies become apparent. There is clearly a need for more consistent reporting of production and trade statistics, and for more studies on the value of trade at all levels. While various estimates are available for the worldwide retail value of the trade, in most cases these appear to be based on guesswork or on the updating of previous estimates, most of which are also based on guesswork. Of particular importance is the impact of rapidly growing markets, such as in the Far East, and their demand for wild-caught fish and the impact of growing internal markets in countries such as India and China. Both are likely to be substantial markets that could provide significant opportunities for countries that export wild-caught ornamentals, however little is currently known about the details of such markets.

The value of re-exports is difficult to quantify, as are the trade flows of wild-caught ornamentals that are transhipped or re-exported. This may mean that the value of the trade in wild-caught ornamentals is under-recorded and under-valued as a result, as not all the value is recorded in a clearly identifiable form. Simply by importing and then re-exporting wild-caught fish, an exporter will increase the value of the trade, but this value is lost in the statistics; only the overall value of trade, including farmed fishes can be estimated. To what extent countries such as Singapore and Malaysia rely on the trade in wild-caught ornamentals from other countries cannot currently be determined, however they do derive some benefit from the trade through differentials between import and export prices. There are reliable statistics which allow the intra-EU trade to be determined, however it is still not possible to identify what proportion of this is wild-caught fish. Interviews with EU-based importers indicate that there is a significant trade in wild-caught fishes between EU Member States, which must generate profits and taxes (e.g. VAT), however it is not possible to quantify this.

It has not been possible to even estimate the number of people who benefit from the trade in wild-caught ornamentals in collecting and exporting countries as so few studies have been carried out and some of the existing studies are outdated and/or have methodologies that are not robust. It is not even possible to identify with certainty all the countries that export wild-caught ornamentals, as statistics do not differentiate between wild-caught and farmed sources. With these cautions in mind it can at least be said that the number of people involved in collecting wild-caught ornamentals around the world probably lies in the tens to hundreds of thousands, and the number of people

directly dependent on the trade (mainly family members) will be much higher. Indirectly the industry will provide employment and benefits to support industries (e.g. box manufacturers, transport industry) about whom very little is published, making accurate estimates impossible.

Whether involved full time or part time in collecting, the harvesting of wild-caught ornamentals appears to be locally significant for a number of communities, at least based on the limited number of livelihood studies that have been carried out. Seasonal restriction, whether by nature (e.g. floods, adverse weather) or by governments (e.g. close seasons) can limit the ability of collectors to harvest and they may take up other livelihood activities at such times. In addition, demands for growing food often dictate that collectors cannot devote themselves full time to the ornamental trade. However, collecting ornamentals is often a key cash-generating activity, providing money in areas where employment opportunities are very limited, and can be used to fund other activities (e.g. inputs for agriculture) or essential services (e.g. education, health). The value of cash income to remote communities should not be underestimated and a high-value product, such as ornamental fish, can provide a key source of income.

The high value, low volume of biomass harvested and relatively low impact of the harvest in many places means that the trade in ornamental aquatic organisms provides a livelihood for people without necessarily making a significant impact on the environment. This compares to other activities such as timber harvesting which usually have a major negative impact. Examples from around the world show that harvesting can be low impact and have minimal effect on the target populations although, as with any fishery, there will always be some impact on any population where harvesting takes place. It would be useful to have a transfer of best practice to discourage poor fishing practices for the ornamental industry and encourage sustainable and responsible use of resources.

It is also the case that mortality in the aquatic supply chain is generally lower than some publications have quoted. Where data are available, mortality is usually very low at 1-5% due to technology developments and better training for those supplying wild-caught fish; less recent figures are now of very questionable relevance due to these advances. There is now no reason to assume that mortalities of 1% at any stage of the supply chain are not achievable.

As some parts of the trade are now reaching mortality levels of 1% or less routinely, there is scope to reduce mortalities across the trade. Work with collectors has shown that even simple interventions can achieve a significant reduction in mortality. A reduction in mortality in areas where it is too high would bring many benefits in the form of greater sustainability (fewer organisms would need to be harvested) and in financial returns (collectors would get paid more; traders, exporters and importers would lose fewer fish).

Contrary to some negative reports, one of the benefits of the trade is in terms of conservation. This is due, in part, to the preservation of the natural environment by collectors who rely on the resource and have a strong interest in preventing environmental degradation. Further they also have an interest in preventing damaging and unsustainable alternative livelihoods such as timber harvesting from developing. While the trade inadvertently conserves some species by breeding them in large numbers, including some that are threatened or even extinct in the wild (mainly due to loss of habitat), there is an increasing trend for hobbyists to participate directly in conservation of species either ex-situ or in-situ. This may be through organised breeding programmes, or in in-situ conservation by raising funds to support in-country conservation initiatives. Again, the lack of readily available information makes it hard to even identify these conservation networks, let alone to quantify their support for conservation. Given the large number of aquarists involved and the time and facilities they can devote to such activities, it is reasonable to assume that this support is of considerable value both in terms of money expended and in the supply and generation of knowledge about the care and breeding of endangered species or even those which are now thought to be extinct in the wild (as defined by the IUCN Red List). It is also clear that the trade supports

conservation through the provision of expertise and by providing broodstock to ex-situ conservation projects.

Regardless of whatever it does, the trade in wild-caught ornamental aquatic organisms may be under threat from factors outside its control. Foremost among these is climate change which may result in environmental changes to which the ornamental organisms are unable to adapt. There is a risk that coral reefs will become so degraded by oceanic warming and ocean acidification that they will be unable to support their current biota, let alone sustain livelihoods for reef-dependent communities. Similarly, tropical forests are also at risk from climate change and other anthropogenic influences, notably the clearance of forest for agriculture.

Various approaches to the regulation of the harvest or wild capture have been taken at the local and international level. In summary, the two most common approaches are the white list, which states the species that may be harvested and exported, and the blacklist, which bans certain species from trade usually on the grounds that they are food fish stocks and should therefore be protected for the wider benefit of the population or for reasons of conservation. Blacklists tend to be easier to maintain, as they are shorter. By contrast, white lists can be very long and harder to maintain due to taxonomic changes and species discoveries. It is also easier for those checking exports to deal with a short blacklist, as far fewer species need to be identified.

The trade is sometimes criticised for the short lifespan of ornamental aquatic organisms in the aquarium, although verifiable and up to date data on this is rarely reported. While there is a similar lack of reliable and verifiable data on this from the aquarium hobby, there are many indications that such assertions do not reflect current practice and the achievements of the average aquarist. Most aquarium fishes appear to be capable of living for a long time in the aquarium, probably longer than they would in the wild (most fishes will die from predation at an early age). Improvements in technology now mean that organisms that would have been a challenge to keep alive even a decade ago can now be maintained or even bred in the aquarium. It is now possible to buy kits for the propagation of corals and for the rearing of marine larvae, something that would have been unthinkable just a few years ago. Comparisons with what happened in the 1990s or even earlier are therefore of little relevance to what happens today and the hobby has made major strides in the maintenance of a huge range of organisms.

In summary as with any trade there are negative impacts and aspects, however in the ornamental aquatics trade over the past one to two decades, great steps have been made to reduce these impacts. Best practices are increasingly being shared in the trade that benefit a wide range of stakeholders and bring benefits to the organisms being traded. As such the trade brings benefits to all those involved in the trade, in particularly communities in biodiversity rich-economically poor countries, allowing them to utilise their biodiversity sustainably. Finally, and particularly important to note, as the transport of live ornamental aquatics requires specialist conditions for international transport, there are few other industries that are as visible and as relatively easy to monitor.

Background to the Project

The main objective of the study is to provide validated and objective evidence on the international trade in wild caught ornamental aquatic organisms and specifically the benefits that it provides. It is the purpose of this study to review as wide a range of information sources as possible and identify where the trade makes a positive contribution (especially to livelihoods and sustainable use) and to draw out examples of best practice. While the report will necessarily identify areas where the trade does have negative impacts, it is not the purpose of this study to explore these issues in detail, nor to seek means to address such issues in detail. In the long-term, this study is intended to provide a reference source to the industry, conservation and development specialists on means by which the trade may bring benefits to communities which depend on natural resources for their livelihoods.

In terms of the threats to biodiversity, conservation and habitats, the trade is often portrayed as being a major problem but, in the wider picture, the trade in aquatic ornamental organisms is a rather small threat compared to other issues affecting the wider environment. Any impact that does occur is often limited and/or highly restricted in area. This is not to say that the trade in aquatic ornamental organisms is not without problems and there are cases where it has caused or is causing problems for biodiversity. It is the aims of this study to place these perceived problems in perspective and provide an objective view of the trade.

Approach and Methodology

Approach

The approach was outlined in the Inception Report:

- **Desk study and literature review:** the desk study covered the published and grey literature on the key issues relating to the trade in aquatic ornamental organisms as identified in the ToR. DICE drew on its extensive experience on dealing with and advising on the management and utilisation of wildlife, and the international trade in wildlife and their products. Some work specific to the ornamental fish trade was already in existence at DICE and this was used as the basis for this study.

Literature Review Annex A

It was proposed that the Literature Review covered the following main areas.

Activity 2.1: Review of scientific literature. This was the first task to be undertaken using a mixture of bibliographic databases and existing knowledge shared by the consultants. This task was split between the two researchers with Ian Watson covering the grey literature and unpublished information and David Roberts covering the scientific literature.

Activity 2.2: Review of grey and unpublished literature. The consultants already had access to an extensive range of materials that could be used, however it was intended that this would be expanded substantially by internet searches and direct communication with relevant agencies and individuals. Where it was not possible to obtain copy, this is made clear with the caveat that another author reviewed the information.

Activity 2.3: Literature Review. The Literature Review was intended to include at least the following:

- Overview of the industry to identify its scale and overall role in the economies of developing countries. Profiles of the main countries exporting wild-caught ornamental organisms were included.
- Key issues as perceived by the research, NGO and government bodies reporting on the industry.

- Profiles of the key players in the trade and how they currently benefit from the collection, trading and export of aquatic ornamental organisms. Where information was available, benefits accruing along the value chain were identified and attributed to the various participants to determine the relative distribution of benefits.
- Fishing methods and fishery profiles. The review included unsustainable fishing methods and the means that have been used to reduce their use and promote sustainable alternatives. The main species derived from natural fisheries were profiled to include such information as may be available on their management and sustainability.
- Alternatives to the collection of aquatic ornamental organisms. This included a review of dual use (e.g. food/non-food organisms), alternative land uses (e.g. intact forest vs clearance for timber and agriculture), as well as a review of alternative livelihood options (e.g. migration to cities, gold mining, timber felling). The review considered the positive and negative impacts of alternatives and their potential impact on ecosystems and fisheries.
- External threats to ornamental fisheries. This included direct use issues such as coral mining, and food fisheries as well as indirect uses such as hydropower. A brief review of global threats such as climate change and ocean acidification was included.
- The role of legislation in the management of the trade in aquatic ornamental organisms. Examples of country-specific regulation were reviewed to indicate difference in approach and implementation (e.g. permitted vs banned lists, capacity of regulators) were provided and examples of good practice highlighted. International legislation was examined at two levels. Using the EU as an example, Community-wide rules for the importation and trade in aquatic ornamental organisms were reviewed and the impacts considered. International, usually non-binding legislation such as the Convention of Biological Diversity and CITES was reviewed and their impact on the trade assessed.
- The economics of the trade. This considered the benefits at several levels, i.e. collectors, communities, traders, exporters, importers and how various actors enter the trade. Constraints to participation in the trade were taken into account, as was how the regulatory environment enables or inhibits the trade.
- Conservation benefits. In addition to species that are maintained by the industry, examples of where self-interest can help to conserve a resource to ensure its continued use in the future were identified.
- Animal welfare is a contentious issue for the trade. The review examined best practice in the trade and examples of how this has been promoted most effectively. Information was also sought on survivability of ornamental aquatic organisms and how this compares with survival in the wild. However, a review of this issue necessarily involved consideration of poor or unacceptable practice.

The protocol for the formal literature search is shown in Annex A. In practice, it was necessary to change the search strategy used for finding literature and information on the industry. Initial searches using bibliographic databases either yielded very few results if search terms were restricted or yielded a very large number of irrelevant results if search terms were broadened. It became necessary to carry out specific searches for individual topics using targeted search terms such as “coral harvest Fiji” or “tree loss impact fisheries”. Although this was quite time consuming it did usually yield useful results. In some areas, no reliable information seems to be available and where the only data available are likely to be biased (usually by respondents being self-selected) or unverifiable, this is noted. It was also found that many relevant reports and papers did not come up in searches as the titles contained no reference to ornamental fish (or any other similar terms) or

other terms relevant to this report. Some relevant information was found in reports that appeared to have no relevance to this work.

It also became clear that much of the information was not generally available and that it would be necessary to make direct contact with key informants. This approach yielded some important information and also led to new leads on information and contacts. Some key reports and information could not be located for a variety of reasons. It was quite common to find that the URL for a report was no longer valid and that it was also not possible to trace the author(s). There was also a problem with obtaining information from government websites as contact emails were often found to be invalid or could not be delivered due to an “inbox full” problem. Also, some legislation is only available in the language of the country and even summaries are not available in English. This limited what is available for review.

Some useful information resides in sources that are informal and tending to be anecdotal such as aquarist websites, however this is included as it is sometimes the only information available on a topic. Not all aquarist groups contacted replied so some information on conservation programmes will be missing.

Industry statistics Annex B

The full report on trade statistics is shown in Annex B. It has long been known that trade statistics are problematic and that there are many inconsistencies even within a single data source. The most commonly quoted statistics are taken from FAO via FAOSTAT, either through online queries of through the FAO software, FishStatJ. All statistics in this report taken from FAO were through online queries to the Fisheries and Aquaculture ([online query](#) accessed on 11/12/2014); the worldwide productions statistics are presented in Table 1.1.

As can be seen from Table 1.1, there are some inconsistencies in the reporting of statistics and the allocation of exports to the categories “ornamental fish nei”, “ornamental freshwater fish” and “ornamental saltwater fish”. Such inconsistencies are common in FAO statistics due to different member states interpreting the reporting guidelines in different ways.

Trying to obtain other, comparable statistics is difficult and only the EUROSTAT database provides anything like comparable data. However, even this indicates that there are some problems in comparing data due to the different reporting methods used, particularly the reporting of values at import and export.

There is also the question of the internal market for ornamental aquatic organisms which is for most countries largely unknown. However, this is likely to be substantial, especially in countries such as India and China where there is a rapidly expanding middle class and an expanding ornamental trade. This is going to be an area of major growth in the future however, given the lack of available information on the markets, it is not possible to predict to what extent internal production will meet this demand, nor how this will impact on demand for wild-caught fish.

While it is well known that re-exports contribute a major proportion of trade in some countries, information on re-exports is not readily available apart from the intra-EU trade. Information on the worldwide value of the ornamental trade is highly speculative and some estimates seem to be little more than guesswork. These issues are explored in more detail in Annex B.

Table 1.1: FAOSTAT summary data for exports of ornamental fish 2010-2011. All data are in USD '000.

Land Area	Trade flow	Commodity	2010	2011
Africa	Export	Ornamental fish nei	2,560	1,451
Africa	Export	Ornamental freshwater fish	123	96
Africa	Export	Ornamental saltwater fish	-	3
Africa Total			2,683	1,550
Americas	Export	Ornamental fish nei	34,900	34,200
Americas	Export	Ornamental freshwater fish	-	88
Americas	Export	Ornamental saltwater fish	-	3
Americas Total			34,900	34,291
Asia	Export	Ornamental fish nei	126,179	128,711
Asia	Export	Ornamental freshwater fish	32,455	35,736
Asia	Export	Ornamental saltwater fish	27,992	30,925
Asia Total			186,626	195,372
Europe	Export	Ornamental fish nei	33	14
Europe	Export	Ornamental freshwater fish	46,374	49,297
Europe	Export	Ornamental saltwater fish	54,044	77,464
Europe Total			100,451	126,775
Oceania	Export	Ornamental fish nei	4,306	3,856
Oceania	Export	Ornamental saltwater fish	153	224
Oceania Total			4,459	4,080
Total			329,119	362,068

nei = not elsewhere indicated

Legislation on the ornamental fish trade Annex C

The report on legislation is shown in Annex C. There is a substantial body of legislation governing the industry. The examination of legislation is incomplete as it was not possible to obtain copies of legislation from some countries and for some others it is only available in the language of that country and it was beyond the scope of this report to obtain translations. As a last resort, summaries of the legislation can be referred to but it is not possible to check if such reports are accurate and complete without access to the original legislation. Two forms of legislation were examined, national legislation and that covering more than one country, such as that derived from international agreements or from EU legislation.

Country legislation takes a number of approaches to regulation of the trade. Some countries have no direct legislation covering the trade, however they are the exception as most have at least one piece of primary legislation applying to the capture and/or trading of wild-caught aquatic ornamental organisms. Countries take one of two measures to regulate what the trade can and

cannot catch and export. Some restrict this by having a “blacklist” of species that cannot be traded, either due to their conservation status or, more commonly due to them being an important resource for food fisheries. The other method is to have a “white list” of species that are permitted in trade. The latter is much harder to manage as the lists are much longer and will need frequent updating to keep up with changes to taxonomy such as the discovery of new species, something that is still common in the Neotropical region.

CITES and the ornamental fish trade Annex D

The report on CITES and the ornamental aquatics trade is covered in Annex D. The landmark 1973 Convention on International Trade in Endangered Species (CITES) was conceived in the spirit of cooperation, aims to ensure that the international trade in wild animals and plants, including all parts and derivatives, does not threaten their survival. In essence CITES operates by banning commercial international trade in an agreed list of endangered species, and by regulating and monitoring trade in others that might become endangered. Currently c. 35,600 species are listed on CITES, and 180 countries are signatories to the Convention. Of the species listed on the CITES appendices only fish and corals were considered in this review, although there are a number of amphibians, reptiles and plants that could be considered ornamental aquatic or semi-aquatic species. Further there are a number of other species that were not considered as they are not used for the ornamental trade and/or if they are they are extremely rare. As such, relatively few taxa that are of concern to the ornamental aquatics trade are listed on CITES with the exception of corals, which has complete listings owing to the issue of look-alike species. Six taxonomic groups were considered,

- *Arapaima gigas* (Arapaima)
- *Scleropages formosus* (Asian arowana – Appendix I)
- *Hippocampus* spp. (Seahorses)
- Helioporidae spp. (Blue corals – only one species is extant, *Heliopora coerulea*)
- Scleractinia spp. (Stony corals)
- Tubiporidae spp. (Organ-pipe corals).

All of these are listed on Appendix II of CITES (species that may become threatened with extinction if trade is not strictly regulated: strict controls on trade but not total embargo) with the exception of *Scleropages formosus*, which is listed on Appendix I (species in trade that are threatened with extinction, strict embargo on commercial trade).

***Arapaima gigas* (Arapaima)**, the world’s largest freshwater fish species, is listed on Appendix II of CITES. However, recent studies have now suggested that the genus comprises 4-5 species, with *A. gigas* being only known from old museum species. Much of the published literature, as well as trade data, are therefore likely to refer to species from the genus other than *A. gigas*. In the last 2-3 years, there has been a dramatic increase in the numbers of individuals being traded, rising from mostly less than 10,000, to over 30,000 in 2012. The majority were imported as captive bred to have gone to Hong Kong, with a lesser number going to Japan and the US. These were exported from Peru, with relatively few coming from Brazil and Colombia.

***Scleropages formosus* (Asian arowana)** is the only species considered here that is listed on Appendix I of CITES. As such the vast majority of the trade is under source code D of CITES. The trade has increased rapidly, from less than 20,000 individuals per year in 1996 to 1999, to over 160,000 individuals by 2012. This increase relates to the growing number of CITES registered breeding facilities, with currently 47 registered in Indonesia, 56 in Malaysia, and 32 in Singapore and 1 in Thailand ([CITES 2015b](#)). Hong Kong, Japan and Singapore are the main importers, from Indonesia and Malaysia. Under CITES regulations the *S. formosus* can only be traded and sold if they are bred in captivity and are of second generation (F2) and beyond. Only tagged captive-bred *S. formosus* from CITES-registered operations are allowed to be imported, exported or re-exported. Additional

requirements for the import and export of the CITES listed *S. formosus* include, implanting a microchip at the dorsal muscle prior to export, and they must be pre-packed for inspection, with only one fish in each clear packing bag allowing easy viewing by inspectors, prior to export/import. The restrictions and control measures has both restricted the sales of *S. formosus* and created a complete tracking database to identify the global location and distribution of individuals.

([Anon. 2014](#))

Hippocampus spp. (Seahorses) has been listed on Appendix II of CITES since 2004, there appears to have been a decline in live individuals coming from the wild, with an increase in those listed as farmed. In contrast all but a few dried seahorses are listed as wild-collected. The trade in dried wild collected seahorses appears to have declined from a high of over 13,000 kg in 2005 to just over 2,000 kg in 2012. When dried seahorse statistics are converted to numbers of individuals from kg based on a conversion factor of 200 to 500 individuals per kg, it is clear that the trade in dried seahorses is considerably higher than the trade in live individuals. The US and the EU were the main importers of live seahorses, while Hong Kong was by far and away the largest consumer of dried seahorses. Vietnam was the main exporter of live seahorses, followed by Sri Lanka, and Indonesia. Thailand exported the vast majority of dried seahorses. However, the volume caught as by-catch should not be underestimated, with 11 million for 17 countries.

Scleractinia spp. (Stony corals) made up the majority of corals associated with the ornamental aquatics trade; being traded as live or as raw coral, particularly as 'live rock' that is used to condition marine tanks with the micro flora and fauna it holds. There are issues over the units used to record the quantities traded within the CITES Trade Database and these are discussed in Annex D. The majority of the trade recorded as without units (i.e. blank) is from wild collection. It is traded in both live and in its raw state, although it is traded in higher quantities as live, and raw coral can also refer to corals destined for curios. In terms of trade as weight, the majority is from the wild. Trade using weight has declined sharply, although it appears to be picking up in the last two years. The largest importer of both live and raw coral, when the units are not recorded ([blank]) is the US, followed by the EU. For the raw coral trade, after the EU, Japan is next largest importer. In contrast, based on trade recorded as weight, Taiwan is the largest importer, followed by the EU for live corals. The largest exporter, both live and raw coral, when the units are not recorded ([blank]) is Indonesia. In terms of raw coral, after Indonesia, Fiji is the largest exporter. In terms of exports by weight, for live coral, Haiti is the largest exporter, followed by Indonesia, and Fiji.

Finally, it should be noted that the international trade in live specimens is relatively easy to monitor and is visible, as it passes by necessity through border points in distinctive boxes.

The ornamental fish trade and livelihoods Annex E

This issue is explored in more detail in Annex E. The ornamental fish trade supports livelihoods in a number of ways through the harvesting and trading of wild-caught ornamental aquatic organisms. There are relatively few examples that are described in detail to show how individuals, households and communities benefit from the trade. Further, very little information is available to reveal any details of the value chain apart from some descriptions of the main actors involved and the prices and incomes obtained. More detailed information on trading relationships, the flow of credit and goods, as well as costs incurred at each stage of the value chain is generally lacking. This is a key area for future research, as it would help to reveal the true value of trade flow, who benefits and how the benefits of the trade are distributed.

The most studied ornamental fishery is that on the Rio Negro where Project Piaba has been working to improve livelihoods and handling practices of the *piabeiros* (fish collectors) and traders for some years. While a qualitative description of the flow of benefits (e.g. trade goods, credit) has been made, there is a need to explore this in more detail through an examination of costs and the flow of cash benefits into remote communities.

Comparison with other livelihood activities for remote fishing communities suggests that collecting ornamental aquatic organisms compares favourably in terms of income received, although this very much depends on location and the trade networks in place. In some locations, ornamental fish collection is a marginal activity rather than a mainstream income but in others, it is a major source of income and whole communities may be directly or indirectly dependent on the trade. This makes it difficult to generalise, as the benefits can be quite different, even within a country. There are also some fisheries that use the same resource in different ways according to location, such as the *arowana* fishery in Peru where fishers may harvest *arowana* just for food, for food and the ornamental trade, or just for the ornamental trade. Collection is often highly seasonal as fishes of the fishery may not be available year round. This may be due to flooding or to other seasonal conditions such as strong winds. In this respect, it is no different from many other activities carried out in exporting countries, as many forms of employment and income, especially those related to agriculture can be highly seasonal.

Fishing methods used in the wild caught ornamental trade Annex F

There is a very wide range of fishing techniques used to catch ornamental aquatic organisms, from use of hands to SCUBA diving equipment. At its most basic, it is a supplementary activity to household incomes, often carried out by children using the most basic of equipment. The most commonly used equipment is the net in one form or another and this may be held in a frame or may be used as a barrier in which fish are trapped and then caught by hand or with hand nets. The outlay for nets can be very low, especially for hand nets and even large barrier nets are no longer expensive and are more durable than they used to be. Nets are often home-made, especially where very fine mesh such as mosquito netting is used. Hand nets are mainly used for catching fish individually and larger frame nets are usually used for catching shoal fish.

Traps are used for some fish and these usually rely on the fishes' natural behaviour such as seeking shelter in holes in wood. Other forms of trap tend to be miniature versions of the traps used for food fish that rely on fish migrations to lead fish through the trap entrance into a retaining chamber from which they can be retrieved later. Most traps are not baited.

The catching method needs to be used carefully to avoid damage to the fish. Damage is an important cause of losses either at the collecting stage or further along the supply chain at the middlemen or exporters. Proper handling involves not treating the fish roughly but it may also involve some specialised techniques such as decompression for fish caught at depth. Evidence indicates that proper training of fish collectors has a significant effect on post-harvest mortality and thus losses. As well as any welfare concerns, any losses represent lost income and also mean that more fish than necessary will have been caught so good fish catching and handling are key parts of any moves to promote sustainable fisheries and better incomes for collectors.

Animal welfare issues in the ornamental trade Annex G

Probably the greatest source of concern is post-harvest mortality and some very high rates have been quoted. However, caution is needed as some widely used figures are based on very limited sampling and are largely anecdotal in nature. In addition, improvements in handling and shipping now mean that reports from more than 10 years ago are of questionable relevance to what happens today. There are not many studies published on mortality along the aquarium value chain but those which are available indicate much lower levels of mortality than the 30-35% at each stage which was commonly reported. There is also some reliable data in unpublished reports which, taken with published work, indicates that mortality for collectors can still be too high but equally, with proper training, can be reduced to less than 5%. For fishes which are in good condition and have been handled correctly, any further losses should be very low and often <1%. It would be useful to have some hard data on this as many UK importers record losses of below 1% regularly but this cannot be verified by hard data.

The issue of which aquatic organisms can be maintained in the aquarium has changed significantly in recent years as new knowledge and new technology have been developed. These have made organisms that had previously been thought to be impossible to maintain in the aquarium now relatively straightforward to keep and even breed. This has been driven in part by industry developing sophisticated aquarium equipment but also by aquarists who have worked out how to keep some of the more challenging ornamental aquatic organisms. This has developed to the stage where aquarists can now breed and rear marine fishes, something that even professional aquaculture scientists would have struggled to do only 20 years ago. Information on the care of aquaria is now available from many sources such as the OATA information for fishkeepers. There still remains a problem with fishes which grow large and, although some fish which grow to over 30cm can be kept and even bred in domestic aquaria, some very large fishes (mainly catfish) which are still in trade still have a question mark hanging over the issue of whether they can be kept successfully in the aquarium or not. These can also be a problem for the trade and in many retail shops a tank for returned fishes that have outgrown the aquarium is a common sight. Such fish should really only be sold to people who have been fully informed of the potential size of their purchase and its housing requirements such as via the OATA care sheet for tankbusters or the Maidenhead Aquatics Databank. It is also the case that some retailers will now no longer stock fish that grow to a large size and/or are unsuitable for the home aquarium.

The longevity of aquarium fishes Annex H

This section of the report was the most problematic as virtually no verifiable data was available, even for the most common ornamental aquarium fishes. The lack of literature on the subject was confirmed by scientists working in the field who stated that they were not aware of any studies on lifespan in the wild. Likewise, most information from the hobby is anecdotal and cannot readily be verified.

Some very limited information on the lifespan of coral reef fishes was identified in the scientific literature; however this needs to be treated with caution. In the studies examined, maximum longevity was reported and this, in isolation, means little, as it does not reveal anything about life expectancy or how mortality varies with age. There was some observational information that mortality is high in fishes until they manage to establish a territory, but little that could be compared directly with longevity in the aquarium. It is likely that the vast majority of reef fishes die at the larval stage and then mortality will be high post-settlement until they reach sub-adult size; this is only by comparison with other marine fishes. Limited information on reef fishes in the aquarium suggested that longevity was probably at least as good as in the wild; however this data tends to only report maximum lifespan. More data on average lifespan and mortality patterns in the aquarium would be needed for meaningful conclusions to be made.

For freshwater fish, very little data on survival in the wild could be found. Information on maximum longevity in the aquarium came from some online polls and so must be treated with some caution. Accepting that maximum lifespan is not a particularly useful statistic on its own, the information did suggest that many aquarium fishes are capable of living for a long time in the aquarium, probably much longer than most would live in the wild.

Threats to the ornamental fish trade Annex I

In terms of the industry, a major threat is pressure from campaigners opposed to the trade in wild-caught animals or even to the keeping of animals as pets *per se*. This could potentially result in a ban on the trade in wild-caught aquatic ornamental organisms and at its most extreme, only a very limited range of aquatic organisms being permitted as pets. Beyond a ban, most of the threats come from anthropogenic changes to the environment, including habitat loss and climate change. The impacts are sufficiently large in some areas that the harvesting of ornamental aquatic organisms may not be possible in the future as the resource may be too small to be economically viable, or

stocks may be so low that continued harvesting would not be sustainable and so it may be banned. The ornamental industry could fall victim to resource degradation over which it has no control and for which it is not responsible.

Global warming appears to be the greatest single threat. Most notably, this has led to widespread coral bleaching with some reefs suffering repeated and significant damage. If this trend continues, there may be very little intact reef left by 2050. Ocean warming is also indirectly affecting land areas as it can lead to changes in rainfall patterns and in the frequency and intensity of storms. The impact of this on fish populations is not well known, however high flows in UK rivers are known to cause reduced recruitment, while prolonged summer floods can lead to a lost year class. Existing El Nino events are already known to affect fish catches in the Amazon and additional changes to rainfall patterns may increase this impact. Repeated events such as this would inevitably have a major impact on fish species.

Pollution is also a significant threat, either as point pollution, such as untreated sewage, or as diffuse sources, such as increase nutrients. Effects may be additive as oceanic warming combined with eutrophication can lead to phase shifts on coral reefs, resulting in coral death and excessive growth of algae; the latter prevents reef recovery. It is likely the gold mining affects ornamental fish populations, although this is partly based on inference from other fish populations. Gold mining can lead to heavy sediment loads in rivers and to the presence of harmful amounts of mercury in the environment. High suspended sediment loads are known to affect fish through physical effects on the gills and also through the effect it has on fish that rely on vision for finding mates. Sediments also clog gravels and smother important habitat such as leaf litter that will impact on fish populations.

Environmental degradation can come from sources that are not obvious. Tree felling has led to changes in run-off patterns and has resulted in a major increase in soil erosion leading to high sediment levels in rivers. In turn, this can lead to high sediment levels in estuaries that can affect inshore reefs. Loss of tree cover is associated with major changes in fish populations, due to potentially warmer water as a result of the loss of shading and increased algae and macrophyte growth as a result of increased light levels. As tree felling is often associated with the development of agriculture, typically cattle grazing or plantation crops, there may also be added impacts from pesticides and fertilisers.

The wild-caught ornamental trade, conservation and development

Annex J

The ornamental fish trade is often portrayed as having negative impacts but it does bring some real developmental and conservation benefits. These benefits are best shown by Project Piaba which has been working for many years on the Rio Negro ornamental fishery to improve livelihoods and to ensure the sustainability of the industry. While the importance of the ornamental fish industry has declined in recent years, mainly due to competition from farmed sources, the industry does still play an important role in the livelihoods of families on the middle and upper Rio Negro. This reliance on the ornamental fish industry has been one of the factors which has led local communities to value and hence conserve the resources on which they rely, particularly the forests which are essential to many of the ornamental fish populations.

Similarly, moves by the marine ornamental trade have led to a sustainable industry being developed which sustains the export trade and enables local communities to maintain livelihoods with minimal impact on the reef environment. Similar work elsewhere in the South Pacific has made this a centre for best practice on sustainable livelihoods from the collection of marine ornamental organisms.

The ornamental trade does bring some essential services to remote areas which may not otherwise exist. One of the key services is to bring cash to isolated communities through payments for

ornamental aquatic organisms and this may also be supported by the provision of trade goods which might otherwise be uneconomic for traders to take to remote areas without ornamental aquatic organisms to trade on return. With a change from a largely barter-based system to a cash economy in remote communities, these services have become important.

The ornamental fish trade in perspective Annex K

The ornamental fish trade is sometimes portrayed as being purely a source of conservation problems through unsustainable or destructive fishing. As well as not always being justified, these criticisms do not take account of the conservation efforts by hobbyists, the trade and professional scientists. There are now a number of fish conservation networks that seek to preserve endangered species through either breeding programmes or funding in-situ conservation work. It is very difficult to value such networks as most of the effort is provided free of charge and the other resources put in by aquarists such as fish houses, food or stock are usually not known and thus unquantifiable. However, it is reasonable to assume that a considerable effort is being put into ensuring that some endangered species found in the aquarium trade will be conserved ex-situ if the worst happens.

The trade may unwittingly contribute to the conservation of species by having them in trade. A good example is the white cloud mountain minnow, which is extinct in much of its former range, but survives in the aquarium trade by the million. The trade supports conservation breeding by sourcing endangered species and passing them on to experienced aquarists for breeding. The trade also takes part in a great deal of routine breeding of organisms such as the farming of clams and corals which can not only contribute to the supply for trade but also can be used for reef rehabilitation. Again, there is very little information available on this and it is not possible to value this work or even to identify all the species that are being protected in this way.

With the increased use and functionality of the internet, the opportunities for fundraising and coordinated actions on conservation have increased. There are now some examples where funding from aquarists is being put to use on in-situ conservation work, although one of the most successful of these still relies on fund raising at events rather than by internet funding. Such schemes are not easy to find, especially where they have no website and so no estimate of any kind can be made of the amounts raised.

Annex A: Literature Research Protocol

Results of standardised scientific literature review search

Two peer-reviewed publication databases were searched, namely ISI Web of Science (WoS) and SciVerse SCOPUS. These two databases cover both natural and social sciences. The search strings, including Boolean operators and wildcards, were used in the WoS field code, "Topic", which also includes title, abstract and keywords, while in Scopus the search will be set to "Article Titles, Abstracts and Keywords". The following English language search terms were used

- Ornamental AND fish* AND trad*
- Ornamental AND invert* AND trad*
- Ornamental AND coral* AND trad*
- Ornamental AND fish* AND industr*
- Ornamental AND invert* AND industr*
- Ornamental AND coral* AND industr*

Note that wildcards (*) were used to maximize the identification of related words. For example, "trad*" was used to pick up terms such as "trade", "trading", "traded" etc.

The search process for the two databases are slightly different due to the way they structure subject areas (i.e. difference in number and nomenclature of 'research areas' in WoS, and 'subject areas' and 'major subject areas' in Scopus) and hence the subjects which the search can be limited to, or which can be excluded.

From the search results 15% of papers were selected at random and then classified as relevant or not relevant based on the title following a systematic evidence review protocol. As the 15% of papers were selected at random from WoS and SCOPUS, only one paper was found in both random searches. This paper was marked as relevant in both searches, and although it is a single paper, it is somewhat reassuring that assignment of relevance was consistent.

ISI Web of Science (WoS)

Through the use of the six search term combinations 2,053 papers were retrieved, of which 85.0% (1,753) were unique. Of those only 7.9% (21 of the total 263 papers assessed for relevance) were deemed relevant based on the title. In terms of search term redundancy, 87.5% of the papers resulted from a single term (based on all 1,753 papers), 10.1% of papers were found by two, 0.9% by three, 1.2% by four, 0.1% by five, and 0.2% by all six. Based on the 15% of papers classified as relevant or not relevant Term 5 (Ornamental AND invert* AND industr*) gave by far the most results, however only 2 of these papers were deemed relevant. Term 1 (Ornamental AND fish* AND trad*) gave the most relevant results (16, 50%), although as a percentage of those returned 83.3% (5) of papers from Term 2 (Ornamental AND invert* AND trad*) were considered relevant (Table A.1).

Table A.1: Search term efficiency and relevance based on 15% of unique papers returned

Search Terms	% papers returned (n)	% papers returned relevant (n)
1	12.2% (32)	50.0% (16)
2	14.1% (37)	18.9% (7)
3	2.3% (6)	83.3% (5)
4	12.9% (34)	20.6% (7)
5	72.2% (190)	1.1% (2)
6	3.0% (8)	25.0% (2)

SciVerse SCOPUS

Through the use of the six search term combinations 533 papers were retrieved, of which 66.2% (353) were unique. Of those 34.0% (18 of the total 53 papers assessed for relevance) were deemed relevant based on the title. In terms of search term redundancy (based on all 353 papers), 65.7% of the papers resulted from a single term, 25.5% of papers were found by two, 2.3% by three, 6.2% by four, 0.0% by five, and 0.3% by all six. Based on the 15% of papers classified as relevant or not relevant Term 1 (Ornamental AND fish* AND trad*) gave the most results, of these half were deemed relevant. Terms 1 to 3 (Ornamental AND (fish*, invert*, coral*) AND trad*) all gave 50.0% of resulting papers deemed to be relevant (Table A.2).

Table A.2: Search term efficiency and relevance based on 15% of unique papers returned

Search Terms	% papers returned (n)	% papers returned relevant (n)
1	64.2% (34)	50.0% (17)
2	13.2% (7)	57.7% (4)
3	20.8% (11)	54.5% (6)
4	47.2% (25)	20.0% (5)
5	11.3% (6)	16.7% (1)
6	5.7% (3)	33.3% (1)

Discussion on extent of scientific literature relating to the ornamental aquatics trade

If the search results are combined, 219 papers are shared by both journals, which represents 62.0% of the total identified using SCOPUS. However, based on the percentage relevance, WoS would result in 138 relevant papers (7.9% of total WoS output), whereas SCOPUS would result in 120 relevant papers (32.0% of total SCOPUS output). This suggests that just using SCOPUS would capture 87.0% of the relevant scientific literature. However, one should remember that relevance was based on the title following the first stage of a systematic evidence review protocol. It is therefore likely that the number of papers would reduce further once the abstract is considered and finally once the paper as a whole is then considered. Given that there were less than 140 relevant papers based on the title, and that this number would only reduce further if the abstract and the paper as a whole are considered, it is somewhat worrying that there is such little scientific literature in existence.

These results point to a significant lack of research into the ornamental aquatics trade. It also highlights the difficulty of finding research papers relevant to this report and of selecting keywords

that will generate useful results. A paper may have useful information in the text, but if this is not included in the title and/or the keywords used for indexing the paper, they would not necessarily have shown up in the searches. Further, it appears that much information has not been published in the scientific literature but has been published in proceedings of conferences or as reports that are not generally indexed by databases such as SCOPUS or WoS. Much more information was found by targeted web searches (e.g. by searching for “ornamental fish exports Colombia). Looking at the titles of scientific papers suggested another reason in that there is little consistency in the terms used; for example the terms “ornamental fish” and “aquarium fish” are used interchangeably. This inconsistency applied to the paper title and the keywords in the terms used. There were also some papers that proved to be of use but that had nothing to suggest that they dealt with the ornamental aquarium trade in either the title or the keywords. Some papers proved to be untraceable or not available. Some could not be obtained as the URL to the paper no longer worked (mainly applying to reports from consultants and NGOs) or because it was not possible to obtain a copy due to the age of the paper. It was possible to expand the literature by examining the literature quoted in papers and reports, which yielded a number of papers that did not come up by any other source.

Annex B: Industry Statistics

Industry statistics

As with many data sets concerning global trade it is difficult to have confidence in most statistics relating to the trade in ornamental fish as, on closer examination, many anomalies emerge. The reasons for this are varied and in some cases no apparent reason can be determined, however as with all trade statistics, a number of common reasons can be identified. A common reason for inaccurate statistics is that some governments lack the capacity to document export activities accurately or do not have the resources to do so. This can lead to the use of partial sampling of exports (i.e. not all shipments are recorded), which are then multiplied up to give an estimate of total production. This is more likely to occur where exports take place from many points. Partial sampling by year also occurs where an inflator is used to adjust exports between sampling years. It is also clear that there are also undeclared and under-reported exports from some countries (e.g. unofficial sales across borders or under-declared value). To examine these problems in more detail is beyond the scope of this report and would involve substantial effort to examine export data in a number of countries. This problem does not affect just the trade in ornamental fishes as it also applies to food fish and miscoding, under or over-reporting and inaccurate reporting of production and trade are common.

While there is currently no way of identifying wild-caught and farmed ornamental aquatic organisms in trade it is possible to identify which countries are the key suppliers of wild-caught organisms. Table B1 below indicates the countries identified as supplying wild-caught organisms to the UK, although it should be noted that some also supplied farmed organisms.

Table B.1: Countries known to supply wild-caught ornamental aquatic organisms to the UK trade. Information supplied by OATA.

Exporters of marine fish	Exporters of freshwater fish
Australia	Argentina
Brazil	Brazil
Christmas Island	Burundi
Cook Islands	Cameroon
Cuba	Colombia
Dominican Republic	Congo Dem Rep. (Zaire)
Ecuador	Congo Republic
Egypt	Guinea
Fiji	India
French Polynesia	Indonesia
Ghana	Kenya
India	Malawi
Indonesia	Malaysia

Japan	Niger
Kenya	Nigeria
Madagascar	Paraguay
Maldives	Peru
Marshall Islands	Senegal
Mauritius	Sri Lanka
Micronesia	Taiwan
New Caledonia	Tanzania
Philippines	Thailand
Solomon Islands	Vietnam
Sri Lanka	Zambia
Sudan	
Taiwan	
Tonga	
USA	
Vanuatu	
Vietnam	
Yemen	

Worldwide exports

The most commonly quoted statistics are taken from FAO via FAOSTAT, either through online queries or through the FAO software, FishStatJ. All statistics in this report taken from FAO were through online queries to the Fisheries and Aquaculture ([online query](#) accessed on 11/12/2014); the worldwide productions statistics are reported in Table B.2. It is important to note that the FAO statistics do not differentiate between wild-caught and farmed fishes.

Table B.2: FAOSTAT summary data for exports of ornamental fish 2010-2011. All data are in USD '000.

Land Area	Trade flow	Commodity	2010	2011
Africa	Export	Ornamental fish nei	2,560	1,451
Africa	Export	Ornamental freshwater fish	123	96
Africa	Export	Ornamental saltwater fish	-	3
Africa Total			2,683	1,550
Americas	Export	Ornamental fish nei	34,900	34,200
Americas	Export	Ornamental freshwater fish	-	88
Americas	Export	Ornamental saltwater fish	-	3
Americas Total			34,900	34,291
Asia	Export	Ornamental fish nei	126,179	128,711
Asia	Export	Ornamental freshwater fish	32,455	35,736
Asia	Export	Ornamental saltwater fish	27,992	30,925
Asia Total			186,626	195,372
Europe	Export	Ornamental fish nei	33	14
Europe	Export	Ornamental freshwater fish	46,374	49,297
Europe	Export	Ornamental saltwater fish	54,044	77,464
Europe Total			100,451	126,775
Oceania	Export	Ornamental fish nei	4,306	3,856
Oceania	Export	Ornamental saltwater fish	153	224
Oceania Total			4,459	4,080
Total			329,119	362,068

nei = not elsewhere identified

An initial examination suggests that at the very least, there is some inconsistency of reporting by countries and how they allocate exports to the three categories “ornamental fish nei”, ornamental freshwater fish” and “ornamental saltwater fish”. Data reported for the Americas seem anomalous with very little recorded in the way of freshwater fish exports. Reference to Peru highlights this in Table B.3.

Table B.3: FAOSTAT export data for ornamental marine fish from Peru. All data are in USD '000.

Land Area	Trade flow	Commodity	2008	2009	2010	2011
Peru	Export	Ornamental fish nei	4,242	3,132	4,454	3,543
Peru	Export	Ornamental freshwater fish	0	0	0	52

As Peru exports no marine ornamental fish, the recording of exports under “ornamental fish nei” rather than “ornamental freshwater fish” might be misleading and a search restricted to the latter term would return a major underestimate or trade value. For marine exports, analysis of the results for volume (tonnes) and value (USD '000) reveals further anomalies in reporting (Table B.4).

Table B.4: FAOSTAT export data for ornamental marine fish from Oceania. All data are in USD '000.

Oceania FAO exports	USD '000	Tonnes	USD/tonne	USD '000	Tonnes	USD/tonne
Land Area	2010			2011		
Fiji, Republic of	588	175	3,360	675	0	-
French Polynesia	104	24	4,333	75	21	3,571
New Caledonia	182	6	30,333	124	6	20,667
Papua New Guinea	150	11	13,636	49	36	1,361

It would be expected that the value per tonne would be roughly comparable between countries for marine ornamentals but there are major anomalies. The data for Papua New Guinea 2011 may simply be an error; if it is assumed that the value is missing a zero, the value per tonne would be USD 13,610, which is very close to the 2010 value. In additional, freshwater fishes may be included in the total, this would give a lower value per tonne. However, for Fiji and French Polynesia to have values per tonne, which are ten-fold lower than New Caledonia seems unlikely. The most probable answer is that the countries are reporting weight in a different manner with Fiji and French Polynesia reporting total weight of the shipment and New Caledonia reporting estimated weight of the fishes and inverts only. Actual weight of the organisms shipped would be impossible to determine in practice and would be at best a rough estimate. Analysis of ornamental marine exports on a wider geographical scale reveals even greater anomalies. It is assumed that export value is likely to be the more reliable statistic.

Comparison of export and import values of ornamental fishes reveals further anomalies as data from exports from Guyana to the US (Table B.5).

The difference between export value from Guyana and import value in the US can be explained by differences in reporting, however the ratio between the values should be more consistent. No explanation could be found for this and it may simply be due to recording errors.

It is also worth bearing in mind that individual countries and FAO revise the manner in which statistics are recorded or measured from time to time. This can sometimes be spotted by a major change in a statistic between two time periods but this is not always possible. Without a detailed knowledge of the FAO statistics for that period and of the reporting country, this is very difficult to detect. It is not known to what extent this affects ornamental fish trade statistics.

Table B.5: Imports of ornamental fishes from Guyana to the US.

Year	Number of fishes ¹	Declared import value ¹ US\$	Total value of exports from Guyana US\$ ²	US imports value as % of total exports
1998	2,790,743	338,503	123,000	275%
1999	20,633	2,791	n/a	n/a
1999	2,538,751	312,557	118,000	265%
2000	2,750,378	414,500	83,000	500%
2001	1,988,085	286,856	110,000	260%
2002	1,585,657	206,454	92,000	224%
2003	1,916,989	178,057	No data	n/a

¹ Data supplied by US FWS ² Data supplied by FAO FISHSTAT. No explanation was provided by US FWS for the inclusion of two figures for 1999.

Worldwide imports

It may be expected that export and import data would correspond, however for a number of reasons, this is not the case. Due to re-exports, the imports value should be higher as re-exporting of fish will result in an increase in costs and thus recorded value. In addition, the fact that export values are FOB and import values are CIF should mean that import values are substantially higher. However, using the same FAOSTAT dataset as for imports does not reveal this (Table B.6).

The grand totals of USD 344M for 2010 and USD 350M for 2011 imports can be compared with those for exports that are USD 329M for 2010 and USD 362M for 2011. It is hard to explain this difference as exactly the same dataset was used for both statistics. According to [FAOSTAT](#) export and import values are defined in the following terms:

Export value is measured as *“Free-On-Board. FOB-trade values include the transaction value of the goods and the value of services performed to deliver goods to the border of the exporting country. Export values are mostly reported as FOB.”*

Import value is measured as *“Cost-Insurance-Freight. CIF-trade values include the transaction value of the goods, the value of services performed to deliver goods to the border of the exporting country and the value of the services performed to deliver the goods from the border of the exporting country to the border of the importing country. Import values are mostly reported as CIF.”*

Where only FOB price is available, for agricultural products it is adjusted:

“Value indices represent the change in the current values of Import c.i.f. (cost, insurance and freight) all expressed in US dollars. For countries which report import values on an f.o.b. (free on board) basis, these are adjusted to approximate c.i.f. values (by a standard factor of 112 percent).”

It is not clear if this is applied to the trade in ornamental fish. What is clear is that comparing export and import values over time results in very inconsistent ratios whereas they would be expected to remain roughly constant or, given the rapid increase in airfreight costs in recent years, to have shown an increase. Table B.7 shows this is not the case.

Clarification was sought from FAO on the anomaly between export and import values but the statistics department simply confirmed that the conversion value of CIF = FOB * 112% is used. Examination of shipping costs indicate that this value is much too low.

Table B.6: FAOSTAT summary data for imports of ornamental fish 2010-2011. All data are in USD '000.

Land Area	Trade flow	Commodity	2010	2011
Africa	Import	Ornamental fish nei	2,109	4,584
Africa	Import	Ornamental freshwater fish	355	405
Africa	Import	Ornamental saltwater fish	20	129
Africa Total			2,484	5,118
Americas	Import	Ornamental fish nei	59,083	61,154
Americas	Import	Ornamental freshwater fish	8,481	8,138
Americas	Import	Ornamental saltwater fish	1	26
Americas Total			67,565	69,318
Asia	Import	Ornamental fish nei	36,868	34,785
Asia	Import	Ornamental freshwater fish	42,738	40,551
Asia	Import	Ornamental saltwater fish	14,957	16,428
Asia Total			94,563	91,764
Europe	Import	Ornamental fish nei	9,420	8,974
Europe	Import	Ornamental freshwater fish	128,513	126,292
Europe	Import	Ornamental saltwater fish	36,989	43,072
Europe Total			174,922	178,338
Oceania	Import	Ornamental fish nei	4,477	5,919
Oceania	Import	Ornamental saltwater fish	8	-
Oceania Total			4,485	5,919
Total			344,019	350,457

Table B.7: Comparison of export and import values for all ornamental fish. All values are in USD '000.

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Export	177,670	178,675	188,012	255,692	273,037	264,198	277,728	313,243	329,943	314,090	329,119	362,068
Import	247,940	247,702	257,071	279,776	303,950	318,806	338,328	350,476	406,286	376,583	344,019	350,457
Import% export	140%	139%	137%	109%	111%	121%	122%	112%	123%	120%	105%	97%

More reliable data on imports may be had from the EUROSTAT database. Data for EU imports are taken from the [EC Export Trade Helpdesk](#) (accessed 22/12/14). Unfortunately, no directly comparable data are available prior to 2012 due to changes in coding which mean the datasets cannot be made to the FAOSTAT data. The dataset is too large to be included here but is summarised in Table B.8.

Table B.8: Summary of ornamental fish import data for EU Member States.

	2012		2013	
Extra EU 28	EURO	USD	EURO	USD
0301 11 FW	68,686	89,315	61,096	83,145
0301 19 Other	12,353	16,021	12,448	16,940
Total extra EU 28	81,039	105,336	73,544	100,085
Intra EU 28				
0301 11 FW	15,146	19,543	15,884	21,616
0301 19 Other	9,677	12,550	8,324	11,328
Total intra EU 28	24,823	32,093	24,208	32,944
Grand total	105,862	137,432	97,752	133,029

EURO/USD exchange rate based on annual interbank exchange rates of EURO=USD 1.2969 (2012) and EURO-USD 1.3609 (2013) from [OANDA](#) 22/12/14. All figures are in EURO '000 or USD '000

The Harmonised Customs Codes 0301 11 (ornamental/freshwater fish) and 0301 19 (live fish “other”) do not exactly match the categories used by FAO so direct comparison is not possible; in particular, EUROSTAT has no category for marine ornamental fish. In addition, it has been pointed out (Gerald Basleer, Basleer Bio Fish pers. comm. Interview Jan/Feb 2015) that some trade in invertebrates is probably not accounted for as strictly speaking, most live ornamental invertebrates must by law be recoded under other codes. These include what is probably a substantial volume of live seafood (e.g. ornamental lobsters and crayfish should be included with live lobsters for food) and to disaggregate ornamentals from this would be beyond the scale of this report.

Re-exports

There has been a re-export trade for decades where fish are exported from one country and then re-exported from another rather than going directly to the receiving market. This arose for two main reasons, firstly as a means of connecting via an airline hub to destination markets which were not accessible from the original exporting country and secondly to enable exporters to offer a wider range of fishes to importers, thus saving them the problem of having to source a number of small shipments. Hong Kong, Singapore and Miami have traditionally served as re-export hubs but now other states such as Malaysia and Indonesia have an important role to play. The production has also changed with what were low cost countries now off-shoring production to lower cost countries due to increasing wage and other production costs. Thus Singapore has off-shored some production to Indonesia and Malaysia. In addition, it can be much more practical for some producers to export via another country for logistical reasons. For example, many producers in Malaysia are closer to Singapore airport than Kuala Lumpur and it makes a lot more sense to them to export via Singapore. There is also a lot of informal cross-border trade from collectors who will sell to any cash buyer leading to unrecorded trade across borders such as from Guyana to Brazil and from Brazil to Peru and Colombia. The FAO statistics do not appear to record re-export accurately as shown in the Table B.9. While there appears to be an active trade in export and re-export of wild caught ornamental aquatic organisms, it is not possible to capture the additional economic value this generates for countries which engage in significant re-export trade.

As can be seen, there are no re-exports listed for Singapore. Trade statistics for Singapore are shown in Table B.10.

Table B.9: Re-exports from South East Asia main hubs. All values are in USD '000.

Land Area	Trade flow	Commodity	2007	2008	2009	2010	2011
China, Hong Kong SAR	Re-export	Ornamental freshwater fish	4,145	4,230	4,199	4,101	4,200
China, Hong Kong SAR	Re-export	Ornamental saltwater fish	374	340	395	296	185
Malaysia	Re-export	Ornamental fish nei	1	218	0	0	0
Malaysia	Re-export	Ornamental freshwater fish	10	0	0	0	0

Table B.10: Import and export trade statistics for Singapore. All values are in USD '000.

Trade flow	Commodity	2007	2008	2009	2010	2011
Export	Ornamental fish nei	66,079	68,796	59,940	55,877	58,639
Export	Ornamental saltwater fish	-	-	-	3,052	3,206
Import	Ornamental fish nei	23,465	24,646	23,336	-	-
Import	Ornamental freshwater fish	-	-	-	22,900	21,569
Import	Ornamental saltwater fish	-	-	-	1,755	1,740

Given the small size of Singapore and the limited market, there must be a substantial re-export trade but this is not represented clearly. It is also clear that the basis for reporting has changed over time with “ornamental fish nei” being replaced by a breakdown into “ornamental freshwater fish” and “ornamental saltwater fish”.

Internal trade

There is a substantial, but largely unquantified, internal trade in ornamental aquatic organisms where production in-country is mainly or exclusively used to supply internal market demand. This trade does not appear in generally available statistics. Some examples of where there is substantial internal production for the home market include:

- US where there is a major ornamental fish farming industry in Florida and a growing production of marine ornamentals in several states.
- China has an expanding middle class and a long history of ornamental fish production. The popularity of shows, such as CIPS, indicates the popularity of the hobby in China and this internal market is likely to be very large, however statistics are not readily available. The [Guangzhou International Aquarium Show](#) reported growth in demand of 10% between 2013 and 2014.
- Similarly, India is becoming an important producer of ornamental fish and the internal demand is reported to be growing, however, there are no reliable statistics on this.
- Data from the Czech Republic suggests c.10 million Euro’s export per year within the EU.

While it is probable that this internal trade is substantial, it is not possible to quantify it on the basis of currently available information.

The worldwide value of trade

A number of values are given by different authors on the total value of the worldwide trade in ornamental aquatic organisms; however it is difficult to give some of these values much credence as they are based on questionable assumptions and incomplete data. Very little work has been carried out on the retail value of the trade in any country, unlike the rest of the pet industry. Nonetheless, various figures for the value of the trade may be given and are quoted in Table B.11. Data where the derivation has been explained and where a credible estimate has been derived are indicated in the table.

Table B.11: Estimate value of the global trade in ornamental aquatic organisms.

Data	Value USD	Reference	Comments
Global retail value of ornamental aquatic organisms	10 billion	Dey (2014)	No source or derivation for this number is provided
Global retail value of all trade, including hardware, food, etc.	20 billion	Dey (2014)	No source of derivation for this number is provided. The relationship between these two values is unlikely.
Global export value of exports 2004	251 million	Ploeg (2012)	Based on FAO statistics
Global retail value of ornamental aquatic organisms 2009	4.1 billion	Ploeg (2012)	Assumes 240% mark up by importers and 260% mark up by retailers
Global retail value of all sales including equipment and foods	27 billion	Ploeg (2012)	Assumes that livestock sales represent 15% of retail sales value
Global wholesale value of ornamental fish	900 million	Basleer (1994)	
Global retail value of all sales including equipment and foods	7 billion	Andrews (1990)	If updated for USD inflation this would be USD 10 billion by 2012 suggesting that there has also been substantial growth in retail sales.

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Annex C: A review of legislation on the ornamental fish trade

Introduction

There are two basic approaches taken to the regulation of the trade in wild caught ornamental fish. The first relies on a permitted list, which states what species may be caught, traded and exported. This tends to be problematic in practice, as lists have to be constantly updated in line with changes in taxonomy, mainly due to the discovery and description of new taxa and revisions of existing names and/or phylogenies. As the trade tends to be ahead of taxonomy in discovery and commercialisation of new taxa, lists are usually out of date and inevitably taxa, which are not on the list, appear in trade. The second approach is to use a prohibited list, which bans the exploitation of named taxa for the ornamental fish trade, usually on the grounds of conserving stocks of food fishes or due to conservation concerns. The latter approach is easier to handle, as it will be much shorter and so less subject to taxonomic uncertainty. Legislation may also have wider objectives such as implementing the requirements of CITES by signatory states. In addition to permitted and prohibited lists, quotas, close seasons and trade suspensions may also be applied to regulate the trade in certain species, mainly to protect their populations. It should be noted that the terms “black list” and “white list” are often used to indicate prohibited and permitted by different countries and should be considered to be interchangeable.

It is clear that the ability of various countries to implement legislation varies. This is a problem that does not just affect the ornamental fish trade; many developing countries do not have the capacity or resources to implement legislation effectively. Shipments of ornamental aquatic organisms are not hard to identify as they are all required to be clearly marked as such but, trying to control the export of ornamental aquatic organisms is made difficult by the need to at least be able to assign a provisional identity to an item in a shipment. This requirement may challenge an inspector with the need to be able to identify hundreds of taxa, often to species level. Even where trained veterinary officers are used, identifying hundreds of species is still very challenging which, again, makes the use of permitted lists much more difficult than the shorter prohibited lists. Many countries lack the resources to be able to implement legislation and may be unable to deploy a sufficient number of staff to inspect shipments, let alone be able to deploy skilled graduates with an in-depth knowledge of taxonomy and the skills to be able to identify aquatic ornamental organisms.

National legislation in South America

There is a useful comparison of legislation from Peru, Brazil, Colombia, Venezuela and Guyana in TRAFFIC (2006). Reference to the legislation of Brazil (Normativa 202 for marine fishes, 203 for freshwater fishes and 204 for stingrays of 2008), for Peru Ministerial Resolution Nº 147-2001-PE and Colombia Resolucion 3532 DE 2007 3532 DE 2007 reveals a mix of approaches to regulation of the harvest and trade in ornamental fishes. The permitted list approach as used by Brazil and to some extent by Colombia may present problems due to the constantly changing state of the trade and of fish taxonomy. New fishes are constantly being discovered and put into trade as can be seen by their appearance on the EU market. The permitted lists are not updated often and updating is usually slow and bureaucratic leading to regulation always lagging behind trade. The permitted list for Brazil has risen to now include 725 species of fish (c.f. 500 species in 2012). While it is the case that the trade ought not to trade in non-permitted fishes, it does highlight the problem of maintaining a permitted list. Prohibited lists as used by Peru and in part by Colombia are easier to maintain and usually are stable for years, usually only in need of updating in the case of changes in international protocols such as CITES. Fishes placed on the prohibited list are generally food fishes and are often of limited interest to the ornamental trade. They may not present a serious constraint to trade and are generally justified in protecting food fisheries and ensuring food security. Exemptions to Prohibited lists may be made for fishes produced from aquaculture (as in Colombia) and there may also be strict quotas in operation to allow for limited trade in species on the prohibited list such as for stingray export from Brazil. There is little published evidence on the

effectiveness or otherwise of either permitted or prohibited lists on controlling the international trade in ornamental fishes or in protecting food fisheries. Both Peru and Brazil practice 100% inspection of export shipments to check for species which should not be exported. The appearance in trade of fishes on prohibited lists indicates that regulation is not always effective.

Brazil places veterinary controls over the export of ornamental fish but, as the legal framework for this is unclear and not specific to ornamental fish, the legislation is in need of amendment. This is planned to take place in 2015 and at the same time, responsibility for veterinary inspections of ornamental fish exports will transfer from the Ministry of Agriculture to the Ministries of Fisheries. The government vets will also transfer ministries. Exporters in Brazil must have a registered and trained fish health person who can be a private vet under contract; some companies employ a full-time member of staff to fulfil this function. The in-house specialist is responsible for certifying an export shipment as being fit for shipping. The papers are checked and the shipment inspected by the Ministry of Agriculture vets for health and by IBAMA for compliance with the “white list” of species permitted for export (see Figure C.1). If the shipment passes this inspection, the vet places the official stamp on the export health certificate and signs it. There have been some problems in the past with vets who have not been notified as being authorised officers signing certificates for shipment to the EU. There are two vets available to certify exports from Manaus and they do not currently work at weekends. Unless the number of export shipments from Manaus increases significantly, the number of vets available for inspecting fish exports is not likely to increase.



Figure C.1: Inspection and approval of fish for export from Manaus. Before a shipment can be approved for export from Manaus, inspections are carried out by a vet from the Ministry of Agriculture and a wildlife officer from IBAMA.

Colombia, Venezuela and to some extent Brazil (on the cardinal tetra fishery on the Rio Negro) ban the catching of ornamental fish during the main breeding season; a sound move for promoting sustainability of the trade. From the warnings about low stock levels put out by Colombian exporters prior to the close season, it appears that this close season is respected. A close season for collecting is not universally applicable, and its use will depend on the specific habitat being fished. In some cases, nature ensures that collecting cannot take place during the breeding season for many fishes such as in rivers, which flood to a height at which it is impossible to collect fish.

Some countries also apply a quota system to regulate exports of ornamental aquatic organisms. Brazil has quotas for freshwater stingrays under Regulation No 036/2003, which provides for annual

quotas and for certain species to be prohibited from export. Araújo et al. (2004) listed the species of freshwater stingray found in Brazil and provided information on which species are prohibited from export and which are subject to export under quota. At the time of publication 14,500 individuals were permitted for export, individual quotas being set for each of the 5 species under quota (note: this system was under review at the time of a visit by IW to Brazil and it was reported that quotas for the 2014/15 season had not yet been released in February 2015). For comparison, Araújo et al. (2004) noted that about 21,000 freshwater stingrays are killed annually under control measures operated by tourism resorts to reduce the likelihood of tourists being stung.

South and South East Asian legislation

It has proved to be very difficult to obtain information due in part to the legislation not always being available in English, but also due to the relevant government agencies being hard to contact. Malaysia is reported to have little legislation relating to the harvesting and trading of wild caught aquatic organisms, perhaps reflecting the fact that there are so few opportunities for making use of this resource due to widespread environmental degradation and habitat loss.

Kottelat and Whitten (1996) reported that in Indonesia *"In addition the Trade Department decreed that large (>15 cm) individuals of an otherwise unprotected species, the clown loach Botia macracanthus (IW now referred to as Chromobita macracanthus), should not be exported in order to safeguard the breeding stocks for continued capture for the aquarium trade. Despite the volume of the trade in this species, the stocks show no signs of depletion and it is unclear how this regulation can affect the stocks. Fishermen catching a larger individual would eat it or sell it as food fish instead of as an aquarium fish, but are unlikely to release it. The only justification for this regulation is perhaps to ban the export of mature individuals, which could be used abroad to establish a breeding stock, which would compete with the national trade. However, the fish is already reportedly being bred in Thailand."* IW – this fish is now being bred in a number of countries and adults are still only rarely available.

South Pacific legislation

South Pacific countries that export ornamental aquatic organisms have at least some legislation relating to the regulation of collection and export, however some also have retained traditional means of regulation such as village territorial rights that can provide an additional control over collection. Although not formal regulation and with no legal powers as such, this type of control can be very effective due to the social aspects which tend to provide strong pressure on those who break traditional rights agreements to conform. Given that the communities are on the spot and able to provide round the clock surveillance of fishing activities, these traditional regulatory mechanisms can provide better enforcement than that provided by a formal but under-resourced government agency.

Fiji provides an example of good regulation, which, while based on formal legislation, also has a degree of regulation through traditional management systems termed *qoliqoli*. Fiji has also used non-legal forms of regulation such as codes of practice agreed between government and the fisheries and food industries (IW pers. obs.). As industry signs up for such codes of conduct, they can provide an effective form of regulation. The ornamental industry is mainly regulated by the Fisheries Regulations under the Fishery Act (1942 but subject to many amendments) and the Endangered and Protected Species Act (EPSA 2002). There is also the Underwater Breathing Apparatus Regulations (1997) under the Fisheries Act that prohibits the use of SCUBA apparatus for the catching of fish, but does provide for the power to grant limited time exemption. The legislation has been reviewed by Manoa (2008) and Lovell and Whippy-Morris (2008), both of whom concluded that the legislation was inadequate in scope, due in part to the fact that parts of the Fisheries Act needed to be amended to provide for the collection of ornamental fishes rather than food fishes. Nonetheless, the Act does provide a working framework for the regulation of the ornamental trade in Fiji from collection to export. The Endangered and Protected Species Act was brought in to enforce CITES in

Fiji and to set down the conditions under which species covered by CITES could be harvested and traded. This Act provides for the regulation of the CITES species utilised by the trade in Fiji, notably live corals and live rock for the aquarium trade (the trade in curios is no longer permitted). The trade in corals and live rock is also regulated by the Environment Management Act (EMA 2005), however as noted by Manoa (2009) this is incomplete in its coverage and there are inconsistencies between the EPSA and EMA, which needed to be resolved. Regardless of whether the legislation is complete, the fact that the ornamental industry has been judged by a number of independent surveys to be sustainable (see e.g. the non-detriment finding under CITES in Lovell and Whippy-Morris, 2008) it does appear that Fiji is a good example of working regulations which involves government, industry and local communities.

A number of Pacific Island Countries and Territories (PICTs) have regulations for the management of the aquarium fish trade, described Chapman and Stanley (2013). The regulations for Vanuatu are also described in Anon. (2009). Vanuatu has a long-established aquarium fish industry that is regulated under the Fisheries Act No.55 of 2005. This regulates the harvesting and export of all aquarium products (including fish, corals, clams) such as not permitting the export of wild-caught clams (the export of cultured clams is permitted and is a growing business). Similarly, only cultured corals are permitted for export. Only permitted fishing methods may be used and this includes a ban on toxicants (there is no evidence of their use in Vanuatu) and the regulations also require fish-friendly handling techniques. Stocks are protected by the use of quotas and by exclusion areas that are in place to protect important tourism or protected areas. The regulations extend beyond the strict regulation of the fishery to cover working conditions, health and safety and the care of organisms post-harvest. Significantly, the regulations set a limit for mortality in holding stations of a maximum of 3% and allows for inspection by the Department of Fisheries for the purpose of ensuring that all conditions required by the regulations are being met. To ensure that quotas are being observed and to protect vulnerable species, it is a requirement that exporters maintain accurate records of all organisms collected and exported.

Chapman and Stanley (2013) note that there are “*approved plans in Vanuatu and Tonga (being reviewed). Plans or regulations in various stages of progress in Kiribati, Marshall Islands, Federated States of Micronesia, Solomon Islands, Papua New Guinea, and French Polynesia*” but provide limited details on implementation and/or development of the regulatory frameworks. The report also recognised that there was scope for the development of the trade in Samoa but Samoa specifically prohibits the harvesting of ornamental fish (IW pers. obs. 2011). Palau was also listed as an aquarium fish exporter but has subsequently introduced a ban on the exports of all live fish whether for food or the aquarium trade. Further detail is provided by Kinch and Teitelbaum (2008) who reviewed regulations in PICTs. Tonga has set in place a Marine Aquarium Fish Management Plan which limits what can be caught (at least in part to comply with CITES but also to maintain inshore stocks which may have multiple users), what gear can be used and who can participate in the trade. It also provides for reporting and inspection. In the Cook Islands, the trade is regulated through the Marine Resources Act (2005) but no further details of its coverage were given. In the Marshall Islands, the trade is regulated under the Marine Resources Act (1997) that is implemented by the Marshall Islands Marine Resources Authority. This has put in place a draft management plan for the aquarium trade. The authors noted that the Solomon Islands had no specific regulations for the aquarium industry under the Fisheries Act (1998) but there is some regulation under the Wildlife Protection and Management Act (1998).

Australian legislation

Marine ornamental fisheries in Australia are subject to strict regulation as are all marine fisheries. The Great Barrier Reef is the centre for an important marine ornamental fishery and the Queensland fishery legislation and management serve as a good illustration of the Australian approach to marine fisheries. The Queensland Fisheries Regulations 2008 are the source of the various instruments used to govern and manage the ornamental fishery, which is split into a marine fish and invertebrate

fishery and a coral fishery, the latter being subject to additional conditions. The Fisheries Regulations allow for a number of means of regulating and managing the fishery including:

- Limits on the areas that may be fished for ornamental fish and invertebrates or for coral. The areas that can be fished are tightly defined and are quite limited in area.
- Limits on the gear that can be used to catch fish, invertebrates and corals. Very limited range of equipment is permitted, all of which is intended to result in a sustainable fishery with minimum impact of the reef.
- Limits on the number of licences that are issued and on the number of boats and catchers that can be employed under each licence. In addition, there are controls on what the licence holder can and cannot delegate to others, limiting the scope for licence holders to act as a proxy for others. In the terms of the licence, the licence holder needs to be actively involved to some extent in the fishery.
- Limits to which species can and cannot be caught for the aquarium trade and strict quotas for some species, either on a daily or annual basis. There are also size limits for certain species.
- There are also some prohibitions on the trade and movement of fish, invertebrates and corals which include their possession in the aquarium. Certain species may only be kept in the aquarium if they are from farmed sources.

All holders of an aquarium fishing licence are required to maintain a logbook, the format of which is determined by the Queensland Government. Licence holders are required to submit monthly logbooks, and if they have not been fishing, are required to notify the dates between which they had ceased fishing. The logbook data is used for fishery management and the data are built into the regular reviews of the fishery that are designed to ensure sustainability. The Queensland is a good example of how a fishery can be managed through non-legal means such as codes of practice. These are described by the Queensland Government (2009) and include the Stewardship Action Plan (SAP) and the Environment Management System (EMS). The SAP was developed primarily by the aquarium fish industry with assistance from the Queensland government. The objectives of the SAP are:

1. describe 'best practice' collection standards in the Marine Aquarium Fish Fishery (MAFF) and Queensland Coral Fishery) (QCF)
2. detail contingency operational plans for coral bleaching events and formalise linkages with response plans developed by fishery and protected areas managers
3. form a Complaints Assessment Committee to oversee the validity of complaints and severity of breaches
4. form a Review Committee to continuously improve the SAP.

In addition to the aim of ensuring sustainability, the SAP is also intended to differentiate the Queensland aquarium fishery as being distinct and committed to sustainable and responsible use of the resources. The EMS is much wider in scope, covering a wide range of activities which may impact on the Great Barrier Reef and seeks to identify environmental risks (this may include environmental risks which may impact on the aquarium fishery).

The fishery is subject to regulation under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 that allows operators to be given a Wildlife Traders Operation approval. These:

1. acknowledge that the fisheries are being managed in an ecologically sustainable manner, and
2. allow the export of products caught in this fishery.

As such, they are likely to be subject to external review from time to time to ensure sustainability. Reporting by the Queensland government on the [coral fishery](#) and the [marine aquarium fishery](#)

indicate that the fishery is being managed in a sustainable manner as catch per unit effort has remained relatively constant over time and the coral fishery has consistently taken less than its quota allows.

Maldives legislation

The legislation covering the ornamental fish industry in the Maldives was reviewed by Saleem and Islam (2008). The legal instruments are not recorded but their impact is detailed. The ornamental trade was subject to a quota of 100,000 pieces for all fishes (no quota is mentioned for invertebrates) but this was found to be unworkable and led to undesirable effects such as over-collection of some species. The blanket quota was replaced by individual species quotas. These are grouped into three categories. Category A includes fish which are not permitted for export as it was felt that they would not survive in captivity (changes in technology and husbandry suggest this list is in need of revision) and a few other items which are not permitted to be caught. Category B contains a number of fish families but the restrictions in place are not explained, and Category C contains 71 species from a number of families that are subject to a total quota of 300,000 pieces. In addition, the export of corals is banned with the exception of organ pipe corals (*Tubipora musica*), which is permitted to be exported for the Indian traditional medicine market. Additional restrictions are in place to restrict conflict with the tuna long-line industry which uses live fish as bait (restrictions on the use of live bait for tuna long lines is not mentioned). This extends to the green chromis (*Chromis viridis*) that would otherwise be a popular aquarium export.

EU legislation

This has a major impact on the trade in the EU and thus the UK, although the major impact is on farmed fish and coldwater fish in particular. Failure to comply with this legislation can result in significant fines for both the shipper and the importer. The principal legislation is included under Directive 88/2006. Tropical, freshwater fish destined to be kept in an enclosed environment such as an aquarium are largely exempt from legislation although veterinary health certificates are still required. However, as legislation is under constant review, this may change, particularly as new disease threats emerge. Economically damaging diseases such as spring viraemia of carp and koi herpes virus only restrict the trade in susceptible species such as carp, and no fishes which the ornamental trade harvests from the wild are likely to be affected. Widening of the coverage for epizootic ulcerative syndrome could have a major impact on the trade as there are potentially many susceptible species in trade. As no susceptible species have been identified within the EU, it is assumed there would be no justification for such an expansion in coverage and that only control measures in the event of the disease being identified will remain the requirement. Tropical marine ornamental organisms for the aquatic trade are not currently covered by EU disease legislation although attempts have been made to include some shrimp diseases (such as shrimp white spot virus). See also the section on Threats to the Trade for further discussion.

Legislation also exists for the control of exotic or invasive organisms that may potentially affect biodiversity or require excessive costs to control once established. The main current concerns relate to aquatic plants such as floating pennywort, (*Hydrocotyle ranunculoides*), which can cause serious damage to aquatic ecosystems. It is likely that EU legislation on invasive alien species will come into force in the near future and it is likely that it will impose further restrictions on trade. This will probably not affect the trade in tropical wild caught aquatic organisms, the vast majority of which are unlikely to survive in most EU climates.

Some EU legislation does not specifically apply to wild-caught ornamental aquatic organisms and may not even make reference to fish but applies generally to a wide range of animals. Regulation 1/2005 deals with the transport of wild animals and places a duty on the shipper and carrier to maintain conditions appropriate for the animals in transport. While these are not defined for fish, the general indications would apply, such as ensuring transport time is minimised, that the fish would be packed appropriately for the length of journey and that the persons handling and

transporting the fish had been given proper training. It is also a requirement that an emergency plan is in place for the shipment in case of delay, accident and so on to ensure that the welfare of the animals would not be compromised. In practice, additional checks on transport conditions are provided by airlines that will not accept shipments of live animals unless their packing and transport conditions comply with the IATA Live Animal Regulations.

Directive 88/2006 has limited implications for the trade in wild-caught ornamental aquatic organisms as it deals with aquaculture animals, and the prevention of diseases. While the controls deal mainly with aquaculture animals they do make reference to ornamental fish kept in ponds where there may be some risk of disease transfer from coldwater fish and thus the full provisions of the Directive apply. This does not apply to retail or wholesale premises as long as they are not connected directly to natural waters and have appropriate controls on place to prevent the spread of disease or to garden ponds. Ornamental fish kept in aquaria are currently exempt from the controls in this Directive.

Directive 88/2006 gave rise to the need for veterinary inspections of all consignments of fish, crustaceans and molluscs (including wild caught specimens) and the production of export health certificates to an internationally recognised standard to accompany shipments of ornamental fish, which was ultimately implemented by Regulation 1251/2008 and Regulation 346/2010. Although it did not appear to be the intention of Directive 88/2006 to apply to ornamental aquatic organisms intended for closed systems (e.g. aquaria), the way it has been implemented makes it a requirement for an export health certificate to accompany all shipments of ornamental aquatic organisms, which contain fish, crustaceans or molluscs. The export health certificate has to guarantee that the shipment is free of certain diseases and show no clinical signs of disease:

- For fish – epizootic haematopoietic disease, viral haemorrhagic septicaemia, infectious haematopoietic necrosis, infectious salmon anaemia, koi herpes virus
- For molluscs – *Bonamia exitiosa*, *Perkinsus marinus*, *Mykrocytos makini*, *Martelia refringens*, *Bonamia ostrea*
- For crustaceans – Taura syndrome, yellowhead disease, white spot disease

The veterinary inspection service should also certify that the organisms do not come from a location where there is evidence of higher mortality, although this requirement is of more relevance to aquaculture animals than to wild-caught ornamentals as surveillance is closer and more frequent on aquaculture establishments. It is worth noting that the known risk from ornamental fish is low and applies mainly to carp (KHV) and a small number of farmed, coldwater fish such as goldfish, which may harbour some of these diseases. The greatest problems for the trade have been posed by koi herpes virus although evidence suggests that the illegal trade in fish for re-stocking angling waters has been a significant element in the spread of KHV. Epizootic ulcerative syndrome (EUS) affects a wide range of tropical fishes in countries where it occurs, including some that are in the ornamental trade, however there is no firm evidence that it could be transferred to, let alone established in the EU. While EUS was originally listed in Directive 88/2006, a subsequent re-evaluation of the risk it may pose to EU fish stocks and aquaculture led to it being removed from the list by Implementing Directive 32/2012. Similar comments apply to white spot disease of shrimp, which also appears to be no more than a theoretical risk to EU aquaculture or native crustaceans.

UK legislation

Once within the UK, fish are protected by the Animal Welfare Acts that make it offence not to look after welfare and avoid cruelty. Regulation 1/2005 is implemented in England by The Welfare of Animals (Transport) (England) Order 2006 (WATO) and by equivalent national legislation in Scotland, Wales and Northern Ireland which places a duty of care on anyone transporting any invertebrates (not just CITES invertebrates). WATO has few specific provisions for the transport of ornamental fish,

but the general provisions apply to the commercial transport of ornamental fish. It is also a requirement that all pet shops selling vertebrates are licensed.

In the UK, legislation is already in place under the Wildlife and Countryside Act (1981 and as amended), which restricts what can and cannot be released into the wild and effectively prohibits the intentional release of ornamental aquatic organisms into the wild without express permission. The Import of Live Fish Act (1980 and as amended) prohibits the import of non-native fish and their eggs, although there are exceptions for some species important to the ornamental trade such as carp and goldfish. There are some differences in the Act between England and Wales and Scotland. The Act in practice (by making a list for permitted species for England and Wales; a prohibited list is used for Scotland) exempts all fish to be kept in aquaria and fish to be kept in a garden pond as long as the latter poses no risk of escape to the natural environment. The lists of species covered include a white list (mainly comprising genera) and a black list (mainly comprising specific species, which have the potential to become established within the UK).

Finally, Figure C.2 illustrates how legislation impacts on various points within the ornamental aquatics supply chain between producers and consumers, using the trade between Brazil and the UK as an example. The legislation is complex and may apply to one or more stages in the supply chain. The Animal Welfare Act (2006) applies broadly in the UK and applies to anyone (whether an individual or a company), placing a duty of care on them to have due regard for the welfare of any animal in their care.

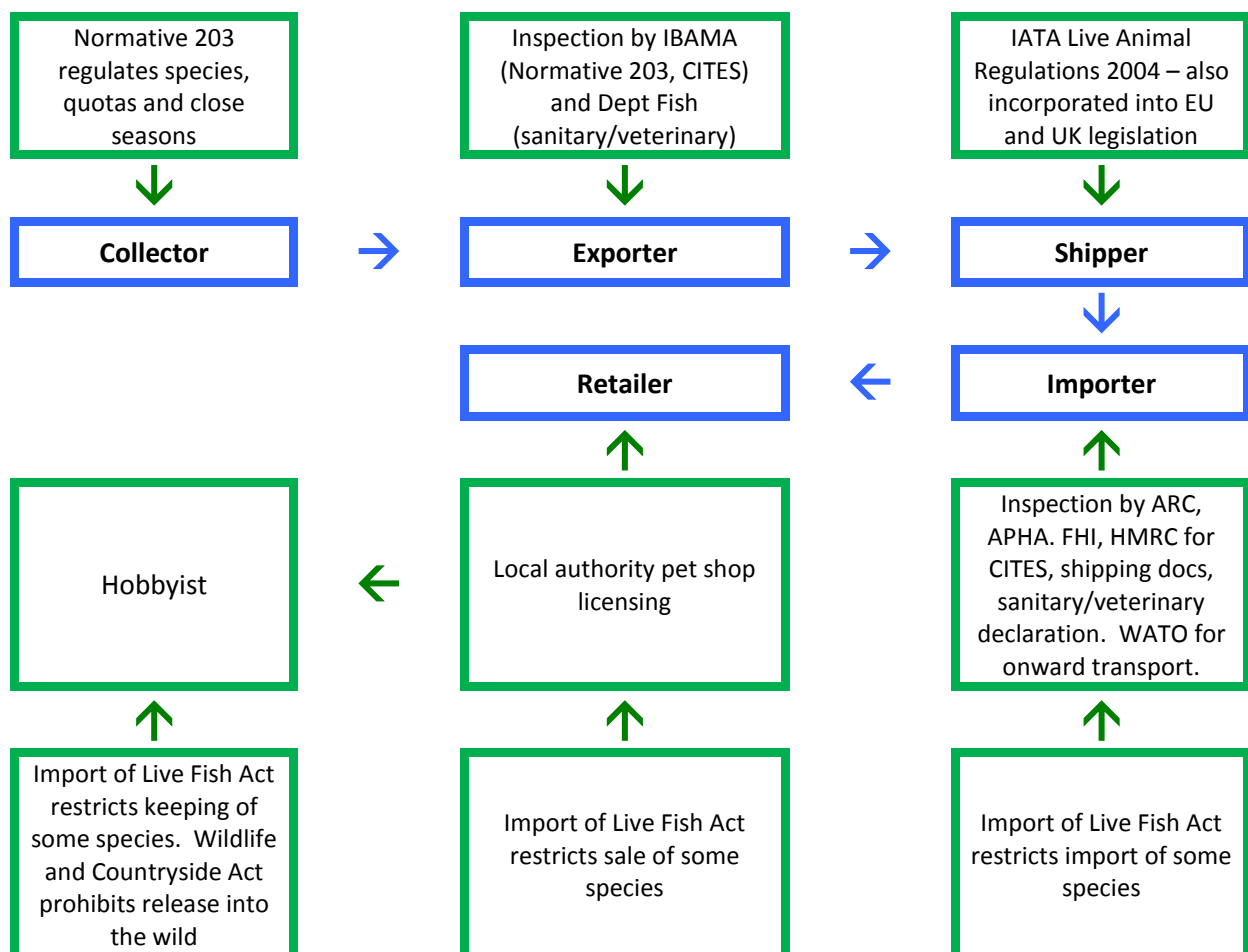


Figure C.2: Legislative flow process for exports from Brazil to the UK

OIE

The OIE ([World Organisation for Animal Health](#)) is not a regulatory organisation as such and does not have direct, legal powers to regulate the trade in ornamental aquatic organisms, however it has effectively been incorporated into legislation by some countries, mostly notably by EU Member States. Directive 88/2006 requires that the provisions of OIE be taken into account and that any country trading with or within the EU must comply with its requirements. This has posed problems for a number of countries that export ornamental aquatic organisms to the EU as they were not signatories to OIE and did not have the resources to meet the requirements for membership. It was a particular problem for the South Pacific as many of the islands have a very limited ability to detect or monitor diseases as required by OIE (and this Directive 88/2006) let alone to supply guarantees about whether exports to the EU were free of named diseases. In the case of the South Pacific, assistance has been coordinated through SPC and some have now achieved OIE membership, although other countries have faced major difficulties in complying with the requirements.

IATA

While the International Air Transport Association (IATA) Live Animal Regulations are not formal legislation, the fact that nearly all airlines carrying ornamental aquatic organisms require shipments to comply with the Regulations means that the effect is similar to legislation. In addition, for the EU Member States, Regulation 1/2005 requires those shipping by air to comply with the IATA Live Animal Regulations (IATA LAR 2004) which effectively gives them legal status. The Regulations oblige those consigning or shipping live ornamental aquatic organisms must comply with some conditions designed to ensure the live arrival of the shipment, which can be summarised as:

- The current requirement is for the organisms to be able to survive for 48 hours from the time of acceptance by the airline. Most shipping times from leaving the exporter's premises to being received by the importer are less than 24 hours.
- All boxes must be labelled clearly with appropriate environmental conditions. These would differ between coldwater and tropical fishes. Requirements would include minimum and maximum temperature and avoidance of exposure to sunlight.
- Labelling must also include handling instructions such as "this way up" indicators, some form of indications of contents such as "live tropical fish" and generally some form of recommendation to keep dry.
- To avoid problems with language, bilingual labelling is common and all requirements are clearly indicated in non-verbal form, such as "this way up" arrows and a thermometer showing the correct temperature.

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Annex D: CITES and the ornamental aquatics trade

The landmark 1973 Convention on International Trade in Endangered Species (CITES) was conceived in the spirit of cooperation and aims to ensure that the international trade in wild animals and plants, including all parts and derivatives, does not threaten their survival. In essence, CITES operates by banning commercial international trade in an agreed list of endangered species, and by regulating and monitoring trade in others that might become endangered. Currently c. 35,600 species are listed on CITES. Currently 180 countries are signatories of CITES. CITES regulations are implemented at the national level through a signatory's management authority, with advice being provided to the management authority from the signatory's scientific authority. However, it should be noted that *"although CITES is legally binding on the Parties-it does not take the place of national laws. Rather it provides a framework to be respected by each Party, which has to adopt its own domestic legislation to ensure that CITES is implemented at the national level"* (cites.org).

The Conference of the Parties (CoP), the supreme decision-making body of the Convention, which comprises all 180 member States, has agreed on a set of biological and trade criteria to help determine whether a species should be included in Appendices I or II. At each regular meeting of the CoP, Parties submit proposals based on those criteria to amend these two Appendices. Those amendment proposals are discussed and then submitted to a vote (cites.org).

Countries exporting CITES-listed species are required to demonstrate the levels of export are not detrimental to the survival of the species concerned. This is based on well informed science-based decisions compiled and made by the CITES Scientific Authority of the country concerned, and is essential to preventing over-exploitation through international trade and central to the successful implementation of CITES (i.e. non-detriment finding). In addition many members set their own quotas; Res. Conf. 14.7 (Rev. CoP15) on management of nationally established quotas recognizes that such quotas are a management tool, used to ensure that exports of specimens of a certain species are maintained at a level that has no detrimental effect on the population of the species.

Although CITES has enjoyed undeniable success, concerns have been raised over the impact such regulation is having on trade and livelihoods. This concern is heightened as other international conservation efforts—most notably the Convention on Biological Diversity (CBD)—move forward.

CITES Appendices

Taxa are listed on a series of Appendices (cites.org),

- Appendix I – Species in trade that are threatened with extinction: strict embargo on commercial trade- (export and import permits required) 800 species listed,
- Appendix II – Species that may become threatened with extinction if trade is not strictly regulated: strict controls on trade but not total embargo (export permits required) 32,500 species listed,
- Appendix III – Facility for range states to create strict controls for range species.

CITES Significant Trade Review

Trade in Appendix II species should not be detrimental to the survival of the species; it must be maintained at sustainable levels. The status of individual species is reviewed where trade volumes appear to be significant and therefore potentially detrimental (see Resolution Conf. 8.9 (as revised)). More than 230 animal taxa have been reviewed to date.

The EU and CITES

The EU is an important consumer market for CITES species, particularly due to the open trade policy within the EU between member states. The EU ranks as a top global importer by value of many wild animal and plant commodities, including tropical timber, caviar, reptile skins and live reptiles (2005). An estimated declared import value of CITES species is EUR 93 billion in 2005 (EUR 2.5 billion excluding timber and fisheries). CITES is applied in the EU by member states through a framework of

regulations, plus Annexes as opposed to the Appendices (Council Regulation (EC) No 338/97; Commission Regulation (EC) No 865/2006; Commission Implementing Regulation (EU) No 792/2012). Enforcement provisions must be transferred into national legislation and supplement with national laws The European Community Wildlife Trade Regulations; in the UK this is through the Control of Trade in Endangered Species Regulations (COTES) 1997 (last amended in 2009) and Customs & Excise Management Act 1979 (CEMA). In addition, the EU Regulations go beyond CITES in many places. The main differences are that the EU has (a) 4 Annexes (including non-CITES species), (b) stricter import conditions, (c) housing conditions for Annex A species, (d) transport conditions, (e) restrictions on internal trade of Annex A species, and (f) EU suspensions and negative opinions. Further, the EU Wildlife Trade Regulations make Compliance with the IATA Live Animals Regulations for air transport and the CITES Guidelines for Transport legally binding. The Commission can also restrict imports for specimens of Annex B species subject to high transport mortality.

Other trade mechanisms

World Trade Organisation (WTO) – was specifically put in place to facilitate effective, open international markets and seeks to avoid direct import/export barriers (wto.org) such as CITES. It should be noted that hidden barriers, such as those based on technical requirements or process distinctions might be illegal under WTO (but also see WTO Agreements on Technical Barriers on Trade). In relation to CITES, the WTO's Committee on Trade and Environment's terms of reference are to "... identify the relationship between trade measures and environmental measures, in order to promote sustainable development ..." and "... make appropriate recommendations on whether any modifications of the provisions of the multilateral trading system are required, compatible with the open, equitable and nondiscriminatory nature of the system ..." ([WTO 1994](#)). As part of the WTO's Technical Barriers to Trade Agreement technical standards ([WTO 2015](#)), any technical standard, including state sponsored ecolabels, must be based on internationally negotiated and transparent standards (e.g. ISO-International Organization for Standardization). The use of technical standards should not create unnecessary obstacles to international trade, and should not be more trade restrictive than necessary to fulfil a legitimate objective including protection of the environment.

Rio Declaration on Environment and Development – has two principles of specific interest to the question of trade. Firstly, Principle 3, the right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations. Secondly, Principle 15, in order to protect the environment, the precautionary approach shall be applied. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation ([UNEP 1992](#)).

Convention on Biological Diversity (CBD) – objectives are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources (cbd.int). However, there is no mention in the text or linkages with other relevant conventions such as CITES at the time of developing the Convention. Synergies and areas of cooperation between CITES and CBD are being explored.

Finally, it appears the CITES is at a turning point as to whether it will evolve in line with the principles of the CBD or the WTO.

Ornamental aquatics species and CITES

Of the species listed on the CITES appendices only fish and corals are considered here, although there are a number of amphibians, reptiles and plants that could be considered ornamental aquatic or semi-aquatic species ([CITES 2015a](#)). Further there are a number of other species that we do not consider here as they are not used within the ornamental trade and/or if they are they are rare; these included sharks, paddlefishes and sturgeons, *Anguilla anguilla* (freshwater eel), Cui-ui, Blind carps and plaeesok, *Cheilinus undulatus* (Humpheaded wrasses), *Totoaba macdonaldi* (Totoaba),

Pangasianodon gigas (Mekong giant catfish), Australian lungfish, Coelacanths, medicinal leeches, *Lithophaga lithophaga* (marine mussel), freshwater and pearl mussels, *Strombus gigas* (Queen Conch), black corals, fire corals, lace corals, and species listed on Appendix III (*Isostichopus fuscus* (sea cucumber) from Ecuador, and *Corallium elatius*, *C. japonicum*, *C. konjoi* and *C. secundum* (precious or red corals) from China. Finally, while there is a trade in Tridacnidae spp. (Giant clams), currently listed on Appendix II, for the ornamental aquatics trade, it is difficult to disaggregate this from the trade in live clams for the food trade and therefore, were not included in the subsequent analysis.

Relatively few species that are of concern to the ornamental aquatics trade are listed on CITES with the exception of coral taxa which has complete listings owing to the issue of look-alike species (i.e. the difficulty that could occur with say a customs officer differentiating species that are listed and those that are not; another example of this is all orchids are listed although not all species, or even genera, are in trade). In this review we considered the following six taxonomic groups, all of which are listed on Appendix II of CITES with the exception of *Scleropages formosus*, which is listed on Appendix I (NB that in the case of corals, fossil corals are excluded from CITES listings).

- *Arapaima gigas* (Arapaima)
- *Scleropages formosus* (Asian arowana)
- Seahorses (*Hippocampus* spp.)
- Helioporidae spp. (Blue corals – only one species is extant, *Heliopora coerulea*)
- Scleractinia spp. (Stony corals)
- Tubiporidae spp. (Organ-pipe corals)

Due to the reporting timings and the time it takes for data to be uploaded into the CITES Trade Database (<http://trade.cites.org/>) only records up to and including 2012 are considered. Further, data is considered from 1996 only, as this is when a concerted effort was made to ensure the data was cleaned before being made available (UNEP WCMC 2013).

For each taxa, data was downloaded from the CITES Trade Database for the period 1996 to 2012 as a comparative table .csv file, and pivot tables were constructed. Numbers and quantities involved in the trade were based on imported rather than exported values as they are considered to be more accurate (UNEP WCMC 2013). Origin was set to 'blank' to remove re-exports, as only direct trade was looked at, and the purpose of trade was set to 'T', commercial trade. For live trade, the term 'live' was selected and the units were set to 'blank' to remove trade in units such as kg which were rare and often represented the taxon plus water in the container they were being shipped in. In those species where non-live trade was analysed, such as dried seahorses, the raw data was 'eye-balled' to determine the most appropriate terms. In the case of seahorses 'bodies' was used, and the units of the trade, again in the case of seahorse 'kg' was used. This was performed for all taxa to make sure all component of trade in the taxa where being considered. Finally, in all cases the following sources were considered, C (captive bred), Wild (wild taken specimens), F (F1 or subsequent generations that do not fulfil C), and U (source unknown), everything else was combined as 'Other'. As mentioned later for Asian arowana, source 'D' was also included as this species is listed on Appendix I of CITES (UNEP WCMC 2013).

Results

Arapaima gigas (Arapaima)

The arapaima is the world's largest freshwater fish species, growing to 4.5m in length, and inhabits the Amazon and Essequibo basins in South America. Until recently the genus was considered

monotypic (*Arapaima gigas*), which is listed on Appendix II of CITES. However, recent studies have now suggested that the genus comprises 4-5 species, with *A. gigas* being only known from old museum species. This reclassification, which occurred in 2013 and therefore outside the range of this study, is likely to have serious implication for the trade in this species (Akst 2013; Stewart 2013a, b). Much of the published literature, as well as trade data, are therefore likely to refer to species from the genus other than *A. gigas*. As can be seen in Figure D.1, there has, in the last 2-3 years, been a dramatic increase in the numbers of individuals being traded, raising from generally less than 10,000, and often less than 5,000 (1996-2010), to over 30,000 in 2012. Of those traded the vast majority were imported as captive bred, with those of wild or F origin making up a relatively small fraction of the total.

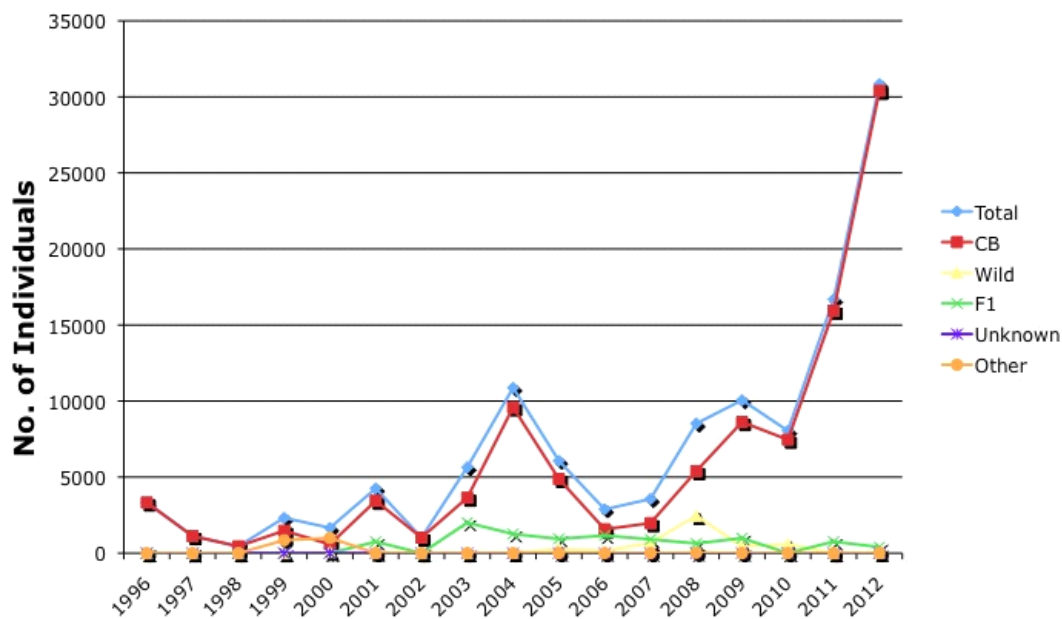


Figure D.1: Dynamics of the live trade in *Arapaima gigas* from different sources between 1996 and 2012.

In terms of importation of *A. gigas*, the majority appear to have gone to Hong Kong (55.2%) between 1996 and 2012, with a lesser number going to Japan (21.3%) and the US (20.8%). Very few appear to have entered the EU (1.0%), with only 223 individuals directly entering the UK (Figure D.2). A recent development has been the farming of arapaima in the Far East (notably Malaysia and Thailand) but, as this trade appears to be largely internal, it is not reported in the CITES statistics.

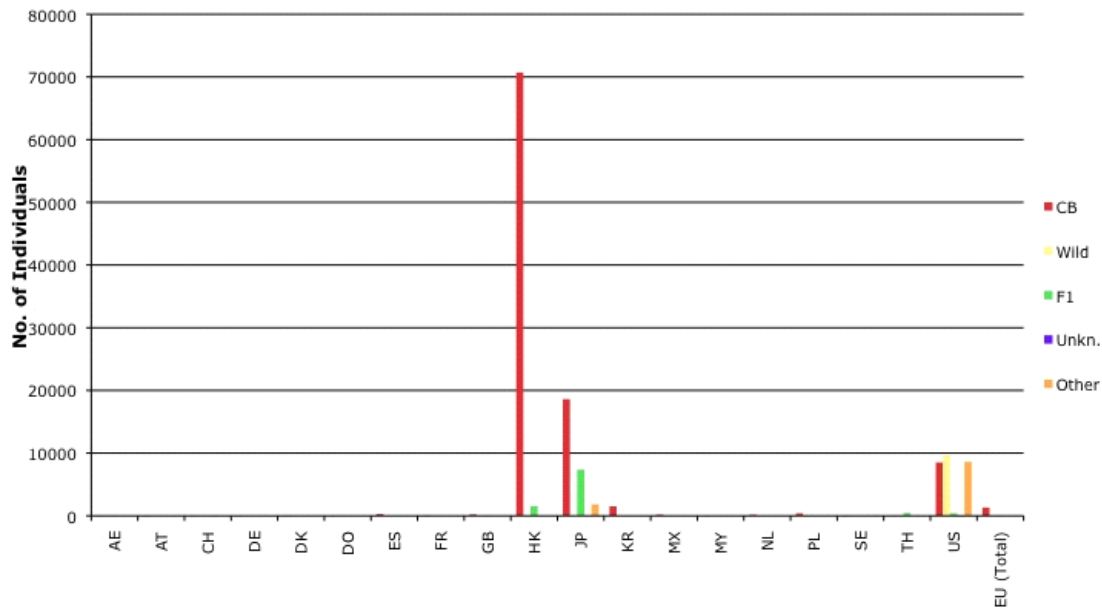


Figure D.2: Dynamics of importing countries in the live trade in *Arapaima gigas* between 1996 and 2012.

The majority of *Arapaima gigas* are exported from Peru (71.9%), a range state country, with relatively few coming from Brazil (3.8%) and Colombia (2.4%). In addition a number appear to be coming from Singapore (20.0%), with Taiwan (1.8%) and Thailand (0.3%) exporting very few (Figure D.3).

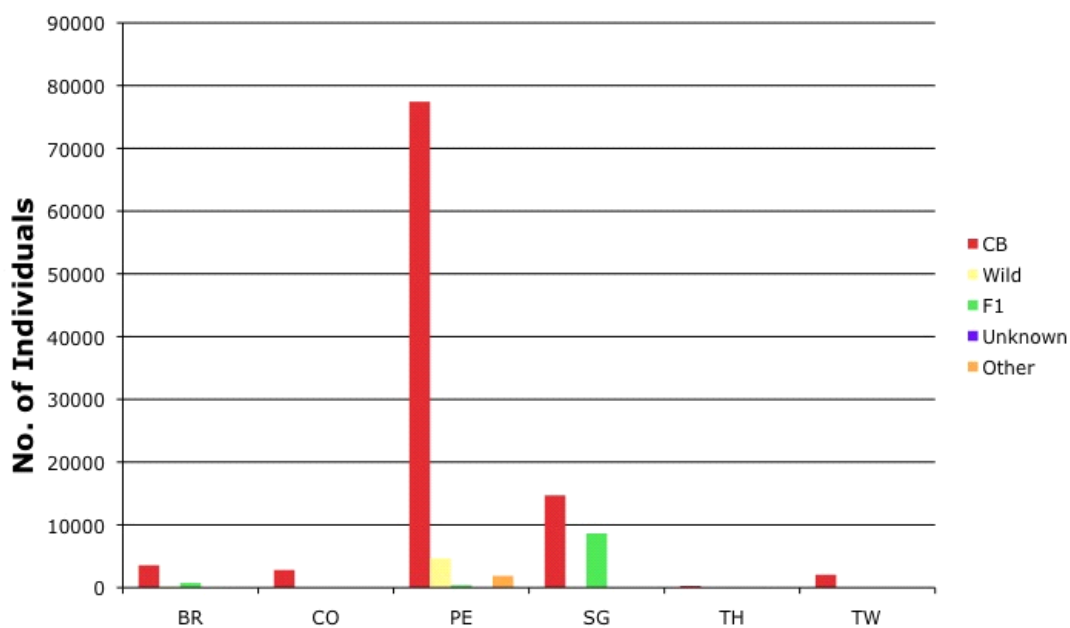


Figure D.3: Dynamics of exporting countries in the live trade in *Arapaima gigas* between 1996 and 2012.

As can be seen in Figure D.4 the dynamics of exporting countries has changed somewhat over time with Peru becoming the main exporter in the last 4-5 years; Singapore peaked as the main exporting nation in 2004 and 2005.

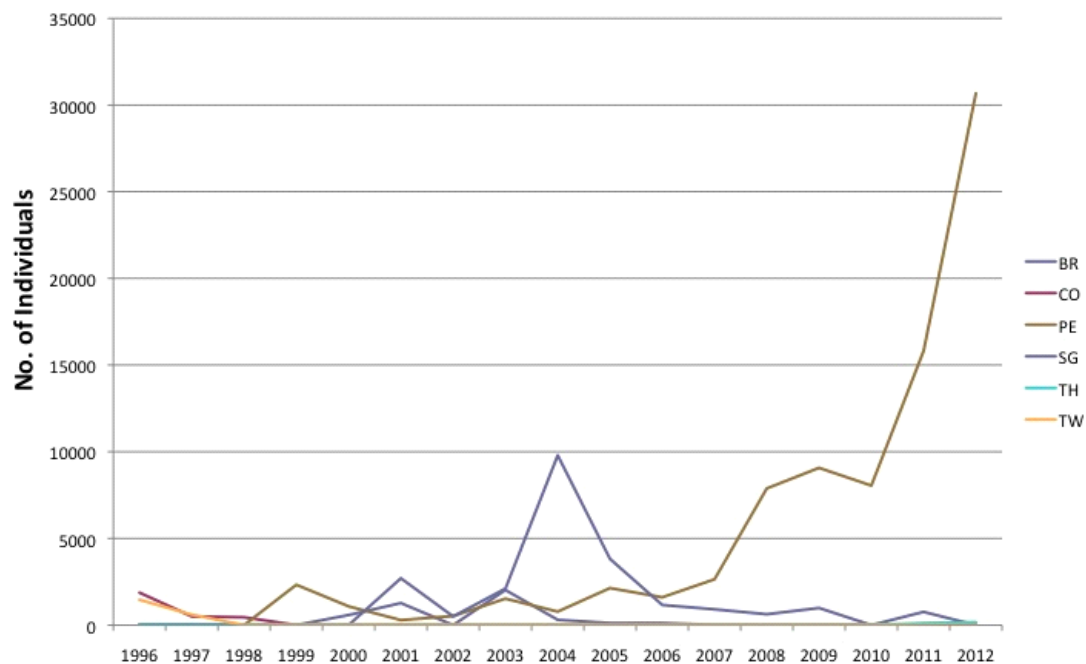


Figure D.4: Dynamics of exporting countries in the live trade in *Arapaima gigas* through time between 1996 and 2012.

Scleropages formosus (Asian arowana)

The Asian arowana, *Scleropages formosus*, is the only species considered here that is listed on Appendix I of CITES, as such the vast majority of the trade is under source code D which refers to “Appendix-I animals bred in captivity for commercial purposes ... , exported under the provisions of Article VII, paragraph 4, of the Convention” ([UNEP WCMC 2013](#)). The trade in this species has increased rapidly, from less than 20,000 individuals per year in 1996 to 1999, to over 160,000 individuals by 2012 (Figure D.5). This increase relates to the increasing number of CITES registered breeding facilities, with currently 47 registered in Indonesia, 56 in Malaysia, 32 in Singapore and 1 in Thailand ([CITES 2015b](#)). Under CITES regulations the *S. formosus* can only be traded and sold if they are bred in captivity and are of second generation (F2) and beyond. Only tagged (e.g. microchipped) captive-bred *S. formosus* from CITES-registered operations are allowed to be imported, exported or re-exported. A microchip is implanted in the dorsal muscle prior to export, and they must be pre-packed for inspection, with only one fish in each clear packing bag allowing easy viewing by inspectors, prior to export/import. The restrictions and control measures has both restricted the sales of *S. formosus* and created a complete tracking database to identify the global location and distribution of individuals ([Anon. 2014](#)).

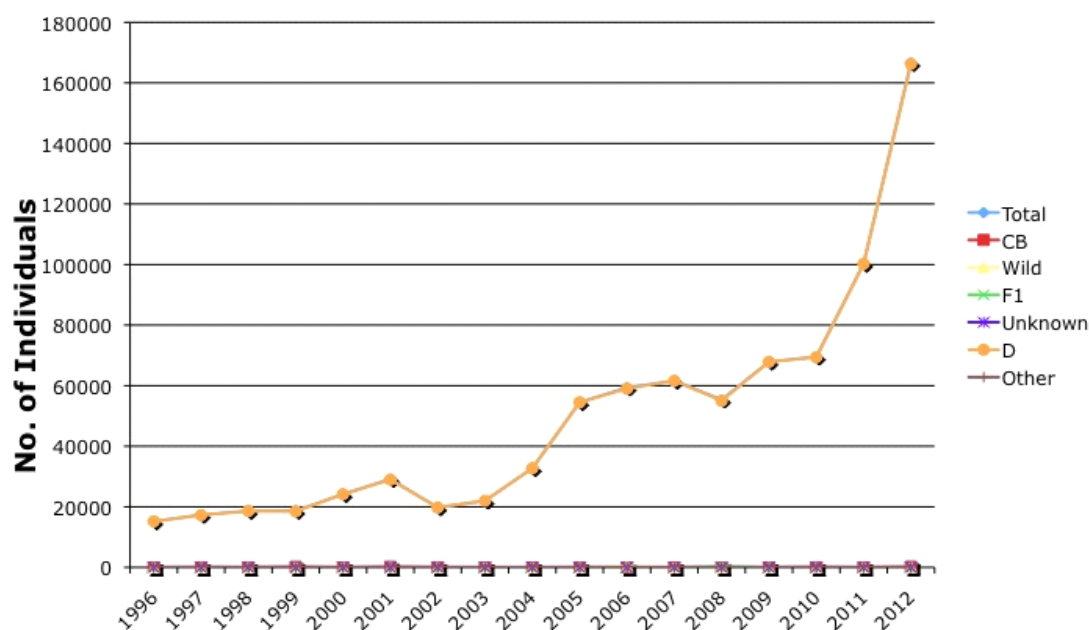


Figure D.5: Dynamics of the live trade in *Scleropages formosus* from difference sources between 1996 and 2012.

As the vast majority (99.8%) of individuals of Asian arowana have been exported under source code D, the following analyses are based solely on this source code. The Asian arowana is native to South East Asia, and the vast majority of the trade appears to be confined to these countries and regional neighbours. Hong Kong (29.7%), followed by Japan (25.1%) and Singapore (18.0%) are the main importing countries, although imports to China (12.5%), Thailand (6.6%) and Malaysia (6.5%) are not insignificant (Figure D.6).

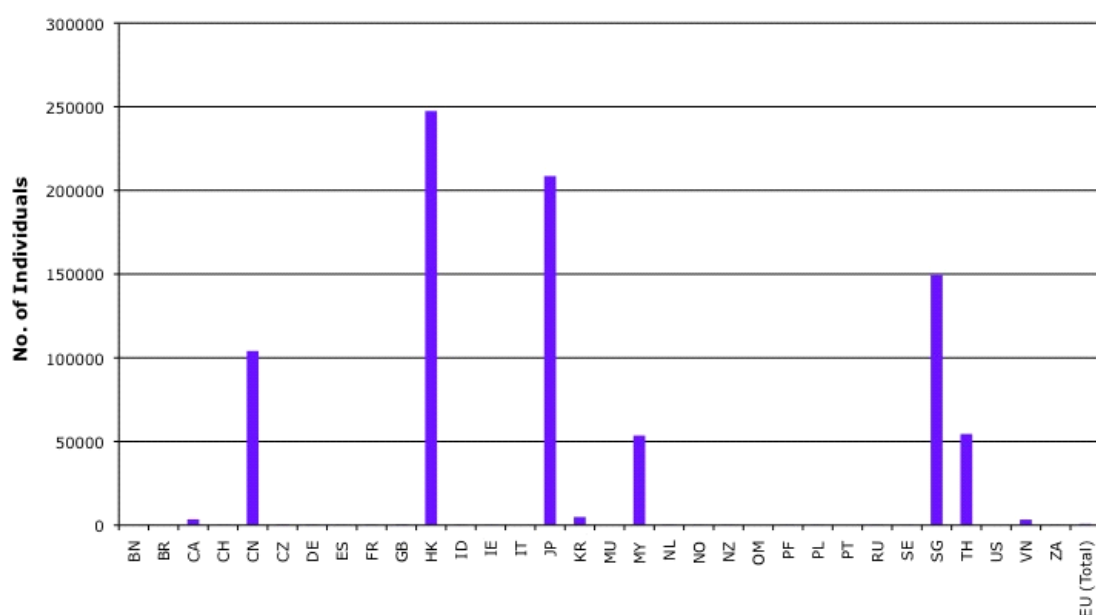


Figure D.6: Dynamics of importing countries in the live trade in *Scleropages formosus* from source D between 1996 and 2012.

Three South East Asian countries export the overwhelming majority of the individuals in trade, Indonesia (53.0%), followed by Malaysia (40.2%) and Singapore (6.7%) (Figure D.7), the latter two are also notable importing countries.

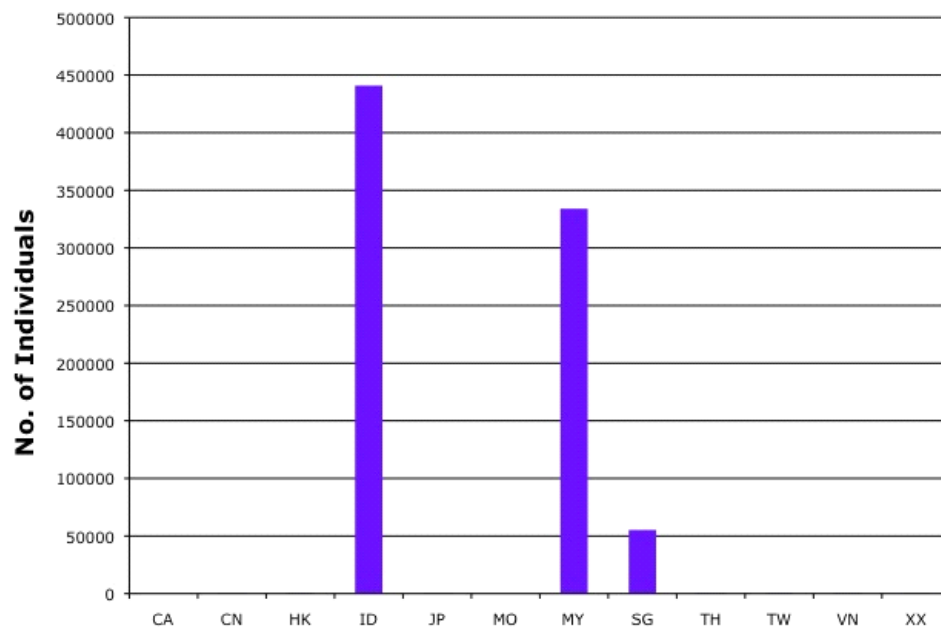


Figure D.7: Dynamics of exporting countries in the live trade in *Scleropages formosus* from source D between 1996 and 2012.

While Singapore has remained a relatively minor player in terms of exports, although it has been steadily increasing, the dynamic of trade coming out of Indonesia and Malaysia have changed in recent years. From around 2004 Indonesia increased exports of *S. formosus*, while Malaysia remained at less than 20,000 individuals per year. However, exports from Malaysia increased considerably in 2011 and in 2012 to over 100,000 individuals, compared to just over 50,000 being exported from Indonesia (Figure D.8).

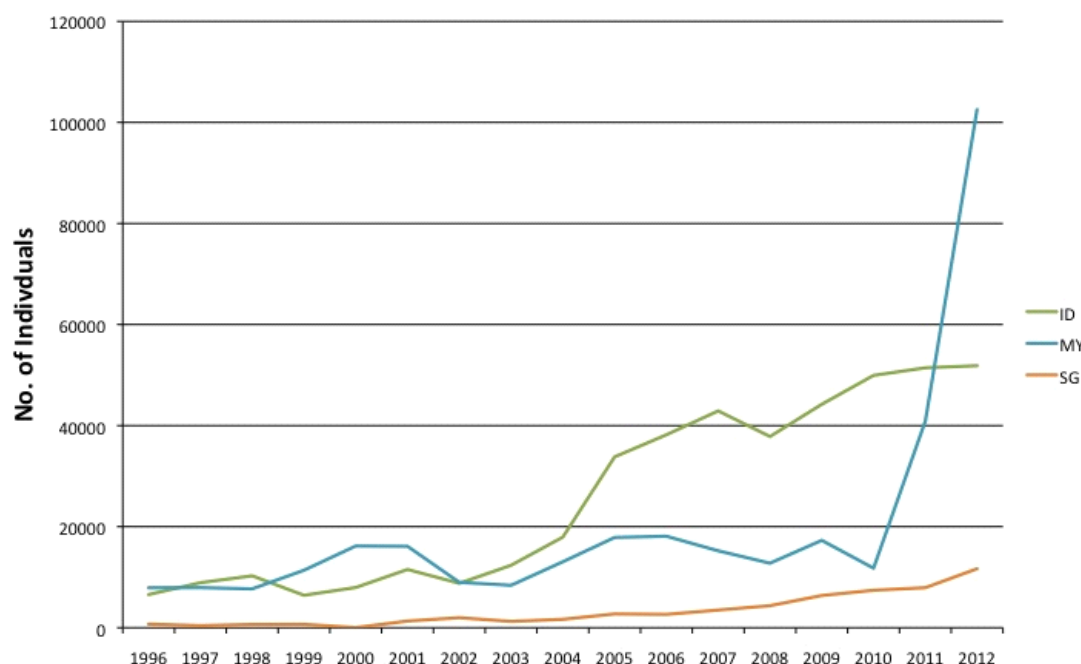


Figure D.8: Dynamics of exporting countries in the live trade in *Scleropages formosus* from source D through time between 1996 and 2012.

Seahorses (*Hippocampus* spp.)

The genus *Hippocampus* (seahorses) has been listed on Appendix II of CITES since 2004 (speciesplus.net). During this 8-year period to 2012, in terms of numbers of live individuals, there appears to have been a decline in those coming from the wild, with an increase in those traded under source code F (F1 or subsequent generations that are captive bred but do not fulfil the definition of 'bred in captivity') (Figure D.9). The majority of individuals in trade are listed as being from F (c. 42,500 in 2012), followed by captive bred (c. 13,500 in 2012) and then wild (c. 3,200 in 2012). There is a noticeable sharp increasing in number during the period after listing in 2004, and for F from 2005. This could be due to 'bedding in' of the new listing into national legislation and those involved in the import, export and customs becoming more aware of their status on CITE. In addition 2004 data may only represent part of this year as the species were only uplisted partway through 2004. This may also explain the decline in those listed as wild and an increase in those that are F. However, misapplication of source listing is common as seen in listing of reptiles as 'Ranched' when in fact they should be listed as wild collected.

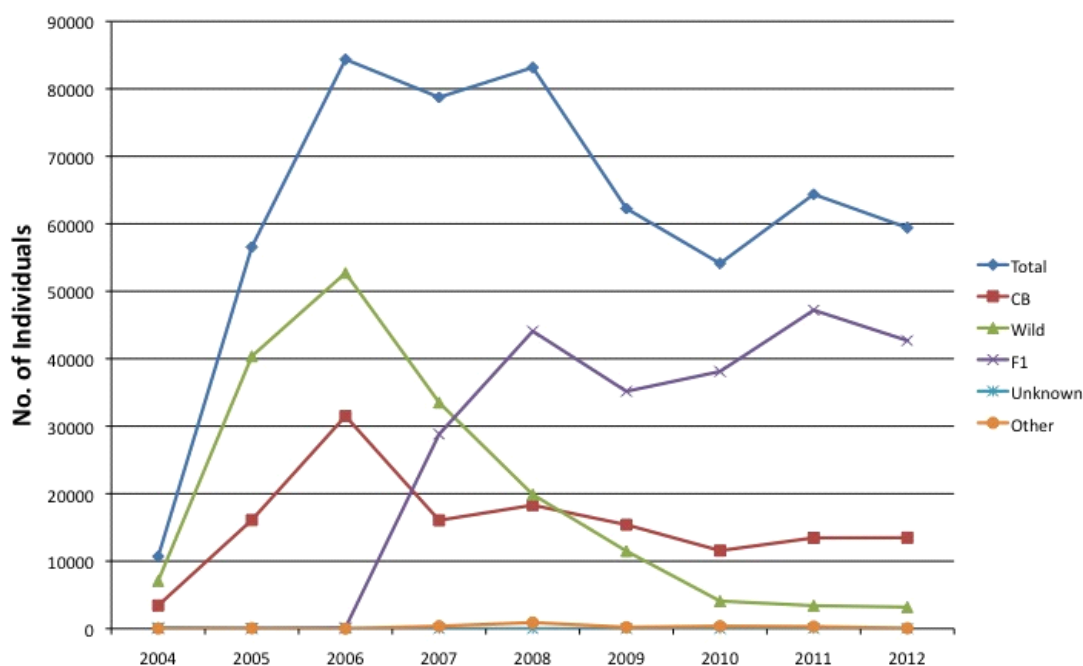


Figure D.9: Dynamics of the live trade in *Hippocampus* spp. from difference sources between 2004 and 2012.

In terms of trade of dried individuals, for medicine and curios, all but a few were listed as wild-collected. The trade in dried wild collected seahorses appears to have declined from a high of over 13,000 kg in 2005 to just over 2,000 kg in 2012; although in the previous year over 8,000 kg were traded (Figure D.10). If one assumes that the trade in dried seahorses from medicinal purposes is at least stable, or more likely increasing, given trends in traditional Asian medicines, this decline may mask a significant illegal trade.

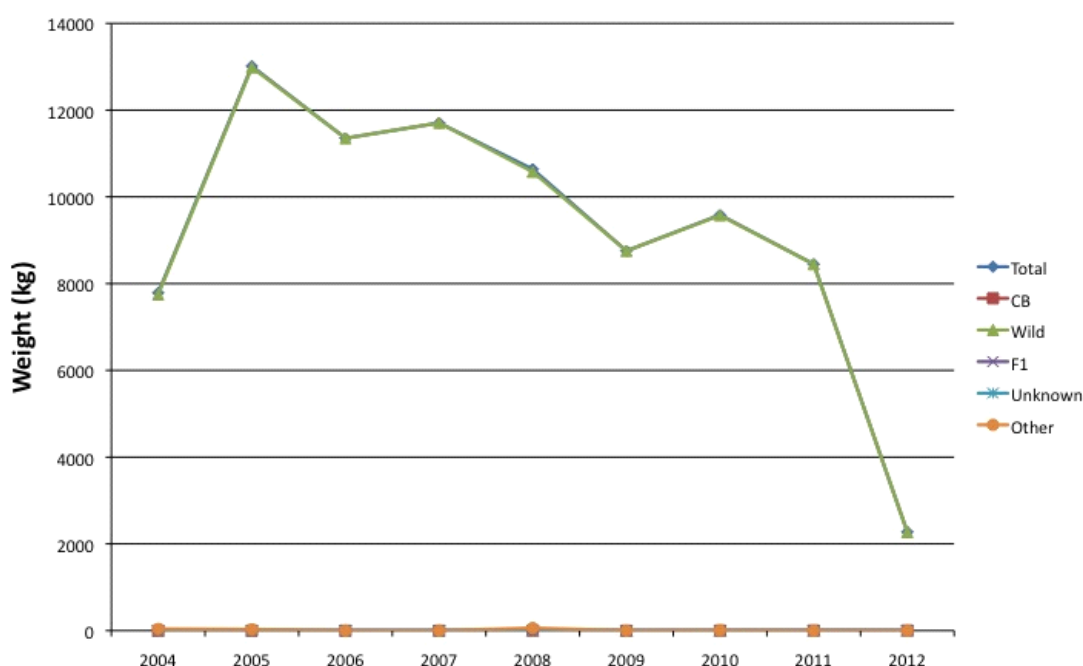


Figure D.10: Dynamics of the dried trade in bodies of *Hippocampus* spp. from difference sources between 2004 and 2012.

Live and dried seahorses are predominantly traded in units of individuals and kg respectively. To allow comparison between the two trades, kg of seahorses was converted into number of individuals. To do this, a search of literature was conducted to determine the weight of dried seahorses, as well as websites offering quantities of dried seahorses (often sold as the number of seahorses per kg) and custom seizure records. We were therefore able to estimate that 1 kg of seahorses was equivalent to 200 to 500 individuals, depending on the size of the species and individuals. This suggests a 50% loss in weight when drying occurs, which is consistent with other findings. Even with the uncertainty in terms of numbers of individuals per kg, it is clear that the trade in dried seahorses, as a group, is considerably higher than the trade in live individuals (Figure D.11). However, the significant volume of seahorses caught as by-catch should not be underestimated (Lawson 2014). Lawson (2014) extrapolated total volumes of seahorses in reported by-catch for 17 countries and obtained a figure of approximately 11 million; the majority being caught by trawl nets.



Figure D.11: Comparison of live and dried *Hippocampus* spp. between 2004 and 2012 based on number of individuals using correction factors of 200 and 500 individuals per kg for the dried trade.

Of the species traded, *H. kuda* is by far the most frequently traded in terms of number of overall (64.4%), in particular from the wild and as F. After *H. kuda* is *H. reidii* (17.7%) with the majority being captive-bred. While a number of other species are also traded, they appear to be in considerably lower numbers, the majority constituting less than 1% of the total trade (Figure D.12).

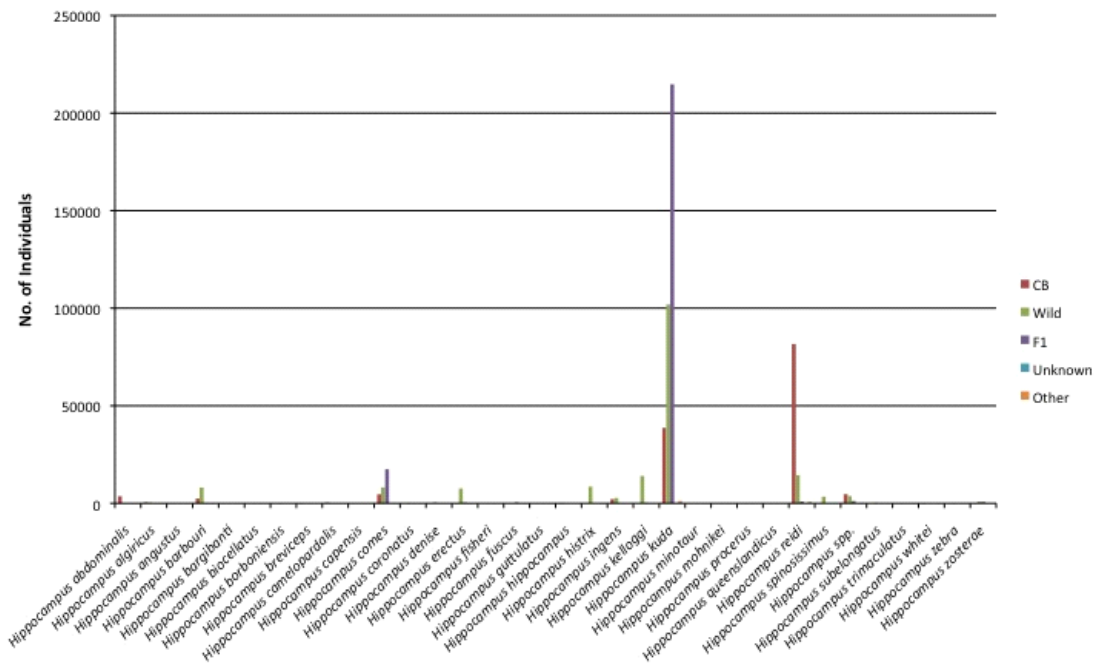


Figure D.12: Dynamics of imported species in the live trade in *Hippocampus* spp. between 2004 and 2012.

When compared with the trade in dried seahorses collected from the wild, the species involved are different, with little overlap between this and the live trade. While there is some trade in *H. barbouri*, *H. histrix*, *H. ingens*, *H. kelloggi*, *H. kuda*, it is either at low levels in both or is dominate in one of the trades; either live or dried. Trade in both *H. spinosissimus* (28.8% of trade) and *H. trimaculatus* (30.1% of trade) appears to be around 25,000 kg over the period, with c.15,000 kg of *H. kelloggi* (17.8% of trade) and c.7,000 kg of *H. algiricus* (8.2% of trade) being trade (Figure D.13).

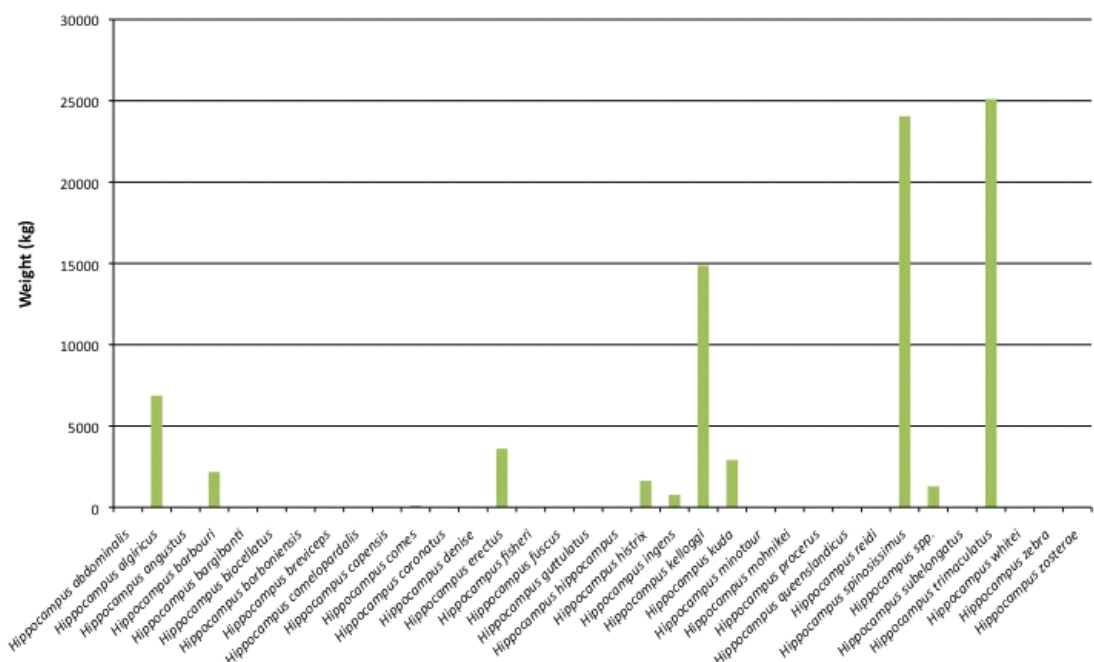


Figure D.13: Dynamics of imported species in the wild dried bodies trade in *Hippocampus* spp. between 2004 and 2012.

Of the 37 countries listed as having imported live seahorses between 2004 and 2012, 47.2% of the trade went to the US, followed by 24.5% to the EU (including 3.7% to the UK, France imported 12.1%), and then Singapore with 2.1%; all other countries imported less than 0.5%. Comparing the USA and EU, the majority of the US trade was composed of wild and F individuals, while the vast majority coming into the EU were captive bred or of F origin (Figure D.14).

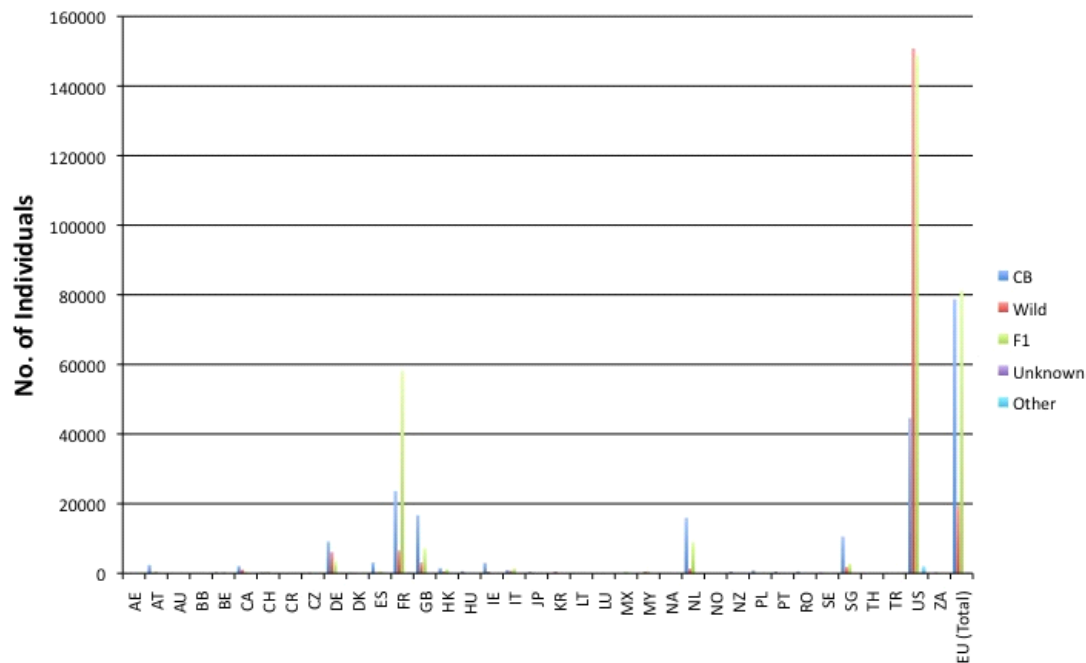


Figure D.14: Dynamics of importing countries in the live trade in *Hippocampus* spp. between 2004 and 2012.

In terms of the importation of dried individuals, Hong Kong was by far and away the greatest consumer with 88.1% of the trade, followed by China with 10.4% and then Singapore, Japan and the USA with 0.8%, 0.6% and 0.1% respectively (Figure D.15).

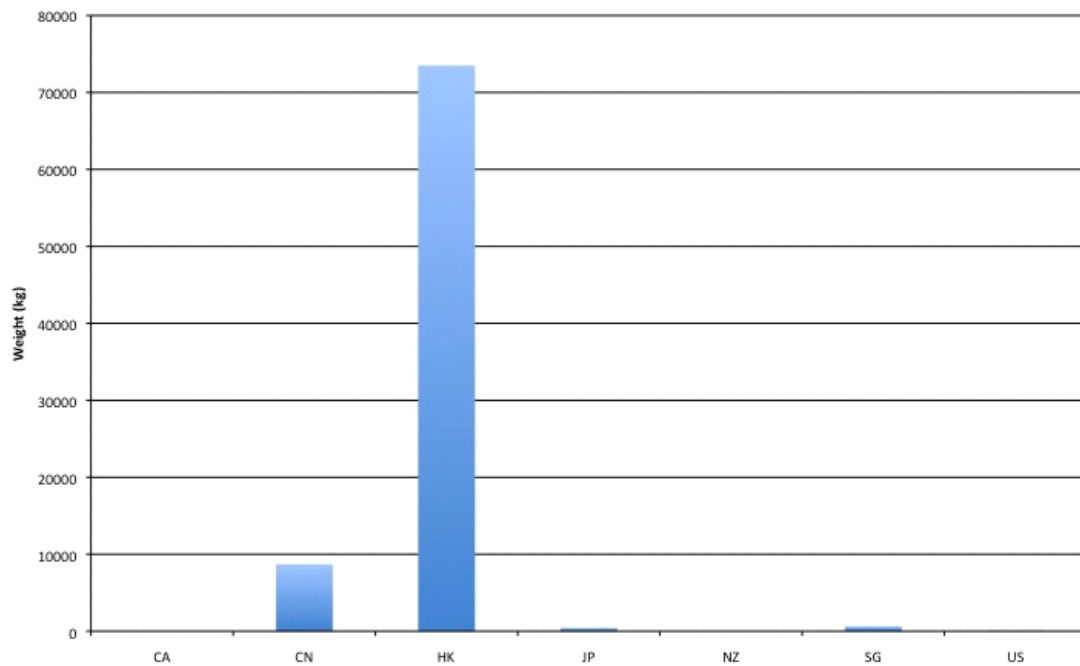


Figure D.15: Dynamics of importing countries in the dried bodies trade in *Hippocampus* spp. between 2004 and 2012.

Like the species in the live vs dried trade, countries of export differed between these trades possibly reflecting species distribution. Over 65% of individuals in the live trade were exported from Vietnam (the majority being exported as F, although around one-third were listed as wild), followed by Sri Lanka with 16.3% (the vast majority listed as captive bred), Indonesia with 9.4% (the vast majority listed as wild), Australia with 4.1% (the vast majority listed as captive bred) and 3.0% from Brazil (the vast majority listed as wild). The remain 19 countries exported less than 0.1% with the exception of two countries that had less than 1% (Figure D.16). It has been suggested that in the case of Vietnam the majority of the *Hippocampus* harvest is as a result of bycatch. Meeuwig et al. (2006) identified five species of *Hippocampus* in catch landings ($n = 4184$). *H. spinosissimus* and *H. trimaculatus*, comprised 34% and 62% of the landings respectively; *H. kuda* comprised 4% and *H. histrix* and *H. kelloggi* accounted for <1%. It should be noted that in the case of the Philippines that following the listing of *Hippocampus* spp. on Appendix II of CITES trade was suspended as Filipino legislation prohibits the export of live Appendix II species ([Christie et al. 2011](#)).

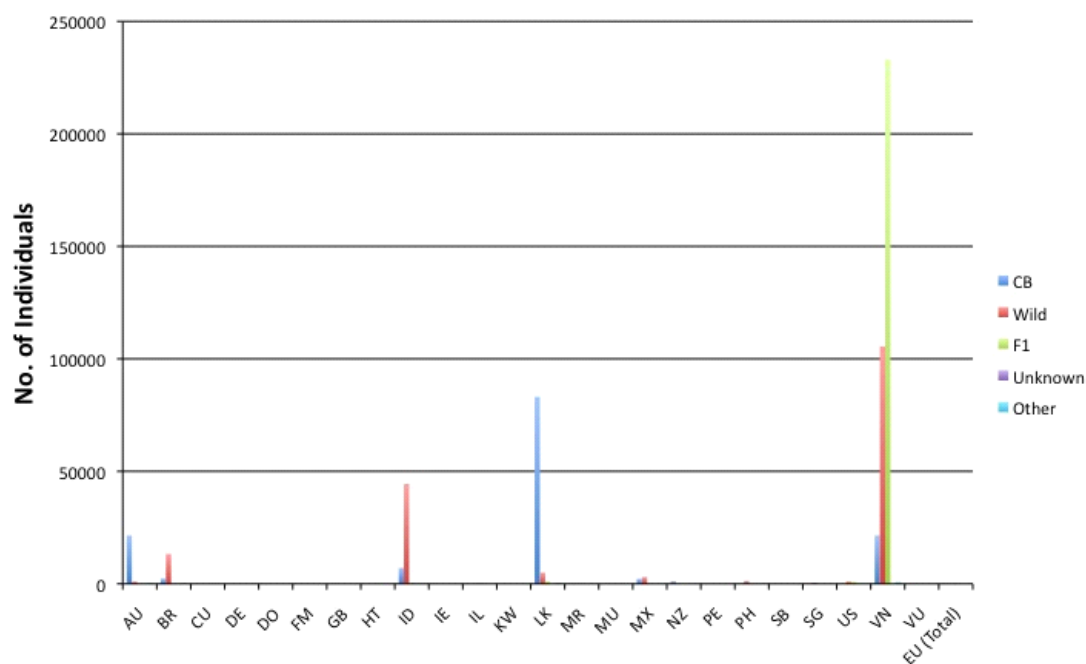


Figure D.16: Dynamics of exporting countries in the live trade in *Hippocampus* spp. between 2004 and 2012.

Thailand exported 82.6% of dried seahorses, with 7.2% coming from Guinea, 3.7% from Singapore, 3.0% from Malaysia and 1.3% from Mexico. The remaining 9 countries each exported less than 1% (Figure D.17).

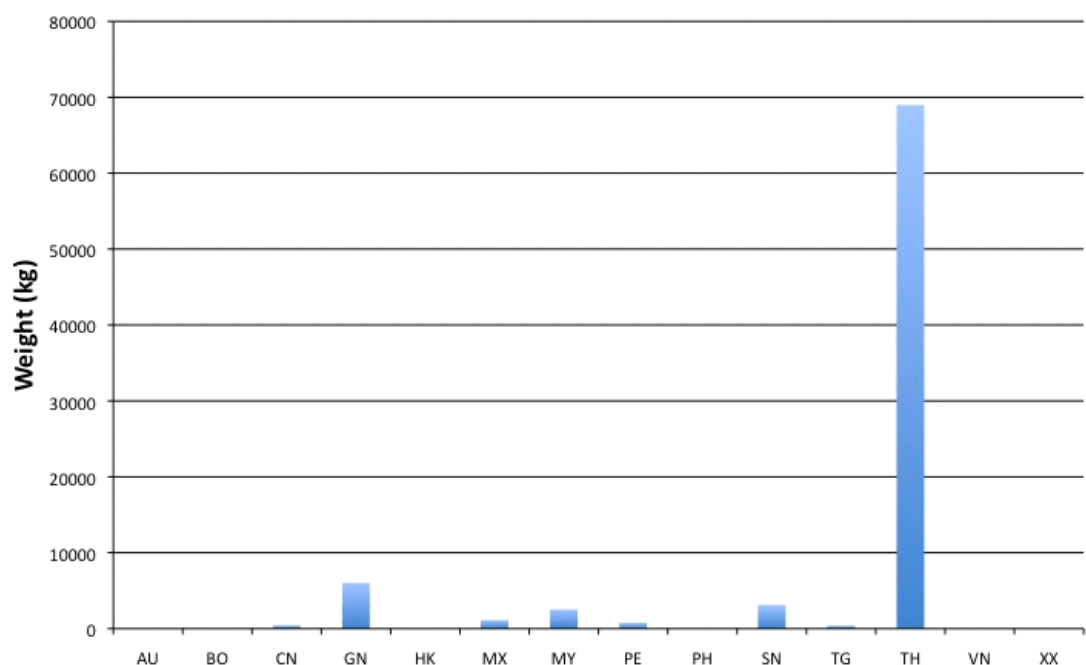


Figure D.17: Dynamics of exporting countries in the wild dried bodies trade in *Hippocampus* spp. between 2004 and 2012.

Corals of significance to the ornamental aquatics trade

There are three main taxa that are significant within the trade, namely Helioporidae spp. (Blue corals – only one species is extant, *Heliopora coerulea*), Scleractinia spp. (Stony corals) and Tubiporidae spp. (Organ-pipe corals). All are listed on Appendix II of CITES although fossil taxa are exempt. Understanding the dynamics of the trade in corals is extremely difficult owing to their taxonomy, and difficulty in identification to species level. As a result CITES trade may be listed from the species level all the way to the level of Order. Extraction of data from the CITES Trade Database is therefore problematic as for example Scleractinia spp. will only return trade as this name rather than all species within Scleractinia. A request was therefore made for trade data to the WCMC (United Nations Environment Programme's World Conservation Monitoring Centre) who holds the CITES trade database. Unfortunately only data from 2004 to 2013 was provided and therefore the analysis was limited to the period 2004 to 2012.

It should be born in mind that the trade in coral is heavily regulated with major exporters such as Fiji, Indonesia and Malaysia, having strict annual quotas (see the following for the current 2015 quota - [CITES 2015c](#)). In the case of Fiji, removal of corals for the aquarium trade is 0.0085% of total estimated colonies on the reef with a living cover reduction of 0.0014%. Such levels of extraction have very minimal impact on the ecosystem. Further live coral exports represent an important fishery to Fiji, bringing economic benefit to the coastal peoples and the national economy (Lovell & Whippy-Morris 2012).

Helioporidae spp. (Blue corals, specifically *Heliopora coerulea*)

The Family Helioporidae is now represented by a single extant species, *Heliopora coerulea*, which is found throughout the Indo-Pacific. The trade is therefore rather limited compared to Scleractinia. The vast majority of trade is in the form of live or raw coral that is collected from the wild, and trade in individual pieces rather than in kg. Of the two forms of trade 85.1% is raw coral, whereas live coral is only 14.9%, and combined 99.9% is wild harvested (Figure D.18).

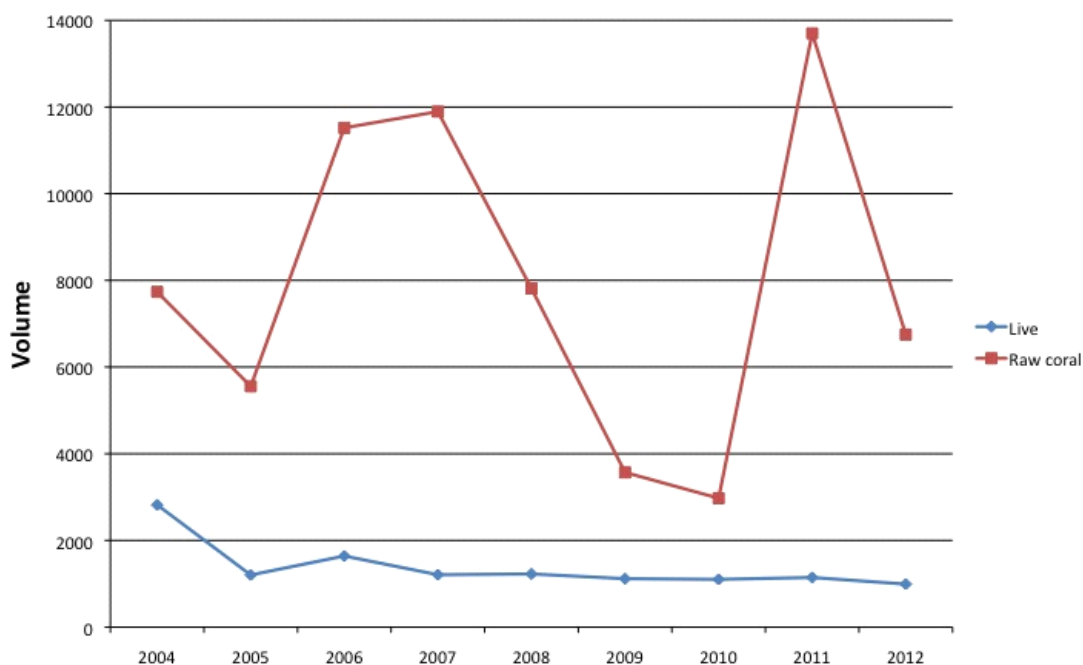


Figure D.18: Dynamics of the wild live and raw coral trade in Helioporidae spp. between 2004 and 2012.

While raw coral makes up the bulk of the trade, live coral is imported by considerably more countries (29 compared with 11). The EU is the largest importer of live corals (40.1%), followed by the US (39.3%). However the US is the largest importer of raw coral with 92.4%, while the EU only imports 3.9% all of which, apart from a very small proportion (c. 0.05%) is imported by Italy. The rest of the live coral trade is imported by Germany (17.9%), France and Italy with 7.7% each, and the UK with 7.0%. The remaining countries each constitute mostly less than 2% (Figure D.19).

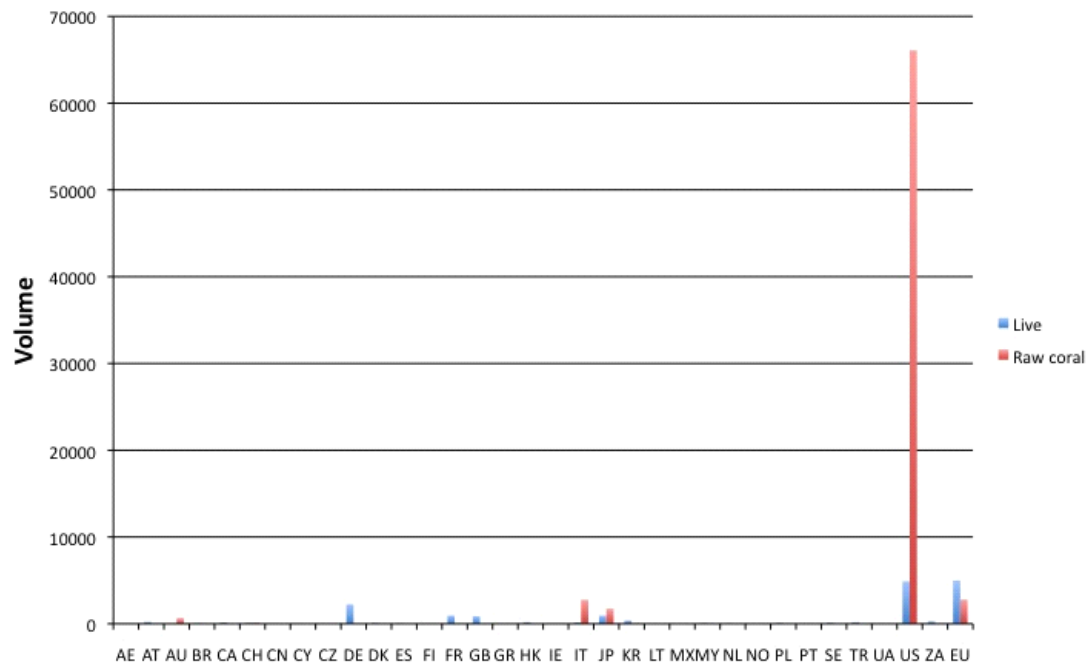


Figure D.19: Dynamics of importing countries in the wild live and raw coral trade in *Helioporidae* spp. between 2004 and 2012.

With the exception of a couple of incidences of export from China and the Marshall Islands, 87.5% of exports come from the Solomon Islands with the rest coming from Indonesia. However, of the export of live coral, Indonesia has 68.3% of the market (Figure D.20).

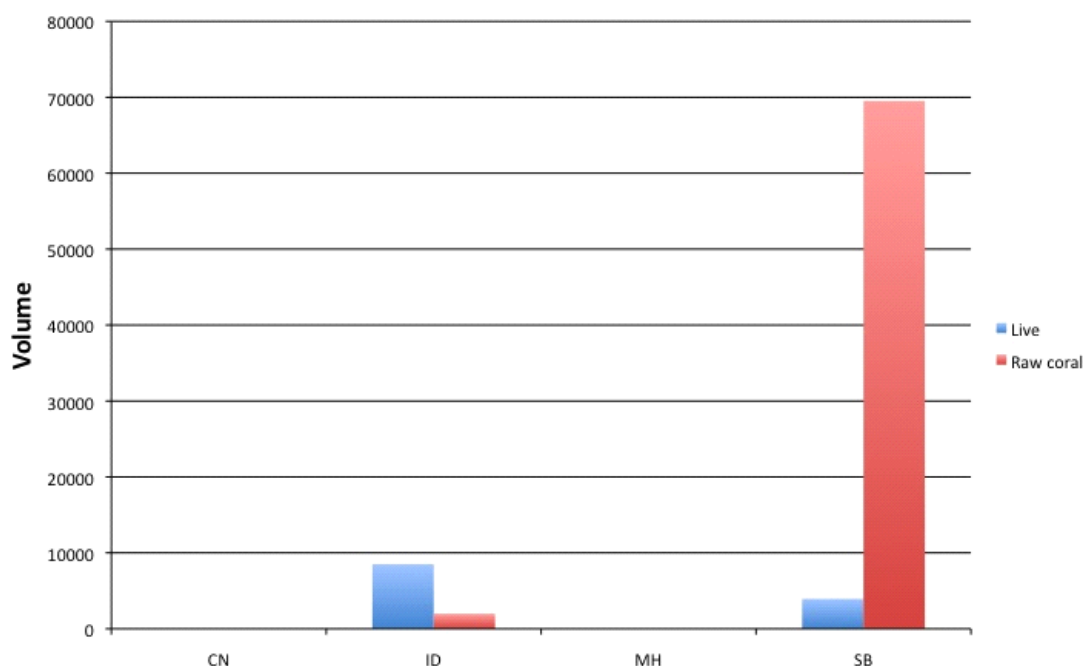


Figure D.20: Dynamics of exporting countries in the wild live and raw coral trade in Helioporidae spp. between 2004 and 2012.

Tubiporidae spp. (Organ-pipe corals)

The Family Tubiporidae is represented by a single genus, *Tubipora*, which is found throughout the Indo-Pacific. Like the blue coral, trade is therefore rather limited compared to Scleractinia corals. The vast majority of trade is in the form of live or raw coral that is collected from the wild, and trade in individual pieces rather than in kg. Of the two forms of trade 79.5% is raw coral, whereas live coral is 20.3%, and combined 99.8% is wild harvested (Figure D.21).

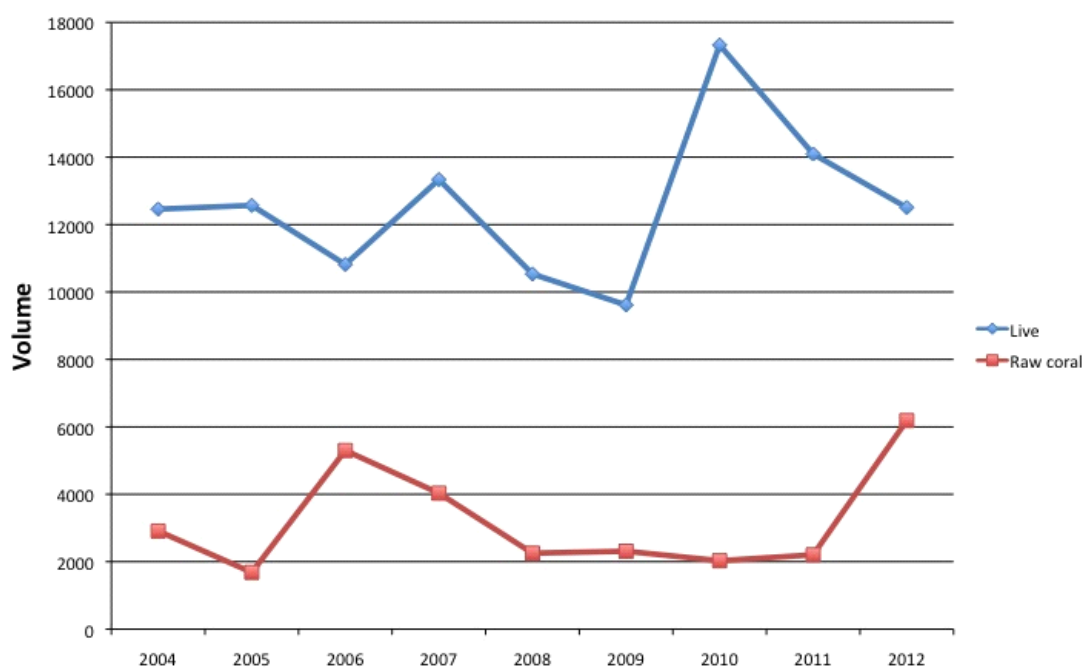


Figure D.21: Dynamics of the wild live and raw coral trade in Tubiporidae spp. between 2004 and 2012.

While raw coral makes up the bulk of the trade, primarily for the curio trade, live coral is imported by considerably more countries (41 compared with 20). The US is the largest importer of both live and raw coral with 57.0% and 57.1% respectively. In comparison the EU imports 26.3% of live coral and 11.2% of raw coral. After the US, the market then divides, live coral imports are then dominated by the UK (10.8%) followed by France (7.2%), whereas the raw coral trade is then dominated by Japan (24.9%), which imports more than the whole of the EU, and Italy (10.5%), with imports the majority of raw coral coming into the EU. The remaining countries each constitute mostly less than 0.5% (Figure D.22).

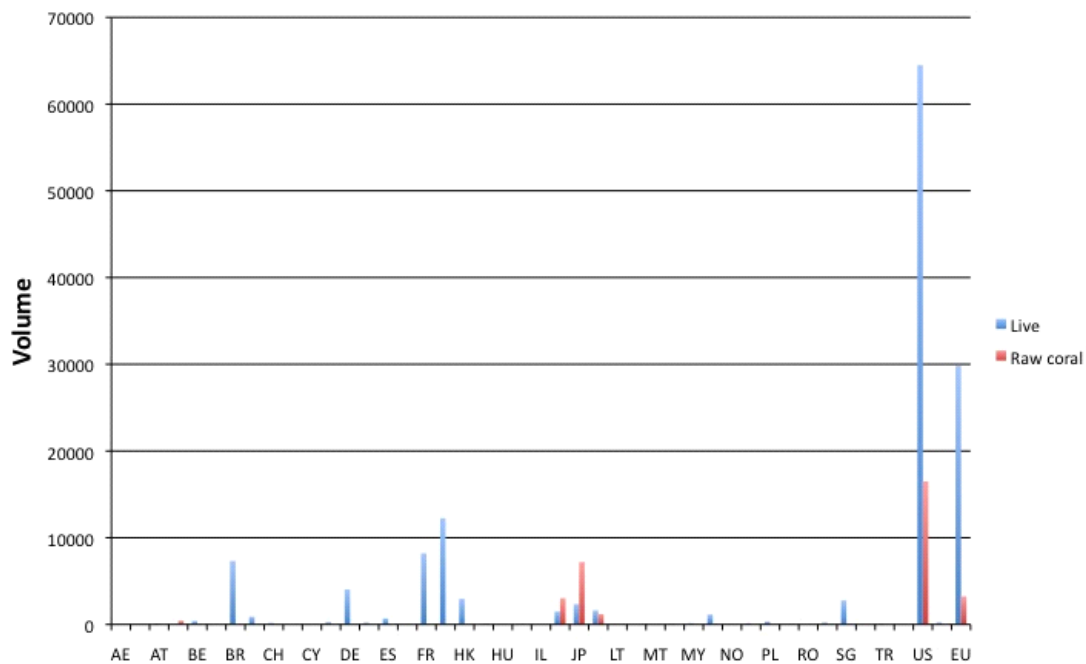


Figure D.22: Dynamics of importing countries in the wild live and raw coral trade in Tubiporidae spp. between 2004 and 2012.

Live exports are dominated by Indonesia, with 55.6%, while the Solomon Islands dominates raw coral exports with 68.9%. Fiji then follows in live and raw coral exports with 29.4% and 20.9% respectively. The third largest exporter of live corals is then Tonga with 6.2%, while Indonesia exports represent 7.2% of the raw corals trade (Figure D.23).

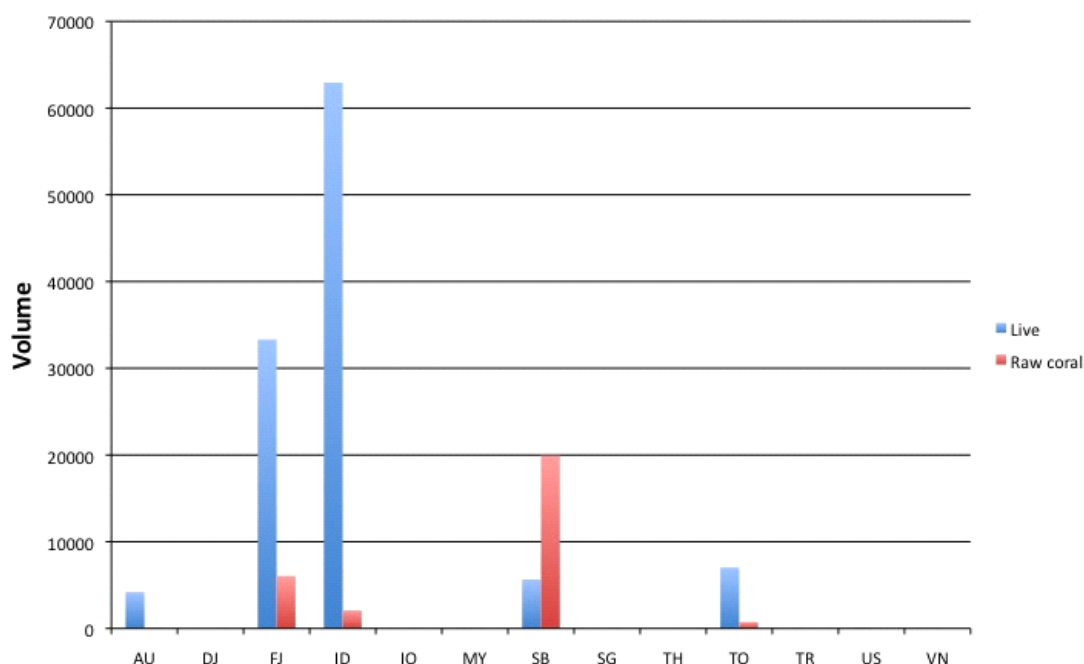


Figure D.23: Dynamics of exporting countries in the wild live and raw coral trade in Tubiporidae spp. between 2004 and 2012.

Scleractinia spp. (Stony corals)

The Order Scleractinia contains the majority of corals associated with the ornamental aquatics trade; being traded as live or as raw coral, particularly as 'live rock' that is used to condition marine tanks with the micro flora and fauna it holds; although raw coral does include trade as curios. There are issues over the units used to record the quantities traded. As above, [blank] mainly refers to individuals, however this is difficult to determine in the case of corals, hence the word 'volume' is used. The analysis is therefore divided into 'volume' and weight (kg). The majority of the trade recorded as without units (i.e. blank) is from wild collection, with a small quantity as F, and has shown a slight gradual decline over time. It is traded in both live and in its raw state, although it is traded in higher quantities as live (Figure D.24). The peak in 2010 is an anomaly due to 3,009,216 live *Scleractinia* spp. being imported to Israel from unknown exporter/s (listed as XX) and source for the purpose of commercial trade. This illustrates the issues with using such data.

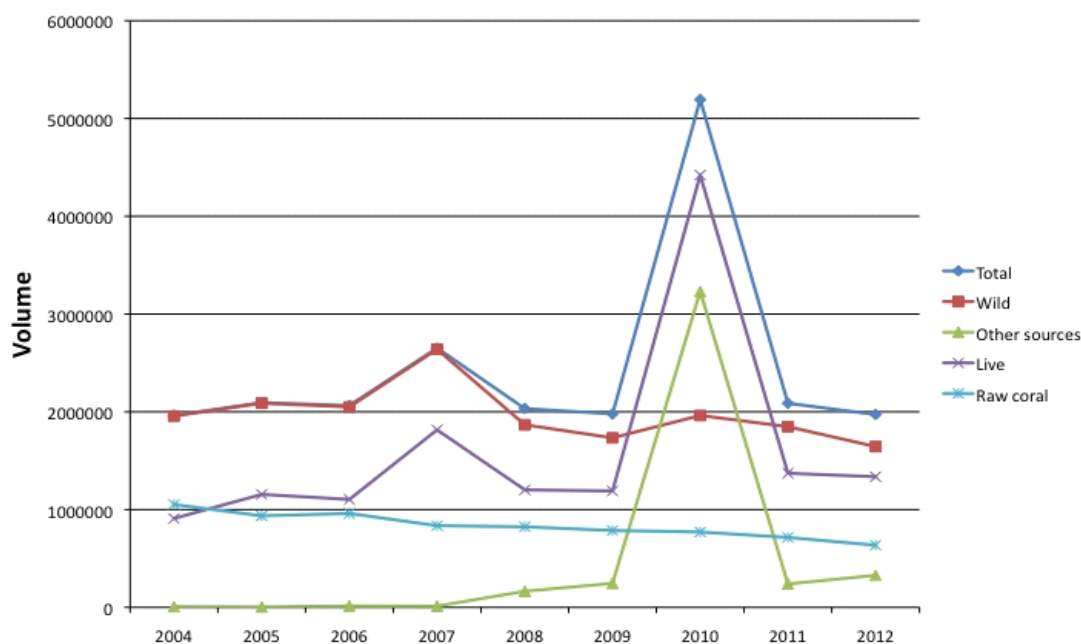


Figure D.24: Dynamics of the trade in Scleractinia spp. between 2004 and 2012 recorded without units (i.e. Blank – may correspond to number of individuals) (NB Total = Wild + Other Sources).

In terms of trade as weight, again the majority is from the wild, but this time as raw coral, which is the recommended unit for this term (Resolution Conf. 11.10, [CITES 2015d](#)). Trade using weight has declined sharply throughout the period, although it appears to be picking up in the last two years (Figure D.25).

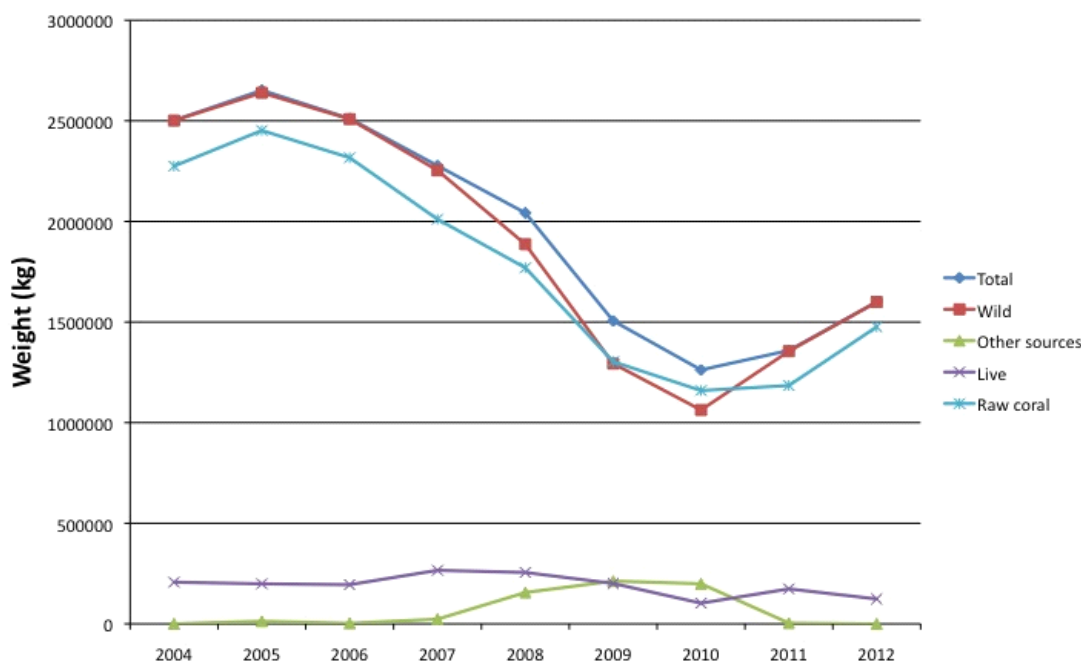


Figure D.25: Dynamics of the trade in Scleractinia spp. between 2004 and 2012 recorded in kg (NB Total = Wild + Other Sources).

The largest importer of *Scleractinia* spp., both live and raw coral, when the units are not recorded ([blank]) is the US (44.5% and 70.0% respectively). This is followed by the EU (22.6% and 12.7% respectively). Then, in terms of live coral Israel (20.8%), although this could be as a result of the previously mentioned anomaly in 2010. This is then followed by France (7.8%) and the UK (5.9%), however should the Israel figures be shown to be an anomaly then the percentage share of the import market would increase (live – US 56.2%, EU 28.6%, France, 9.9%, UK 7.5%). For the raw coral trade, after the EU, Japan is next largest importer (11.8%). Like the live coral trade other importers are often less than 1% (Figure D.26).

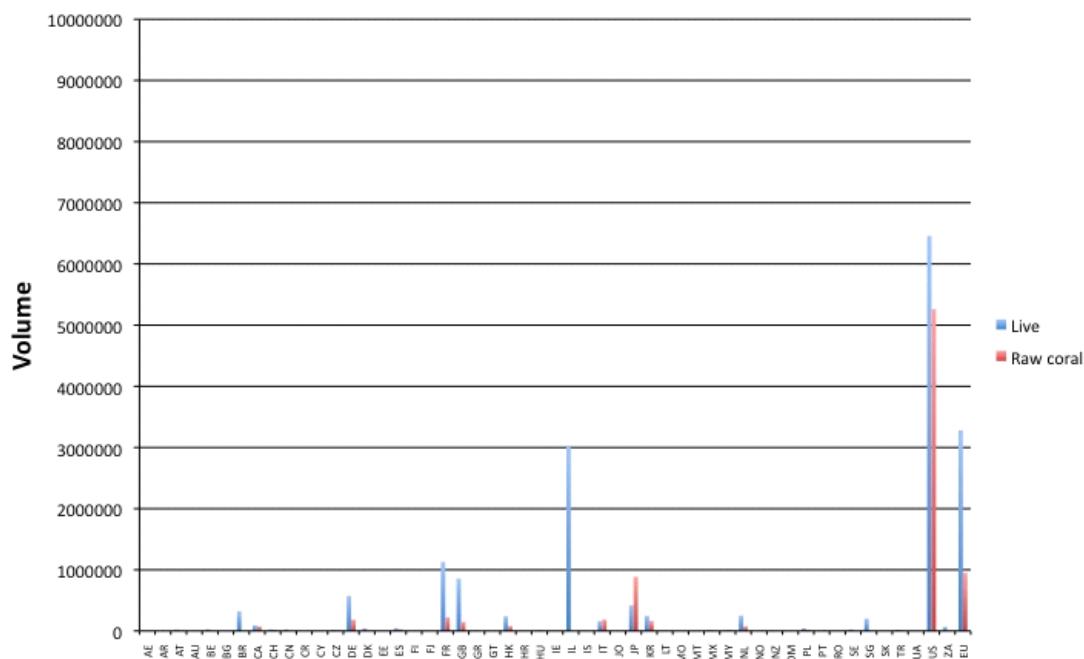


Figure D.26: Dynamics of importing countries in the live and raw coral trade in *Scleractinia* spp. between 2004 and 2012 recorded without units (i.e. Blank – may correspond to number of individuals) and not corrected for the Israel anomaly.

In contrast, based on trade recorded as weight, Taiwan is the largest importer with 59.0%, followed by the EU as a whole (30.1%) and Italy (15.6%) for live corals. In terms of raw coral, the US remains the largest importer (77.3%), with the EU as a whole importing 19.3% and the UK importing 5.8% (Figure D.27).

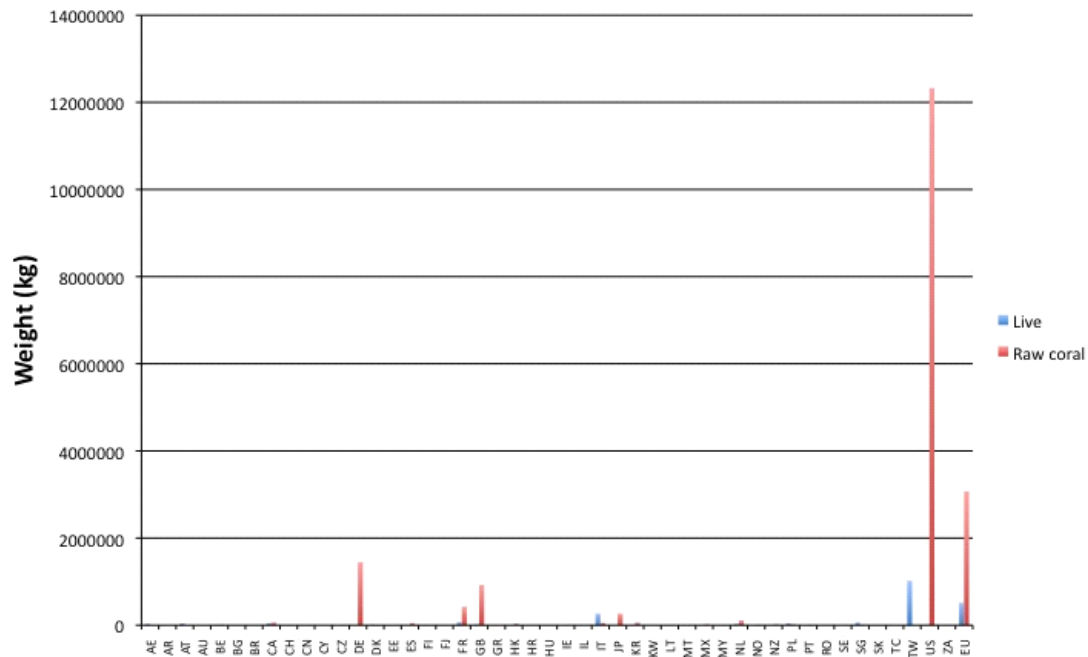


Figure D.27: Dynamics of importing countries in the live and raw coral trade in *Scleractinia* spp. between 2004 and 2012 recorded in kg.

The largest exporter of *Scleractinia* spp., both live and raw coral, when the units are not recorded ([blank]) is Indonesia (71.8% and 63.8% respectively). Then for the live trade this is followed by the Israel anomaly, which recorded the exporter as unknown (XX) with 20.7%, then Australia and Fiji (7.6% and 7.5% respectively, 9.5% and 9.4% when corrected). In terms of raw coral, after Indonesia, Fiji is the largest exporter (13.0%), followed by the Solomon Islands, Tonga, and Vietnam (8.1%, 6.5 and 6.1% respectively). Like the live coral trade, other exporters are often less than 1% (Figure D.28).

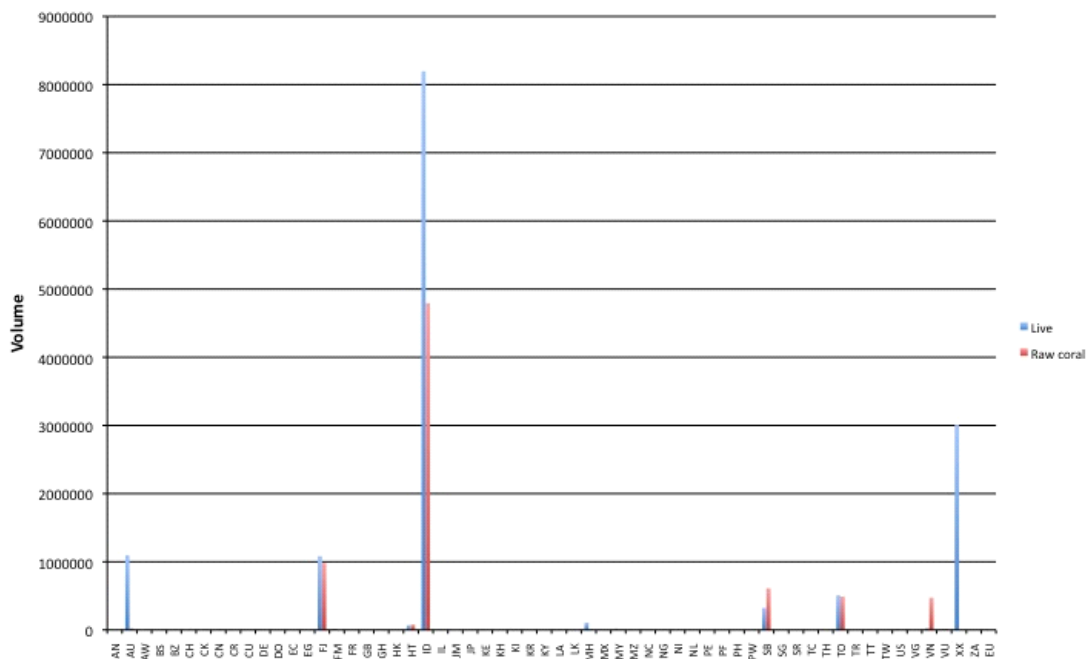


Figure D.28: Dynamics of exporting countries in the wild live and raw coral trade in *Scleractinia* spp. between 2004 and 2012 recorded without units (i.e. Blank – may correspond to number so individuals).

In terms of exports by weight, for live coral, Haiti is the largest exporter (36.2%), followed by Indonesia (35.9%), and Fiji (21.4%). However, as raw coral, Fiji is the largest exporter (65.1%), followed by Tonga (15.4%) and Indonesia (12.5%) (Figure D.29).

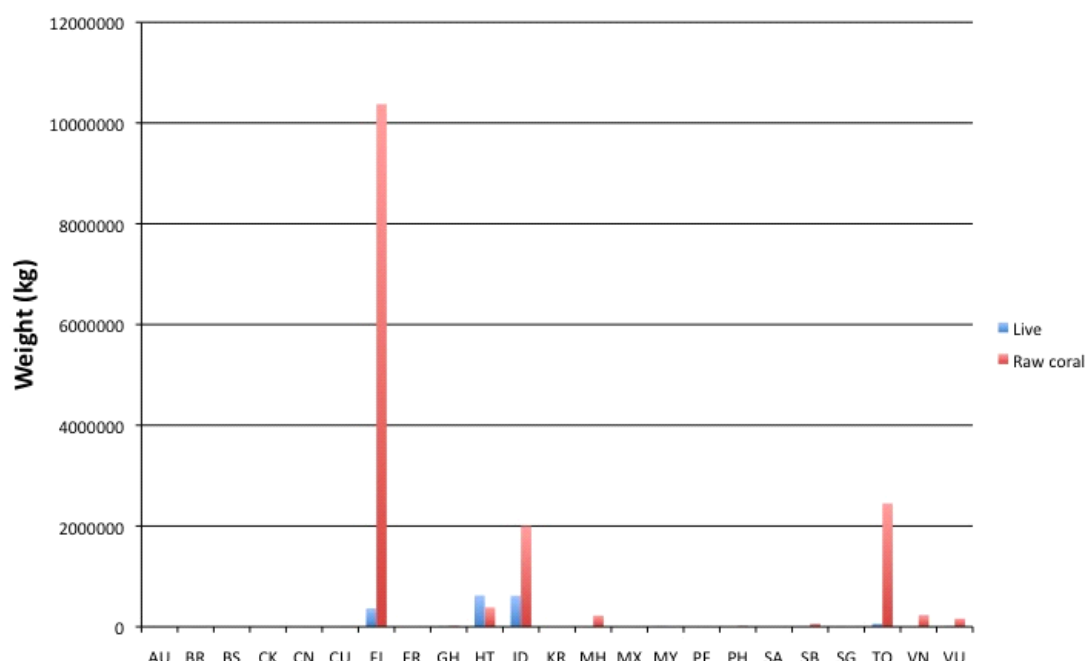


Figure D.29: Dynamics of exporting countries in the wild live and raw coral trade in *Scleractinia* spp. between 2004 and 2012 recorded in kg.

Note on the CITES trade database and corals: Resolution Conf. 11.10 ([CITES 2015d](#)) provides definitions of the different types of coral specimens in trade. The preferred (and alternative) units of measure can be found in Annex VII at the back of the Commission Regulation ([EU-Lex 2006](#) but also see CITES [CITES 2011](#)). Accordingly, Member States or Parties should record trade in corals as per the following advice:

Dead coral (described as coral (raw) – code COR) should be recorded in kg (unless transported in water in which case it would be individual specimens). If there are no units, then it would assumed it refers to kg since most dead coral trade at generic or species level would not be transported in water.

Live coral (code LIV) preferred unit is number of individual specimens as they are transported in water and therefore, using weight would not be appropriate.

Live rock (also description code COR) – is usually transported in damp newspaper (not water like live corals) and accordingly is recorded as kg. Coral rock is not identifiable to the level of genus but is recognizable to the level of order.

However, it should be noted that dead coral enters the curio trade mainly, rather than the aquatics sector (live rock enters the aquatics trade). The inclusion of both “dead coral” and “live rock” under COR and using the descriptor raw therefore creates confusion, making interpretation of trade statistics difficult (see Draft report to the USCRTF [Anon. 2015](#)).

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Annex E: The ornamental fish trade and livelihoods

The ornamental trade and livelihoods

There is little in the way of hard information on the importance of the ornamental fish industry and how it supports livelihoods, or on how costs and revenues are distributed along the supply chain. There is some information available based on household surveys, which shows how important the trade can be to collectors in some areas. However, there is little that provides an indication of how ornamental fish collection ranks as a “business” compared to other livelihood activities, such as farming, petty trading or casual labouring. This makes it difficult to compare the industry against other activities carried out in areas where ornamental fish are collected, traded and exported as often only prices or some household data are available.

Employment in the ornamental industry

Very little information is available on this at any stage in the supply chain and much of what is available is of doubtful accuracy as the methodologies used are either not stated or based on limited sampling and/or estimates. In addition, most head counts of ornamental fishers do not take into account whether the fishers are gathering ornamentals as part of a livelihood strategy or whether it is the sole livelihood activity undertaken. The methodological flaws may well mean that the number of people benefiting from the trade in wild-caught ornamental aquatic organisms is under-recorded. However, even with these cautions, it is reasonable to assume that several hundred thousand people are employed in the harvesting and initial care of fishes and that this must result in the involvement of a few million people in support industries and further along the supply chain. Some examples of quoted figures are given below.

Estimated number of people employed in the aquarium fish sector in South America

These figures should be treated with caution, as it is not even possible to determine the methodology used in some cases, let alone to carry out any verification of the figures quoted. Estimates taken from scientific papers tend to be more reliable or at least allow for an assessment of their reliability, as the methodology is described and the number of surveys conducted is quoted. The numbers below should be taken as indicative of the number involved rather than a measurement.

Colombia (Data taken from ACOLPECES, 1990)

- Direct employment, collectors, intermediaries and exporters – 5,000 persons
- Indirect employment in support industries such as transport – 5,000 persons
- Number of persons directly or indirectly dependent on the industry – 40,000
- Total number of persons benefiting from the industry – 50,000

Information from Steve MacAlear (Tres Fronteras Acuario Colombia, pers. comm. interview 21/03/15) indicated that in the Laetitia area there are about 50 Ticuna Indians engaged more or less full-time as collectors with perhaps up to 200 with informal, part-time collecting activities. Collectors were recorded as earning COP 15-40,000 per day (USD 5.76 – 15.12) compared to coca growers who earn COP 50-90,000 per day (USD 18.90 – 34.04).

Mancera – Rodriguez and Alvarez – León (2008) summarised work by other authors on employment in the ornamental fish trade in Colombia and noted that “*Galvis-Vergara et al. (2007) estimate 2,500 people depend on ornamental fish for their livelihoods and emphasise that, while the trade in ornamentals may not generate significant income at a national level, it is important in marginalised regions such as Puerto Gaitán, Puerto Inírida and Puerto Carreño. According to the WWF Colombia, there were approximately 2,300 fishermen (plus their families) dedicated to ornamentals in Guainía, Arauca, Putumayo, Amazonas and Guaviare, thus, constituting an economic alternative for a large group of people (Incoder, 2006b). They also noted that the importance of the ornamental fish trade in the country is not just limited to international trade. It also constitutes an important source of*

income for coastal, rural and indigenous communities and frequently contributes, in good measure, by creating job opportunities and generating income associated with export activities.”

Brazil (Data taken from Watson 2000, adapted from information supplied by Project Piaba)

- Number of collectors based around Barcelos, Rio Negro – 3,000
- Number of families in Barcelos dependent directly or indirectly on collecting – 1,000 (Prang, 2001)
- Number of collectors in Amazonas – 8,000-10,000

Note: the number of families dependent on collecting in Barcelos is now thought to be about 300 licensed collectors but not all are currently active (January 2015).

Peru (Data reported by Gerstner et al. 2006)

- Direct employment – 3,000 families
- Indirect beneficiaries (not specified) – 100,000 persons

There are no data available to estimate the overall contribution that the industry makes to incomes in these areas, although there are some reports available at the village level. It would not be appropriate to assume that household income surveys could be used to derive incomes by multiplying it by the number of people involved in collecting, as individual household incomes are highly dependent on location and even what occurs in two villages in Peru that are close together can be quite different (Moreau and Coombes 2008). It is even more difficult to assess the importance of the trade in these areas to the local economy as nothing is available on how spend by collectors feeds into the local community. However, it would be reasonable to assume that the trade has wider benefits in South America by bringing traders into remote communities allowing access to trade goods that may otherwise not be available. There is also the question of the value of cash income in remote areas where often the only forms of trade are informal bartering that does not allow for the accumulation of cash for key services such as education and health.

Estimated number of people employed in the aquarium fish sector in the South Pacific

Solomon Islands – c. 400 persons involved in the coral reef aquarium and curio trade (no figure is available for aquarium trade only) (Albert et al. undated)

Fiji – Persons employed in the ornamental fish industry – 600 (this figure probably includes people working for exporters, not just collectors) (Teitelbaum et al. 2010) to 1,000 (Lindsay et al. 2004)

Number of persons employed by [Walt Smith International](#) 110 directly and 200 indirect (mainly collectors)

Kosrae, Federated States of Micronesia – 19 persons employed (Wabnitz and Nahacky 2014)

A review of the Fisheries for Food Security Programme (Chapman and Stanley 2013) gave a wider perspective on employment and the value of the ornamental trade to PICT (Pacific Island Countries and Territories) *“the marine aquarium trade in the Pacific Islands is a story of successful private sector development. There are currently 12 countries involved, with at least two others wishing to enter the trade. The business is estimated to be worth USD \$40–60 million a year to Pacific Island countries and territories (PICTs) and accounts for 10–15% of the global supply. It is estimated to provide some level of income (ranging from full-time employment to occasional sales and royalty payments) to over 5,000 Pacific Island households.”*

Seidel and Lal (2010) summarised the involvement in the ornamental aquarium trade in PICTs. This is shown in Table E.1.

Table E.1: Involvement in the aquarium industry in the PICTs, adapted from Kinch and Teitelbaum (2008).

Marine aquarium trade in PICTs	No. of households involved	No. of companies
Cook Islands	10	1
Fiji	600	5
French Polynesia	10	3
FSM	20	1
Kiribati	200	12
Marshall Islands	50	5
New Caledonia	2	2
Palau	30	1
PNG	50	1
Solomon Islands	250	2
Tonga	150	4
Vanuatu	100	3
Total (12)	1,472	40

Estimated number of people employed in the aquarium fish sector in South East Asia

It has not been possible to find much data on employment in this region. There is some data on the industry, however as it is so heavily dominated by farmed fish it says little about the trade in wild-caught ornamentals. However, there is one detailed study by the EU-PREP programme in Indonesia, which contains useful and detailed information, although it provides little information beyond the villages studied.

“Bali-Banyuwangi (East Java/Bali, Indonesia) has more than 2000 ornamental fisherman, many of them located in Banyuwangi. There are about 1500 fishers with 143 middle-men, in the 4 villages of Bangsring village, Ketapang village, Mandar Village, and Gilimanuk” (EC-PREP 2005).

Estimated number of people employed in the aquarium fish sector in South Asia

Again data for this region is also hard to find, presumably as the trade is also dominated by farmed fish. Some information is available, however it does not give an indication of the overall importance of the trade.

Sri Lanka

- Aquarium fish collectors in the southern coastal areas from Galle to Matara – 500 persons (Rajasuriya 2009)
- Snorkel and SCUBA divers involved in reef fish collection in south Sri Lanka – 567 persons (Howard 2012)
- Total employment in collection – 500 persons (Wood 1985)
- Number of ornamental fish divers in Dehiwala – 200 persons, Weligama – 100 persons

Estimated number of people employed in the aquarium fish sector in Africa

Data from Africa are fragmented and sparse, and do not necessarily reflect the current level of trade.

Cameroon – c. 2,200 persons in Mount Cameroon area; this figure represents the population in villages which depend on the ornamental fish trade and probably includes people who are not involved in the trade (Brummet et al. 2010).

The socio-economic relevance of ornamental fisheries

While the value of the ornamental fish trade is relatively low compared to other industries based on natural resources (e.g. mining, food fisheries) or even compared to other non-timber forest products, the industry does provide a very valuable source of cash income to families in some areas.

The value of this trade is described for Peru in Moreau and Coomes (2007), for Brazil by Prang (2001) and more generally in Watson (2000). The collection of ornamental fish in South America tends to be carried out by families rather than individuals with different family members taking specific roles. In any area, there will be families that specialise as ornamental fish collectors. As well as the direct benefit to the families from the cash income they receive, there are wider benefits such as drawing in traders that supply trade goods to remote areas and take ornamental fishes back to other traders or exporters. The cash that these families spend also has a role in supporting the local economy. The sums may be small (usually in the range of US\$500–1,000 per family per annum), but, given the lack of paid employment in remote areas, can play a vital role in supporting remote communities.

The collectors in Peru

Moreau and Coombes (2006, 2008) studied the ornamental fish trade in two communities in Peru, one on the Ucayali River and the other on the Tapiche River, both near to the town of Requena, an important buyers' collection point for the area. Both communities collected a mix of fishes, including the arowana, a high value fish popular in the Far East. All the households surveyed had diverse incomes from a range of activities with a variation in participation in the ornamental trade between the two communities and in its relative importance to livelihood between households. Table E.2 is taken from Moreau and Coombes (2008) and shows just how important the ornamental trade can be for households in the study area.

Table E.2: Income Shares and Participation Rates by Economic Activity in Isla Verde and San Juan, Peruvian Amazon, July 2001-2002.

	Isla Verde	San Juan
Aquarium fish collection		
Income share (%)	37.2 (0–72.6)	45.8 (0–92.9)
Participation rate (%)	90.9	57.7
Agriculture		
Income share (%)	33.2 (15.7–70.1)	25.4 (0–93)
Participation rate (%)	100	96.1
Food fishing		
Income share (%)	14.9 (5.1–23.5)	9.0 (0–45.8)
Participation rate (%)	100	96.1
Livestock		
Income share (%)	9.5 (0–32.7)	6.6 (0–38.5)
Participation rate (%)	90.9	80.8
Extraction		
Income share (%)	3.1 (0–12.1)	9.7 (0–57.6)
Participation rate (%)	72.7	84.6
Outside income		
Income share (%)	2 (0–11)	2.2 (0–44.9)
Participation rate (%)	63.6	73.1
Crafts		
Income share (%)	–	1.3 (0–25.7)
Participation rate (%)	–	46.2
All income (USD)		
Mean household income (USD)	26,348	124,286
N	2,395	4,780
	11	26

NB. Number outside parentheses = proportion of total village income generated by each activity. Numbers in parentheses = range in the proportion of total household income contributed by the activity. Participation rates = proportion of sample households that earned income from each activity. Income for any activity includes both subsistence and market amounts. 1 USD = 3.47 NS. Extraction in Table E.2 refers here to the collection of forest (e.g. timber, palm fruit) and aquatic (e.g. turtle eggs, reptiles) products.

In addition Moreau and Coombes (2006) recorded that households engaged in the ornamental trade earned USD 586 (Isla Verde) and USD 1,149 (San Juan) annually from arowana fishing for the ornamental trade representing 20.7% and 13.2% of household income respectively. Costs were not recorded, therefore it is not possible to determine how profitable this income activity is, nor how it compares to other activities. However, from the high participation rate it can be assumed that householders perceive it as profitable and/or an essential source of cash income. It should be noted that although agriculture has a very high participation rate, much of the produce is for household consumption or local trade and so actual cash income will be limited. The data also show just how difficult it can be for remote communities to make a livelihood beyond simply subsistence level and how few opportunities there are for income from outside sources.

Fish are usually bought by middlemen who will then take them for sale in Iquitos. In the case above, the main buying centre was Requena although buyers for arowana may travel more widely to source fish. In most cases, the middlemen will sell the fish on directly to the exporters although some collectors reported selling fish to intermediaries in Nauta. The middlemen represent an important source of credit to households engaged in the ornamental industry, although this relationship is open to abuse with reported cases of debt being used as an excuse for paying low prices for fish (this cannot be confirmed but it is very widely reported by ornamental fish collectors around the world). This is by no means limited to the ornamental sector and it is a common complaint by small-scale fishermen in developing countries (IW, pers. obs.) Middlemen are generally specialised buyers and sellers of ornamental fish although sometimes, exporters will send someone to buy fish directly on their behalf. Some exporters also use this system to take orders to the collectors to fulfil specific export orders.

Pykäläinen (2004) studied the ornamental fishery in the Allpahuayo Mishana National Reserve (RNAM). The fishery was already established when the RNAM was declared a reserve. It was estimated that 40 families in the RNAM were involved in the ornamental fish trade. One consequence of the establishment of RNAM was that the local families had the right to prevent those from outside the Reserve boundary entering it to catch ornamental fish, thus giving residents more control over the fishery. Pykäläinen (2004) does not give a clear explanation of the price structure or annual incomes for the fishermen but some idea of potential income can be made from some example calculations:

- Fishermen can collect about 500-1500 small tetras per day and receive PEN 40-80 per 1,000 fish (USD 11-22) according to the season
- Fishermen can collect 20-30,000 *Otocinclus* per day in the low water season and get paid PEN 40-80 per 1,000 (USD 11-22)

The income from ornamental fish is lower than for some other income activities, notably those relating to the timber trade, however, as notes Pykäläinen (2004), *“ornamental fish are one of the non-timber products whose sustainable use can have a highly significant impact on the conservation of the ecosystem. The 7 fishermen that receive enough income from the trade in ornamental fish will abandon more destructive practices and will also defend the ecosystem against outsiders who may come to extract key resources for its sustainability and balance.”* It was estimated that 1 million ornamental fish were being collected annually.

The Rio Negro fishery

Information in this case study is taken from Chao (1992), Chao and Prang (1997), Prang (2001), and updated by interviews with IW in January 2015.

The lower and middle Rio Negro was the area that really launched the ornamental fish trade from Brazil, following the discovery and subsequent commercialisation of the cardinal tetra (*Paracheirodon axelrodi*) in the 1950s. The cardinal tetra still dominates the export trade from the area although trade has declined significantly in the last decade due to competition from farmed

cardinals produced in the Far East, US and Czech Republic with the number of cardinals exported from Manaus being now only about 12-13M annually compared to a peak of about 30M (Mike Tuccinardi independent consultant, pers. comm. interview Jan/Feb 2015). The trade in ornamental fishes contributed about 65% to the economy of Barcelos and at least 1,000 families in the municipality are directly involved in the trade (data from Prang 2001, the current contribution is probably significantly less due to a decline in trade). The trade was the main source of income in cash and traded goods for many of the families in Barcelos. Collecting is restricted by water height mainly to the months of August to April and also by a close season to protect spawning stocks. Recent changes and especially the development of farmed cardinal tetras have led to a decline in trade from Manaus, however the full implications of this for the trade and for Barcelos in particular are not currently known. Exports from Brazil have also tended to shift to Belem, partly as a result of the high demand for higher value fishes such as the L-number plecos (a general term applied to a number of Loricariid catfish which more or less resemble *Hypostomus*) from the Tapajos and Xingu. Competition from farmed cardinals and from Colombian wild-caught cardinals is made worse by high shipping costs from Manaus as shown in Table E.3.

Table E.3: Inclusive shipping costs for cardinals tetras from different sources arriving Tampa FL, US. Source: Maria Inês Balsan (Project Piaba), presentation for Project Piaba expedition January 2015.

Source	Cost USD /kg for shipping to Tampa
Manaus (wild)	10.78
Colombia (wild)	5.02
Singapore (farmed)	4.50
Thailand (farmed)	6.40

Airfreight to the EU can be cheaper than to the US with TAP (Portuguese national airline) charging only USD 4/kg to Lisbon. Some competition on airfreight routes may help to improve export prospects for Manaus as there are currently not many options for routes to the US. The impact of this on the landed price of cardinals can be seen in table E.4.

Table E.4: Landed costs for cardinals tetras from different sources arriving Tampa FL, US. Source: Maria Inês Balsan, presentation for Project Piaba expedition January 2015

Source	Year	Price USD each
Wild ex-Manaus	2010	0.42
	2012	0.58
Farmed ex-FL	2010	0.78
	2012	0.78
Farmed ex-Singapore	2010	0.79
	2012	0.55

Factored into the landed price must also be expected mortality, which for wild caught cardinals from Manaus can still be up to 25% (Mike Tuccinardi, independent consultant, pers. comm.). Despite the lower cost of Manaus cardinals, the losses and lack of year round availability can make them less

competitive when compared to typical mortality of 5% for farmed cardinals from the Far East (Mike Tuccinardi, independent consultant, pers. comm.). One US importer reported a reduction in mortality for cardinals from Manaus from about 25% to 2-3% just by changing suppliers. Direct comparison is complicated by the fact that wild-caught cardinals do well in soft water and not in hard water. However, some farmed cardinals that are reared in hard water do well in hard water but generally experience high mortality in soft water. Evidence from one US retailer suggests that consumers may be willing to pay more for wild caught cardinals than farmed, however the analysis is highly dependent on location within the US due to the relative ease of access to Manaus, US or Far East suppliers and the relatively high cost of airfreight within the US. For this reason, it is very unlikely that a general model would apply to all US retailers. In this case, the retailer sold Vietnamese farmed cardinals for USD 2.50 each or USD 6.00 for three and wild-caught cardinals for USD 2.99 each or USD 5.00 for two. Staff were briefed on the relative merits of wild-caught and farmed cardinals and were able to explain the differences to customers. Customers preferred the slightly more expensive wild-caught cardinals by 2:1.

Barcelos is heavily dependent on the trade in extractive products and opportunities for diversification are limited. Dry years are linked to El Nino events, which can lead to very low rainfall with the consequence that no flooding occurs and hence there is little or no recruitment in the fishes targeted by *piabeiros*. Such an event occurred in 1982-83 resulting in a significant drop in catches around Barcelos (Chao and Prada-Pedrerros, 1992). In such years when ornamental fish collecting has been restricted or impossible (fish are hard to find and breeding is very limited) an increase in slash and burn agriculture and in timber extraction occurs in order to maintain incomes. Neither of these appears to be sustainable, and may in the long-term lead to the degradation of the ecosystem on which the extractive industries are based. One response to the loss of income from extraction has been the migration of families to Manaus, where they are forced to live in extreme poverty. There has also been some local migration from outlying villages into Barcelos. A visit was made to the village of Daracuá which only had a small population in the past but which is now only occupied during fishing trips (for food fish and ornamental fish) as the residents mainly live in Barcelos where they have access to schooling and health care.

A recent development for the Rio Negro has been the growth of the sport fishing industry, primarily for peacock bass (*Cichla* spp.). Anglers tend to live on board boats that act as floating hotels with smaller boats used for angling towed behind. One hotel boat was seen to be towing 13 fishing boats, this at least gives an indication of the potential employment in sport fishing as each boat requires a boatman/guide. Angling boats were seen as far upstream as Santa Isabel. The impact of this activity on the local economy is not known. The impact on peacock bass populations is probably small as most anglers practice catch and release.

The *aviamento* (literally, to supply) system derives from colonial days when it was used mainly as a means to ensure a supply of labour to provide the raw materials demanded by international commodity markets. It was based initially on the trade in raw rubber and other gums. The *aviamento* system ensured the supply of labour by keeping the rubber dealers in debt, and they in turn kept the rubber tappers in debt. The *aviador* (trading house) himself would have been in debt to the exporter. The system deliberately set out to prevent the development of a cash-based economy and ensured the labourers were in debt from the first transaction.

This system has evolved to meet the need of the ornamental fish trade and differs significantly from the system that existed in the rubber boom days. The current system tends towards interdependence between collectors (*piabeiros*) and the *aviadors*. There has also tended to be a shift away from a system that relied wholly on traded goods to one in which cash plays a more important part. The *aviador* is now firmly linked to the *piabeiro* society and *aviadors* often become part of the family life through (for example) becoming godparents or through other forms of elective kinship. It is now more difficult to say who is dependent upon whom. That said, the *aviador* system

may still exploit *piabeiros* through the trade in over-priced or sub-standard goods. However, there is no reason to suppose that any other form of trade would not treat the *piabeiros* in similar fashion.

The *aviamento* system is essential in supplying Barcelos and the wider area with traded goods, ranging from basic foodstuffs to tools and consumer goods. Given the remoteness of many of the communities around Barcelos that use it as a trading centre, the *aviador* still plays a vital role. It is doubtful that many would make the journey from Manaus to Barcelos unless they had products to collect there to sell on their return to Manaus.

As in most trading systems of this kind, the *aviador* acts as a source of credit. More usually, credit is advanced in the form of pre-ordered goods (usually consumer goods) that are paid for by future deliveries of fish; less commonly, money is advanced. No firm evidence is available on the cost of such credit to the *piabeiro*, but the claimed mark up of 40% (profit and the cost of credit) from one *aviador* does not seem excessive when compared with the cost of credit through banks. *Aviadores* claim to make little profit on traded goods. However, the reportedly high incidence of *piabeiros* being in permanent debt to the *aviadores* is clearly open to abuse and effectively prevent the operation of competition between buyers and the *piabeiros* need to clear their debts before moving from one *aviador* to another. Project Piaba has set up a co-op, Ornapesca, which is designed to improve fish quality, reduce losses and improve the income of *piabeiros*. The proposal to increase margins for the *piabeiros* by dealing directly with the exporters has not gone down well with the middlemen who would lose a substantial income if deprived of the trade in ornamental fishes and it is not yet clear how this will work out. It may be that the middlemen will still have to become involved, but the fishery as it operates at the moment (January 2015) is not generating the best return to the *piabeiros* of the community of Barcelos and the trade is in decline. There are a number of key issues to resolve, the most important being that of improving the quality of the fishes which is often poor due to lack of attention to water quality by *piabeiros* and middlemen in order to reduce losses and improve their marketability. Secondly, it is also important to improve returns to those involved in the trade to make up for the decline in the cardinal trade. This needs to be linked to better marketing, as the exporters in Manaus are not as good at this as their competitors in Peru and Colombia.

The following, from Prang (2001), is based on an interview with a single *piabeiro*, however it is believed to be typical of the income for a full-time (August-November and January-April) collector. From August to October, the collector can gather an average of 20,000 cardinal tetras per week, giving a total of 240,000 for the period. In November and January-April (fishing rarely takes place in December), the collector can gather 7,500 cardinal tetras per week, giving 120,000 for the period. This gives 360,000 for the collecting season. The *piabeiro* is paid US\$5 per 1,000 fish, equivalent to US\$1,800 for the season. This equates to an average of US\$257 per month or US\$150 per month over the whole year. This compares favourably with the average Brazilian salary of US\$100 per month. Typically, after deduction of traded goods from the *aviador*, the *piabeiro* would be left with US\$90 per month. Given the few opportunities for employment locally, this may be considered to be a good wage. The prices then increase rapidly through the trading system and are presented in Table E.5 modified from Prang (2001).

Against expectation, the buyer is not taking the highest mark-up. The exporter takes this, but it should be remembered that at least 40-50% of the selling price will be made up of freight and handling charges and usually shipping costs will at least double the cost of the fish, depending on packing density and unit price. These mark-ups may be taken as representative for any inexpensive fish sold in volume. Mark-ups may differ for less common, more expensive fishes. However, at a meeting with *piabeiros* in Barcelos (January 2015) it was reported that while the price paid to *piabeiros* by middlemen has not changed in several decades or the price has even decreased, middlemen are getting the same price or higher from the exporters.

The *piabeiro/aviador* type system is not unique to the Rio Negro fishery, nor is it unique to the ornamental fish trade. It often forms part of a trading system for fishery and agriculture goods and for many non-timber forest products. It provides a means for buyers to access remote and dispersed producers and for producers to access goods and credit to which they may not otherwise have access. The system can be exploitative with buyers keeping their producers constantly in debt as a means of ensuring they have to sell to a single buyer in order to pay off debt. Against this, there is often a high risk to the buyer who may advance goods or cash against future deliveries that may not take place in which case the buyer will experience a real loss. A typical collecting trip near Barcelos is shown in Figure E.1.

Table E.5: Price of cardinal tetras from collection to retail, March 1999. Updated prices from January 2015 are shown in brackets (based on large cardinals, the size if not stated by Prang).

Point in distribution chain	Price per each sold US\$	% mark up of price paid to collector	% mark up from previous stage	Main expenses
<i>Piabeiro</i>	0.005 (0.0064)	-	-	Canoe, knife, machete, nylon mosquito netting
Buyer	0.01 (0.012)	100%	100%	Boat, fuel and oil, repairs, non-payment of advances, mortality of fish
Exporter	0.10 (0.12)	2,000%	1,000%	Transport of fish (Barcelos-Manaus), mortality, water, utilities, installation, labour, food and medical treatment of fish, customs, taxes, packaging and marketing
Importer	0.26	5,200%	260%	¹ Transport (Manaus-Miami), mortality, water, utilities, installation, labour, food and medical treatment of fish, customs, taxes, packaging and marketing.
Wholesaler	0.65	13,000%	250%	Transport (Miami-Detroit), mortality, water, utilities, installation, labour, food and medical treatment for fish, customs, taxes, packaging
Retailer	2.00	40,000%	300%	Mortality, water, utilities, installation, labour, food and medical treatment of fish, customs, taxes, packaging, buying in small lots, selling on small scale

¹ Note: shipping costs typically account for 40-50% of the landed price of a shipment.

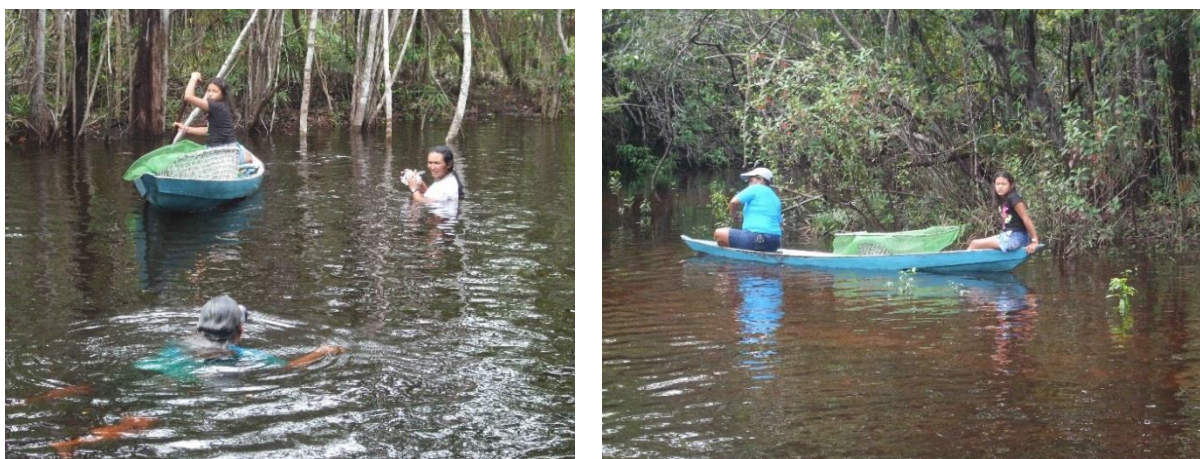


Figure E.1: Collecting ornamental fish is a family business on the Rio Negro

Interview with Adelson Cardoso de Lima, piabeiro

This interview was carried out after a Project Piaba meeting with *piabeiros* in Barcelos on 31st January 2015. Adelson has been a *piabeiro* for 52 years having started work with his father at the age of eight. The trade used to provide a good living but in the last ten years, income has declined sharply. Whereas his four fishing trips each month would yield about BRL 600 (about USD 295 at Jan 2013 rate and USD 254 at January 2014 rate ref [OANDA](#)), he now earns as little as BRL 300 per month (about USD 114 [OANDA](#) average rate Jan 2015). As this is paid in trade goods such as rice and beans, he sees no cash return and has to borrow cash from the middleman to finance fishing trips which can cost BRL600-1,000 per month (about USD 228 – 381 about USD 295 at Jan 2013 rate and USD 254 at January 2014 rate ref [OANDA](#)); hence he is permanently in debt. He gets the same price or less for his fish, as he got 30 years ago while the price of food staples in Brazil has risen. As an example, he used to get BRL70 per 1,000 (about USD 39.32 at Jan 2000 and USD 37.86 at Jan 2010) large cardinals but now he only gets BRL 12 per 1,000 (about USD 4.57 ref [OANDA](#)). The fishing season lasts from 10th August to 30th April and during the close season when fish are spawning, he gets a government payment of BRL 635 per month (about USD 247 ref [OANDA](#)). A fisher who catches fish for the food trade reported similar problems and has now stopped selling to middlemen as payment time was at least one month and prices were poor. He now sells for cash on the local market.

Adelson thinks that the market for ornamental fish has declined with both the volume of fish bought and the prices being lower. As a consequence, the number of *piabeiros* and the number of middlemen in Barcelos have declined. Ten years ago, the economy of Barcelos relied heavily on the ornamental fish trade, now very little cash comes in from the trade and the whole economy of the town has suffered as a result.

He usually goes collecting four times each month, each trip being one day in duration. He sells about 180 *caçapas* (fish bins) per month and reckons that about 10 *caçapas* worth of fish will be reported as dead by the middlemen after the journey to Manaus but he has no way of verifying this. He collects 10 types of fish but, as the type categories may include vague items such as *bodos* (plecos), the number of species collected is higher. He accepts the need to change and welcomes the developments made by Ornapesca.

Recently, Project Piaba has adopted some new measures to increase the benefit to the ornamental fish collectors. The first of these has been the application for Protected Area of Origin (Indicação de Procedência) status for fishes from the Rio Negro. This will only apply to fishes caught in a restricted area by members of the second initiative, Ornapesca, an organisation set up to act as a cooperative for the *piabeiros* to sell their fish, receive training and to be accredited as being responsible in terms of collecting only fish for which there are orders and handling them carefully to

reduce mortality. The economy of the Rio Negro has declined since the economic slump of 2007 and the ornamental fishery has declined further in the last few years. The loss of employment and income has had significant, detrimental effects on Barcelos with unemployed men turning to drugs and alcohol. The social effects have been marked and, with so few other livelihood opportunities, there is a need to turn around the ornamental trade and help the community get back some of the lost income.

Ornapesca is not yet fully operational but it is expected to increase incomes by dealing directly with exporters and cutting out the middlemen. This will mean that the *piabeiros* will have to improve their handling standards and ensure that they have stock available to meet the requirements of the exporters and thus their markets. At least four persons from Project Piaba Brazil and Ornapesca will attend training in the US in fish quality and health management and will also visit potential US customers in order to give them a better appreciation of market requirements and demand. A quarantine facility on board a barge will enable Ornapesca to ensure only high quality and healthy fish are sold and sent to Manaus. It is too early to tell whether this arrangement will work and how the middlemen will respond to being cut out of the supply chain. One major US retailer, Petsmart has agreed to have a “Rio Negro” corner in its stores to highlight the work and inform customers about the fishery and the benefits it brings. One importer, Segrest has also agreed to buy PDO (Protected Designation of Origin) certified fish. The market advantage to buyers is not clear and there is currently no price premium for the PDO fish so it is too early to tell if this scheme will be successful and sustainable. However, there is a proposal that US importers will donate a fixed sum per cardinal (probably 0.0004 USD) to Ornapesca and one Czech breeder of cardinals has promised to contribute an amount equal to that paid to the *piabeiros* for each farmed cardinal he sells. The Brazilian government has agreed in principle to fund the cost of at least one barge for Ornapesca and to provide support in the form of training for small and medium enterprises. The exact route for the financial support is still to be decided but at least some of it will be made available through the University of Amazonas and SEBRAE, a Brazilian small business development agency. Ornapesca also has at least the backing of the local authorities in Santa Isabel and Barcelos.

Coral reef fish in Indonesia

The market and trading system for reef fishes for the ornamental industry in the Banggai Peninsula, Indonesia is described in some detail by EC-PREP (2005). The system is similar to that in other areas in which buyers purchase fish directly from collectors and then sell on to traders. The traders may represent an exporter directly or may act as an agent for the exporter. Direct access to traders and exporters is difficult for most collectors as they live in remote fishing villages with very limited transport connections. Traders may consolidate catches from several sources to be delivered to exporters directly or via local airfreight.

Incomes derived by collectors vary considerably as there are a number of systems in operation varying from collectors who operate independently (and usually using minimal equipment) through to those who are employed on a share basis on board boats. In the latter case, the income after costs have been deducted is usually shared three ways with the boat owner getting 50% and the collectors and boat captain sharing the remaining 50%. While buyers and traders continue to advance credit to collectors, there is an increasing trend towards the use of loan sharks charging high interest rates. This can result in collectors having to increase fishing effort in order to pay off loans with potential for unsustainable fishing. Indebtedness may be used to ensure that a fisherman remains a client of a middleman (this applies to food fish and ornamental fish collectors) and families in some areas are rarely out of debt and are forced to take extreme measures such as resorting to destructive fishing methods simply to pay off debts (EC-PREP 2005). The report provides a number of examples of how prices vary along the local supply chain from the village of Monsongan (see Table E.6).

Table E.6: Prices received along Tumbak trading route for Banggai cardinalfish in IDR.

	Monsongan Fishermen	Monsongan Local Collector (2)	Tumbak Buyers from Manado/Bitung	Manado Buyers From Bali Exporter
Now via KM Sinabung	300 (USD 0.03)	No longer trading?	1,000 – 1,250 (USD 0.10-0.12)	3,000 – 6,000 (USD 0.30-0.60)
Until early 2004 Tumbak boats	200 – 250 (USD 0.02)	300 – 350 (USD 0.03)	1,000 – 1,250 (USD 0.10-0.12)	3,000 – 6,000 (USD 0.30-0.60)

Source: EC-PREP (2005). USD = IDR9857 average exchange rate for 2005 ref OANDA.

Prices along the supply chain are adjusted to take account of mortality and so actual prices can vary according to the source of the fish and the route by which they travel to the exporter. Based on the above, it was estimated that income from ornamental fish collecting was IDR 280,000 – 400,000 per family per month (about USD 28.40-40.58) from the Banggai cardinalfish with additional income from other ornamental fishes. This compares to about IDR 300,000 per month (about USD 30.44) for women (food) fish traders.

Higher income was received by collectors in another village compared with those in Panapat during the height of demand for Banggai cardinalfish where they obtained income of IDR 300,000 (about USD 34) to 1,500,000 (about USD 169) every few weeks (2002). However, this declined rapidly after the Far East financial crisis of 1997-1999 to IDR 150,000 (about USD 16.90) per trip (2005), which does not supply enough money for even a single person to live on. The report also shows how prices have changed over the years which has had unexpected impact on buyers' profits (see Table E.7). The report then goes on to give further details of income derived by ornamental fish collectors (see Table E.8).

Free divers earn less than compressor divers but their costs are lower. Against that, costs for a trip are likely to be higher for compressor divers and they may also need more credit due to the need for more fuel (they travel further), fuel for the compressor, food and so on. The report concludes that the ornamental fish collectors do not earn enough each month to support a household and therefore must take part in other livelihood activities and other household members must also have an income generating activity. Ornamental fish collecting may account for up to 50% of household income in the areas studied.

Table E.7: Comparison of buying and selling prices in the last ten years in Banyuwangi.

	1990-2000 The price of fish before the crisis		2000-2004 The price of fish after the crisis	
Species	Buying prices IDR	Selling price IDR	Buying price IDR	Selling price IDR
Clown fish	400 (USD 0.04, 2000)	1,000 (USD 0.10, 2000)	600 (USD 0.07, 2004)	1600 (USD 0.18, 2004)
Long-nose butterfly fish	2,000 (USD 0.20, 2000)	6,000 (USD 1.20, 2000)	3,000 (USD 0.35, 2004)	9,000 (USD 1.05, 2004)
Dik damsel	300 (USD 0.03, 2000)	900 (USD 0.09, 2000)	600 (USD 0.70, 2004)	1,200 (USD 1.40, 2004)
Blue damsel	300 (USD 0.03, 2000)	700 (USD 0.07, 2000)	500 (USD 0.06, 2004)	1,250 (USD 0.14, 2004)
Coral beauty angelfish	1,000 (USD 0.10, 2000)	2,000 (USD 0.20, 2000)	3,000 (USD 0.35, 2004)	9,000 (USD 1.05, 2005)
Coral beauty angelfish	-	-	700 (USD 0.08, 2004)	2,000 (USD 0.23, 2004)
Damsel angelfish	-	-	700 (USD 0.08, 2004)	2,000 (USD 0.23, 2004)
Blue green puller	200 (USD 0.02, 2000)	500 (USD 0.05, 2000)	350 (USD 0.04, 2004)	600 (USD 0.07, 2004)
Humbug damsel	200 (USD 0.02, 2000)	700 (USD 0.07, 2000)	400 (USD 0.05, 2004)	900 (USD 0.10, 2004)
Indian humbug	200 (USD 0.02, 2000)	700 (USD 0.07, 2000)	400 (USD 0.05, 2004)	900 (USD 0.10, 2004)
Cleaner fish	200 (USD 0.02, 2000)	600 (USD 0.06, 2000)	400 (USD 0.05, 2004)	900 (USD 0.10, 2004)
Emperor angelfish	7,000 (USD 0.70, 2000)	20,000 (USD 2, 2000)	15,000 (USD 1.73, 2004)	55,000 (USD 6.36, 2004)
Scorpion fish	2,500 (USD 0.25, 2000)	7,000 (USD 0.70, 2000)	4,000 (USD 0.46, 2004)	11,000 (USD 1.27, 2004)
Gaimard wrasse	400 (USD 0.04, 2000)	1,000 (USD 0.10, 2000)	1,000 (USD 0.12, 2004)	2,500 (USD 0.29, 2004)

Source: EC-PREP (2005). IW note: some of the inconsistencies in the above such as two entries for coral beauty are not explained or commented on in the text. All exchange rates taken from OANDA.com, average rates for the year are used and all values are rounded.

Table E.8: Summary of estimated monthly income per livelihood activity at Bangsring Village (IW – assumed date 2005).

Livelihood Main Stake holder	Estimated Income Bangsring Village IDR
Financier	IDR 2,000,000-5,000,000 per month (USD 203-507)
Ornamental fish collectors	
- Free dive divers (around 20 days fishing)	IDR 600,000-1,200,000 per month (USD 61-122)
- Compressor Divers (around 15 -20 days fishing)	IDR 800,000-2,000,000 per month (USD 81-203)
Odd job wage worker	IDR 300,000 (USD 30) per month + Uang makan (meal allowance)
Packer (twice per week)	IDR 200,000-400,000 per month (USD 20-40)
Food fishers using nets and <i>tongkol</i>	IDR 300,000- 600,000 per month (USD 30-61)

Source: EC-PREP (2005) USD = IDR9857 average exchange rate for 2005 ref OANDA.

Coral reef livelihoods

Teh et al. (2013) estimated that over 6 million people worldwide rely on coral reefs for a livelihood, of which about 25% are thought to be ‘gleaners’ (this group is likely to be harvesting mainly for subsistence purposes and this is often an activity carried out by women). The global value of coral reefs is therefore about USD 30 M per year of which fisheries contribute about USD 5.7 M. Clearly, in this context, the ornamental fishery is tiny and represents a minute fraction of the fishery activity on reefs. Nonetheless, it can be locally important either as a primary livelihood or as part of a wider livelihood strategy. To further put the ornamental trade in context, Teh et al. (2013) estimate that over 3 million people are involved just in collecting sea cucumbers. The total number of ornamental collectors on reefs is unknown, however given the volume of the trade, it is likely to be a very much smaller number. This may explain why the authors did not specifically include ornamental fish collectors in their analysis. The authors point out that many reefs are over-fished, mainly for the food industry and that some are threatened from blast-fishing (for food fish) and cyanide (for live food fish and for ornamental fish). The way cyanide is used for gathering ornamental fish and food fish differs mainly due to the fact that fewer, larger fishes are harvested for food and, while larger fish may need more cyanide to stun them, fewer fish are harvested leading to a smaller number of reef areas affected. Mous et al. (2000) compared the impact of various destructive fishing methods on corals reefs and concluded that the use of cyanide for harvesting food fish in Indonesia resulted in the destruction of only 0.047-0.06 m² per 100m² of reef per year, rather less than the natural rate of recovery and about 10 times less than that caused by harvesting ornamental fishes, although to put both in context, destruction by blast fishing (a technique, as stated elsewhere, that cannot be used to collect ornamentals) led to losses of 3.75m² per 100m² of reef per year. Given the growing population in many coastal states, pressure on reefs is likely to continue to grow, which may impact negatively on ornamental fish collectors if the resource continues to be over-exploited and degraded by other activities.

Teh et al. (2008) compared income for various small-scale fishing activities in Fiji. They found that harvesting live reef fish and live corals for the ornamental trade was a more profitable activity than harvesting live food fish and *bêche de mer*. The total ornamental harvest (live rock, corals and fish) also tended to provide a greater export value than the most valuable other export from the fishery e.g. aquarium products USD 6,486,486 (2004) and *bêche-de-mer* USD 4,324,324 (2004). At the household level, the aquarium trade also provided the highest incomes with live aquarium fish and corals bringing in USD 265 per week and live rock USD 241 per week. This compared to only USD 41

per week for *bêche-de-mer* and USD 87 for live reef food fish. Compared to the Fiji government assessed minimum income required to provide basic needs of USD 97 per week, it can be seen that the aquarium trade is capable of providing a good living and (as discussed elsewhere) in Fiji, the industry is sustainable. Hand et al. (2005) reviewed the aquarium trade in Fiji and concluded that it was generally well regulated and had scope for expansion with a possible doubling in exports within 10 years with no major inputs beyond an improvement of the management of the industry.

Cinner (2014) considered coral reef livelihoods more widely, but also did not include any specific studies on the ornamental trade. He pointed out that many fishers of coral reefs are not carrying this out as the “livelihood of last resort” as is often reported but identify strongly with the fishing lifestyle and have a strong attachment to the reef. This can mean that fishing communities may have a strong stake in a fishery and will respond positively to measures, which lead to more sustainable management of reef resources. The idea that fishers are inherently liable to over-fish a resource is not supported and they may even be its best protection. However, the situation is rather more complex as those with a small stake in the fishery were thought to be less likely to respond positively to conservation measures. In addition, responses to co-management varied according to whether fishing on the reef was the sole livelihood source or whether it was part of multiple livelihoods. However, as those with reef fishing as the sole livelihood tended to be much less well off than those with multiple livelihoods, the situation may not be clear-cut. Those with fishing as the sole livelihood have fewer alternative opportunities if fishing opportunities are reduced and so may be expected to resist changes, which might reduce income. There may also be a link between access to education and wealth, which could have affected this view. Cinner (2014) also warned against taking the view that alternative livelihoods would reduce pressure on the reef. Alternative livelihoods are often presented as a means of reducing pressure on wildlife (especially bushmeat), but have a rather poor success rate in practice. The author pointed out that some alternative livelihood activities such as seaweed farming in the Philippines had actually increased fishing pressure due to migration into the area.

Any attempts to improve livelihoods of reef-dependent communities must therefore be approached with caution. While it is clear that many reefs are being affected by over-fishing, given the weight of numbers and the level of off-take, the impact of food fishing on the ornamental trade is likely to be far greater than that of the ornamental trade on food fisheries or even the reef in general. It also is likely that those living in reef-dependent areas would have great problems in finding alternative livelihoods without migrating to other areas and that some alternative livelihoods may also impact on the reef (e.g. coral mining or lime production that uses timber from hinterland forests (which can increase erosion and sedimentation) or mangrove wood exacerbates erosion).

Germain et al. (2015) examined the livelihoods of a women’s ornamental fishing cooperative in Baja California Sur, Mexico. They found that the business was biologically sustainable, but not financially sustainable; the women were not making use of all the opportunities provided by the local reef. The co-operative was catching 54 species of fish, of which 50 were limited by quota. The authors carried out a detailed livelihoods analysis, giving a more in-depth study than usual taking into account wider issues such as the human development index. The maximum income level was well above the poverty line, although average incomes were generally low and lower than those of other women in the community. The minimum salary earned by the co-op members was far below the level established as a poverty line. Interesting contrasts were found between women in the co-op and other women living in the community. Women in the co-op were more likely to be single, divorced or widowed and thus would be the head of household. This would mean that women in the co-op would be much more dependent on the ornamental fish trade as there were fewer other sources of household income. As the community had high unemployment levels, maintaining an income would be of particular importance. The lower income of the women in the co-op was taken as an indicator that their livelihoods were not sustainable and that the women needed to earn more to reach a satisfactory living standard. The authors noted that the under-utilised quota would make a

significant contribution to incomes if it were to be taken up. Given that the co-op owned its essential assets and that it had direct links to buyers (rather than going through middlemen) there should be scope for better incomes and higher sales. If they had been indebted, as are so many fishers, the situation would be much less optimistic; however they do appear to be in a strong position to develop their business. Against this, the women reported inconsistent demand and fluctuating prices as a potential threat. Being in the Gulf of Mexico, the area is also subject to annual threats such as hurricanes. Despite the potential for higher income, some of the women interviewed expressed the wish that their children would not become involved in fishing and wished them to take up more reliable or higher earning jobs such as in tourism.

Anon. (2010) provided some limited information on the marine ornamental trade in Kenya. *“Kenya ranks among the top exporting countries in the marine aquarium fish trade in the Western Indian Ocean. There were 145 licensed marine aquarium fish collectors who were working full time between 2004 and 2005. These collectors were either employed or contracted by 8 companies that were licensed to export marine aquarium fish in Kenya. Most of the aquarium fish from Kenya is exported to around 15 countries including the United Kingdom, USA, South Africa, Hong Kong, Germany, France, Japan, Netherlands, Austria, Israel, Denmark, Poland, Hungary, Italy, and Romania. Generally, aquarium fish collectors target juveniles because they are more colourful, easier to handle and transport by air.”* FAO statistics indicate that the trade is relatively small amounting to about USD 40-100,000 per year.

Some data is available for the South Pacific that indicates how important the trade in organisms harvested from coral reefs for the aquarium trade can be for livelihoods in island communities. Anon. (2009) summarise trade in PICTs as *“in 2003, PICTs’ contribution to the global trade was estimated as 10%, representing a value of USD 25 million and involving 150 fish species and more than 50 coral species. Live rock is currently the most important marine aquarium product, contributing just over 70% (USD 18 million) to the value of the trade in the Pacific. Live corals contribute USD 5 million and fish USD 2 million. These values break down to roughly 700 metric tonnes of live rock, 200,000 pieces of live corals and 400,000 individual fish. The marine aquarium trade has, therefore, become a very important source of income and revenue for PICTs, especially for those where income earning opportunities are limited. The marine aquarium trade fishery has been established in many PICs, including Cook Islands, Fiji, Kiribati, Palau, Solomon Islands, Tonga and Vanuatu, and is proving to be economically beneficial for these countries. For instance, in Fiji, the industry was worth FJD 20 million annually [about USD 8.7M] in export earnings in 2001, and is the only source of foreign exchange for Christmas Island in Kiribati”* (IW note – Christmas Island or Kiritimati now has a sport fishing and tourism industry which brings in some income). While these totals are small compared to the value of the tuna trade in PICTs, unlike the tuna trade, value is returned directly to small island communities and households rather than through governments (e.g. from fishing licence agreements) or the multinational enterprises that operate canneries and fish processing plants in the region.

Anon. (2009) provide some specific information on the value of the trade to Vanuatu *“Vanuatu’s marine aquarium trade fishery has been in existence for the last 15 years, and has survived despite high airfreight and local investment costs (as compared with other fisheries). Although Vanuatu’s reefs are not extensive, they provide sufficient habitat for ornamental resources that can maintain a small, but sustainable industry. In Vanuatu, about 300 species of non-food reef fish are important ornamental species out of a total of 543 species currently recorded for Vanuatu (FishBase, 2004), including many species of invertebrates, clams, soft corals, and cultured hard corals. It is, therefore, a fishery with a significant diversity of target species of marine organisms, including plants and algae, and abiotic resources such as rocks. The direct social and economic impact of the marine aquarium trade, and contribution to the national economy, are significant. Currently, the trade brings in over USD 500,000 annually in export earnings, and contributes about USD 1 million to local economies. In*

addition, about USD 19,000 per year is paid directly to resource owners (for access to fishing grounds) around Efate's west coast, especially the three main villages of Pango, Mele, and Lelepa/Mangaliliu."

Details of individual PICTs were reported by Kinch and Teitelbaum (2008) and are summarised below:

- Cook Islands – the trade has been relatively small with only 18,000 wild-caught pieces being exported from 1988-98, dropping to 10,000 from 1999-2008. From 2003 to 2008 about 30,000 giant clams were exported but this has to be ceased due to the Cook Islands not being a member of OIE.
- Fiji – *"The aquarium trade in Fiji Islands provides approximately 16% of all fisheries revenue for the nation and is second to tuna. Economic values of the aquarium trade for Fiji Islands have dropped in the last two years from a general average of around USD 18 million annually to USD 14 million in 2008. This decline is due to current management policies, which have seen a reduction in live rock quotas of 50%."* (IW note – Fiji is a member of OIE and CITES).
- French Polynesia – the industry is small with only about 44,000 fish being exported annually, with an average value of USD 230,000.
- Kiribati – (IW note: most exports from Kiribati and from Kiritimati, not Tarawa). Flame angels account for most of the trade and it peaked in 2007 at about USD 1 M. Kiribati and Kiritimati in particular have problems in accessing international markets due to limited airfreight capacity (there was only one flight per month to Kiritimati) and high freight costs. In addition, Kiribati is not a member of OIE or CITES which further limits trade.
- New Caledonia – has a very small trade with only about 400-700 fish exported annually with another 4,000 being taken by the domestic market.
- Papua New Guinea – is a new entrant to the trade and the single enterprise is still in development.
- Marshall Islands – export a range of organisms for the aquarium trade including fish, corals and clams. The export of live rock is not permitted. It is thought that the trade has scope for expansion.
- Vanuatu – exports about USD 2 M worth of ornamental aquatic organisms annually. This is mainly live fish but also includes some cultured corals and clams (Vanuatu is a member of OIE and CITES).
- Solomon Islands – has exported ornamental aquatic organisms since 1995 and, although the trade is dominated by fish, there is also a significant trade in live corals.

Details of the trade in corals from the Solomon Islands is provided by Lal and Kinch (2005) who carried out a financial analysis of the trade to determine its profitability and likely returns to communities. The overall value of the coral trade was reported *"as total industry gross revenue earned from the export of live and dead coral, other aquarium products and cultured coral is approximately SBD 5.0 million/year [USD 680,000]. Industry financial profit is SDB 1.6 million/year [USD 217,600] or 32 % of the FOB value. Operating costs associated with running the warehouse for the two exporters is about SBD 1 million/year (USD 136,000). When deducting the payment to villagers, the net financial profit earned by exporters is SBD 1.8 million/year"* (USD 244,800). While this is small compared to the exports for tuna from the Solomon Islands, Lal and Kinch (2005) report that the industry benefits up to 200 villages involved in the ornamental aquarium trade of which 30-40 are involved in supplying corals. These villages are often in remote areas where access to employment is very limited (c.f. the tuna processing plants which concentrate employment in a single location). Profitability of the collection of organisms for the aquarium trade is dependent on location as the Solomon Islands has problems of limited transport infrastructure and high transport

costs. For example, for Maaru Sound, a villager selling a range of aquarium organisms could expect to earn SBD 11,000 (USD 1,496) in gross revenue with a gross margin of SBD 7,800 (USD 1,060) with transport being the biggest single cost item. By contrast, the gross margin for farmed corals was only SBD 1,336 (USD 182) and, after all costs were taken into account a loss of SBD 1,679 (USD 228) was incurred. If the villagers were to double output, the coral farming would become profitable. Similarly, at Nggela Islands, wild coral harvesting was more profitable bringing a gross margin of SBD 6,580 (USD 894) and a profit of SBD 5,362 (USD 729) compared to coral farming which was not profitable and would remain so unless the production was increased. Again, high transport costs were responsible for the lack of profitability.

Some information on Tonga is in the [FAO country profile](#) that shows “*exports of fishery products in 2007 were USD 2.8 million and represented about 36 % of all exports of the country. The major exports by value were tuna (29%), live rock (21%), soft coral (12%), deepwater demersal fish (11%), and aquarium fish (10%).*” However, those figures may not represent the current situation as a number of initiatives in Tonga such as aquaculture for the aquarium trade have taken place but are not yet reported in production and export statistics.

The trade in Nigeria

Information on the industry in Africa is generally poor and often out of date. Ukaonu et al. (2011) reported on the industry in Nigeria. Despite the industry having been established for over 40 years, the authors note that getting reliable information on the trade is difficult and they had to examine export documents to be able to get a reliable estimate of the value of trade. Examination of FAO statistics reveals a number of gaps in the records. They report about 70 commonly exported species of ornamental fish (fresh and marine water species) in the Nigerian export trade, but note elsewhere that up to 100 species are exported. The authors report a decline in trade between 2006 and 2007 being reflected in a reduction in companies holding export permits from 60 to 40. The total volume of ornamental fish exported in 2006 was 1,292,259 pieces with a value of USD 711,000 declining to 1,132,286 pieces with a value of USD 662,000. FAO statistics indicate that exports from Nigeria remain low.

The ornamental fish collectors in Malawi

Information is mainly derived from Bull-Turnøe (1992) and Grant (1996) with additional information from IW (pers. obs. 2012) and Konings (Cichlid Press, US, pers. comm. Interview Sept 2014).

Lake Malawi was one of the newer sources of ornamental fishes from Africa when it opened up in the 1970s. The trade is unusual in being based almost entirely on the export of cichlids, predominantly rock-dwellers. In the 1970s and 1980s, these fish were in high demand and commanded high prices. Subsequently, the demand for wild fish fell as a result of strong competition from cheap, farmed fish from the Far East and Florida, which may be one tenth the cost. In addition, shipping costs, and especially airfreight, have increased significantly, making wild caught fish expensive. Originally three exporters operated from the lake, falling to two in the mid-1980s and then to a single exporter, Stuart Grant Ltd, based in Malawi. As of 2012, there were three exporters in Malawi, however Stuart Grant Ltd remains the main exporter.

The original Stuart Grant Ltd catching and exporting station was set up in 1973, but has been expanded and changed over the years. In 1992, the station employed 101 workers directly, including boatmen, divers, fish house staff and support staff. No breakdown of wages is available, however the average wage for all staff in 1992 was MWK4 per day, approximately equivalent to USD 1.54. This compares with the national average wage at that time of MWK 1.8 per day. Current wages (2000) are from USD 25 per month (unskilled labour) to USD 40 per month (dive team leader).

All staff are salaried, and are not paid on the basis of fish caught. All staff are provided with free housing and other benefits.

In addition to employing 101 workers directly, the collecting station supported 461 people through families and dependants. There are very few alternatives for income generation in the area, and the operation provides additional benefits in the form of purchase of food and materials and the employment of casual workers (builders, carpenters, etc.). It is also reasonable to assume that if the station did not exist, the area would not have an electricity supply. Direct benefits to government of Malawi include tax on profit at 50%. Further benefits come from reimbursable airfreight and handling charges.

The demand for wild caught Malawi cichlids seems to be still falling and Stuart Grant Ltd now mainly catches and exports to order with only 1,000 boxes being exported in 2012. Originally responding to a demand from aquarists to dive in the lake and see the cichlids in their natural habitat, a visitor centre has been constructed, accommodating up to 20 guests. In addition to being based at the station, excursions to other parts of the lake may be arranged. This new business means that many of the existing staff have changed roles to support an ecotourism industry. This seems set to continue developing and, unlike the fish export business, appears as if it will attract significant tourist income to the area. The implications of this for employment, local traders and other support services are not known. Staff receive a bonus for ecotourism work.

Incomes and prices as stated above, the workers at the collecting station earned an average of MMK4 per day in 1992 (about USD 30-40 per month depending on how many days worked). Earnings in 2000 were in the region of USD 25-40 per month. Prices for Malawi cichlids are difficult to compare, given the wide range of species and colour morphs in trade. Costs have risen, however prices have been more or less static.

Value chains and the ornamental fish industry

Arguably, the ornamental fish trade does not fit very well with the definition of even a simple value chain as defined by Kaplinsky and Morris (2000):

“The value chain describes the full range of activities which are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers, and final disposal after use.”

This would typically describe manufacturing and much of the trade in agricultural products where varying amounts of transformation take place along the value chain. For the ornamental fish trade, what arrives in the final consumer’s aquarium is the same as started the journey from the wild with no transformation or added value. Prices rise along the value chain but no value is added. It is perhaps more useful to consider the ornamental trade in terms of a global value chain which can be defined as:

“The fragmentation of production processes and the international dispersion of tasks and activities within them have led to the emergence of borderless production systems. These can be sequential chains or complex networks, their scope can be global or regional, and they are commonly referred to as global value chains (GVCs)” (UNCTAD 2013).

This describes some aspects of the ornamental fish trade quite well as the fishes typically travel through one or more intermediaries in a number of countries (e.g. from Malaysia to Singapore to UK and possibly inward to other EU markets). There are a number of studies on the ornamental fish industry that describe parts of the supply chain, however there is little describing the entire global value chain in sufficient detail to enable analysis. Typically, a part of the supply chain is described with reference to the various actors involved and prices at various stages in the chain but any detail on costs is usually absent. In its shortest form, the ornamental supply chain could have as few as four stages; Collector → Exporter → Importer → Retailer. None of the actors above add any value

to the fish in the conventional sense, but where fish are subject to quarantine, the fish are treated for any diseases and parasites they may be carrying and may also adapt the fish to eating prepared feeds. Costs can be identified but generally not quantified (Table E.9).

Without detailed information on costs incurred at each stage it is difficult to make informed comment on price setting along the value chain. Various reports have commented on the difference in price along the value chain; however this means little without reference to costs. As shown in Table E5, prices along the supply chain increase rapidly from one actor to another, this does not necessarily mean buyers are exploiting sellers, nor does it mean that the trade is exploiting collectors. Collectors generally have little idea of the value of the fish they are selling and may not even understand the final use as an aquarium may be something they have never encountered. This usually means that collectors will have no way of determining a fair price for the fish they sell and this does lay them open to exploitation. However, prices paid to collectors may be low with good reason.

Table E.9: Supply chain costs and revenues.

Stage	Costs	Revenues
Collector	Fuel, boat, nets, diving equipment, plastic bags, holding tanks/cages transport	Sale of fish, corals invertebrates
Middlemen	Transport, hired help, buying fish, plastic bags, oxygen, holding facility, fish care, losses, equipment and fuel provided to collectors	Sale of fish, trade goods, credit interest
Exporter	Buying fish, staff, holding facility, plastic bags, oxygen, fish boxes, overheads, losses, health certs, CITES permits, freight agent costs, transport	Sale of fish
Exporter or importer	Airfreight, ground handling charges, tax and duty	Airfreight (to airline), agents' fees (ground handling), tax/duty (to govt)
Importer	Clearance charges, import permits, tax and duty, staff, holding facilities, losses,	Sale of fish
Wholesaler	Staff, facilities, losses	Sale of fish
Retailer	Staff, facilities, losses	Sale of fish, equipment, food

Middlemen have to factor in a number of possibilities of which the two greatest risks are mortalities and credit not being repaid. Often collectors are advanced credit to finance a collecting trip or are given goods in anticipation of the buyer receiving fish or cash as repayment. If a collector should fail to repay an advance, that represents a real cash loss for the buyer which may be unrecoverable. This is often built into the price paid by a buyer who will discount the price accordingly. A buyer may also discount prices based on quality, including anticipated mortality. For example, an exporter in

Guyana paid much higher prices to collectors in Rupununi who collected to order with very low mortality than to collectors elsewhere who often supplied unwanted, undersize or poor quality fish.

From then on, it is easier to identify how costs may rise, forcing up prices, but little information is available to work out just how this affects prices along the value chain. Intermediaries in the value chain who supply exporters will incur costs for travelling to remote areas to buy fish and transport them to the exporter. Along the way they may also have to house the fish temporarily and they will experience some losses. Arguably, the exporter takes the biggest risk in the value chain, as they will have invested substantial cash up front to buy the fish they sell and there is no guarantee that they will get that cash back. If a shipment is delayed or mishandled, serious losses may be incurred leaving the exporter with what is usually an unrecoverable loss. It is not unknown for importers to not pay for a shipment or claim unreasonably high allowances for DOA (dead on arrival) fishes; this problem is by no means limited to the ornamental industry and those involved in the food fish trade can find themselves in a similar position. Similarly, some importers have paid for goods in advance which have not been received, leaving them with a loss. While the importer makes a substantial investment in stock and facilities, their losses may not be great compared to the exporter. Retailers probably have the highest level of investment due to the requirements for retail establishments and any stock losses incurred will be real losses that contribute to costs. While it is quite easy to identify these costs, it is far harder to quantify them and very little information is published on this.



Typical boxes used for shipping fishes to Manaus



Fish-friendly size grader used for small tetras



Fish buyer's holding station at Barcelos on the Rio Negro



Boats used by buyers to transport fish from the collectors to the holding station

Figure E.2: Typical boats used by middlemen on the Rio Negro for the collection, buying and short-term storage of fishes.

In practice, the simple supply chain shown above will have more actors involved and possibly more links in the chain. Most commonly, a large number of collectors supply an exporter through a number of intermediaries. This may even be spread over a number of countries through consolidation where an exporter will seek to expand the range offered by buying in fish from other countries. This can appeal to smaller importers and to retailers who can order a wide range of fish without having to incur the disproportionately high costs involved with small shipments. This was a service typically offered by Hong Kong and Singapore, which would consolidate supplies from across South East Asia, the South Pacific and Miami. These countries would serve as a consolidation point for fishes from South America. More recently more countries have become involved; for example, a Malaysian exporter now offers fish from India, Myanmar and Vietnam to increase its offer of wild caught fishes.

The effect of shipping costs on the price of fish

It is often noted that there is a large difference between the exporter's list price for fish and the price charged by an importer. Several authors have reported on changes in fish price along the value chain, but this information alone is of limited value unless costs are taken into consideration. In the case of import to the UK, the charges for a shipment are substantial and make a major contribution to the landed price of the fish. This can be seen from the examples given below.

Example 1 – fish imported from Colombia

Colombia is one of the most important sources of ornamental fishes from South America and has a number of competitive advantages over some other exporting countries, notably in having good air connections and a very competitive airfreight rate. The costs for a shipment from Colombia are shown in Table E.10.

Table E.10: Cost breakdown for a shipment from Colombia to London Heathrow (LHR) in January 2015.

	USD	GBP	% total costs	Cumulative costs GBP
Cost of fish	5,771.64	3,822.56	51	3,822.56
Documents Colombia	80.00	52.98	1	3,875.54
Cost of boxes/packing	616.00	407.98	5	4,283.52
AWB/freight	3,253.30	2,154.66	28	6,438.18
Handling LHR		151.56	2	6,589.74
Agency fees LHR		35.00	0	6,624.74
BIS LHR		5.50	0	6,630.24
DEFRA/APHA/ARC fees		245.88	3	6,876.12
VAT		691.62	9	7,567.74
Duty		-	0	7,567.74
Total costs	9,720.94	7,567.74		

As can be seen from Table E.10, the fish themselves only contribute 51% of the landed costs, the rest being taken up in airline, handling and processing fees. As an example, the total charges levied by the UK government (VAT, duty, DEFRA/APHA) add up to £937.50 or 12% of the total landed cost. Airline costs account for 28% of total costs. The effect of this on the price of some selected fishes from the shipment is shown in Table E.11.

The effect varies greatly from one box to another with small, inexpensive fish packed in hundreds per box having a lower cost increase than larger, more expensive fish, which tend to be packed in tens per box. Naturally, this has an impact on the prices charged further along the value chain, which is ultimately reflected in the retail price.

Table E.11: The effect of non-fish costs on the landed cost of selected fishes from a shipment from Colombia to London Heathrow (LHR) in January 2015.

Fish	No per box	List price each GBP	Cost fish only per box GBP	Average costs for shipping/handling GBP per box	Landed cost per box GBP	Landed cost per fish GBP	Landed cost % of list price
<i>Hemmigrammus armstrongi</i>	600	0.12	71.53	85.12	156.65	0.26	219
<i>Corydoras arcuatus</i>	150	0.30	44.71	85.12	129.82	0.87	290
<i>Sturisoma panamense</i>	12	1.32	15.90	85.12	101.01	8.42	635

Example 2 – fish imported from Brazil

This differs from the Colombia shipment in that it consists mainly of higher value fish packed at relatively low densities. In this case, the impact on the landed cost of the fishes is slightly less than that for the Colombia shipment (Table E.12).

Table E.12: Cost breakdown for a shipment from Brazil to London Heathrow (LHR) in September 2014.

	USD	GBP	% total costs	Cumulative costs GBP
Cost of fish	8,471.10	5,190.24	59	5,190.24
Documents Brazil	-	-	0	5,190.24
Cost of boxes/packing	616.00	377.42	4	5,567.67
AWB/freight	2,341.14	1,434.42	16	7,002.08
Handling LHR		108.72	1	7,110.80
Agency fees LHR		75.00	1	7,185.80
BIS LHR		5.50	0	7,191.30
APHA fees		257.25	3	7,448.55
VAT		1,334.17	15	8,782.72
Duty		-	0	8,782.72
Total costs	11,428.24	8,782.72		

The impact on the landed cost of fishes differs from that of the shipment from Colombia due to the effect of the species imported (see Table E.13); in this case, there were no low-value fishes packed at high density.

Table E.13: The effect of non-fish costs on the landed cost of selected fishes from a shipment from Brazil to London Heathrow (LHR) in September 2014.

Fish	No per box	List price each GBP	Cost fish only per box GBP	Average costs for shipping/handling GBP per box	Landed cost per box GBP	Landed cost per fish GBP	Landed cost % of list price
<i>Crenicichla compressiceps</i>	120	1.72	205.87	128.30	334.17	2.78	162
<i>Baryancistrus xanthellus</i>	70	2.14	150.11	128.30	278.41	3.98	185
<i>Peckoltia oligospila</i>	36	1.78	63.97	128.30	192.27	5.34	301

Example 3 – farmed fish imported from Thailand

For comparison, a shipment from Thailand is included (see Table E.14) to show that costs are comparable to those for wild-caught fish.

Table E.14: cost breakdown for a shipment from Thailand to LGW in February 2015.

	GBP	% total costs	Cumulative costs GBP
Cost of fish	2,887.15	49	2,887.15
Documents Thailand	50.00	1	2,937.15
Cost of boxes/packing	118.00	2	3,055.15
AWB/freight	1,704.00	29	4,759.15
Handling/ARC LGW	88.44	2	4,847.59
Agency fees LGW	35.00	1	4,882.59
DEFRA/APHA LGW	113.95	2	4,996.54
VAT	833.73	14	5,830.27
Duty (crustaceans)	16.80	0	5,847.07
Total costs	5,847.07		

This shipment differs slightly from the other two as it includes costs for duty on crustaceans, which are not levied on fishes (Table E.15).

It can be seen from the above that the costs of shipping fish from the source country to the UK will typically at least double the cost without anyone in the ornamental trade making any profit. Usually, airfreight is the biggest single contributor to the non-fish costs. Reporting price along the value chain without taking these factors into account will and has caused misleading conclusions to be drawn. The increase in landed price is also a significant factor in determining prices in the UK, hence the apparent disconnect between the exporter's list price and the UK retail price.

Table E.15: The effect of non-fish costs on the landed cost of selected fishes from a shipment from Thailand to London Heathrow (LHR) in February 2015.

Fish	No per box	List price each GBP	Cost fish only per box GBP	Average costs for shipping/handling GBP per box	Landed cost per box GBP	Landed price per fish GBP	Landed price % of list price
Guppy	600	0.13	78.00	102.07	180.07	0.30	231
Sword tail	150	0.18	27.00	102.07	129.07	0.86	478
Blue diamond discus	10	2.70	27.00	102.07	129.07	12.91	478

Comparison with the food fish trade

Small scale producers in the food fish trade often face similar problems to those faced by ornamental fish catchers, notably in needing access to buyers and credit and a lack or even absence of market information, which would allow them to judge whether prices offered were fair or not. In some cases, buying is competitive such as in Malawi beach landings where fish sellers bid against each other for each boat's catch. In some cases, the buyers will operate as a series of monopolies or as a cartel to control prices which is not in the interest of producers. Truly informed trading where sellers and buyers have a good idea of what a fair price should be is rare. Artisanal fishers usually report that they get poor prices and say that middlemen make much more money than they do. This is often the case but it should be born in mind that fish is highly perishable and that a buyer or trader may experience serious losses if unable to sell the fish quickly.

Wamukota et al. (2014) reviewed value chains for two fishery products in Kenya, sea cucumber and octopus, both of which are harvested from reefs. Traditionally, the markets have been different with sea cucumber being almost exclusively for export to Asia and octopus mainly for local consumption with an increasing trend towards exports. The market for sea cucumbers has increased worldwide as Chinese wealth has risen. As a result sea cucumber harvesting in many parts of the world is currently at unsustainable rates. Only local producers and buyers were interviewed, as the authors were unable to obtain responses from those further along the value chain. Sea cucumbers are caught by free diving or SCUBA and sold to trader/processors who will preserve the product for export. The traders sell direct to a limited number of Chinese buyers, sometimes under contract. By contrast, octopus may be sold by fishermen directly to consumers or to traders at the landing sites. Traders will then sell the fish to consumers or to processors. There is access to a wider range of buyers for octopus fishers. The local and international value chain for octopus was more complex and contained more options than that for sea cucumber. The price obtained by fishers for octopus varied little depending on who was buying, although prices for octopus sold to hotels tended to be higher. Prices obtained by fishers for sea cucumber bought by small-scale traders were constrained by the small-scale traders, who were the only source of buyers in most cases. By contrast, the small-scale traders had access to a wider range of buyers, which enabled them to look around for the most competitive buyer. This put the small-scale traders in quite a strong position. However, their ability to sell directly to Chinese buyers is very limited, as the Chinese buyers tend to only deal with a limited number of large-scale traders. It is perhaps no surprise that traders earn more than fishermen, however the difference depends on what is being sold and how access to final markets is controlled.

Chiwaula and Chaweza (2010) examined the value chain for Lake Chilwa in Malawi. The fishery is largely small-scale in nature as is much of the trading and processing associated with it. The value chain begins with fishers who sell on to fish traders and processors and may end with retailers but

will involve a number of other actors such as net suppliers, fuel wood suppliers and boat makers. Fishers may own their boat or they may hire it. In the case of the latter, the catch is divided 50:50 between the boat owner and the crew. This can leave the crew with low income and debts (often to the boat owner). Small-scale processors may also have to hire space in a smoking kiln if they do not own one. Generally, fishers do not become involved in fish processing (and thus added value), although other members of their family may carry out-processing. Fish from Lake Chilwa are sold at a number of locations, which differ between fresh and processed (dried or smoked) products and may be some distance from the Lake. By far the largest proportion of the catch is sold by fishers as fresh direct from the landing beach, either to retailers or more often via processors and traders. The most common reason given for a fisher choosing a buyer is that one was available rather than a buyer who offered a good price, not such an irrational choice in a place where fish spoils rapidly and may become unsalable or fetch a very low price. There are obvious comparisons here with the ornamental fish industry where collectors might find themselves with fish which may die if not sold quickly (or they may represent an additional cost the longer they are kept) and the rapid sale to the first available buyer might be a rational option for them too. The authors reported that fishers made on average a marketing margin (gross revenue minus direct costs) of about MMK 561,000 per year. Boat owners were able to make a substantially higher margin, about six times higher than that for fishers. Interestingly, a survey of price setting indicated that fishers were responsible for setting price about three times more often than buyers. This may not operate in the fishers' interest as further analysis showed that fish sold by auction made a much higher marketing margin, although they only accounted for 5% of sales. Processors and wholesalers made much higher marketing margins in the region of MMK 2 M per year (about USD 13,400), although they also had much higher costs. Retailers had a slightly lower marketing margin of about MMK 1.75 M per year (about USD 11,725) due to downward pressure on prices from consumers, which squeezed their profits.

The above comparisons suggest that the ornamental fish trade is not so different from other artisanal fisheries with fishers tending to get low prices and buyers tending to make more money from trading than do the collectors. The studies also highlight a common problem of credit access and indebtedness, which is by no means limited to fishing communities. Small-scale farmers also have similar problems and may be permanently indebted to seed and fertiliser suppliers or moneylenders and is widely reported such as in DPH, DfID Research Into Use Programme and also affects small-scale aquaculture (Edwards 2009). As with ornamental fish collectors, local elites and land-owners often use debt as a means of ensuring that client farmers cannot move to another buyer and they are often required to pay off the debt by labouring. This can further reduce the ability of small-scale farmers to increase their own production, locking them into a permanent debt cycle, which can never be cleared without some form of external intervention.

Brewer (2011) studied value chains for food fish at a number of sites in the Solomon Islands. There were a number of value chains that varied from fishers selling direct to buyers in the local market to those who sold to middlemen who aggregated fish to sell at major fish markets, restaurants or for export. The value chains were complex with many different options for fish to get to markets with varying actors involved in getting them there. While the author did identify that costs varied along the value chain, these costs were not reported and it is difficult to assess how much they contributed to price at each stage. On Guadalcanal communities are dispersed and travel can be time-consuming and thus expensive. Travel by boat between islands or where road transport is not possible would also raise prices appreciably. With this in mind, prices along the value chain did not rise sharply, although it may be that customer resistance to high prices may constrain what price fish can be sold for in markets and thus the prices that can be paid further down the value chain. Accordingly, margins were relatively small at each stage with the widest margin between villages and the capital market in Honiara. Margins between villages and regional capital markets were smaller as selling prices in regional markets tend to be much lower than in the capital. Unfortunately, no comparative figures are available for the live coral trade in the Solomon Islands. A study was carried out on this, however it is no longer available and a request for a copy did not

result in a reply. As there are very few outlets for live corals and the area harvested is believed to rely on farmed corals, it is likely that the value chain would be short and it would be expected that collectors would get a relatively good price.

Direct comparison between the food fish industry and the ornamental fish trade is difficult due to the problem of obtaining reliable statistics and the fact that the actual weight of ornamental fish in trade is not recorded. [FAO](#) statistics reveal that total landings from capture fisheries were just over 91 million tonnes in 2012. Ploeg (2012) estimated that 1.5 billion ornamental fish were traded internationally in 2009 (this figure includes marine and freshwater, farmed and wild-caught). If it is assumed that each fish weighs about 3g (freshwater fish tend to be smaller than this, some marine fish may be heavier) the total weight of all internationally traded ornamental fish would have been about in the order of 4500 tonnes (or 0.005% of total landings from capture fisheries), an amount dwarfed by the food fish industry. The 1.5 billion ornamental fish has an export value of USD 327 million (Ploeg 2012) or about USD 73 thousand per tonne. This is far higher than any value for food fish, with the possible exception of sashimi-grade bluefin tuna. For the higher value marine trade, the difference is even starker. Wabnitz et al. (2003) reported that about 20-24 M marine ornamental fish were in trade and, using an assumed weight of about 3 g per piece, that would give a total weight of 60-72 tonnes, an amount which would not even show up on error bars in food fishery statistics. In 2014, about 1.6 M marine aquarium fishes were imported into the UK ([DEFRA Freedom of Information request](#)). The exact number is difficult to determine as the reply from DEFRA refers to “marine and some other species of fish” and thus may over-estimate the number of marine ornamental fish imported. Using the same converter that is equivalent to about 4 tonnes, the value of which was GBP 3.212 M equivalent to about GBP 803,000 per tonne (data supplied by OATA from information supplied by DEFRA). Full results from the Freedom of Information request as posted by DEFRA are given in Table E.16 below.

Table E.16: UK Imports of fish under codes 030110 and 0301190 (taken from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/395331/RFI7144_UK_imports_of_fish_under_codes_030110_and_0301190_2_amended.pdf)

Country	2012	2013	2014
Australia	6,838	8,593	3,720
Belize	21		23
Brazil	28,580	1,917	1,435
Canada	114	126	34
Colombia	53,140	26,042	
Costa Rica	1,638	1,148	
Cuba	4,766	5,807	5,724
Czech Republic	28,307	51,785	0
Dominican Rep	34,216	157,465	91,077
Egypt	237	715	
Fiji	89,999	88,690	65,321
France	3,770	11,240	
French Polynesia	10	178	1,117
Germany	89		

Ghana	645	16	
Hong Kong	128,366		
India			25
Indonesia	868,398	652,653	507,018
Israel	199,571	59,892	24,463
Italy		1	
Japan	8,057	461	254
Kenya	75,945	83,992	88,262
Madagascar		1,011	2,674
Malaysia	83,782		319
Maldives	96,987	103,936	84,447
Mauritius	533	963	414
Micronesia	17,509	13,699	8,106
New Caledonia	4,751	6,265	7,529
Nicaragua			365
Nigeria		234	
Papua New Guinea	785		
Peru	4,765		
Philippines	259,364	219,552	210,852
New Caledonia			
Portugal	20,473		
Philippines	259,364	219,552	210,852
Singapore	1,001,849	93,386	32,931
Sri Lanka	284,848	132,986	89,121
Sudan	555	316	5,618
Taiwan	12,522	1,057	276
Thailand	94,224	10,427	12,064
Tonga	321		29
UAE		156	36
USA	175,545	221,583	144,562
Vanuatu	4,065	6,842	12,325
Vietnam	43,710	7,680	5,089
Total number	3,898,659	2,190,366	1,616,082

Further comparison can be made with Saleem and Islam (2008) who provided information on exports of ornamental fishes from the Maldives. In 2007, 358,378 fish and invertebrates were exported from the Maldives, with a value of USD 590,530 or about USD 1.65 per piece. Assuming an average weight of 3g per piece (this would apply to fish, the weight of invertebrates is not known) that would give a total weight of about 1 tonne and a value of about USD 590,000 per tonne. This compares with exports of all tuna products from the Maldives in 2007, which totalled 57,945 tonnes with a value of USD 91,755,000 giving a value of about USD 1,583 per tonne. Examples of the value of some food fish are given in Table E.17. It should be noted that prices for the same product may vary quite widely for different markets (e.g. canning, processing, fresh fish trade) and in different geographical locations due to a combination of local demand and costs of reaching markets.

Table E.17: Typical prices paid for high value food fish in major markets.

Product	Date	Market	Form	Price USD/tonne
Skipjack tuna ¹	August 2014	Thailand canning	Frozen	1,850
Yellowfin tuna ¹	August 2014	Spain canning	Frozen	3,420
Yellowfin tuna ¹ >10kg	August 2014	Auction, Japan	Frozen	2,920
Albacore tuna ¹ >10kg	August 2014	Wholesale, Japan	Frozen	3,460
Leopard coral trout grouper ²	Jan-Sept 2012	Hong Kong	Live	21,000
Green grouper ²	Jan-Sept 2012	Hong Kong	Live	7,090
Average all groupers ²	Jan-Sept 2012	Hong Kong	Live	13,300

Source: ¹ Infofish International 5/2014. ² Infofish International 1/2013.

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Annex F: Fishing methods used in the wild caught ornamental trade

Fishing methods used for the ornamental aquatic trade

A huge variety of fishing methods is used to capture ornamental aquatic organisms ranging in complexity from hand picking to a combination of barrier nets and hand nets used by SCUBA divers. Methods may be passive or active and often make use of the natural behaviour of fish to enable their capture. Even natural objects may be used where aquatic organisms use them for shelter.

Hand picking

This is a widely used technique mainly suited to use in shallow water where relatively slow-moving organisms are sought. On shallow reefs it may be combined with picking for food. It is often a subsistence activity carried out by women, particularly in the South Pacific islands such as Fiji and Tonga. Typical organisms sought would include sea cucumbers, starfish, crustaceans and sedentary fish, although more active organisms may be caught where they tend to remain in shelter, as they form a natural trap from which the animal can be extracted.

A more specialised form of hand picking can occur on floodplains where fish become trapped in muddy pools as floodwaters recede. Such fish are easy to catch by hand as they can be felt moving through the mud and have little opportunity to escape. These fisheries are often dual use for food and for ornamental fish. In some areas, these accessible fisheries may be reserved for particular groups; in the Rupununi floodplain in Guyana, they are restricted to women-headed households, as they do not usually have access to other fishing opportunities. The fate of fish caught in drying ponds is usually to die, although a few very tough species can survive in the mud long enough for the rains to arrive. Floodplain ponds are a seasonal source of food for crocodilians and birds, both of which find the fish easy prey as the ponds dry up and shrink. As most will die, the fish trapped in floodplain ponds have little chance to make any further contribution to the population.

Natural objects

Fish and other aquatic organisms often hide in natural objects and will tend to stay there when they feel threatened, this can make them relatively easy to harvest. Many tropical rivers contain a great deal of wood from fallen trees and branches. The wood softens over time creating natural holes and tunnels, which may in turn be enlarged further by fishes. Many species of catfish like to rest up inside the wood during the day and can be harvested simply by holding up the piece of wood and shaking it over a net to catch the fish as they fall out. This is commonly used in South America to harvest catfish such as loricariids and doradids. In certain areas, lateritic rock is formed, which takes the form of boulders resembling clinker and which are riddled with cracks and holes. Fish may be harvested by a similar method or lifting the rock and holding it over a net to catch the fish as they fall out (see Figure F.1). In Guyana this yields large numbers of loricariids but also some juvenile cichlids.

In lakes, similar techniques may be used but there are also some specialist natural objects, which can provide a specific opportunity. There are a number of shell-dwelling cichlids in Lake Tanganyika (such as *Neolamprologus multifasciatus*) where the females live and spawn inside a shell, usually of the genus *Neothauma*. Females are caught easily simply by picking up shells (this involves diving), however males generally need to be caught by more active means as they are usually too large to fit in the shells.

(a)



(b)



Figure F.1: typical harvesting methods used on the Rupununi River. (a) Rock fishing on the Rupununi River, Guyana. (b) “Tacuba” fishing on the Rupununi River, Guyana.

Traps

In their most basic form, traps simply copy what represents the natural habitat of the fishes. For example, clown loach *Chromobotia macracanthus* (Tomey 2002) naturally live in hollow wood in rivers and by placing bundles of bamboo pipes on the river bottom, juvenile clown loaches can be caught as they tend to enter the pipes and not flee as the trap is pulled up.

There is a great variety of more complicated traps, often based on something used for catching food fish. Most traps work on the basis that the fish can get in easily but then either cannot find the exit or the structure of the exit makes it very hard for the fish to get out. Traps can be a good way of catching fish with minimum damage and, while the fish are generally protected from predation while in the trap, the presence of aggressive fish in the trap can lead to other fish being damaged. Traps may be baited to attract fish or may be placed so as to take advantage of fishes' natural movements. By careful placing and timing, traps can be quite selective.

Traps are reported to be used widely in Africa and their use is described in Nigeria by Mbawuike and Ajado (2005). Three types of gear were described, made from locally available natural materials and based on traditional traps used for food fish. The traps work in similar ways, trapping fish which are (mainly) moving upstream and then enter the trap, guided by a frame of woven material in the shape of a funnel or fence. The largest gear is the *aso-oro* which can be 7.8m long and the smallest is the *igu* or *uge* which is 1.74m long, suited to the environment in which they are used (rivers or creeks). Catches correspond to size, with the *aso-oro* having a catch per unit effort of 40kg and the *igu* having a catch per unit effort of 20kg. The reported range of fishes caught is relatively small.

Net and chase

This is a very common means of catching fish in freshwater and on reefs. In the simplest form it consists of a hand-held net into which fish are chased, typically with a paddle. A good example of this is the *rapiché* net used on the Rio Negro fishery, which is an elongated D-framed net. It is held still while the fish (typically cardinal tetras) are chased into the net with a paddle (see Figure F.2). The net can then be tilted and lifted to trap the fish. Smaller hand nets can also be used and these can sometimes be seen in use on reef fisheries.

(a)



(b)



Figure F.2: The use of the rapiche net for catching small “piabas” in a creek. (a) Fisher on the Rio Negro with a *rapiche* net. (b) The *rapiche* in use with a canoe paddle being used to chase fish into the net.

A more sophisticated version involves chasing the fish into a static curtain net, which is typically only 4-6m long with depth of about 1.5 -2m, and usually made of very soft material. The fish are chased onto the net, usually by divers, the fish then tend to become trapped temporarily in the soft mesh from which they can be removed by hand or with a small hand net. This tends to be a very selective method of fishing and unwanted fish can be returned to the water or allowed to disentangle themselves from the curtain net. This technique is sometimes used on freshwaters such as Lake Malawi but is more often seen on coral reef fisheries. By-catch is minimal and the environmental impact of the method is low as the catching net is static and does not tend to cause damage to the reef as do more active netting methods.

Active netting

Seine nets may be used sometimes but are limited to areas where there are few obstructions that could snag the net and possibly damage it. These are most likely to be used over sand. Sandy beaches also tend to attract those who are seine netting for food fish and these often remove so many fish that there is little left for the ornamental fish catchers. In parts of the Amazon basin, seine netting may be used as a combination of containment and active netting for catching discus. Discus live in areas where there is a lot of woody debris called *galhadas*, which makes most fishing methods impossible. An area of woody debris is contained within a seine net, the wood is removed and the seine is then hauled to catch the discus (Crampton 2008).

A specialised form of active netting takes place in some fisheries for arowana (*Osteoglossum bichirrosus* and *O. ferreirei*) in areas where adult males are caught to enable the harvesting for fry. A long gill net, typically 30-50m long is set around an area where arowana are known to occur and the fish are then driven into the net by splashing. The fish become trapped in the gill net from which they can be removed, the fry harvested and the males returned to the water outside the net.

Diving

Diving as a method of catching fish is very limited in freshwater but does find some specialised uses. It is the only practical method by which most fish can be harvested from the fast flowing southern tributaries of the Amazon such as the Tapajos and Xingu. This is dangerous work where divers descend, usually following a rope and weighted to ensure they sink rapidly to the bottom of the river, where they then catch fish by feeling for them with their hands. This is used to collect the high value loricariids from such fisheries. It is generally recognised to be a young man's job, as it is very physically demanding.

Diving to catch fish is also carried out on Lake Malawi and Lake Tanganyika where divers will either dive using SCUBA or hookah apparatus. Hookah apparatus relies on a compressor, usually in a boat to deliver air to the divers and has the advantage over SCUBA of allowing longer dive times. Fish can either be caught by hand nets or by using a static curtain net as described previously. This can be a very selective method of fishing allowing fish to be selected by species, size and sex. It also allows for fish to be caught at depth as the fish can be placed in containers, usually small plastic barrels with netting over the top, which can then be hauled to the surface slowly (sometimes over a period of a few days) in order to decompress the fishes and allow the swim bladder to equilibrate to the change in depth.

Diving is the main method for catching reef organisms for the ornamental trade and can be carried out using snorkel, SCUBA or hookah apparatus from shore or boat (Figure F.3). As there is a substantial investment required to purchase the equipment for SCUBA and hookah diving and to purchase a boat and engine, ownership tends to be restricted to the wealthier members of a community or the equipment may be supplied by a middleman or exporter. Snorkel equipment is relatively cheap and available to most people in coastal communities. Free diving using snorkel is usually restricted to water less than 10m deep and divers can only stay down for a few minutes at most. By contrast, those using SCUBA or hookah gear can work at greater depths and stay down for an hour or more, enabling them to catch a much wider range of organisms and to use more complicated catching gear.

(a)



(b)



Figure F.3: Typical harvesting methods used by collectors in Bali. (a) A free-diver returns to the shore with his catch for the morning. (b) Hookah diving requires much more equipment and is generally used by wealthier collectors.

Catching gear for snorkel tends to be restricted to hand picking or hand nets. After catching, the fish are placed in mesh bags or containers with a mesh closure over the mouth. As fish are caught, they

may be returned to the surface where they can be kept suspended by inflated plastic bags until the diver is ready to return to shore. The method is physically demanding and, combined with the restrictions on dive time and depth, catches tend to be quite small. Use of SCUBA or hookah gear in conjunction with a boat allow for collectors to travel greater distances and reach organisms at greater depth which, combined with longer dive times, allow for the collection of much greater numbers of organisms. Once collected, organisms are usually stored on the boat in plastic tubs or held individually in polythene bags for a period of hours or, on longer trips, several days.

These methods can be sustainable with minimal impact on the reef when collection is on the basis of a “collect to order” or “do not collect” basis to avoid unwanted fish being caught. If used in conjunction with a barrier net and/or hand nets, impact on the reef is minimised but, if used in conjunction with coral breaking to get access to organisms hiding in the reef, substantial damage may be caused. The use of *moxxy* nets (rather like a cast net which is placed over the coral to prevent fish escaping) is also associated with damage as it usually involves coral breaking to access fish contained within the net.

Toxicants and anaesthetics

Although these are used in food fisheries in freshwater, usually based on plant extracts, they are rarely used for gathering ornamental fish; presumably because recovery tends to be poor and the fish usually die. They are more often used for gathering coral reef fishes and this is associated with severe damage to the reef (see also under “Threat to the Trade”). Anaesthetics are also used in scientific surveys and both quinaldine and clove oil have been used (e.g. Webster and Hixon 2000, Boyer et al. 2009) but this is not without criticisms as both can cause limited coral death. Quinaldine has been used for harvesting ornamental fish, however its use appears to have been very limited, presumably due to the cost. Much more commonly used is cyanide, the use of which was pioneered in the Philippines but spread to other countries such as Indonesia. Cyanide caught fish are associated with high post-capture mortality as, while the fish appear to recover, they will often die later due to unrecoverable organ damage. The losses tend to occur after they have been sold by collectors and middlemen, and therefore results in monetary losses for exporters, importers and retailers. For this and other reasons, cyanide caught fish are very unpopular with the trade. The main concern is that cyanide causes moderate to severe damage to coral reefs as it kills a wide range of organisms, most notably the zooxanthellae in corals, leading to their death. This issue is explored in more detail under “Threats to the Trade”.

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Annex G: Animal welfare issues in the ornamental trade

Animal welfare issues

As with any trade in live animals, the ornamental aquatics trade has been criticised over welfare issues, some of which are justified, some of which are not. There are strong welfare incentives at all stages of the ornamental fish supply chain for high welfare standards. In the case of collectors, dead or rejected fish represent lost income and for those further along the chain (exporter, importer, retailer) the losses are very real as fish will have been paid for and so not only is that money lost, but there is also a loss of income from the eventual sale of the fish. Lastly, the aquarist will have paid hard cash for fish and has a strong interest in keeping them alive. What can be kept in the aquarium has changed over time and will continue to change. Concepts of what is acceptable to trade for the domestic aquarium have therefore changed, however criticisms have not necessarily taken such changes into account. Aside from the sustainability issue, this is probably the biggest challenge to the industry.

Can it be kept alive and on good health?

This has changed a great deal over the last few decades with new knowledge being acquired by aquarists and the development of new technologies by industry. The impact has been greatest on the marine hobby, where developments in technology mean that fish and invertebrates previously considered to be impossible to maintain in the aquarium for more than a few months, can now be kept relatively easily by the experienced aquarist. A good example of this would be coral reef fishes that require sponge in their diet; these can now be kept in the aquarium due to the development of sponge-based foods. Similarly, some obligate coral eaters can adapt to the aquarium and will live quite happily on foods that do not even contain coral (Svein Fossa, OFI pers. obs. by email Jan 2015) although, given the challenges of keeping these fish, many importers and retailers will not stock them. Even greater developments have now taken place for maintaining coral reef invertebrates, and even corals themselves. These include pumps to recreate the surge zone, high intensity lighting, constant dosing systems for foods and (micro) nutrients, and sophisticated filtration systems. Corals that were previously thought impossible to maintain now grow so well that aquarists can exchange surplus corals with each other.

Similar advances have taken place with freshwater fish, with water treatments such as reverse osmosis for the production of purified water now being seen as commonplace. This has made the keeping of soft water species much easier. Many other developments have taken place, often developed by aquarists and subsequently commercialised which make the keeping and breeding of ornamental fish easier such as the numerous investigations into the natural habitats of fishes which provides essential information on their care requirements. Industry has also played a key role in the development of more reliable and more efficient equipment such as heaters and filters. The development of better and more specialised feeds has undoubtedly had a major impact on the ability to keep fish in good health and enable them to be bred in captivity. Commercially produced feeds are now available for even specialised feeders such as wood eaters. The publication of specialist books on fish care and the development of online forums, as well as other sources of information and advice mean that the aquarist now has access to a huge resource on the maintenance and breeding of aquarium fishes. Typical sites include [Planet Catfish](#) and the [British Cichlid Association](#) where forum members can exchange information on the care and breeding of many species. There is now a wide range of foods, some of which are targeted at a single species (e.g. discus or Asian arowana, *Scleropages* spp.) tailored to the requirements of that fish rather than the generalised foods. The keeping of herbivorous species is now made simpler by the availability of a range of plant-based foods for different groups of fishes (e.g. Rift Valley cichlids, algae-grazing loricariids). These foods have overcome the problems that used to be experienced by aquarists, such as Malawi bloat, which was caused by feeding unsuitable feeds to Malawi *mbuna* cichlids.

Some fishes viewed as being very difficult to keep, and thus rarely seen in trade, tend to be acquired by experienced aquarists who want to find out whether it is possible to maintain such species in the aquarium, and discover what factors will allow them to thrive ex situ. There are still some very demanding fishes that are only suited to experienced aquarists as they require regular, large scale water changes or very specialised feeding. Aquarists and the trade have played a key role in the development of technologies and techniques for keeping challenging species in the aquarium. It is also worth considering that the ornamental fish farms collectively keep and breed a huge number of freshwater and increasingly, marine species, far more than have been bred by public aquaria and scientific institutions.

The improvements in husbandry and technology are best highlighted by the marine aquarium trade and the keeping of reef aquaria in particular. Originally, if coral were to be found in a marine aquarium it would have been simply as bleached, dead coral. Even as recently as Moe (1992) a marine aquarium including corals would have meant making a lot of equipment from scratch (notably filters) and having to make up a lot of custom-mix micro-nutrients and trace elements in order to keep the corals healthy. Now, one does not have to go to anything like the same amount of effort and all the equipment and accessories required for maintaining reef organisms are available from commercial supplies. There are now available products and techniques that would not have been imagined only 20 years ago, such as coral fragging kits (frag is a term commonly applied to fragments of coral use for propagation) and specialised foods for culturing larval marine organisms. It is now not only possible to keep corals alive for many years, but it is relatively straightforward to propagate them. In addition, the development of specialised foods, such as those containing marine algae or sponges, means that even specialised feeders can now be maintained relatively easily in the aquarium

Is it too large to keep?

The answer to this depends very much on the experience of the aquarist and the facilities available. In the tropics, it is easy to keep large fish in a pond, however in temperate areas, providing suitable sized housing can be a problem. Amazonas magazine (July/Aug 2014) contained a number of articles by aquarists keeping large fishes (i.e. least 30cm in length) in large aquaria from 3-10,000l capacity. Most of the fish featured are not difficult to find in trade. The wisdom of doing this was challenged in the next issue (Amazonas magazine Sept/Oct 2014) by professional keepers from public aquaria who pointed out that some of the fish would grow to lengths for which even a 10,000l aquarium would be considered too small. The problem of fishes that are too large for the average aquarist has tended to decrease since many aquarium shops stopped stocking them. In the UK, it is now less common to find fish with the potential to grow very large and they tend to be available only at specialist outlets where proper advice can be given. The [Big Fish Campaign](#) works with the trade to restrict the sale of fishes considered too large for the domestic aquarium, and seeks to educate the public at, for example, aquarist fairs. This campaign is backed by a number of UK retailers including one major chain. It is difficult to be prescriptive on this, however as a general rule no fish should be sold to anyone who has not been made fully aware of potential problems (large size, specialist diet, aggressive nature, etc.). As well as widely available books on the subject, care sheets on this subject can also be found on websites such as [OATA care sheets](#), the [Maidenhead Aquatics Databank](#), or the [TMC care guides](#). These all contain at least the basic information necessary to guide an aquarist on making a purchase and more information would normally be available in store.

Mortalities in the supply chain

Where best practise is used mortalities at all stages can be reduced to very low levels.

Catching mortality

There are some fishes that cannot enter the trade, as they will not survive even catching and die in the net, presumably of shock. Some fish are very sensitive to handling stress or adverse water quality conditions, and may die while being transferred to the holding or selling point. There are

also some particular fish that require specialised handling to reduce mortalities, such as Rift Valley cichlids that are found at depth and need bringing up to the surface very slowly over a period of hours or days to decompress and allow the swim bladder to slowly deflate. Fishes may also require specialised handling where they are predatory or aggressive and may require to be kept individually, as is the case with many coral reef fishes. While this will remove the aggression between fishes, it does require much more effort to maintain water quality as frequent water changes have to be carried out and if these are not performed, higher mortality may result.

There are two forms of mortality to consider, immediate mortality and delayed mortality. Immediate mortality tends to be from acute water quality problems, such as high ammonia or nitrite levels and delayed mortality tends to result from sub-lethal levels of ammonia or nitrite which cause gill damage and make the fish prone to developing bacterial infections. Such mortalities may take a few days to develop by which time the fish may have been traded on. Additional stress from transport may add to the initial stress leading to delayed mortality. The use of toxicants, such as cyanide, can cause particular problems as fish may die immediately or they may die subsequently, some weeks after being poisoned. Cyanide-caught fish are unpopular with the trade due to the high and unpredictable losses that can occur. The development of an accurate and reliable cyanide field test kit would help to remove cyanide-caught fish from the supply chain if buyers had the means to be able to reject such fish. There are tests under development (e.g. Vaz 2012), however these are some way from being validated as a practical test for use outside the laboratory. The development of an easy to use and rapid test kit for use by the trade would be an invaluable tool for the elimination of cyanide-caught fish but until a reliable and workable test is developed, this is still a long way off.

Training for collectors in correct procedures for handling, transporting and keeping fish can have a significant effect on fish mortality and lead to a substantial reduction to levels of just a few percent. In addition, training collectors to return any damaged fish immediately will help as these are very likely to die even with good care.

Mortality in transport

Mortality in transport can occur for a number of reasons. It may be beyond the control of anyone in the ornamental trade as it can occur due to mishandling or delays. Potential problems during air transport are missed connections due to delayed flights and incorrect handling by ground staff. If a shipment misses its connecting flight, it may be delayed for many hours and, while shippers will usually pack fish to allow for possible delays, unusually long delays can result in a rapid deterioration in water quality leading to high DOA (dead on arrival) or post-shipping mortality. Some fish are much more sensitive than others and the rummy-nose tetra and hatchet fish are known to be particularly at risk. Most species are more robust and can survive times which long exceed the IATA guidelines of 48 hours. Mishandling by ground crews can include placing boxes of fishes in the open in the tropics where they are likely to over-heat or leaving them in the open in temperate areas in winter when chilling may occur. Boxes of ornamental fish are all labelled with the correct handling requirements as required by IATA, and this includes clear guidance on acceptable temperature limits, however these guidelines are not always followed. An exporter in Peru reported that while DOA on shipments to China were generally <5%, delays due to missed connections could lead to a rise in DOA of 50%.

To minimise mortality, shippers can take a number of precautions. Fish can be packed at a density adjusted for the sensitivity of the fish and the likely maximum door-to-door shipping time (with an appropriate allowance for possible delays). Guidance on appropriate packing densities and best practice for shipping are given in Andrews (2011) and Ploeg et al. (2012). All shipments sent by air must comply with the IATA Live Animal Regulations (see Legislation section), which lays down conditions for the packing, handling and transport of fishes by air. Within the EU, transport is also regulated by Regulation 1/2005, which covers transport by any means (see Legislation section)

Mortalities in holding

Collectors often hold fishes for hours or days before they can be sold, with resulting losses at this stage. Improvements to holding conditions, such as regular and careful water changes or holding fish in cages, can lead to very much reduced mortality at this stage. Similarly LINI has worked with ornamental fish catchers in Bali to reduce mortalities in holding.

Mortality will also occur at the exporter where fish are held prior to export. Self-reported mortality levels at exporters include 1-2% per day (Bali, reef fish) and <1% (arowana held at exporter in Peru). They also reported low DOA of 1-2% for most shipments. Pyle (1993) reported mortalities of 1-2% from holding facilities prior to export.

Mortalities at importers and retailers

Although no comprehensive survey has been carried out, some informal polling of importers in the UK revealed expected DOA of <1% and mortalities in holding of 1-2%, although there can be higher mortality due to problems which usually arrive with the fish (e.g. mishandling stress or an infection). Pyle (1993) reported mortalities of 5-10% for shipments from the Pacific but did not say exactly where the mortalities occurred (i.e. DOA or DAA).

Yeeting (undated extract) provided details on excess DOA associated with exports from Kiritimati. DOA were reported to be a concern and SPC put a training scheme in place to improve handling practices by collectors and exporters. Bad practice was reported to be due to *basically all unintentional and purely caused by the lack of proper training on industry practices, especially for new comers entering the industry*. The results of this intervention have not yet been reported but continuing efforts are being made by SPC to ensure best handling practices are adopted by collectors and exporters. Progress has been noted (Colette Wabnitz, SPC, pers. comm., by email) *I've gone back to Kiritimati twice since to specifically focus on best practices in the trade – in essence working with fishermen from every single company on the island and going through each step from collection to export. Most fishermen have excellent skills underwater; we therefore focused on handling on board the boat, transfer to the holding pens and packing. The fishermen were keen to learn and most were quick to put suggestions into practice. The weak link by a long shot is the fact that bar one company, all hold their fish in cups, in large nets, in the ocean until shipping. I did notice improvements in awareness and handling when visiting and working with fishermen the second time around*. The PICTs and SPC seem to offer a number of examples of best practice and indicate how even modest and simple interventions can bring about a significant improvement in fish quality and survival.

Evidence collected on a visit to Barcelos on the Rio Negro in Brazil revealed a very mixed picture. Examination by a vet of fishes held at an exporter showed that many fishes had evidence of poor water quality, which had led to gill necrosis, one of the key factors leading to mortality for the fishery. Examination of fishes obtained from *piabeiros* showed very little sign of gill damage in freshly caught fish or those that had been held for a short time at a collecting station indicating that the condition is caused by poor handling and poor water quality, both issues that are easy to fix by some simple training. Project Piaba and Ornapesca will make the delivery of such training an early priority to ensure that fish mortality is minimised and the quality of the fish is improved. An American importer indicated that mortality of up to 25% can still occur in holding for quarantine of cardinal tetras shipped from Manaus; a figure much lower than is often quoted but still not acceptable either from a commercial or welfare point of view. The level of mortality was reported to be mainly related to the exporter with the best giving combined DOA and DAA of <2-3%. The importer considered that cardinal tetras from Colombia were a better option due to more reliable delivery and low mortality that rarely exceeds 5%.

An American importer of marine fishes indicated generally very low levels of mortality. Some of the company's best supplies consistently deliver shipments with DOA (dead on arrival) of less than 0.5% average and some shipments even have zero DOA. DAA (dead after arrival) also tends to be very low

at <1%. Claims for DOA by retailers receiving stock from that importer were on average 2.8% with the highest claimed being 4%, however the best retailers usually claimed for DAA of <1%. Mortalities whether for fish received by the importer or for fish sent to retailers is very low and related to the quality of the holding systems and the experience and ability of the exporter or retailer. It seems reasonable to assume that mortality in the marine trade should not generally exceed 5% from exporter to retailer. Some research is needed in this area to provide some clear and unambiguous evidence of actual mortality rates across the industry.

Reported mortality rates

In a Written Answer to question (HL 4091) House of Lords Hansard, 30 March 2006, Column WA145 it was stated that mortality of ornamental fish imports to the UK monitored by the Animal Reception Centres (ARCs) had a mortality rate of less than 1%. This bare statistic hides the fact that it is based on a very large sample size with 100% inspection of ornamental fish imports and therefore represents a realistic assessment of mortality at the point of import. Other reports where no data are quoted should be seen in the context of the ARC figure of 1%. Some very high mortality rates have been reported for the ornamental trade but these are not always reliable and can be based on sample bias. For example, Olivier (2001) reported rates of 50-60% for Brazil prior to export, and that only 10% of cardinal tetras (*Paracheirodon axelrodi*) survived from collection to the exporter. Despite huge advances in handling on the Rio Negro fishery, such data are still reported despite being very old and being based mainly on unverifiable sources. Other mortality rates are reported by Olivier, however these appear to be based on single, anecdotal reports, rather than representative surveys. Despite this, Olivier offers the table below with no sources being cited (Table G.1).

Table G.1: Mortality rates for ornamental fish along the supply chain quoted by Olivier (2001).

	Mortality rate	Cumulative mortality rate
Before transportation	30-40%	35%
During transportation	25-30%	48%
At the wholesaler	25-30%	62%
At the retailer	25-30%	73%

The above data are repeated in Monticini (2010) (see Table G.2) with the addition of more data from a survey at Barcelos on the Rio Negro and in the UK.

Data from Olivier and Monticini cannot be verified, and are very much higher than rates reported elsewhere. The data for Project Piaba are derived from Dowd (2003) and are fully verifiable and the most credible data quoted. Some other examples of verifiable data are given below.

Abreu et al. (2014) also looked at the Rio Negro Barcelos fishery studying mortality in pencilfish (*Nannostomus trifasciatus*) during transport from Barcelos to Manaus; a journey of 24-30 hours by boat with the fish being carried in open plastic boxes. Although the study was to determine the effects of feed additives on survival, all treatments have mortalities of <1% and some boxes had zero mortality. The fishes were stocked at 40 fish per litre, a stocking density comparable with that used by ornamental fish traders so the trial fairly reflected normal conditions for transport.

Table G.2: Mortality rates for ornamental fish along the supply chain quoted by Monticini, (2010).

	Mortality rate		Cumulative mortality average rate		Mortality rate
	Olivier (2001)	Project Piaba	Olivier (2001)	Project Piaba	Monticini (2009)
Before transportation (Barcelos)	30-40%	<1%	35%	<1%	35%
During transport	25-30%	0.2%	48%	<1.15%	40%
At the wholesaler (Manaus)	25-30%	c1%	62%	<1.96%	40%
At the retailer (UK)	25-30%	3.5%	73%	<5.46%	30%

Weber (2001) looked at mortality in a range of fishes in transport and at the importer/wholesaler. Out of shipments containing a total of 27,266 fishes, which were shipped directly and thus the unpacking of the fishes could also be monitored directly, the mortality rate was 1.57%; including two transshipment consignments actually reduced mortality and out of 29,146 fishes, 427 individuals died to give 1.47% mortality. For freshwater fishes the transportation mortality rose from 1.47% (423 dead out of a total of 28,782 freshwater fishes imported) to only 1.56%. The highest loss in percentile terms was 6% for the order Atheriniformes (rainbowfishes and silversides); 15 of the 250 individuals died. In numerical terms the largest number died among the Characiformes (characins and their allies), with 334 individuals representing 3.29% of all the characins imported. According to the importers, 81.73% of the 427 fishes that died in transit were wild-caught. Of these, the 300 *Petitella georgiae* were of particular significance, as they comprised two whole bags indicating the high mortality, which can follow even a few fish dying in transit. 16.86% of the dead fishes were captive-bred, and the origin of 1.41% is unclear. Losses within the individual consignments varied between 0 and 13.79%, with no apparent connection between losses and the absolute duration of transportation.

Hormuth (2010, abstract only) carried out research into mortalities in ornamental fish imports at a major importer in Germany. A total of 293 bags were examined on arrival and of these, 193 bags were followed during acclimation at the importer's facility to determine mortalities. The study took place over a period from November 2008 to February 2009. Dead on arrival figures were 935 out of 71,218 fish equivalent to 1.31% mortality overall. Of these 329 fish were farm bred equivalent to 1.0% mortality and 606 were wild caught equivalent to 1.60% mortality. These figures for DOA are very much lower than those reported by Olivier (2001) and Monticini (2010) and are in line with figures generally reported by the trade. Of the wild-caught fish, mortality was mainly accounted for by the total loss of fish in three bags (reasons not stated, nor species mentioned). Mortality during acclimation was also low at 0.9% for the farmed fish and 2.5% for the wild-caught fish. It is noteworthy than properly conducted studies that quote data all show very low mortalities on import.

Lim et al. (2003) studied mortality in a simulated shipping exercise carried out in Singapore using guppies. They examined 104 bags of fish packed in 5l bags at a density of 100 fish/l after a simulated shipping lasting 40 hours (note that this did not include handling) with fish packed as for transport to (e.g.) the US. DOA was recorded as was mortality after 7 days. As may be expected, there was a rise

in the total and un-ionised ammonia level in the water but dissolved oxygen levels were still high. The pH of the bag water was low, presumably due to a rise in CO² due to fish respiration. Mortality rates were variable but generally low and averaged 2.6% on unpacking, varying from 0-9.9% with a median value of 0.5%. Mortality in the 7 days after unpacking was on average 10.8% with a range of 0-26% and a median of 9.5%. The authors put the differences in mortality due to variations in the quality of fish that had been sourced from a number of farms. They suggested that some fairly simple measures on conditioning of the fish, notably the use of salt in the shipping water would make the fish more resistant to the stresses of shipping. It is likely that similar results would be obtained with wild-caught fish.

There is a trend for older publications to show higher levels of mortality; this may be a reflection of improvements in handling in recent years. Schmidt and Kunzmann (2005) studied mortality in marine fish in Bali between collection and the exporter. They measured mortality before arrival at the exporter (DOA), and mortality prior to export, DAA (dead after arrival). Mortality was very variable and the main factors appeared to be the time spent in transit and the packing practice of the person transporting the fish. DOA varied from 0.8% to 11% and both extreme values were perceived as anomalous. Only 2% of fish died during acclimation at the exporter but there were 49-79% DAA but that includes fish which were injured rather than dead and some shipments contained a high proportion of injured fish. Actual total mortalities varied from 11-40%, which are unacceptably high but still lower than some reported values.

LeGore et al. (2005) indicated that mortality in an ornamental fishery in Puerto Rico was <1% and that mortality >3% would be unacceptable to their customers, but did not provide any data. They did note that the collectors do not use intoxicants to catch fish as they find this raises mortality above the acceptable limit of 3% and so they have elected not to use them.

A useful analysis of mortalities in the marine trade comes from Wabnitz and Nahacky (2014) who examined practice on Kosrae, Federated States of Micronesia. The collectors and exporters had all received training in best practice for the collection, handling, transport, holding and shipping of ornamental reef organisms and the results of this can be seen in the mortalities exhibited. Observed mortality during the monitoring period was:

- From collection through transport to the exporter's facility <1%
- At the exporter's facility prior to export <1%
- At the importer (verified DOA on arrival via Los Angeles) <1.4%

The US importer reported that the fish were fit and healthy. These figures are not unusual for those who have received training from SPC and there is no reason to doubt that they can be considered to be the industry norm that any country could achieve.

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Annex H: The longevity of aquarium fishes

Longevity of ornamental fishes

The longevity of ornamental fishes in the aquarium is subject to much debate, as the majority of our knowledge is based on anecdote rather than hard data. The problem is made worse by the difficulty of determining longevity, and further, the fact that it is not a very informative metric particularly if only the maximum age is reported. For example knowing a fish may live for 30 years in the wild is not a particularly useful piece of information in isolation without knowing what proportion of any cohort makes it to that age. Average lifespan, or better still mortality rates over time or population structure (frequency distribution of different age classes in a population), are much more informative. However, such information is again rarely available. Given the lack of reliable data, an additional problem of studying longevity and other associated metrics is comparing data from aquarium fishes in the wild with information on the same species in the aquarium, as it requires data to be known for both wild and aquarium populations. In practice, the vast majority of fishes in the wild will die at a very young age, with relatively few being recruited to the spawning population; after all, a fish only has to give rise to a single spawning adult to theoretically pass its genes on to the next generation and a spawning pair of fishes only needs to give rise to another spawning pair to achieve population equilibrium.

Different approaches were necessary to obtain information on fishes in the wild and in the aquarium. The initial approach was to use “top 10” -type lists to identify aquarium fishes most commonly kept and then to search on [FishBase](#) and identify information on lifespan, longevity and age. However, it rapidly became apparent that there was very little information, especially for freshwater fishes, further some information was reported without reference and so could not be verified. A general web search was then used with the search term “species” and “age”, “longevity” or “population structure” but this too returned very little so the term “species” was replaced with “genus”. This returned much more information; any information relating to members of a genus, which are not in the aquatic trade (e.g. subject to food fisheries only) was disregarded. This search turned up information in peer-reviewed journals and on aquarist websites. Single reports such as are typically found on aquarists’ blog sites or bulletin boards were disregarded and only information taken from aggregated sources such as online polls was used in this report. While online polls suffer from a certain bias in the form of self-selected respondents, the larger number of responses will help provide a reasonable indication of expected longevity or typical lifespan in the aquarium. There was a major difference between searches carried out for coral reef fish genera and freshwater fish genera. Far less information was found for freshwater fishes in the scientific literature. As a last resort, direct contact was made with a number of scientists working in the field on a range of aquarium fishes. They confirmed that there is very little work on the longevity or population age structure of aquarium fishes in the wild.

Assessing the age of an individual fish is problematic, even in temperate waters where fish usually lay down a clear growth check during winter. This growth check is reflected in bony structures such as otoliths and opercula and in other structures such as scales or even fin spines. Interpretation of age from even well marked structures such as otoliths is subject to observer error and some fish species are difficult to interpret due to unclear growth rings. In addition, old fish, which have stopped growing or are growing very slowly, may not show distinct growth rings and so the true age of the fish might not be measurable. The problems are much worse for tropical fishes as there is often no major check on growth as is seen in the temperate winter. Some checks may be seen due to spawning or to adverse seasonal conditions such as low water when food may be in short supply but generally, even otoliths are much more difficult to interpret. For this reason, many studies on tropical fisheries and population age structure rely on age-based methods to identify cohorts. This works well for fish which have a distinct spawning period and tend to have indeterminate growth (i.e. they will continue growing until they die) but far less well for many aquarium fish species which

tend to grow to adult size rapidly and then may not grow to any measurable extent for the rest of their lifespan. These problems may explain why reports on age, population structure and longevity for aquarium fishes in the wild are hard to find.

Coral reef fishes

There is some peer-reviewed literature on the lifespan of coral reef aquarium fishes in the wild but the information needs to be treated with caution. For a number of species, longevity is a misleading statistic as only a very few fish survive to adulthood and even then, mortality may be high until a key resource can be accessed. Coral reef fishes may be split into two types, those that rely on the reef but do not associate strongly with a reef structure (usually shoaling fishes swimming in close proximity to the reef) and those, which absolutely rely on a reef structure for survival and/or reproduction (such as coral or anemones). The latter is represented by some common aquarium fishes.

Anemonefish/clownfish. Buston (2003) reported that survival in anemonefish (*Amphiprion percula*) is linked to dominance. Anemonefish are protandrous hermaphrodites and the largest and most dominant fish are females. Females dominate the key resource for anemonefish, large anemones. If an anemonefish cannot get access to the shelter provided by an anemone it will be subject to very high predation risk. The mortality rate of anemone fishes living in association with an anemone was low at 14% per annum, lower than for other reef fishes. Social ranking was negatively correlated with mortality, with decreasing social rank leading to increased mortality. It has also been found that the dominant fish in an area can depress the growth of juveniles, which have succeeded in settling on the reef (Ochi 1986). This is further complicated by the density of host anemones as a high density of anemones can lead to juveniles being able to escape adult social pressure (Ochi 1986). The highest ranked fish had a mortality of only 5% per annum, which compares with estimates of other adult reef fishes of 12-100% (Munroe & Williams 1985) and 5-70% (Eckert 1987) quoted by Buston (2003). A study by Buston and Garcia (2007) confirmed the relationship between social rank and mortality but also provided estimates of the age of the dominant females and the expected remaining lifespan. The latter was estimated at 14.0 years, which is already quite high for a small fish but the estimated maximum age for a female was 30.8 years. This high longevity was linked to the protection from predation provided to high-ranking individuals by living in an anemone. However, these results only apply to the small proportion of fishes that make it to adulthood and achieve sufficient rank to obtain a place in an anemone. The authors of this report summarise work from others in Table H.1.

Damselfishes. Doherty and Fowler (1994) provide data for the age structure of *Pomacentrus moluccensis* and *P. wardii* at several locations on the Great Barrier Reef. Recruitment, survival and thus the age structure of the population varied considerably between locations and to a lesser extent between years. Generally, the number in a cohort declined with time after settlement on the reef (damselfishes are pelagic and then settle on the reef after metamorphosis) but the percentage remaining was very variable with year and location; varying from 5-15% at 6 years post-settlement and very few fish survived beyond 9 years. Fowler (1990) studied *P. moluccensis* also on the Great Barrier Reef, providing information on the age structure of populations. This also showed that survival declines quite rapidly in the first few years of life and that few fish make it to 8 years of age.

Gobies. The Gobiidae hold a number of records; apart from containing some minute fishes, they also hold the record for the fish with the shortest recorded lifespan. *Eviota silligata* grows to only 21mm and is thought to live for about 59 days in the wild. Other small gobies have also been shown to have a short lifespan raising the question of whether this is determined as a characteristic of the species at birth or whether it reflects high rates of predation (c.f. the anemonefishes which appeared to be very long-lived by nature but only those at the top of the dominance hierarchy get to live to their full potential). The lifespan of gobies is generally measured in months, not years and sometimes even in days. The authors compared the lifespan of some gobies in the wild with those

held at the Waikiki Aquarium. The age of the gobies was unknown at the time of purchase but can be assumed to be months (Table H.2).

Table H.1: Longevity estimates of *Amphiprion percula* and other long-lived damselfishes (Pomacentridae), the source of the estimate, their habitat (tropical v. temperate), their size (maximum standard length, LS), and their predicted longevity (+, greater; -, lesser; =, equal) relative to *A. percula* based on habitat and size* (Taken from Buston and Garcia 2007, and data from several authors).

Damselfish	Source	Habitat	LS (mm)	Longevity (years)
<i>Amphiprion percula</i>	This study, stage-structured matrix model	Tropical	65	30
<i>Pomacentrus wardii</i>	Fowler & Doherty (1992) otoliths (validated)	Tropical (=)	60 (-)	10
<i>Dascyllus albisella</i>	Hill & Radtke (1988), otoliths (unvalidated)	Tropical (=)	117 (+)	11
<i>Parma victoriae</i>	Brown (1982), scales	Temperate (+)	200 (+)	15
<i>Stegastes altus</i>	Kohda (1996), observation of marked individuals	Temperate (+)	120 (+)	15
<i>Hypsypops rubicunda</i>	Clark (1970), scales	Temperate (+)	300 (+)	17
<i>Pomacentrus moluccensis</i>	Doherty & Fowler (1994), otoliths (validated)	Tropical (=)	90 (+)	17
<i>Parma microlepis</i>	Tzioumis & Kingsford (1999), otoliths (validated)	Temperate (+)	150 (+)	37

*All else being equal, damselfishes are expected to have similar longevity to *A. percula* due to their shared evolutionary history. Ecological factors are, however, expected to influence longevity: temperate fishes are expected to live longer than tropical fishes; large fishes are expected to live longer than small fishes.

†These estimates of maximum Ls come from FishBase (<http://www.fishbase.org/search.php>).

Table H.2: Lifespan of gobies in the wild and Waikiki Aquarium. Data taken from Randall and Dalbeek (2009).

Goby	Lifespan in wild	Lifespan at Waikiki Aquarium
<i>Trimma</i> spp.	3 months	12-20 months
<i>Eviota nigriventris</i>	-	23.5 months
<i>Priolepis nocturna</i>	-	3 years 3 months
<i>Gobiodon okinawae</i>	4 years	9-13 years
<i>Kellogiella</i>	-	22 months
<i>Silhouettea aegyptia</i>	< 2 years	-
<i>Istigobius decoratus</i>	22 months	-
<i>Asterropteryx semipunctatus</i>	16 months male 14 months female	- -
<i>Istigobius goldmanni</i>	13 months male 11 months female	- -

In addition, they report that while *Asterropteryx semipunctata* lives for up to 16 months in the wild, a specimen maintained at the University of Hawaii survived for 11 years in the aquarium before it was released. While the data from the wild and the Waikiki Aquarium do not match in all cases, it is

reasonable to assume that gobies are likely to survive longer in the aquarium than in the wild. The authors provide some additional information on other fishes held at Waikiki Aquarium in Table H.3.

Table H.3: Survival time in years of individuals of species of fishes at the Waikiki Aquarium, Honolulu. Data taken from Randall and Dalbeek (2009).

Species	Age in years
<i>Pygoplites diacanthus</i>	13
<i>Acanthurus pyroferus</i>	13
<i>Stegostoma varium</i>	13
<i>Chaetodon auriga</i>	14
<i>Centropyge potteri</i>	14
<i>Zebrasoma veliferum</i>	15
<i>Genicanthus personatus</i>	16
<i>Caranx ignobilis</i>	16
<i>Neocirrhites armatus</i>	17
<i>Centropyge flavissima</i>	17
<i>Carcharhinus melanopterus</i>	18
<i>Myrichthys magnificus</i>	18
<i>Gnathanodon speciosus</i>	19
<i>Chaetodon ulietensis</i>	23
<i>Siganus uspi</i>	24

Freshwater fishes

Freshwater fishes are extremely diverse, coming from a wide range of habitats and adopting a similarly wide range of life strategies as a consequence. As may be expected, the lifespan of freshwater fishes is very variable, whether in the aquarium or in the wild. In effect, many freshwater aquarium fishes are annual fishes due to extremes in habitat variation over the year, which tends to result in mass mortality in times of adverse conditions, such as drought. At times, adult fishes can be hard to find in the wild (IW pers. obs.) with the surviving population being heavily dominated by juveniles.

While there are numerous references to the expected lifespan of freshwater aquarium fishes, this is often unsupported by verifiable evidence. While it is reasonable to assume that reports in standard aquarium fish care texts are based on experience, such information may best be treated as anecdotal. However, by taking a wider sample size, a collection of online polls may provide a realistic representation of the expected or maximum lifespan of some common aquarium fishes. Due to the length of the tables only some sample information is provided in Table H.4, which summarises information from one source.

Table H.4: Information taken from [Badman's Tropical Fish](#). Some of the most common aquarium fishes sold in the UK are listed.

Species	Aquarium lifespan in years
<i>Pterophyllum scalare</i>	10-15
<i>Poecilia reticulata</i>	3-5
<i>Paracheiroidon axelrodi</i>	4-5
<i>Hyphessobrycon amandae</i>	2-5
<i>Puntius titteya</i>	5-7
<i>Danio rerio</i>	2-7
<i>Tanichthys albonubes</i>	5-7

Various sources tend to quote similar age ranges that could simply mean that they are reporting each other; however a poll by Practical Fishkeeping magazine in the UK provided new data. Interestingly, this survey provides similar age ranges to those reported in the literature, therefore on balance, the information quoted may be regarded as reasonable, even if not entirely objective and verifiable. With those cautions taken into account, it still appears that common aquarium fishes are capable of surviving for several years in the aquarium (c.f. often quoted figures that most die on the first year after purchase). From the information reported, it is not possible to differentiate data for farmed and wild-caught fish.

No reliable information was found for freshwater aquarium fishes in the wild and all scientists that were contacted covering a wide geographical and taxonomic spread replied that this is an area that has not been researched. Carvalho et al. (2014) indicated a lifespan of about four years for *Hyphessobrycon flammeus*, the flame tetra; however they did not provide any evidence to back up this statement. Similarly, Chao (2001) reported that *Paracheiroidon axelrodi*, the cardinal tetra, lives for approximately a year in the wild compared with five years in the aquarium. Length frequency charts in the same publication suggest that the population consists mainly of sub-adults at some times of the year, which tends to support this view. What is known of the population biology also suggests a very short lifespan for most cardinals with the population increasing rapidly as the flooding expands on to the floodplains and then crashing as the water recedes and the only habitat left is small streams. It may be assumed that this applies to other small floodplain fishes that appear in the ornamental aquatic trade but more research is needed to confirm this.

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Annex I: Threats to the wild caught ornamental fish trade

Threats to the ornamental trade

All of the benefits of the caught ornamental fish trade identified in this report could be lost to the threats listed below.

Apart from the obvious threat of a ban, there are many threats, which could directly or indirectly affect the ability of the trade to deal in wild caught ornamental aquatic organisms or even cause it to cease in some areas. These threats are anthropogenic in origin and vary in severity and geographical coverage. Although some threats affect all habitats from which ornamental aquatic organisms may be harvested, it is easier to deal with the threats by breaking them down and not considering them at the global level.

Over-fishing

While it has to be said that the ornamental trade is responsible for some over-fishing for particular species in certain areas, there is a much wider problem of over-fishing in tropical fisheries. Over-fishing may affect the ornamental fishery directly by reducing populations on which the industry relies or they may affect it indirectly by causing changes in ecosystems, which have knock-on impacts on the ornamental trade.

Over-fishing is widespread and has a number of causes. Harvesting of target species beyond the point of sustainability can occur with any species in one of two forms:

- Recruitment over-fishing occurs when a species is harvested to the point where the spawning biomass is insufficient to maintain the population at its previous level;
- Growth over-fishing occurs when a species is harvested at sizes below the size at maturity, effectively preventing them from recruiting into the spawning population.

Recruitment over-fishing can occur without a change in fishing gear and is often associated with an increase in fishing effort due to, for example, more fishers, more boats, more or longer nets being used. Growth over-fishing tends to be associated with the use of gear that catches smaller specimens such as a change from large mesh nets to using very fine nets. This tends to be a vicious circle with fishers resorting to smaller and smaller mesh sizes as the overall length of the fish declines. Growth over-fishing will tend to be less of a problem for ornamental fisheries as small fish may be accepted by the trade but there are a number of examples where recruitment over-fishing has taken place (e.g. the zebra plec fishery on the Rio Xingu).

Over-fishing can occur regardless of any fishing by the ornamental trade, either due to competition for the same resource or, especially with growth over-fishing, food fishers targeting any small fish in order to be able to catch any amount of fish. A good example of this is on Lake Malawi where seine nets used for catching food fish have caused severe depletion of fish stocks on sandy beaches and small mesh gill nets have caused severe depletion of rock-dwelling cichlids in some areas (see also section on Stuart M Grant Cichlid Conservation Fund).

The total catch of the fishery in the Malawi waters of Lake Malawi amount to about 37,000-62,000 tonnes annually over the period 1999-2009 (Agora, 2010) and the industrial sector accounts for generally only 3,500-4,000 tonnes of that catch. The capture fisheries is dominated by small-scale artisanal fishing. The following information is from Poseidon (2012) based on data collected by IW and IW personal observations. The majority of effort is focused at the southern end of Lake Malawi, with Mangochi District, Nkhosha District being the key locations. Fishing takes place close to the shore (e.g. <1 nm) in shallow (<18 m) waters. Gears used include beach seines, open water seines, gill nets, fish traps, long lines and hand lines. The main species caught (47% by volume) is a small pelagic species usipa (*Engraulicypris sardella*) which is then dried and forms a staple protein source in Malawi. Other key species include utaka (*Copadichromis* spp.), ncheni (*Dimidiochromis*

dimidiatus) and matemba (*Barbus paludinosus*). Chambo (*Oreochromis karongae*), the most favoured species of Malawian consumers, now represents only about 1% of artisanal production. Artisanal fisheries effort has grown rapidly over the last few years and the rapid shift to lower value small pelagic species like usipa at the expense of prime table fish like chambo indicates that the lake is increasingly over-fished.

Commercial fishing occurs at a much smaller scale and is mainly undertaken in Mangochi as well as a small number of pair trawl operations in Nkhotakota. Maldeco operates five small stern trawlers, landing mainly in Monkey Bay. Since their peak in the 1970's, the commercial fisheries effort has gradually declined, although has revived somewhat over the past few years. The main catches are currently ndunduma (*Diplotaxodon limnothrissa*) and utaka (both around 35% of the catch). The increasing catch of the former species, one that tends to inhabit deeper waters (e.g. c. 100 m), suggests that the commercial fleet is having to fish further offshore to maintain catches.

On the basis of the above, it might be thought that there is relatively little overlap between the ornamental and artisanal food fisheries on Lake Malawi but the catch of potential ornamental fishes by the artisanal food fishery remains largely unreported. In part this is due to fishery statistics being compiled on the basis of inspections at licenced landing sites which means that village scale catches for strictly local use tend to be unrecorded. Secondly, it is a reflection of the problems of recoding the species caught and the large number of remote fishing communities around Lake Malawi. While it is clear that the catch of cichlids from Lake Malawi is insignificant in comparison to the food fishery, it is not possible to identify how they interact and conflict with certainty (but see Annex J Stuart M Grant Cichlid Conservation Fund).

Ecosystem over-fishing can also occur where the result is a significant change in an ecosystem usually with knock-on effects. Good examples of this are over-harvesting of herbivorous fish on reefs either for food or for the ornamental trade, which can result in over-growth of algae leading to an algal dominated reef rather than a coral reef (e.g. Wilson et al. 2008, Rhyne et al. 2009, Dee et al. 2014, MacClanahan et al. 2014). A significant cause of this on reef fisheries is the large trade in premium reef species, especially for the live food fish market, which has led to major ecosystem shifts due to the removal of top predators. While such fish (typically large groupers and wrasse) have been targeted by fisheries of many years (see Roberts 2007 for a review of over-fishing) the high demand for premium fishes in Hong Kong in recent years has fuelled demand and led to severe over-fishing. During preparations for field studies in Bali it was observed that there are virtually no high value food fish left on the reef at Les village, as they have been so heavily over-fished that even with a cessation of fishing, recovery of stocks has not taken place. Ecosystem over-fishing may result in phase shifts in fisheries, which might not be recoverable such as the collapse of the cod fishery off Newfoundland. Here the fishery appears to have undergone a permanent shift where even after a cessation of cod fishing, recovery still has not occurred.

Over-fishing by the food fish industry has clear potential to cause major problems for the ornamental industry. Even if the same stocks are not targeted by both fishers, the likelihood of over-fishing leading to ecosystem change can have a major impact on the ornamental fish trade.

Trying to separate fact from fiction on this issue for the ornamental trade is difficult as there is very little in the way of verified or verifiable information. Below are two examples from the ornamental trade, which have at least been verified by two or more sources, or by field observation.

The zebra plec L046 (*Hypancistrus zebra*) was heavily over-fished on the Rio Xingu largely due to collecting by unlicensed fishers to the extent that its collection and export was banned by the Brazilian government. This ban has not secured its future in the wild as its restricted habitat is right in the middle of the Belo Monte dam development and it seems certain that the habitat will undergo major changes. This may not allow the zebra plec and other highly specialised loricariids to persist in the area

Pseudotropheus saulosi, an *mbuna* species from Lake Malawi, has been over-fished to the point at which populations were severely depleted. However, a restocking programme run by one of the exporters, Stuart M Grant Ltd and funded through the Stuart M Grant Cichlid Conservation Fund, appears to be successful; according to recent surveys numbers of *P. saulosi* are no longer declining and may even be starting to increase again. The reversal in fortunes of *P. saulosi* may also have been helped by aquarists opting to not buy wild caught fishes while the species is endangered in the wild (Konings 2015).

Habitat loss

The effect of habitat loss or habitat degradation affects different species in different ways. Some may even benefit from a change that leads to a higher nutrient status or results in the reduction of populations of competitors or predators. However, some species are so highly adapted, that they are unable to tolerate any significant habitat degradation nor are they able to adapt to a new habitat. For such species, loss or degradation of habitat tends to lead to local extinction or even global extinction. The IUCN Red List for fish contains a number of examples of fish that have become lost due to loss of habitat. Some examples of habitat loss that can affect the ornamental trade are given below:

Palm swamp – this occurs in South East Asia, notably in Malaysia and large areas have been cleared to make way for oil palm plantations. While the more charismatic fauna such as orang-utans tend to be the focus of concern about the loss of native forest, there is a largely unexplored fish fauna that is highly endangered as a result of habitat loss. Palm swamp is a hostile environment and that may be why the fishes were originally overlooked as it might have been assumed that very few fish could live there. However, recent studies have shown that a highly specialised and localised fish assemblage does exist in such areas. Although the fish are of rather limited interest to the trade due to the challenges of keeping and breeding them (specialist aquarists realise that the fishes need specific water conditions, the average aquarist may not) there is a hard-core group of aquarists that specialises in keeping them (see for example [The Parosphromenus Project](#)). Not only does the conversion to oil palm plantation lead to the loss of habitat, but the activity is also thought to be responsible for the release of stored carbon, which can contribute to global warming. As Kottelat and Whitten (1996) noted, palm swamp does not recover and so its loss is permanent, as will the loss of the associated ichthyofauna. It may therefore be the case that many of these fishes will only occur in the aquarium in the future. Additional hazards to the fish fauna come from the use of pesticides and fertilisers that pollute and enrich waters to the detriment of sensitive species.

Timber harvesting – timber harvesting can have low impact where selective felling is carried out but too often trees are felled indiscriminately or are clear felled. This can have major impact on the fish fauna, sometimes linked to problems due to climate change. Removing tree cover from forest streams and pools can result in a significant rise in water temperature and many fishes are unable to tolerate this. Overhanging vegetation can also be a significant source of food in the form of seeds, nuts and insects that fall in the water; their removal may remove an important source of food for the fish. Depending on the soil type, removal of a significant amount of trees can lead to a major increase in run-off bringing sediments into the water. This can kill macrophytes, block spawning gravels, and choke the gills of sensitive fishes. Although other factors are involved, loss of forest cover is one of the factors contributing to *Hyphessobrycon flammeus* being classed as endangered by Brazilian authorities (Carvalho et al. 2014); populations are now so reduced in size and location that it is considered that harvesting for the ornamental trade may represent a threat to the continued existence of the species.

Clear felling of timber may be followed by a number of agricultural activities such as plantation crops, soybean growing or cattle grazing. Each of these can have a range of impacts on aquatic habitats and thus on the ornamental trade.

Plantation crops – depending on the crop (e.g. timber vs fruit) there will be varying disturbance of the soils which will result in changes to soil and water chemistry, drainage patterns and sediments run-off. Tree crops may be treated with aerial applications of pesticides and fertilisers, which can cause damage or modification to aquatic ecosystems. Plantations for food crops are likely to result in application of more pesticides and more frequent applications thus raising the risk. Depending on the crops and the crop cycle time, there may also be times when there are extensive areas of bare soil, which will be very susceptible to erosion by rain leading to periodically increased run-off.

Short-term crops – short-term crops such as soybean that may only be in the ground for a few months present different threats to the aquatic habitat. The relatively large amount of bare soil will make it vulnerable to erosion and run-off, which will increase sediment and nutrient inputs to what are often low nutrient environments resulting in eutrophication. This in turn can result in an increase in algal or macrophyte growth. Crops such as maize are particularly problematic for soil erosion due to the large area of bare soils between plant rows.

Fruit trees – although there is a trend towards integrated pest management and the use of biological controls, fruit growing tends to require regular and repeat applications of pesticides and on larger scale farms this may be done by aerial spraying which often leads to spray drift reaching nearby water bodies. Even if the pesticide is not highly toxic to fish, it may still lead to loss of aquatic and terrestrial invertebrates on which fishes rely for food.

Deforestation – Bojsen and Barriga (2002) noted that there was little information on the impact of deforestation on Neotropical streams. They studied streams in the Rio Napo catchment in Ecuador where either clear felling or partial felling had taken place. They found that while biodiversity was not necessarily affected, there was a shift in the population structure with species, which depended on tree cover (for food falling in such as insects and for tree leaves as habitat on the stream bed) tending to decrease. However, fishes that benefited from the more open habitat, such as algae-feeding loricariids, and those that depended on in-stream invertebrates, increased. There was also a shift towards fish with smaller body size and higher reproductive rate in the deforested stream stretches. While these changes may be undesirable from an ecological point of view, they may not necessarily have a negative impact on the ornamental fish trade.

Tourism

There is often competition for or conflict over resources between the ornamental aquarium trade and the tourism industry but it is difficult to identify real issues as opposition to the ornamental trade, especially on reefs, is often motivated by objections to the collection of animals from the wild and/or the keeping of animals in captivity rather than concerns over conservation or preserving the resources for tourism. This is best exemplified in Hawai'i where there has been a long campaign against the collection of ornamental reef organisms on the grounds that populations of some species had been depleted with consequent impacts on recreational diving. Independent monitoring of the fish populations and the various inshore fisheries around Hawai'i (DLNR 2014) indicated that the presence of Fish Replenishment Areas and Marine Protected Areas had been enough to maintain populations of fishes harvested for the aquarium trade. This was further put into perspective as the report also found that greater biomass was removed by the recreational and commercial food fisheries.

In other countries, potential conflict between the aquarium trade and tourism can be resolved by negotiation. For example, conflict between the ornamental aquarium collectors and operators of dive boats near Les village in Bali was resolved by dive boats operating in or around Marine Protected Areas and the ornamental fish collectors operating elsewhere, such as on the areas of reef they had restored.

The trade in freshwater stingrays from South America provides a case where tourism has an indirect effect. The trade in stingrays for the ornamental trade from Brazil is regulated tightly with some species being banned from export and others being subject to strict quotas. By contrast, tourist

resorts often kill freshwater stingrays to eliminate them from surrounding areas to reduce the risk of tourists being stung. This is unregulated and was reported to be responsible for the killing of about 21,000 freshwater stingrays (Araújo et al. 2004). The export of stingrays on the other hand was reported by the same authors to be subject to a quota of 15,500. The export numbers for stingrays can be taken as being accurate as all shipments from Brazil are subject to 100% inspection but it is quite possible that the number killed to protect tourists is higher than the authors quoted.

Wider concerns are summarised by [UNEP](#) which lists the main direct and indirect impacts of tourism in the Caribbean on coral reefs. Tourism can cause damage to the reef by direct interaction between tourists and the reef environment (see also Annex K, Tourism Development) and by the infrastructure associated with tourism developments. During the field visit to Bali, LINI (pers. com.) pointed out that some tourist hotels discharge untreated sewage directly onto the reef. UNEP report this as source of concern. In addition to the damage caused by tourist boats listed by UNEP, major damage can also be caused by the grounding of cruise ships (see also Annex K, Shipping). UNEP summarise the key areas for concern, these are listed below in Tables I1 and I2.

Hilmi et al. (2012) provided similar evidence for the impact of tourism on reef environments in Egypt. Direct impacts reported included trampling and coral breakage by SCUBA divers and snorkelers, and damage due to anchoring and boat grounding. They noted that direct damage was most closely related to areas of high usage. They also reported that the transport and laying of sand to create artificial beaches had led to an increase in sedimentation and a reduction in water clarity with adverse impacts on reefs. They assessed the economic impact of the cumulative damage to coral reefs and fisheries due to increased tourism as between USD 2.626 billion to 2.673 billion million per year, compared to the value of tourism in Egypt which was estimated at USD 10.8 billion annually (no separate figure is given for Red Sea tourism). It should be noted that degradation of the reef habitat in the Red Sea resorts would devalue them as tourist attractions.

Table I.1: The direct impacts of tourism on coral reefs. Table adapted from [UNEP](#) with additional comments by IW.

Activity	Actual and/or potential impacts	IW comments
Snorkelling	Physical damage (breakage, lesions) Kicking up sediment	
SCUBA diving	Physical damage (breakage, lesions)	SCUBA diving also kicks up sediments
Motor boating and yachting	Physical damage from anchoring Physical damage from boat groundings	Fuel spillage is also a problem. A fuel slick can be observed in many boat moorings and it is even possible to smell spilled fuel when many boats are moored
Fishing	Contribute to over-exploitation of reef fish stocks Compete with local fishers	Fishing also tends to concentrate on top predators, leading to ecological imbalance
Collecting (shells, lobsters, conch, coral)	Threatening local survival of rare species Contributing to over-exploitation and competing with local fishers	Even where their collection is not permitted, it is common to see such items for sale at and near tourist resorts.

Table I.2: The indirect impacts of tourism on coral reefs. Table adapted from [UNEP](#) with additional comments by IW.

Activity	Actual and/or potential impacts	IW comments
Resort development and construction	Increased sedimentation	This can be worse where trees are cleared to make way for tourist developments
Resort operation Sewage disposal Fertilizer runoff Irrigation	Nutrient enrichment	Some corals are intolerant of high nutrient levels but the most common effect is algal overgrowth. It is also thought that high nutrient levels are associated with crown of thorns starfish outbreaks
Solid waste disposal	Leaching of toxic substances from inappropriate waste disposal	
Seafood consumption	Over-exploitation of high-priced resource species (snapper, grouper, spiny lobster, conch)	
Demand for marine curiosities	Exploitation of rare/ endangered/ vulnerable species such as shells, black coral, turtles	Even where their collection is not permitted, it is common to see such items for sale at and near tourist resorts. While CITES should prevent the trade in many curios, they can often be seen for sale to tourists.
Construction of artificial beaches and beach replenishment	Increased sedimentation (from sand removal or from beach instability)	
Airport construction or extension	Increased sedimentation from dredging and infilling	There may also be removal of coral for a building material or as hardcore
Marina construction	Increased sedimentation from dredging	
Marina operation	Pollution from inappropriate disposal of oils and paint residues Pollution from fuelling	
Motor boating and yachting	Nutrient enrichment from sewage disposal Pollution from fuelling	
Cruise ships	Nutrient enrichment from illegal sewage disposal Litter from illegal or accidental solid waste disposal	Serious damage can also result from grounding. Dredging or reef removal may also take place to provide access for cruise ships

Obviously, such impacts will have a generally degrading effect on coral reefs with likely impact on the ability of the reefs to support the wide range of organisms collected for the aquarium industry. While the studies did not take the aquarium trade into account, it is highly likely that intense and/or poorly regulated tourism development will threaten the livelihoods of collectors in such areas.

Competition for water

Irrigation in many forms is used in agriculture around the world and can have significant impacts on the environment. At the extreme end would be the Aral Sea, which, by 2007, had shrunk to 10% of its original size due to abstraction for irrigation, notably for the Soviet cotton industry. There are

numerous examples of abstraction for irrigation leading to severe environmental degradation, although the impact of this on the ornamental fish trade is not reported. However, as such schemes tend to have a major impact on food fish populations, either through direct impact from loss of water or indirectly through structures to enable irrigation (e.g. dams), it is very likely that there will be impacts on ornamental fish populations.

Abstraction can also lower the water table, leading to some water bodies drying up. Again, the impact of this on the ornamental fish trade is not reported. Conversely, where the irrigation water is delivered, the water table can be raised. This is often associated with salination of soils and surface waters, which can make them unusable for agriculture so that too may impact on ornamental fish populations. In extreme cases, this may result in fields being converted into saline ponds for aquaculture, however, while the wider environmental impact of this is reported, the impact on ornamental fish populations is not known.

Dams

While the impact of dams on rivers has been researched, generally the sampling methods used mean that the small fishes of interest to the ornamental fish trade are often not sampled and so the impact of dams can be hard to assess. As may be expected, the major impact is a change from a riverine environment to a lacustrine one with consequent effects on the fish populations; typically with a loss or reduction of benthic rheophilic species, which are replaced by those that prefer an open water habitat. Perhaps the most noteworthy dam development is the Belo Monte scheme on the Rio Xingu in Brazil, the world's third largest hydroelectric scheme. There has been an ornamental fishery on the Xingu for decades and this grew rapidly with the discovery of some eye-catching loricariid species, such as the zebra plec (*Hypancistrus zebra*), which fetch premium prices. The fishery is a risky one for the collectors due to the depth at which the fish are found (often >10m) and the fast currents in the river. However, it did attract a considerable number of collectors. The fishery became depleted and a ban on collection of the zebra plec was imposed in order to conserve it. However, as with most of the fishes found in these fast-flowing habitats, they appear to be highly stenotopic and are not likely to tolerate the flow changes, which will take place once the dam is completed. The current Belo Monte construction includes the entire main habitat of the zebra plec. An interview with Greg Prang provides an update on the Belo Monte scheme:

Interview with Greg Prang carried out by Skype 23rd September 2014

Background note: Greg Prang is a social anthropologist who has worked on the ornamental fish trade in Brazil (Project Piaba and the ZSL Darwin Mamiraua project). He now works for the [Hartman Group](#).

The market for ornamentals in the US has changed in recent years with a tendency to be dominated by aquaria as interior decoration and with most purchases being made from chain stores. Studies on sustainability issues generally indicate that the concerned population is a small percentage of the total and that most consumers are not aware of the issues around sustainability for most products.

With the closure of Asher Benzaken's Turkey's Aquarium, trade from the Rio Negro has decreased substantially. The exports from the Mamiraua are also limited and mainly of high value fish, such as discus. What this means for the trade in the long-term is unclear.

Greg carried out some work on mitigation measures for the Belo Monte dam hydroelectric scheme on the Rio Xingu. This was intended to both provide ex-situ conservation for the L-number loricariids that dominated trade from the Xingu and to compensate the collectors by providing them with an export business based on farmed fish. A lack of expertise in breeding the fish is just one of the factors which deterred the collectors from taking part in the scheme. This initiative appears to have stalled (a number of sources have indicated this) and attempts to rescue fish also appear to have failed due to the use of inexperienced people to catch the fish rather than relying on experienced collectors. The fishery was not being managed responsibly with a number of "get rich

quick” firms moving in to exploit the high prices for some L-number plecos with little regard for sustainability so the fishery was already over-fished and subject to restrictive measures. However, the ability to enforce restrictions on the fishery seems to have been very limited as fish from the Xingu still appear in the trade.

Comments by IW. A number of sources have indicated that the ornamental fishery on the Xingu will be badly affected by the dams, as will the fishery on the Tapajos. The fish do seem to be very habitat specific and, while some such as the valuable L-046 zebra plec (*Hypancistrus zebra*) breed readily enough in the hands of experienced aquarists, they seem far more sensitive in the wild and attempts by the collectors to relocate several hundred fishes to a site upstream of the dam site appear to have failed. Banning exports of the zebra plec may fail if the fish cannot be relocated and Brazil may face the situation where the fish is present in the trade but the benefits are all gained by breeders in the Far East, EU and US. The ability of Brazil to enforce its positive list for exports seems to have limited impact as fish which are not on the list frequently appear in trade, either as novel discoveries or fish whose export is banned. It also appears to be contradictory to ban certain species from trade and then destroy the very limited habitat on which they rely. It is quite possible that some fishes from Brazil might be conserved in the future only by being in trade and existing mainly outside of Brazil.

The dam is not nearing completion and the divers are being relocated away from the river making it impractical for them to carry on their business (Prof Leandro de Sousa, Univ. of Pará, pers. comm. presentation and interview 21-22/03/15). The collectors claim that 2,000 of them will lose their livelihoods as a result of the dam but this number is probably exaggerated and most were not full time. It is therefore difficult to assess the true impact on livelihoods and the local economy. IBAMA did not carry out controls directly on the fishery, instead conducting occasional inspections of holding facilities and inspecting all shipments by air to try to regulate the trade. The collectors did release several hundred zebra plecs at a location upstream from the dam site but there is no evidence that they were successful in establishing a population. Despite the ban on collecting, zebra plecs are currently selling for BRL 20-50 (USD 6-15) each to local buyers (a very high price). There will be no compensating habitat to allow for the habitat affected by the dam, although to what extent a new channel connecting the river above the Pimental Dam to the intermediate reservoir for the Belo Monte Dam will provide suitable habitat is unknown as no design features have been allowed that would be similar to the current channel habitat. The current channel will be reduced to the average minimum flow at most and even this may fall during the low water season. In addition, pollution is now being noted from a new mining operation in that area which is leading to sediment and mercury entering the river.

De Sousa also presented information on attempts to establish ex-situ breeding facilities near the dam. The original concept was that the facilities would provide an opportunity for collectors to breed fish and thus make a new livelihood for themselves but, as fishermen are not farmers by nature and had not experience of this sort of business, none of them was willing to participate. The collectors are now facing a very uncertain future as, once the Pimental Dam is closed on 15th September 2015, the river below the dam will fall, the current speed will drop and it seems very likely that at least some of the key species that support the ornamental fishery will disappear. The first breeding facility faced a number of problems relating to the lack of environmental controls and the lack of experienced staff in caring for and breeding the zebra plec, resulting in very few spawnings and only a handful of fry being produced. In the end, Prof de Sousa persuaded the authorities to bring in a professional ornamental fish breeder from Indonesia, Rajenta Sinhardja Rahardja from [Bellenz Fish Farm](#) with extensive experience of breeding zebra plecs to advise on the operation. On his advice, a new breeding facility is being constructed on the University of Pará campus, which should prove to be more suited to the purpose. However, there is still no long-term plan for the conservation in-situ of any of the Rio Xingu species that will be affected by the dam closure.

Eutrophication

Eutrophication is very common and is caused by raised levels of nutrients in water, most typically nitrogen and phosphorus, but sometimes also iron (especially for marine environments), which tend to cause a phase shift in ecosystems from one where macrophytes dominate (although in nutrient poor waters, even macrophytes may be very scarce) to one dominated by algae. Where phytoplankton blooms are fed by excess nutrients, the system can become unstable with bloom and crash becoming a repeated pattern. With each crash of an algal bloom, there are associated problems such as deoxygenation, which can lead to widespread fish kills. Eutrophication can be very difficult to reverse, as some nutrients, such as phosphorus, tend to have long resident time and will cycle between sediments and the water column for many years after nutrient inputs are reduced. A classic example of this is Lake Naivasha in Kenya where common carp (*Cyprinus carpio*), and the red swamp crayfish (*Procambarus clarkii*), which were introduced to improve fishery production, and the large mouth black bass (*Micropterus salmoides*) was introduced for sport fishing. This has led to the original, complex food web in the Lake being replaced by a simplified food web dominated by carp and with macrophytes being replaced by algal growth (Dr Jon Grey, QMUL, presentation, 01/01/12) resulting in a rather unstable ecology maintained by the rapid phosphorus cycling caused by the feeding activities of carp. Very few of the native fishes of the Lake remain.

The impact in freshwater and marine waters will be different. Even in lakes as large as Lake Victoria, the impacts of eutrophication have been evident for some years. Eutrophication linked to the increased use of fertilisers in agriculture, and increased run-off due to tree felling, has led to an increase in nutrient inputs to the Lake accompanied by increased flows of sediments (see for example Goldschmidt 1996, Seehausen 1996). Increasing algal blooms and the associated reduced visibility in the Lake are thought to have contributed to the reduction in biomass and the number of species of haplochromine that rely on clear water to be able to identify males and females that are conspecific. A combination of urban development and intensification of farming can lead to widespread eutrophication of waters leading to major disturbance to ecosystems, and resulting in species loss. This is thought to be one of the factors leading to the loss of the white cloud mountain minnow (*Tanichthys albonubes*) from much of its original range in Southern China (Chan and Chen 2009). The large inputs of partly treated or untreated sewage into waters is a major contribution to eutrophication in many developing countries.

Eutrophication of marine waters need not cause phytoplankton blooms to result in ecosystem disturbance. Even inputs of sediments from sewage effluents can be enough to smother corals and lead to their death. The major impact is from elevated nutrient levels, which lead to excessive growth of algae in reefs. Microscopic algae can grow over the corals smothering them and macroalgae can both smother and out compete corals for space on the reef. If this is in conjunction with a reduction in the population of herbivorous fish, uncontrolled algal growth can take over a reef (see for example review by Fenner 2012). Changes that have taken place on coral reefs have complex causes and are not usually down to a single cause. Eutrophication may lead to loss of live coral on reefs and hence to a reduction on reef-dependent species on which the ornamental trade relies. The subject is reviewed by Fabricius (2005) who reported that, while it is sometimes difficult to separate out the impacts of nutrient and sediment inputs on coral reefs, increased nutrient inputs have been shown to cause significant damage to, and mortality of, corals. Eutrophication has also been associated with increased numbers of crown of thorns starfish, which have caused substantial damage to coral reefs in a number of areas.

Pollution

The effects of pollution vary according to the type of water affected. For example, many heavy metals are more toxic in acidic waters than in alkaline waters. Pollution may be acute, causing mass mortality or it may be chronic, but at sub-lethal levels the effects may be quite subtle and difficult to detect. While some pollutants lead an evidence trail that persists and is easy to trace after the event (e.g. mercury), others can be very difficult to detect due to short persistence in the environment and

short-lived metabolites in the organisms affected by the compound (e.g. pyrethroid pesticides). The potential impact of some pollutants on the ornamental trade is given below.

Heavy metals

The impact of gold mining is well documented, however attention is often on the impact this has on food fishes, mainly due to associated mercury pollution from the gold extraction process. However, the combination of very high sediment loads from mining of the gold-bearing soils and the pollution from mercury can have a significant impact on ornamental fish populations. In Peru, the area around Puerto Maldonado in Madre de Dios province has been severely impacted by a combination of illegal logging, illegal gold mining and oil exploration. It has become a race against time to discover what fishes are there before their habitat is destroyed and they are wiped out (Brian Perkins, WildPeru, presentation for Catfish Study Group March 2014). Lopez-Fernandez et al. (2012) commented that the upper reaches of the Mazaruni River in Guyana are now severely polluted by gold mining with affected rivers carrying a heavy sediment load (as opposed to unaffected rivers which still ran clear, although stained black as they are blackwater rivers) and with large deposits of mine tailings dumped on the banks. Although the Mazaruni is not a major ornamental fish collecting area, gold mining occurs in several areas in Guyana and so is likely to affect the ability of ornamental fish collectors to make a living. Heavy metal pollution may have a greater impact on acid, blackwater rivers, due to very low levels of calcium and very low pH, a combination that can increase the toxicity of heavy metals significantly.

Pesticides

Although the use of pesticides has declined in terms of tonnage, and modern pesticides are less toxic to humans than previous formulations, they can still be highly toxic to aquatic organisms. Even though they may not kill fish, the target organisms are usually invertebrates and so they are often lethal to aquatic invertebrates; one of the main food sources for fish. Pesticides can reach watercourses through careless use or through the discarding of unused mix or even the discarding of empty containers; the residual pesticide in containers can contain enough active ingredient to cause major damage. Even in the UK where pesticide use is heavily regulated, DEFRA still reports a number of serious pesticide pollution incidents each year affecting watercourses. In countries where pesticide use is poorly regulated and the use of even unlicensed pesticides is widespread, there are many more opportunities for pollution of watercourses. Research carried out by the Natural Resources Institute (including research by IW) showed that aerial spraying of pesticides along rivers caused significant ecological damage to non-target organisms. A good example of this is the control of quelea birds (a major crop pest in part of Africa) with aerial spraying of endosulfan a pesticide with high toxicity to fish and aquatic invertebrates. Endosulfan has now largely been replaced with fenthion, however this too is highly toxic to fish and aquatic invertebrates. Aerial spraying is also carried out for tsetse fly control and this can affect watercourses and fish. Useful reviews of the impact of spraying are SEMG (1997), and Bonyongo and Mazvimavi (2007). These indicated that aerial spraying for tsetse control, using deltamethrin and endosulfan, were variable, and impacts on fish and non-target aquatic invertebrates differed between locations and for different species. Some acute toxicity to fish was noted but more often there was a reduced fish population, which tended to recover, depending on the frequency of repeat spraying. In addition to acute toxicity, many pesticides have the potential for causing ecological damage through long-term non-lethal impacts such as endocrine disruption, vertical transmission through eggs leading to reduced fry viability and behavioural abnormalities. Such results are likely to be repeated in fish populations, which the ornamental industry relies on but there seems to be no specific information on this. Conventional crops such as rice also have some potential for causing damage to fish populations although as intensive agriculture is not likely to occur in areas used for catching wild ornamental fishes, the scope for impact may be limited.

Run-off and sediments

Run-off has increased in many areas in recent decades due to changes in agricultural practice, which have led to increased soil erosion and removal of tree cover, which has also led to soil erosion. At its most dramatic, this results in major landslides, however more often the result is less dramatic but none the less lethal to many aquatic organisms. Direct effects due to sediments coating organisms and smothering them are only part of the problem as sediments often bring nutrients with them, which can lead to eutrophication.

Fish may be affected by sediments suspended in water, which can lead to gill irritation and gill damage that can cause the loss of sensitive species. Knock on effects can be on spawning as sediments may coat eggs, thus reducing oxygen uptake and leading to a loss of egg viability or even egg death. Sediments can also choke spawning gravels either smothering the eggs laid on gravel or, where eggs are laid into the gravel causing egg death by reducing water flow through the gravel, which results in low oxygen and possibly high ammonia in the interstitial water surrounding the eggs and thus to higher egg mortality (see for example Smith 2003, Hubner et al. 2009).

Many corals are intolerant of sediments and will die if exposed to repeated or large inputs of sediments (see Cortes and Risk 1985, Kramer et al. 2012). Much of this can be traced to deforestation, which has led to increased soil erosion. The impact can be worse for corals that are already under stress from other factors, such as ocean warming or eutrophication. However, it is clear that increasing levels of sediments can have a significant impact on corals and coral reefs and that such impacts are occurring very widely due to anthropogenic pressures (Fabricius 2005).

Climate change

Climate change can be broken down into several components such as warming or changes in rainfall patterns, however these effects are often interlinked; for example warming leads to higher sea surface temperatures, which in turn can lead to higher rainfall. The causes of global warming may also have impacts beyond climate change, for example higher levels of carbon dioxide have led to ocean acidification. For this reason, it would be unwise to pin changes and impacts on a single factor as any single influence may result in multiple impacts.

Ocean warming

The greatest concern over ocean warming has been coral bleaching, which was first observed as long ago as 1979 and, while there are several causes, high ocean surface temperature is one of the most important. Mass coral bleaching events have been observed frequently since then, sometimes affecting hundreds or even thousands of square kilometres, with coral loss of up to 90%. Coral bleaching is not down to direct death of the coral polyps, rather it affects the zooxanthellae (the symbiotic algae on which corals rely for some key nutrients) and it is their loss that leads to bleaching and consequent death of polyps. Different species of corals vary in their susceptibility to ocean warming and in their ability to recover (see review by Bellwood et al. 2006). This can affect reef recovery as what regrows may not be the same as that before bleaching occurred. In addition, even before the coral can regrow, algae may smother the reef (both micro- and macroalgae may do this), which will inhibit coral settlement and recolonisation. This may result in a phase shift in which the whole coral reef ecosystem changes. This will in turn lead to changes in the fish and invertebrate fauna, especially of reef-dependent species. There is a real possibility that degradation of the reefs may mean they are unable to support harvesting for the ornamental trade and it may become uneconomic or collection may be banned as it could no longer be sustainable.

There is also now some evidence that marine species are shifting their distributions in response to ocean warming, although evidence is still inconclusive regarding how far many species will respond in this way or the impact the expansion of range will have on ecosystems when the recent colonisers become established. At its most extreme it may even allow species to migrate from one ocean to another. There is already some evidence of gene migration around the Arctic Circle due to the loss of sea ice permitting animals to migrate from the Russian Arctic or even from the North Pacific into

the North Atlantic and North Sea (Michael Hardman Univ. of Helsinki pers. comm., Interview Catfish Study Convention Mar 2013).

The overall outlook for coral reefs is poor as the various stressors to which they are now subject, make the risk of repeated and possibly permanent coral loss much more likely. These compound stressors were reviewed in Burke et al. (2011) where the authors point out that the ability of coral reefs to withstand coral bleaching events caused by global warming is much reduced by other factors, notably nutrient enrichment, ocean acidification and sediments. The authors suggest that by 2030, coral reefs may be much more affected by coral bleaching and that a much wider area of coral reefs will be affected, leading to significant coral reef loss. They predict that by 2060, the combined effects of stressors will have a very significant impact on coral reefs and their ability to sustain biodiversity and thus livelihoods. While the authors do identify the aquarium industry as a source of coral reef loss, it is not highlighted as a significant cause.

The impact of ocean warming on terrestrial ecosystems is far harder to predict, mainly because the impact is so dependent on geography, geology and global wind patterns. The impact may also be far from obvious and take place at some distance from the ocean, as seen in the Pacaya-Samiria National Reserve, Peru. The Atlantic has generally been exhibiting warmer sea surface temperatures in recent years. Winds travel over the Atlantic from Africa to South America and as they pass over the ocean, the air picks up moisture. In general, the warmer the sea surface, the more moisture will be picked up. The winds travel westwards across the Amazon Basin, but do not provide significant rain until they meet the Andes and the air rises upwards and cools. This results in very high rainfall on the eastern slopes of the Andes that is the primary driver of the annual floods that affect the Amazon Basin. In 2011, 2012 and 2013 the floodwaters in the Pacaya-Samiria Reserve were higher than usual. During most years, many mammals retreat to “high” ground (the term is relative as the ground is only about 1m higher than the surrounding land), levees which are slightly higher than the forest floor. However, in those high flood years, the levees were inundated and many game animals have disappeared subsequently; presumed to have migrated permanently to drier areas or to have drowned (Bodmer et al. 2014). The impact of this on fishes has not yet been reported and it may even be positive, as more flood habitat will be available. Higher rainfall may have some impact of small stream fishes, especially in the Amazon headwaters by increasing peak flow rates and/or extending flood periods, however the potential impact of this is currently not known.

Sea level rise

Sea level rise may have significant impacts on marine and terrestrial environments but it is difficult to predict how this will affect the ornamental fish industry. Corals may react adversely to an increase in sea level as many inshore corals have narrow limits within which they can thrive. Any rise in sea level may therefore take corals out of their optimum depth range and, if they are unable to adapt, may lead to their loss. Onshore, the areas most likely to be affected are low-lying coastal zones, such as mangrove swamps. Loss of mangrove swamp has already been shown to adversely affect fish and crustacean populations, as mangroves are a key nursery habitat for many species. Rising sea levels in estuary areas could lead to deeper and/or longer inundation due to “backing up” of river waters by the sea. Sea level rise is already affecting some remote oceanic islands that are in danger of inundation. Tuvalu has been experiencing problems for some years, with intrusion of saline waters being a particular problem (IW pers. obs. 2006). However, the wider implications of the actual loss of an island on the surrounding reef are not known.

Ocean acidification

The term “acidification” is a little misleading as the oceans are becoming slightly less alkaline, not becoming acidic. While the change in pH is small, only 0.1 (IPCC 2014), this represents a 26% increase in acidity as the pH scale is logarithmic. This small shift is sufficient to change the carbonate/bicarbonate balance in the oceans in favour of bicarbonate. As many marine organisms and coral in particular rely on calcium carbonate (in the form of aragonite) as a key part of their

structure (shells, hard coral skeletons, etc.), this shift can have a major impact in marine environments. By decreasing the saturation level of calcium carbonate, acidification therefore makes it more difficult for organisms to extract it from seawater with resulting increased metabolic costs. There is some evidence that this is already resulting in molluscs with thinner shells, which may make them more vulnerable to predation. This has been the subject of a review by The Royal Society (2005). A review by Burke et al. (2011) was generally very pessimistic about the future for coral reefs and pointed to ocean warming and ocean acidification being key factors. They suggest that by 2030 thermal stress will affect half of reefs globally rising to 95% by 2050 and ocean acidification will affect reefs in a similar manner with half the reefs being in areas with optimum aragonite solubility, declining to 15% by 2050. It has been suggested that organisms will respond to global warming by migrating away from the Equator. However, this is a doubtful option for coral reefs as many occur in shallow seas and there are huge areas of open ocean that reef organisms may not be able to cross. Burke et al. (2011) indicate that the options will be much reduced by ocean acidification. Rising levels of atmospheric CO₂ resulting in reduced pH in the oceans will reduce levels of aragonite mostly in areas away from shallow, tropical seas, which suggests that areas away from the tropics may become less suitable as habitat for reef-building corals.

Rainfall changes

As discussed, climate change can affect rainfall patterns. While the annual flood pattern in the Amazon Basin may be changed by increased rainfall on the Andes, a possible reduction in rainfall in the Amazon forest area might result in a change to a less dense and more drought-resistant forest flora. The potential impact of this on the ornamental fish collectors of the Amazon Basin is not known, however it may be expected that a radical change in the forests and in rainfall could combine to create a major change in the ecosystem. It may also have a major impact on some of the southern tributaries of the Amazon, such as the Tapajos and Xingu, which have year round high flows under the current rainfall regime. Changes in the fish fauna due to dams on rivers suggest that a reduction in flow may also lead to significant changes in the fish fauna. Sub-Saharan Africa is expected to experience longer and more severe droughts as a result of climate change. While most of Africa has relatively little ornamental trade, increase in droughts may still impact some key environments such as the Rift Valley lakes. For a wider review see Field et al. (2014) and IPCC (2014).

Over-fishing and destructive fishing

There is no doubt that the ornamental fish trade has been responsible for some over-fishing and the use of some destructive fishing methods. This was reported following a recent field visit to Bali and the trip to Les village where damage to corals caused by persistent use of cyanide can still be seen (IW pers. obs.). However, it was also clear that even at Les, there were other factors at play.

Blast fishing

Blast fishing involves throwing a container (usually a bottle or jar) with an explosive with a lit fuse into the water. This is used in freshwaters (such as in Ecuador, IW pers. obs.) but it is most notorious for the damage it causes to coral reefs. This can be seen in [Hugh's Fish Fight](#) where the technique and the effect of its long-term use can be observed. Blast fishing kills fish and so is not used for harvesting fish for the ornamental trade. It causes extensive damage to reefs and in the more extreme cases, the reef is reduced to rubble and coral sand. The combination of total fish killed and the destruction of the reef causes major ecosystem disruption meaning that fish biomass and biodiversity are so reduced that there is nothing for the ornamental trade to harvest. Mous et al. (2000) pointed out that blast fishing causes very high levels of damage to coral reefs equivalent to a loss of about 3.75 m² per 100m² per year, which far exceeds the capacity of the reef to regenerate. This will inevitably lead to the destruction of the reef with little chance of recovery.

Cyanide fishing

Cyanide fishing is used by the ornamental and live food fish industries, the latter being a more recent development. The market for live food fish as a luxury item has boomed in recent years resulting in the removal of a very high biomass of top predators from coral reef fisheries. This alone has caused extensive ecosystem disruption but, combined with the use of cyanide, direct damage is caused to the reef. The ornamental industry has used cyanide for some years since collectors in the Philippines found it to be a cheap and easy method for temporarily disabling fish, thus making them easier to catch. It was often used in combination with breaker bars to break corals and extract the intoxicated fish. Cyanide kills corals by killing the zooxanthellae on which they rely, leading to coral bleaching and ultimately death. Other reef organisms are also affected so the ecosystem damage can be widespread. Reefs can recover from cyanide fishing as shown on the reefs at Les village where cyanide fishing was halted voluntarily by both ornamental and live food fishers. The use of cyanide is very unpopular with the ornamental trade, as fish often die some days or weeks after intoxication, even if they appear to have recovered. This can result in significant losses to a buyer as they have already parted with money for the fish and it is not usually recoverable. The effect of cyanide on reef fishes and on coral reefs has been reviewed extensively by Thornhill (2012). It has been suggested that the ornamental fish trade causes more direct damage to reefs than the food fish trade as cyanide damage is caused per fish caught and the catching of fewer, larger fish for the live food trade may have less impact than the removal of many more, smaller fish for the ornamental trade. However, in terms of biomass removal, the live food fish is likely to be many times larger than the ornamental trade. No matter when or how cyanide is used, it represents a real threat to the ornamental fish industry due to the damage it causes to coral reefs. As well as causing extensive ecosystem disruption and reduction of biomass and diversity of reef organisms for the ornamental trade, it also provides those opposed to the trade with a convincing argument to ban the trade altogether.

The use of cyanide is widespread in Indonesia and is reported to cause damage to reefs, often made worse by associated activities such as coral breaking. As reported by EC-PREP (2005) *“with little technical knowledge regarding proper capture techniques, many collectors resort to the use of destructive practices. The best known is the use of poisonous substances, especially cyanide. These substances not only result in high mortality of target fish, but also kill many non-target organisms, fish and invertebrates, including coral. Collecting often involves both accidental (e.g. trampling) and purposeful (with tools such as oars or crowbars and by hand) damage to the framework of the substrate, especially breakage of corals.”* However, this was not the only illegal fishing activity noted, nor was it the only cause of damage to coral as they also noted serious damage from other activities such as blast fishing, coral mining and anchoring damage. The authors also noted that damage from the harvesting of ornamental fish varied considerably from one area to another and that in some areas surveyed, damage was minor.

Looking at the ornamental fish trade in Banyuwangi (East Java), the authors noted damage due to cyanide use and tried to put this in context:

“Destructive fishing activities such as coral mining, harvesting corals and other coral reef organisms, cyanide and bomb fishing for food fish. The main type of destructive fishing is cyanide fishing. Imagine if 100 fishers work everyday, each using at least 3 lumps of cyanide (weighing roughly 20g) per dive, then a total average of 20 kg of cyanide will be sprayed on the coral reef every day.

Fishers get their cyanide supply from financiers, who mainly get it in bulk from Surabaya. Cyanide is sold for about IDR.50.000 – IDR.60.000 per kilogram. The ease of obtaining cyanide is one reason fishers still use cyanide for ornamental fish collection.”

“This problem is one of concern to the Banyuwangi local government. Several awareness and training activities have been conducted, but there has been no significant change as a result so far. Most fishers still stay with cyanide fishing as a livelihood. According to the local fisheries agency staff, the

eastern part of Banyuwangi beach has been so polluted by high concentrates of cyanide that the coral reef has been badly damaged. Bangsring fishers have been using cyanide in these areas since 1980. This condition is a valid reason for Bangsring fishers catching more fish through sailing far away from home to Madura, Sulawesi and Nusa Tenggara for fishing."

The damage caused to coral reefs by the use of cyanide, mainly for the food fish industry was examined by Mous et al. (2000) who found damage rates of 0.047 – 0.06 m² per 100 m² per year. They suggested that this is lower than the natural rate of recovery and so the reef should not deteriorate to the extent that recovery is not possible. On the basis that catching ornamental fish requires many more "squirts" of cyanide than catching food fish the authors suggest that the use of cyanide for catching ornamental fish may have more impact. However, as mentioned above, reef destruction due to blast fishing is likely to be far more serious and the impact of cyanide alone does not measure the full impact as the food fishery targets a relatively small number of high-value species, which are top predators and their removal from the reef ecology may have a significant effect.

The use of cyanide in the live reef fish food industry in Kudat, Malaysia was studied by Daw et al. (2002). They found extensive use of cyanide that was used as a solution in plastic bottles, which was squirted at the target fish until it was incapacitated. Each bottle contained a solution of sodium cyanide made by dissolving 0.5 – 3 tablets per litre (tablets can be 40-50/kg or 25/kg; it is not mentioned which sized was used), depending on the target species. The authors noted *"that large fish require more cyanide. One fisher related how he used four bottles of cyanide solution, at a concentration of three tablets per bottle, to catch a 57 kg kuatong (E. lanceolatus) and seven 1-tablet bottles to catch a large male lankawit (Cheilinus undulatus)"*. The authors concluded that using 10 X 3 squirts in a day would damage 90 m² of reef and 5 X 1 squirt would damage 2.5 m² of reef.

It is worth considering Fiji as an example of good practice. While the legislation bans the use of cyanide and intoxicants for fishing, it has never been a problem in Fiji and the industry has carried out without having to resort to its use. Coral reefs used by the ornamental trade in Fiji are reported to be in good condition (e.g. Lovell and Whippy-Morris, 2008) and levels of collection of fishes are judged to be sustainable. Using Fiji as an example, there seems little reason to assume that cyanide or intoxicants are necessary for collectors to use for catching ornamental fishes from the reef and, with education and training, it should be possible to end their use in other countries.

Commercial netting

Commercial fishing for the food fish industry can cause extensive damage to coral reefs. It can be direct damage as caused by tickler chains on trawls (these are used to scare fish into open water and into the trawl) or indirect such as "ghost fishing" by lost gill nets that have become caught on the reef and abandoned. They continue to catch fish long after they have been abandoned. As well as causing direct, physical damage to reefs the repeated removal of biomass from reefs can lead to significant ecosystem disruption.

Commercial fishing has caused major problems in some freshwater habitats as well. Notable examples include the introduction of gill nets and trawling to the Africa Rift lakes, which very rapidly led to a reduction in overall size of the fish (growth over-fishing) and a reduction in biomass. This does not necessarily impact on the ornamental industry, but over-fishing by commercial vessels can lead to loss of fishing opportunities for artisanal fishers who may then be forced to find alternative stocks to fish (e.g. *mbuna* in Lake Malawi) and so there is potential for an adverse impact on the industry.

Artisanal fisheries

Artisanal fisheries may compete directly with the ornamental trade by fishing for the same stocks. In many countries what we may consider to be an ornamental fish is generally regarded as food, such as with many medium to large-bodied loricariids. The same would apply to many cichlids, including

some quite small species, all of which are regarded as food in some countries. With over-fishing and pressure increasing on fish stocks around the world, this may become an increasing problem for the ornamental industry. Population growth and the general decline in the production of many fisheries are likely to make this problem worse. Actions by donors to increase fishery production may only make the problem worse.

A report by EC-PREP (2005) in Indonesia reported substantial damage could be caused by the small-scale, local fishery which included *“other fisheries and resource use activities which were seen to directly cause considerable damage include: coral mining, collection of invertebrates (skin diving, compressor diving or gleaning at low tide) where coral colonies are broken apart or overturned such as abalone, tridacna clams, octopus and some kinds of sea-cucumber; collection of invertebrates where the substrate is unintentionally damaged by trampling or similar, such as most sea-cucumber collection, spear-fishing, collection of Tripneustes sea urchins and various edible molluscs, etc. In addition, anchor damage was clearly visible at several survey sites.”* Much of these food items would have been taken for local and home consumption rather than for international trade indicating that any fishing activity on coral reefs has the potential to be damaging and unsustainable.

Invasive alien species

While the ornamental trade is blamed for the introduction of alien species around the world it might also be the victim. The spread of fishes such as tilapias, clariid catfish and large characoids, such as *pacu*, for aquaculture has led to many escapes and even deliberate introductions, which have become established in the wild with serious consequences for the native fish fauna. The introduction of snakeheads into Madagascar has had a major impact on native species, causing local extinction of some endemic cichlid species, and has even been implicated in the loss of the Alaotran grebe. Such introduction can disrupt local ecosystems and compete with local species, both of which may affect the populations of resources used by the ornamental industry.

Unfortunately, the impact of these introductions on ornamental fish species has not been the subject of a specific investigation. However, Kottelat and Whitten (1996) provide a list of introduced aquatic species in South East Asia, most of which were deliberate introductions and all of which had notably adverse impacts on the indigenous population of aquatic organisms. It is very unlikely that any ornamental fish populations would have escaped the impacts of such introduced species. Introductions are very unlikely to end and maybe even be promoted still by agencies such as FAO, which still consider such introductions to be essential for food security and economic development. While the FAO database on introduced fish species does have an entry category of ecological impact, this is often listed as unknown. However the entry for the introduction of *Oreochromis niloticus* to Madagascar is listed as being “adverse”, which is something of an understatement. However, it would be difficult to separate the effect of tilapias on the native fish population of Madagascar from all the other introductions.

The ornamental aquatic trade generally goes to great lengths to avoid the introduction of potentially invasive species. Examples of this include:

- The joint campaign of OFI, OATA, NZB, REPTA and PIJAC to support the objectives of CBD and prevent the [introduction of IAS](#);
- The OATA advice for retailers and consumers on not releasing non-native species such as the [Pet Code of Practice](#) and the promotion of the [Plant Wise Campaign](#).
- OATA co-authored the [European Code of Conduct on Pets and Invasive Species](#) to encourage responsible pet keeping and to educate pet owners on the need to never release them into the wild.
- PIJAC has developed the [Pet Pathway Toolbox](#), which is a collaborative effort between [PIJAC](#) and the Global Invasive Species Programme (now closed). The Toolkit provides industry and regulators with tools to develop programmes for minimising the risk of pet species becoming established and invasive and provides advice to pet owners.

Combined effects

Single factors affecting the environment are quite rare and several impacts will usually occur together, which makes it difficult to separate out the effects of individual factors and also means that the multiple stressors may have a greater impact on a fishery than any single effect. For example, clearing of forest for conversion to grazing land will lead to multiple impacts including loss of tree cover leading to warming and more growth of macrophytes, increased run-off and sediment inputs due to soil erosion and increased nutrient inputs due to application of fertilisers and manure from cattle. Dias and Tejerina-Garro (2010) reviewed the impact of modification of the terrestrial habitat on streams in the upper Parana Basin, Brazil. While there were multiple factors involved and the impacts varied according to stream type, they concluded that there was substantial disturbance to stream ecology with a shift towards dominance by small-bodied fishes with high reproductive capacity in impacted areas. They also noted the presence of two alien species, *Tilapia zillii* and *Poecilia reticulata*, the former having been introduced for aquaculture and the latter for mosquito control.

Airfreight costs

As highlighted earlier (e.g. see Table E3) the cost of shipping is a substantial part of the costs of getting ornamental aquatic organisms to market. Airfreight alone typically makes up about 20-30% of the shipping costs and for export points where there is intense competition for cargo capacity and little completion between airlines, freight rates can be very high. This is best illustrated by the South Pacific where many islands face a number of problems in getting airfreight to international markets. The problems include a limited number of flights per week, limited competition and limited choice between airlines, the lack of direct flights to international markets, which can lead to multiple changes of carrier, leading to long shipping times and a risk of missed connection, and all of these contribute to a high cost for airfreight. Wabnitz and Nahacky (2013) found that while an ornamental industry from Nauru was technically feasible and would be sustainable, the high cost of airfreight and limited options for access to international markets made it uneconomic, even for high value fishes. Similarly, Wabnitz and Nahacky (2014) found that the options for Kosrae, Federated States of Micronesia, was also severely constrained by airfreight costs. It is quite likely that this also applies to some other supply countries which have some potential for increased exports but are constrained by poor airfreight options.

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Annex J: The wild caught ornamental trade, conservation and development

While the ornamental trade is often viewed as being purely exploitative and a threat to biodiversity, it does provide support to the conservation of a range of aquatic species. Aquarists and the trade are taking an increasing role in the development of programmes for the ex-situ breeding of endangered species or even species that are listed as extinct in the wild. A good example of this is the white cloud mountain minnow (*Tanichthys albonubes*), which is now extirpated throughout much of its former range and reduced to a few, relict populations (Chan and Chen 2009). However, its continued existence is assured as millions of these fishes are bred every year for the ornamental trade. Other similar examples include the endemic barbs of Sri Lanka that are now bred for the trade. Below are some examples of how the trade supports conservation and promotes sustainable use of ornamental fish resources. The fact that the ornamental fish trade does not represent a threat to biodiversity in many areas is not often reported, but Kottelat and Whitten (1996) are an exception noting that:

*“The aquarium fish trade has been accused of driving species to extinction because of very selective overfishing, but there is no documented evidence for this. Some species which have been the subject of an important trade have decreased significantly and have disappeared in part of their original range, but this has always been related to other causes (e.g. *Botia sidthimunki* in Thailand). Some species have disappeared also in areas where they had never been collected for the aquarium trade (e.g. the 'silver shark' *Balantiocheilos melanopterus* in the Kapuas basin, west Borneo). On the other hand, some species may be temporarily saved from extinction because of the trade; for example, it is not clear whether the 'red-tailed shark' *Epalzeorhynchos bicolor* (commonly called *Labeo bicolor*) still exists in the wild, but tens of thousands of specimens are exported annually from Thailand, all now captive bred.”*

This statement is probably as true today as it was in 1996. In the case of the red-tailed shark, this still has an [IUCN Red List rating of Critically Endangered](#) and IUCN note that “currently the major threat to the wild population is pollution from agricultural and domestic sources.” At least the survival of this species is assured in the ornamental fish trade.

Project Piaba

Project Piaba was founded in 1989 and seeks to promote an economically viable (ornamental) fishery for the riverine communities of the middle Rio Negro. It is community-based and seeks to involve local communities in all aspects of the management of the ornamental fish trade. The Project works closely with Universidade do Amazonas, Instituto Nacional de Pesquisas Amazonicas (INPA) and IBAMA, the Brazilian environment protection agency. Funding is partly from external (mainly private) sources and from the Brazilian government. The project relies heavily on volunteers for its research programmes.

The Project seeks to improve the economic benefit from the collection of ornamental fishes in a number of ways. An education centre has been built to provide education material for local schools and for the wider local community to inform them of the benefits of the trade and how it is dependent on the forest environment. The centre also serves to educate those involved in the collecting trade on best practice for harvesting, handling and shipping of fishes in order to maintain quality and reduce mortality.

The Project also carries out scientific studies on the ornamental fish resources in order to understand better the ecology of ornamental fishes, the socio-economic and cultural aspects of the collectors and how these factors may affect management decisions for the fishery. One specific aim of their research is to find ways of retaining more of the value of the trade in the area rather than at

present, at points further along the chain of supply. The project is also developing methods for the culture of some higher value species.

One of the founding principles of [Project Piaba](#) is “Buy a Fish, Save a Tree” which is based on the assumption that as long as the ornamental fish industry thrives in the area around Barcelos, the *piabeiros* will have a strong interest in maintaining the forest as, without this, the ornamental fish populations will likely be much reduced. The forests of the Rio Negro are essential not only for maintaining the ornamental fish industry but also to ensure that the associated ecosystem services are maintained. The approach to sustainable fishing and sustainable forests is outlined by Project Piaba in an article on [Buy a Fish, Save a Tree](#). The need to maintain the tropical forests are summarised in Anon. (2008) due to the key ecosystem services delivered which include:

- On average, tropical forests absorb 1 tonne CO₂/ha/year
- Trees in the Amazon basin put about 20 billion tonnes of water vapour into the air annually, feeding rainfall east of the Andes, ensuring river flows and thus activities dependent on rivers such as irrigation, hydropower and fisheries.
- Tropical forest stores 120-400 tonnes CO₂/ha
- About 40 billion tonnes CO₂ was released by global deforestation from 2008-2012

Clearly, while the area of forest which may be protected under Project Piaba and the ornamental fish trade is limited, the general principle applies that conservation of tropical forest by the ornamental fish collectors has much wider benefits, not just on the Rio Negro but also globally. Evidence from Project Piaba indicates that in years when the collection of ornamental fish has been restricted by factors such as low water levels, the *piabeiros* turn to other activities, notably (illegal) harvesting of timber or clearance of forest for agriculture. Evidence collected on a visit to Barcelos in 2015 (IW pers. obs.) suggested that the general contraction of the aquarium industry on the Rio Negro has led to an increase in alternative livelihoods, mainly agriculture, which have resulted in an increase in forest clearance.

Maidenhead Aquatics

Maidenhead Aquatics has been supporting the community from which it obtains reef fishes in Kenya. This support has taken the form of fund raising to replace the roof on a local school and was funded by a donation per box of fish imported.

Maidenhead Aquatics uses suppliers from all over the world, including one based in Kenya. Close to the supplier's facility lies the village of Vipingo where many of the fishermen who collect the fish, which are exported to Maidenhead Aquatic and the fish-house staff that care for the fish live. As in many countries where education is at a premium, the children of Vipingo are keen to learn and gain a proper education, but suffer from an acute lack of facilities, often being forced to study whilst sitting on the muddy floor of their makeshift “classroom.” Together with their supplier, Maidenhead Aquatics has funded and organised the construction of an extension to the school helping to enable more children from the village gain an education. The main building is now constructed with the new roof due to be fitted soon, and benches have now also been purchased for the children so that they no longer have to sit in puddles during the rainy season (see Figure J.1). The funding has also helped to provide simple things such as books, writing paper and sports equipment which will help a little towards benefiting these children and giving them a chance at a decent education and the prospect of employment in their future. In development terms, the amount donated is relatively small at GBP1,500 but it has enabled the community in Vipingo to make some real improvements to their educational facilities.

To quote Maidenhead Aquatics *“Seeing the children’s efforts in trying to gain an education reminded us that it’s essential to try and contribute something back to the hobby of fishkeeping and to the communities that support it, so with the help of our supplier, we’ve been helping to supply much needed school equipment in an effort to make the learning progress a little easier for the children.”*



Figure J.1: Development of the new school building in Vipingo village. The village school was transformed from the old open structure into a new, modern school, complete with proper seating for the pupils. All it took was a little money; the villagers took care of the rest. Photos courtesy of Maidenhead Aquatics,

They now plan to carry out development work to assist their fishers in the Balinese village of Les. Maidenhead Aquatics already has links with Les village and intends to work with them, through the NGO LINI to build a sustainable community and a sustainable supply chain. Maidenhead will support the ornamental fish collectors in Les village to further their reef rehabilitation programme and restore the inshore reef. The scheme uses artificial structures made in the local community and placed on the reef to create structures on which coral can grow and in which reef-dependent fish and invertebrates can live. The restoration, which has taken place so far, has had a significant effect on improving reef ecology and catches for the collectors. Les village was visited with LINI (1W November 2014) to set up field studies and is described below.

Les village has a history of ornamental fish collecting; however this was severely affected in the past by environmental degradation due to a combination of factors, including pollution, eutrophication,

blast fishing, coral mining, sedimentation, rubbish dumping and especially the use of cyanide for capturing live fish for the food and ornamental trades. Cyanide fishing had led to the substantial loss of live corals, however it did retain the basic reef structure; coral mining had resulted in the complete removal of the inshore, shallow reef structure in places. The outer reef of these villages is not far offshore and is easily reached by freedivers working from the shore without a boat. More well off fishermen have boats with hookah apparatus, which enables them to work in a greater depth and access areas not accessible to the freedivers. Fishermen tend to combine food fishing with the ornamental fishery, depending on season and availability. The food fishery mainly targets small pelagics, such as squid, mackerel and frigate tuna. Reef fish are not generally targeted for food as the populations are so reduced and the fish size too small to make it worthwhile.

Other livelihood activities in Les are limited by geography. There is a narrow, rocky coastal strip with steep hills behind which limits the area available for agriculture. Most of the agricultural activity appears to be restricted to part-time and seasonal crops that require little maintenance such as coconut, mango, cacao and rambutan. Apart from petty trading, roadside restaurants and casual labour, there seem to be few other employment options for the villagers.

Although the reefs were damaged by activities such as blast fishing and ship grounding it is generally recognised that the introduction of cyanide fishing in the later 1980s had a significant impact on the reef. Prior to that, collectors had used more sustainable netting methods for catching fish. Due to the ease of capture, cyanide use became widespread and adopted by most fishers in the ornamental trade. It was not until the late 1990s that the fishermen began to recognise that the reef had been damaged severely and by that time, live coral cover was down to about 25%. Live coral cover reduced further so that by 2000, only 10% cover was left in some locations. The fishermen realised that they had a problem, but were generally in denial or did not recognise the link between cyanide use and reef damage, blaming it on pollution, rubbish dumping or some external factor outside their control. A few fishermen had made the link but even they were unable to cease using cyanide as they thought there was no alternative and if they stopped fishing, they would no longer be able to support their families.

The turnaround began in 2000 with the intervention of an NGO, YBN, which began to lobby fishermen in Les village to stop using cyanide and instead use nets. Some equipment and training were provided to the fishermen and it was demonstrated that it was possible to earn a living that was not reliant on cyanide. Coral re-growth was rapid and by 2003 live coral cover was back up to 30%, although fish and invertebrate populations were still much reduced. LINI became involved in 2009 and began to promote the use of artificial reef structures that could be made and put in place by local communities. These took three forms:

- Fish dome: Approximately 100 cm tall and 60 cm in diameter, this hollow structure provides habitat for fishes (which access the dome through small holes), and supports coral and other organisms on its surface.
- *Roti buaya* (crocodile bread, named after a Chinese loaf): Approximately 40 x 30 x 10 cm (L x W x H), this solid structure stands on four legs, and provides both a surface on which coral can grow, and a sheltered area beneath for cryptic organisms.
- Shrimp pot: Approximately 20 cm tall and 20 cm in diameter, this hollow structure has narrow gaps in its sides which allow ornamental shrimp species to pass through and to shelter inside. This artificial reef substrate type does not support coral on its surface.

With a team of fishermen, even the larger fish domes can be placed out on the reef without the need for any equipment other than simple rafts and floats. To enhance the rate of coral recovery, coral frags were attached to some of the substrates. These were fast growing coral species, which have colonised rapidly and grown well to provide additional structural complexity and shelter for reef organisms (see Figure J2). By 2011, live coral cover had increased to 45% and the number and

diversity of reef fishes and invertebrates had increased to a level at which the fishermen noted a significant rise in income. In Les the collection of shrimps and fish from the artificial restoration sites had increased from about 2,500 in 2011 to nearly 8,000 in 2013 resulting in an increase in income. In 2012, LINI calculated that for an investment of USD 1,100 to create a 10 x 10 m plot of artificial reef, after 12 months it would return an average income of USD 190-370 per month for one fisherman, or USD 2,280 – 4,440 per year, meaning the initial investment is paid back in less than two years.

As well as the incentive of potentially increased income from fishing, there is an additional incentive to be had from the manufacture of the artificial reefs structures by the fishermen. The materials are sourced locally and no special equipment is needed meaning that any village can get involved in making them. Fishermen are paid by the piece for making the structures with the costs paid from donations to LINI.

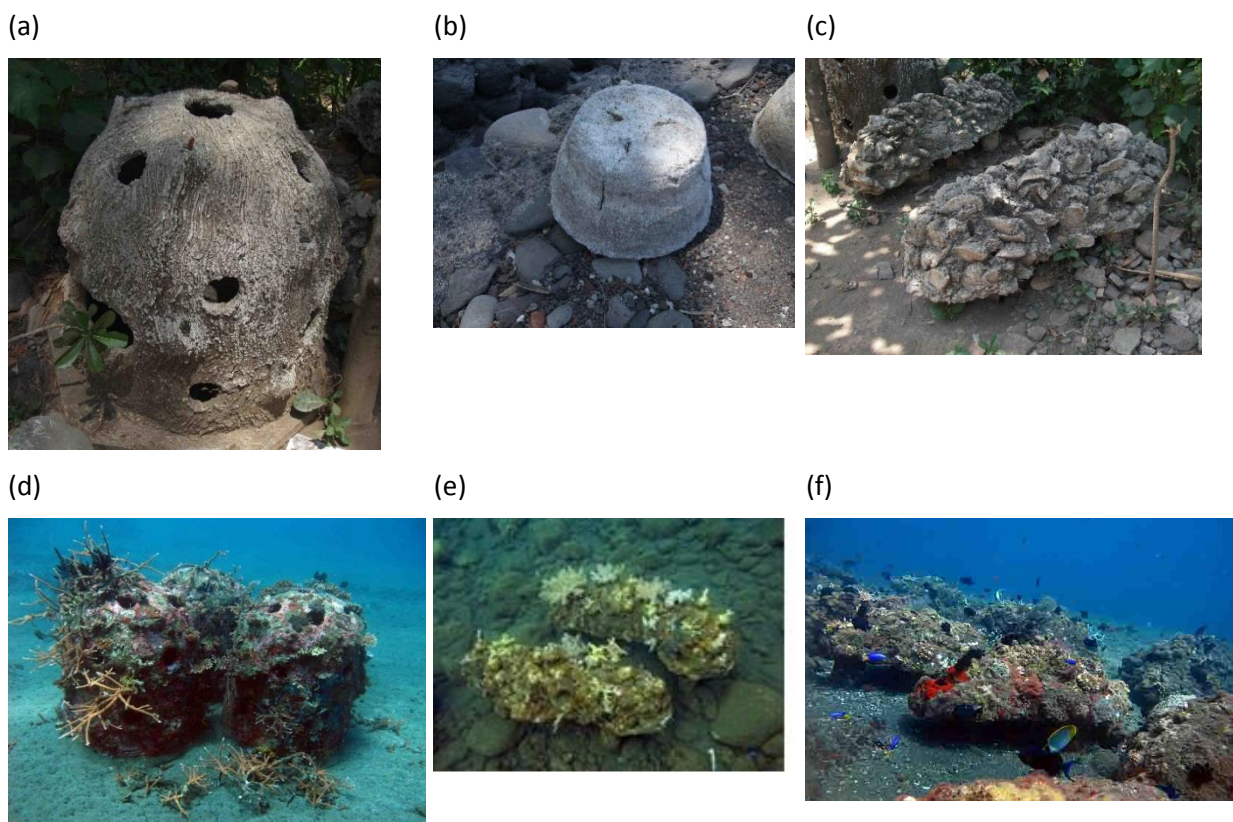


Figure J.2: Artificial reef structures – the upper row shows the newly completed structures and the lower row after being in place on the reef for about 1-3 years. (a) fish dome, (b) shrimp pot, (c) *roti buaya*, (d) fish domes with coral colonisation, (e) *roti buaya* with newly added farmed coral frags attached, and (f) *roti buaya* attract fish very quickly.

As a result of the interventions, cyanide use in Les has now been reduced to zero and there is strong social pressure to prevent anyone reverting to this method. Different communities have responded in different ways to the reef restoration work, some now designating the reef as a no take zone or protected area, while some are now benefiting from increased income from catching ornamental fish. There is little food fish activity on the reef apart from some opportunistic harvesting of organisms such as large gastropods and cephalopods as that part of the reef fish community has still not recovered either in size or in population to make it worthwhile. Other destructive harvesting techniques such as blast fishing have also decreased in East Bali, but are thought to continue in West

Bali. Areas designated as no take zones or protected areas are providing good dive sites once again and providing additional recruitment onto adjacent areas of reef.

From what was a very unpromising start, this shows that considerable progress can be made with community involvement. Outside interventions have been limited and mostly in the form of advice and seed funds. Decisions about the reef restoration and the adoption of non-destructive fishing methods were made collaboratively with the communities, not imposed from outside which has probably led to the strong sense of ownership in the villages and the self-regulation by the communities. Most notably, fishermen have been able to continue a livelihood from the reef that had looked like it might disappear and, as there are very few alternative livelihoods in the area, this has hopefully secured the future of these communities. It will take many years for the reef to return to anything like its pristine state, however it will hopefully return to good ecological condition within the next few years.

Neil Hardy Aquatic Ltd

Neil Hardy Aquatica (NHA), in common with some other importers around the world, used to maintain a number of export stations in order to ensure supplies. This was at a time when exclusive supplies had a high premium and many of the fishes in trade from such wild sources were not available from farmed sources. Some, mostly premium priced fishes, were often re-exported to markets such as Japan. NHA used to maintain collecting and export stations in Sierra Leone, Cameroon, Kenya (Lake Victoria) and in Zaire (now Congo DRC). Of these, the Zaire operation was by far the largest.

There were two centres set up in Zaire by NHA, one in Kinshasa which acted as a collecting and export station and one on Lake Tanganyika at Kalemie which served as a focal point for collecting fishes (mainly cichlids) from the Lake over a wide area. The full cost of setting up the collecting and exports stations is not recorded in detail but was reported to have needed an investment of hundreds of thousands of pounds. At the peak, the station in Kinshasa bought from about 2,000 fishermen and had others employed for maintenance and export operations. At one time, the Kinshasa station was the largest customer for airfreight from Zaire. It exported about 5-600 boxes per month worth about £40-60,000. NHA estimates that it was spending about £500,000 per year in Zaire on fish, wages and support services (such as boxes, airfreight).

Collectors at the Kalemie station were employed directly by NHA but with a bonus paid depending on which fish were caught and how many. Collectors' wages varied depending on season and how much the collectors worked. At the Kinshasa station, *Distichodus sexfasciatus* were only available for part of the year and were a popular re-export from UK to Japan. Collectors would be paid USD 1 per fish if they were in good condition and a collector could collect 3-400 per week and up to 1,000 per week at the peak of the collecting season. This gave the collectors much higher income compared to the typical earnings in their communities of about USD 5 per week. At the height of the season, NHA was putting about USD 10,000 per week into the economy around Kalemie in the form of wages alone.

The outbreak of civil unrest and ultimately civil war in Zaire meant that neither the collecting station at Kalemie nor the export station in Kinshasa was safe to operate and they had to be abandoned. The Kalemie station was looted and destroyed resulting in the loss of the considerable investment in facilities and equipment, not to say the loss of income for the workers. Changes in the markets for fishes from Africa and particularly the fact that so many species are now farmed have meant that it is no longer financially viable to restart the operations. High freight costs and lower prices for the fish also make exports from much of Africa no longer a commercial proposition, although there are some locally-based exporters.

Tropical Marine Centre

Tropical Marine Centre (TMC) is involved in the import of marine ornamental organisms for the aquarium trade and in the development of maintenance systems for the aquarist, industry and public aquaria. TMC imports from many countries and, to ensure continuity of supply and to minimise stock loss, has invested or supplied equipment to a number of its collection and holding stations. These use TMC's own equipment in order to keep the reef organisms in good health and to adapt them to aquarium life. As a result of this increased investment, TMC now achieves a very low level of mortality from collection to sale. In order to prevent over-collection and wastage, TMC operates a policy of collect to order rather than relying on holding stock in anticipation of orders. Typical TMC installations in its collecting and holding stations are shown in Figure J.3.

The hobby, conservation and development

It should be remembered that the ultimate purpose of the trade is to provide consumers with the fish and other organisms that they want to keep in aquaria and ponds. There is an interplay between aquarists and the trade in developing techniques for the maintenance and breeding of challenging species that benefits both parties. Aquarists are taking a greater role in promoting the sustainable use and conservation of aquarium species. Some species are highly endangered in the wild and may only have a future in the aquarium, and hobbyists have a key role to play in this. Where this has taken place in collaboration with public aquaria and research scientists it provides a valuable forum for the exchange of expertise and experience, as well as to channel funding into conservation projects. A selection of such programmes is given below.

Livebearers

Many indigenous fishes in Mexico are threatened by loss or degradation of habitat. Contreras-Balderas (2005) states that of 506 indigenous freshwater species in Mexico, 185 are recorded as endangered and 20 are considered extinct. For viviparous fishes, 31 species were considered as endangered belonging to two families (12 goodeids of which 8 are endangered and 4 threatened, 19 poeciliids of which 8 are endangered and 9 threatened). Of those which are threatened or endangered, human activity is the greatest risk to their survival mainly due to alterations in water supplies or water levels caused by agriculture, urban development and contamination. In addition, many fishes have a limited distribution and a limited ability to adapt to new habitats, making them more vulnerable to threats. For these reasons, Contreras-Balderas (2005) proposed a series of measures to improve the survival of indigenous freshwater fishes in Mexico. Some of these have been implemented in schemes such as are described below. However, it should also be recognised that captive populations of endangered livebearers exist in a number of countries, both in public aquaria and maintained by private aquarists. Contreras-Balderas (2005) also highlighted the high level of endemism and how this elevated the threat to conservation and made it more important for conservation issues for these fishes to be addressed. Noting that some endemic livebearers are effectively relict populations, stranded by a drier climate, he emphasised how human activity has increased their vulnerability.

Medina-Nava et al. (2005) described how two goodeid populations in Mexico have become threatened through a combination of factors including agricultural run-off, introduced non-native species, groundwater abstraction and wastewater discharges. La Mintzita spring was considered especially vulnerable as it is a relict spring and it now heavily used by people for a range of activities. At times, water level is severely reduced. This is part of the habitat for *Skiffia lermiae*, which is rare and although this is not the species' only habitat, degradation or loss of La Mintzita would be a major threat to the survival of this species.

De La Vega-Salazar et al. (2005) listed two species of goodeid as extinct in the wild (*Allotaca catarina* but noted that the Goodeid Working Group reports that it does still exist in the wild and *S. francesae*, but noted that several captive populations exist and the species is sometimes seen for sale,) and three more are in serious danger of extinction (*Zoogoneticus tequila*, *Hubbsina tuneri* and

Ameca splendens but again noted that these species are maintained by the Goodeid Working Group and *A. splendens* is often seen for sale). Multiple factors are involved in their loss including habitat fragmentation, eutrophication, pollution and the introduction of non-native species.



Figure J.3: Reception, sorting and holding of fishes at TMC facilities in the Pacific. Photos courtesy of Tropical Marine Centre, UK.

The Goodeid Working Group

[The Goodeid Working Group](#) (GWG) exists to promote the conservation of goodeids through both ex-situ and in-situ conservation. The group has members in at least 16 countries, ranging from individual hobbyists to specialist aquarist groups to public aquaria and conservation organisations. The GWG has funded research and conservation in a number of countries of which the most notable is the [Mexico Fish Ark](#), which aims to conserve some of the highly endangered fish species of Mexico that are threatened mainly by habitat loss. Dr. Omar Domínguez (Morelia Aqua Lab) provided this (edited) information on work at the Fish Ark:

“Annually we obtain around USD 7,000 from the hobby and zoos, and from the industry we obtain 80kg of flake food for free during 2002 to 2008.”

“We have 39 species of endangered species in aquarium, pond and soil ponds. We try to maintain high numbers and separate the fry and try to avoid inbreeding; sometimes is difficult but we try to do it.”

“We have big soil ponds and in this ponds we maintain around 18 species (in 4 ponds), contrary to expected, the species that is extinct in the wild and which stock come from 4 pairs originally collected in 1998, meaning no genetic diversity at all, is the species that better adapted to semi-captive conditions. We have thousands and they breed, grow, and do very well in ponds where they have predators, daily and annually water parameters changes and so on. That does not means that maintain genetic diversity is not important, but means that if we lost (from the wild) for any reason, not all is lost with that species.”

While USD 7,000 is not a huge sum, it has proved important for the conservation of these highly endangered species, even if their habitats continue to degenerate or even disappear altogether. As well as this targeted effort, the GWG has a breeding scheme designed to ensure that genetic integrity of aquarium populations is maintained and to avoid in-breeding. The British Livebearer Association is a member of the GWG and has raised funds for the Fish Ark. It also works with zoos and public aquaria on projects involving the breeding of livebearers.

The Parosphronemus Project

The [Parosphronemus Project](#) was set up to deal with a single genus of anabantoid that is highly endangered in the wild due to habitat loss, mainly as a result of conversion of acid palm swamp for crops such as oil palm. The Project aims to:

- Increase our knowledge of the genus *Parosphronemus*
- Share this knowledge and strengthening of the awareness of their plight
- Promote control of the biotope preservation and nature conservation on their homelands
- Preserve and enlarge the available aquarium populations

The Project has over 200 members in 16 countries and membership is free. It is not clear how the Project is funded nor how it funds conservation and breeding work.

Rainbowfishes

Rainbow fish have a relatively limited distribution in northern Australia, Papua New Guinea and West Papua. Comments below are based on a presentation by Alex Carslaw (hobbyist, www.rainbowfishuk.com 22/03/15). Rainbowfishes are endangered in many of their natural habitats, mainly due to increasing pollution, eutrophication and introduced fish species. A good example would be *Clitherina sentaniensis*, which used to occur in Lake Sentana in West Papua but is now thought to no longer occur there due to a combination of the introduction of species for fish farming (carp and tilapia), pollution and eutrophication. This species may now only exist in the aquaria of hobbyists. This might be an increasingly common problem for rainbowfishes, which due to biogeography and the topography of the areas where they occur, tend to have restricted and

isolated distributions. Breeding of endangered species is encouraged and coordinated through organisations such as online forums like [RainbowfishInfo](#) and the breeding programme coordinated through the [International Rainbow Group](#). Given the widespread destruction of their natural habitats, the future of some rainbowfishes may lie in the aquarium rather than in the wild.

The Stuart M Grant Cichlid Conservation Fund

Based on an interview with Ad Konings carried out at the British Cichlid Association Convention 6/7th September 2014

Background note: Ad Konings is an author of publications on cichlids of the Rift Valley and Central America. He is a diver and is known for the quality of his underwater photography. He has made 36 trips to Malawi and has published a number of papers on the taxonomy of the cichlids of Lake Malawi. He runs [Cichlid Press](#).

The [Stuart M Grant Cichlid Conservation Fund](#) (SMGCCF) was started by Ad Konings to generate funds for the in-situ conservation of cichlids in Lake Malawi. The initial impetus was provided by poaching in the Lake Malawi National Park at Maleri, a [UNESCO World Heritage site](#), which is under the control of the Department of National Parks and Wildlife. Despite being in a National Park and thus being a no-take area, the inshore rocky area was subject to intense fishing, mainly using gill nets and the rock-dwelling cichlid populations were severely depleted. This, as well as impacting on biodiversity, had a negative effect on ecotourism, as there were so few fish to see. This concern has been raised 10 years ago by Alan Pitman, owner of a tourist lodge in the area. As with many areas in Malawi, there was also concern over the loss of tree cover due to fuel wood harvesting.

As nets are relatively expensive, it was decided to place anti-netting devices (ANDs) around the rocky shore to deter poaching. The ANDs were designed to snag and damage nets, making poaching an unprofitable activity. While the early design of AND was successful, they were not durable enough and could be removed by fishermen. A new AND has been developed made of PVC with stainless steel cable anchors fixed to the rock substrate. The ANDs are anchored at a depth, which makes them difficult for fishermen to spot. However, the new ANDs are more expensive and more time-consuming to fix in place. The tourist lodge has changed ownership and the new owners have placed the AND programme at the bottom of the priorities list (while actively supporting the park guards in their patrolling activities).

Despite the fact that some areas of the park (i.e. Thumbi West Island) were in view of the National Park's headquarters, there was little effective control over poaching. In part, this was due to the guards being unable to patrol the large area of the Park. Strong local pressure can also limit their ability to police no-take zones. The guards at the Maleri Islands have been able to assist to some extent by placing markers to delimit the no fishing area, however they have neither the skills nor the resources to place ANDs. The SMGCCF is assisting the Park guards by providing a new patrol boat with a diesel engine, which will at least enable them to detect infringements of Park law more easily and use less fuel, which has been provided for by the lodge owner.

In addition to trying to prevent depletion of cichlids in the inshore area, the SMGCCF is trying to boost numbers of cichlids in areas where they have been over-fished by ornamental fish collectors. While some collectors behave responsibly, some do not and over-harvesting of some popular species has occurred. There is also a lack of feedback between collectors and the most established exporter, Stuart Grant Ltd (SGL), which means that the collectors do not necessarily report back that some cichlids are becoming harder to find. The SMGCCF has been working with SGL to boost populations of *Pseudotropheus saulosi*, which has been over-harvested at their only known location. The idea was for SGL to breed the fish at their export station and reintroduce them to key areas where populations have been reduced. However, this has not been very successful as the first batch of fish being grown on was lost in a period of exceptionally cold weather and another batch underwent a similar fate. Only limited restocking has taken place, although this does seem to have been successful as the fish have survived and bred. While this scheme has potential for restoring

cichlid populations, it poses many problems in practice, especially where local control is weak. SMGCCF is now looking at developing a separate breeding centre in Malawi. This initiative is being led by [Jay Stauffer](#) of Penn State University.

SMGCCF aims to raise USD 100,000 for cichlid conservation in Lake Malawi and has so far raised about half that amount. All the funds have come from donations, notably by aquarists. Most notable has been the contribution by the Babes in the Cichlid Hobby, who have raised over USD 13,000 for the SMGCCF (see also notes on Babes in the Cichlid Hobby).

Comments by IW. The future of wild fish exports from Lake Malawi is uncertain. The very high cost is a deterrent to all but the most dedicated aquarists. Catching the fish from the Lake involves a team of divers who catch the fish by hand, almost all of them individually at locations that may be several days journey from the exporter. Requirements for conditioning the fish after catching may add several days to a collecting trip, thus increasing costs. Add to this the relatively high cost of airfreight from Malawi, the trade may become uneconomic and unable to compete against farmed supplies. SGL currently employs 12-15 divers, down from a peak of 30. The impact of this reduction on the local economy and livelihoods is unknown. The Fund has now started an education programme for local schools to show them how the conservation work is carried out and to encourage their involvement.

The problem of an unregulated fishery in Malawi is not limited to the National Park. The Department of Fisheries (DoF) also reported a widespread problem with poaching and over-fishing on all lake fisheries. DoF has very limited resources for fishery enforcement, which is mainly limited to inspections at landing points. The DoF operational budget is too small to enable them to carry out a proactive regulatory programme. DoF also reported that even where they did manage to make a successful prosecution, the local magistrates did not always back them up, giving out small fines and over-turning the confiscation of fishing gear. Malawi has a severe rural malnutrition problem with both protein and calorie deficiency widespread. This increases the pressure on fisheries whether inshore or offshore and is a problem, which is quite likely to get worse.

Babes in The Cichlid Hobby

This is a very successful group of women cichlid hobbyists who have raised significant sums of money for conservation projects. The following is based on emails exchanged with Pam Chin, one of the founders:

"About the Babes In The Cichlid Hobby: We are women cichlid keepers who want to make a difference in the hobby. Cichlid habitats are plagued by pollution, over fishing, deforestation, hydro-electrical power projects, mineral exploitation, global warming, floods, and troubled governments. With 20 years of fund raising we have provided financial aid for cichlid research and cichlid conservation all over the world. We strive to widen awareness and encourage responsible cichlid keeping."

"We have raised about \$120,000.00 to date, about 15 years of serious fund raising. Most of the money goes to the American Cichlid Association funds; the Guy D. Jordan Endowment Fund, which is primarily for Cichlid Research and the Paul V. Loiselle Conservation Fund, which is primarily for Cichlid Conservation. Other funds that are not associated with the ACA that we have donated to over the years include the Stuart M Grant Cichlid Conservation Fund [see above under Ad Konings], CARES and a few special projects over the years."

*"What is kind of neat is that not only have the Babes donated money to the Stuart M Grant Cichlid Conservation Fund separately, but we have donated money to the ACA, and then the ACA has donated it to the SMGCCF. Recently the Paul V. Loiselle Fund donated money to the Stuart Grant Conservation Fund to help raise up the *Pseudotropheus saulosi* that SMGCCF let loose back in Lake Malawi. So it is amazing that all these groups have a common ground and support each other endeavors."*

“Our main fund raiser is at the ACA convention. We do two auctions at the ACA, 2 days of silent Auction, where everyone donates fish related items, maybe new, maybe used. Then usually on Friday night late, we do an oral auction for a mature audience. It is usually rare fish donated by sponsors and/or hobbyists. It is about 80 – 100 bags, all girl auction. Girl auctioneers, girl runners, etc. People know that it is for a good cause and so we get premium pricing for it. It is fast and furious, we like to have it done and over in 2–3 hours. Throughout the year there are other fish gatherings and we will do a silent auction, raffle, etc. but the ACA is definitely our biggest take, and why they get a good chunk of the money, we wouldn’t be able to raise it without the ACA Venue.”

“The Babes In The Cichlid Hobby are not part of the ACA, and the Babes are not a club, it is a clique. We don’t have dues, no newsletter, no overhead. 100% of the money goes to Cichlid Research or Cichlid Conservation.”

“We donate to the funds, but we do not have anything to do with how it is awarded. Both of the ACA funds award only the interest off of the principal in the account. They take applications for projects that need funding and they pick who gets the money available. We are not aware of who has or has not gotten funding from the ACA funds. They announce the winners at the convention, but don’t remember the details and these people are rarely there. The ACA has had these funds for many years and they have a formal system in place of how they choose. The Board votes on it with recommendations from the Chair of the fund. Same with Stuart Grant fund, we give the money to the fund, but we don’t have a say what project it goes to.”

The Babes in the Cichlid Hobby has raised an impressive sum of money for conservation projects using very simple means. They also highlight the CARES programme and how that is managed as a means of funding and running fish conservation projects.

CARES

The CARES (Conservation, Awareness, Recognition, Encouragement, and Support) Preservation Program is based in the US and run mainly by aquarists; it aims to involve aquarists in the maintenance and breeding of fish species that are endangered or even extinct in the wild. The objectives of CARES are:

The CARES Preservation Program has four major objectives:

1. to bring AWARENESS to the critical situation of fish in nature, while EDUCATING the public and stressing the importance of our roles as RESPONSIBLE aquarists;
2. to RECOGNIZE, ENCOURAGE, and offer SUPPORT to hobbyists who maintain species at risk;
3. to SHARE fish as well as data and experiences through notes and manuscripts so that others may learn to maintain those identical and similar species; and
4. to PRESERVE species at risk for future generations

The overall objective is to ensure that species which enter the CARES program are spread out among a number of fishkeepers and that the genetic integrity and diversity of stocks is maintained. CARES has a [Priority List](#) which is managed by a panel of advisors drawn from professional scientists and experienced aquarists. In the words of the CARES Preservation Program Coordinator, “CARES has worked on a one-on-one basis with individuals to help with locating conservation priority specimens for exchange. Regarding similar groups, we have had a number of inquiries from overseas clubs wishing to implement CARES (all of whom we welcome).” All of this has been managed on a limited budget to date as CARES is not yet registered as a non-profit organisation and so has limited options for fund raising. The Babes in the Cichlid Hobby have contributed some support funding to CARES and support has also been given by Tropical Fish Hobbyist magazine.

Planet Xingu

Planet Catfish started [Planet Xingu](#) to generate funds for survey and conservation work on catfishes on the Rio Xingu in Brazil. The genesis, aims and achievements of the project can be followed on their website. In brief, the aim was to provide information on catfishes in the reach of the Xingu where work on constructing the Belo Monte dam system has begun. This is likely to fundamentally change the flow regime of the Xingu, which will have adverse impacts on the catfish, especially the loricariids, some of which are thought to be extremely limited in their habitats and distribution. The aim was to raise USD 11,000 through online donations to support work by Dr Nathan Lujan (Academy of Natural Sciences of Drexel University) and Dr Mark Sabaj (Academy of Natural Sciences of Philadelphia). This sum was raised from about 200 donors over 32 weeks in 2013. The funds were used as described by Mark Sabaj:

“Julian Dignall...webmaster for PlanetCatfish...actually came up with the idea. He felt that there was community interest in supporting scientific work...knew me and my project in the Xingu...and so floated the fund raising website as a trial. It worked better than expected with our target of \$11000 raised in just a few months.”

“Reasons why it worked well are 1) all hobbyists know Julian and respect his work, 2) many hobbyists know me from Facebook and presentations I have given to aquarium societies in the US, UK, Germany and Sweden, 3) hobbyists love Xingu fishes...and know they are imperilled. So, contributors felt confident the donations would be put to good use.”

“The donations are very helpful to the project. One reason is because all equipment I purchase off my grant comes with a 60% overhead charge which goes to my institution. So...I am limited to equipment in the original budget. The donations allow me to buy extra equipment for the project...like a compressor for filling air tanks for scuba diving, updated camera equipment, etc. In short...the donations provide important funds for enhancing the overall project.”

The need for this work is highlighted by further comments on the Xingu and the Belo Monte dam scheme.

“Yes, they are translocating fishes trapped during dry downs...usually to the nearest un-impacted stretch of river (but, no data released on mortality rates). Yes, they are talking of establishing breeding facilities...but, the first proposals were too expensive...and the project was put on hold.”

“When I give talks on the Rio Xingu, I often speculate that there are probably more zebra plecos in aquaria throughout the world than in the wild. If not now...then certainly in the future after their habitat is disrupted by the dam complex. Many hobbyists, certainly all of the responsible ones, are into conservation. So, keeping and breeding zebra plecos allows them to contribute directly to the conservation of a species. As we continue to tear up natural habitats for our own use, species will continue to go extinct in the wild. So, why not preserve them ex-situ? For many species, it will be the only alternative. As far as using captive bred stock to repopulate areas...I am all for that provided it is within the native range of the species. But, I am not particularly hopeful that such native ranges will be any more hospitable in the future. Our changes to the environment almost always follow a one-way path...to destruction.”

The zebra plec (*Hypancistrus zebra*) is not the only species endangered by the dam development nor is it the only species whose fate may be more secure in the aquarium trade than in the wild. The zebra plec is now being bred by hobbyists and by commercial breeders in the Far East (IW pers. obs.). Given the rate of habitat loss and habitat modification taking place, there may be many more species joining this group, with less than certain prospects of a return to the wild. An end to the trade in wild caught fishes would need a major change in conservation funding even for ex-situ conservation of affected species. History suggests that developments will continue to take place, regardless of the environmental impact.

The hobbyist/research/industry interface

Rhyne (2010) raises some interesting points about the breeding of marine ornamental aquatic organisms and in particular the role that hobbyists play in using research information to develop techniques for breeding in the aquarium. Rhyne points out that the traditional model of researchers communicating through publications in peer-reviewed journals has been very inefficient in disseminating information to the general public and to the industries, which might be able to turn the research ideas into usable products. A new approach has arisen mainly driven by hobbyists (who may also be researchers and/or in the aquarium industry) to take research information and adapt it for the breeding of marine ornamentals in the aquarium. As well as increasing the range of marine organisms now bred by hobbyists and the trade, it has also resulted in the development of commercial products from the aquarium industry that make use of the transfer of technology originating from the research community much easier for the hobbyists and the professional breeder. Off the shelf solutions for tackling the breeding of species that were once thought to be very difficult to even maintain in the aquarium are now available. The research/industry/hobbyist dialogue has been facilitated through the development of internet-based forums such as the [Marine Ornamental Fish & Invertebrate Breeders Associate](#).

Nature conserves

Although nature can be very destructive, it can also conserve resources and prevent over-exploitation. It is difficult to conduct a systematic review of this, however some illustrative examples are given below:

- The fishery on the Rupununi River in Guyana is only accessible if water is not more than chest high at the river edge. Even in the dry seasons, this cannot always be guaranteed and the collecting season may be shortened or fishing may be impossible for the whole period. This happened in 2005 and 2006 when the worst rains in over a century hit Guyana in January 2005, causing the Rupununi to rise rapidly and become unfishable. The river did not fall sufficiently for over 18 months, meaning the 2006 fishing season was also washed out. The river rarely falls low enough to enable fishing anywhere other than at the river edge so most of the river is never exploited for the ornamental fish trade, as it is inaccessible.
- *Corydoras tukano* is a species found in the upper Rio Negro basin in the Rio Tuquí. Access is limited by the collecting area being in a protected area for indigenous peoples, however it is also limited by the river height. The fishing area can only be accessed when the river is sufficiently high to allow navigation and the fish can only be caught when the river is sufficiently low. These conflicting conditions do not always coincide and in some years the fish either cannot be caught or cannot be shipped meaning no collection takes place.
- *Dicrossus foini* is found in the Rio Demeni, also in the Rio Negro basin. Due to its biology, it can only be caught for a very limited period of the year when it migrates onto sandy beaches from where it can be netted. At other times of the year (and nobody knows when it goes) it is simply not accessible to the ornamental industry.
- Similarly, some cichlids in Lake Malawi are only available for a brief period of the year. These tend to be open water *utaka* species rather than the rock dwelling *mbuna*. They can only be caught when they pass certain points on the Lake at particular times of the year, usually when the water clarity is sufficient for the fish to be seen. They are however accessible to the food fishery for most of the year.
- Seasonality has a major impact on the ability to collect in reef areas. At various times of the year, water may be too rough for safe working and run-off following heavy rain may cloud the water making it very hard to find and catch fish. Countries that experience a monsoon are particularly affected by this.

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Annex K: The ornamental trade in perspective

The ornamental trade in perspective

The collection of ornamental aquatic organisms from the wild is often portrayed as a major threat to biodiversity and to ecosystems; however examination of the evidence suggests something different. While it is undeniable that the collection of ornamental aquatic organisms can cause local depletion of populations or damage to habitats, this impact is often highly localised and often rather more recoverable than other impacts such as pollution. Some examples of how the ornamental trade compares with other activities are given in this section. It is by no means a comprehensive review as comparable information is often not available and data for different impacts are often very difficult to compare as different measures are often used. Where possible, conversions have been made to allow comparison.

Coral extraction

Coral has had uses both utilitarian and ornamental for centuries and has a very long history of being used by coastal populations. Use for the ornamental trade was reviewed by Wood et al. (2012), which can be summarised as:

- Live rock peak use 2,527 mt 2005
- Reef rock (dead coral for use in the aquarium trade) peak use 1.22M pieces 2002
- Live corals peak 1,590,268 pieces 2007

Based on recorded CITES trade between 2004 and 2012, stony corals (*Scleractinia* spp.) peaked in 2005 with almost 2,500,000 kg of raw coral, largely for the curio trade, although by 2012 it dropped to c. 1,500,000 kg. In terms of live trade this has largely remained below 250,000 kg (Annex D).

No information was available on the average weight of reef rock but if a maximum average weight of 500g per piece is assumed, that would account for an estimated weight of 610 mt in 2002. Similarly, it is difficult to estimate the weight of live corals shipped but, based on limited sampling of live corals at a retailer, an average weight of about 250g is assumed (this includes the base piece which is non-coral material) which would give an estimate of about 827 mt live coral traded in 2007. This can be put in context against other extractive coral uses. The actual weight of individual pieces of coral in trade is difficult to assess as CITES only requires that number of pieces be recorded. Green and Shirley (1999) attempted to estimate the average weight of coral sold for the aquarium trade but found inconsistencies in reported data. Such primary data as they examined also indicated that there were differences between different types of corals and also that different markets (US and UK) appeared to be taking corals of different rates. It is also worth noting that changes in the aquarium coral, especially the move towards cultivated coral frags makes previous estimates less reliable for use on the current trade.

Lovell and Whippy-Morris (2008) evaluated the trade in live corals in Fiji. Their conclusions were *“percentage removal of colony numbers for the aquarium trade is 0.0085% of total estimated colonies on the reef flat with a living cover reduction of 0.0014%. Considering both ecological impact and the conservation of biodiversity, the extraction for the corals surveyed is minimal in terms of the reduction of species numbers, the reduction in living coral cover, and consequent impact on the ecosystem.”* Compared to other impacts on reefs, this is very small indeed.

Coral mining

Coral mining is illegal in many countries and has been for several decades but this has not stopped coral mining taking place. Coral is mined mainly as a building material, either sawn into coral blocks or broken up for conversion into lime for making cement. Data on coral mining is hard to get, partly as a result of it often being a small-scale and highly dispersed activity and partly due to the problem of recording illegal activity. Statistics also do not generally distinguish between coral sand and other

mineral sands making it impossible to assess just how much coral sand is being extracted. Conversion factors for live coral volume to weight vary so a range of values is used for illustration. Bosscher (1993, not seen, *pers. comm.* Colette Wabnitz, SPC by email Jan 2015) gave a value of 1.25 g/cm³, Harney and Fletcher give a value of 1.48 g/cm³. Examples of the scale of coral mining are given below:

- Brown and Dunne (1988) recorded coral mining in the Maldives and estimated that coral mining for building (mainly resorts) and road construction had removed about 54,000 m³ of coral which had been harvested over a period of 13 years. In places where coral mining occurred 40-90% dead coral was observed. Using a conversion factor: 1m³ coral weighs 1,250-1,480 kg, then 54,000 m³ of coral mining would remove approximately 67,500-79,920 tonnes of coral from the reefs.
- Managurusamy and Dhanasiri (2012) examined coral mining in Sri Lanka in an area in the southern province where it had a long history. Originally, coral mining was restricted to areas close to shore where mainly dead coral was gathered by hand but, with the building boom which began in the 1960s, demand increased and industrial mining of live reefs began. Coral was mined for the construction industry and for use as a soil improver for acid soils. At the peak, about 1,400 persons were involved in gathering and transporting coral and about 800 in processing it, mainly in limekilns. It was estimated that about 18,000 tonnes of coral was extracted in the coastal reach between Ambalangoda and Dickwella in 1984, declining to about an estimated 4,020 tonnes per annum by 1993. This compares with the trade in live stony coral (*Scleractinia* spp.) that has largely remained below 250 tonnes (based on recorded CITES trade between 2004 and 2012; Annex D)
- Coral mining also occurred in Bali and at one time as many as 100 lime kilns operated along the north coast fed by corals (LINI *pers. comm.* Interview Nov 2014). As a result of further development in Bali, industrial scale harvesting of corals took place, which has resulted in the total loss of the shallow, inshore reef in places such as Les village and Serangan (near Denpasar) where it was removed for construction materials (IW *pers. obs.*). No live corals or coral re-growth was seen at these sites apart from the farmed corals at Serangan. Generally, it may be assumed that large-scale removal of corals from a reef will compromise its scope for re-growth and recovery at best, and more likely prevent natural recovery altogether.
- Bentley (1998) reviewed coral mining in Indonesia and found that coral mining for construction purposes in the Jakarta area has been as high as 10,000 – 25,000 m³ per annum (equivalent to 12,500 – 14,800 tonnes and 31,250 – 37,000 tonnes respectively). There has also been widespread small-scale extraction of coral for construction and for lime production in many areas of Indonesia, especially in Lombok and Bali where it has led to extensive erosion problems. In some areas, as little as 5% coral cover remained and there was no sign of recovery.

Even though these examples are just localised snap-shots of the impact of coral mining, they do indicate that its scale is very much greater than that of the entire live coral and live rock trade for the ornamental industry. This is not to say that the industry does not have issues to deal with; far from it, local over-harvesting of some coral species is reported widely and this needs to be dealt with to prevent damage to the reef ecosystem. To put this further in perspective, Green and Shirley (1999) quote that “*in comparison to other extractive and destructive impacts on coral reef, such as mining and dynamite fishing, the effects of collecting live coral for the aquarium trade are very small.*”

Seidel and Lal (2010) reviewed mining for aggregates in the PICTs. Their review revealed that inshore mining is widespread in PICTs, both for household use and for industrial use and is a traditional material for house construction. Coral and coral sand may also be used in cement manufacture. The authors noted that getting information on the use and trade in aggregates

harvested from inshore areas is difficult as it often goes unrecorded, especially where it is for household use. In addition, the source of aggregates can often not be identified so coral reef and non-reef sources tend to be lumped together. They provide some examples of extraction and value:

“In Fiji, for example, coral sand was mined in the 1990s at Laucala Bay at the rate of about 70,000 m³/yr as a major ingredient for cement production; the aggregate was valued at FJD\$ 1 million or US\$ 693,000 per year (Howorth 1997). In 2006, production for limestone was 215,000 mt and an additional 300,000 m³ of sand and gravel were mined (U.S. Geological Survey 2006) providing paid work for 3,222 people (Fiji Islands Bureau of Statistics 2008). In the Marshall Islands, the aggregate mining and quarrying industry accounted for an average gross value of 0.3% of total GDP, or approximately US\$300,000 per year between 1991 and 2001 (McKenzie, Woodruff et al. 2006). In Tongatapu, Tonga, beach sand sold at US\$10 per m³ made a domestic industry of annually US\$150,000 (Howorth 1997).”

Where comparable statistics for the export of coral sand for use in the aquarium are available, they are clearly insignificant when compared to the amounts above. The value of the large-scale extraction can be compared with that used at the household level and Seidel and Lal (2010) provide an example *“On Funafuti atoll, Tuvalu a 20kg sack of coral aggregate resulted in a net gain of USD 1.7 for the seller.”* That is very low, even compared to a relatively low-value product such as live-rock.

Coral harvesting for the jewellery and curio trade

A surprising amount of coral is harvested for the jewellery trade, either to be made into ornaments for local and traditional use or for export. Not all of this trade is covered by CITES statistics and estimates of its volume are thus difficult to make. Over-harvesting of some corals for the jewellery trade has been reported widely and the harvesting methods can add to the damage such as where trawls are used to harvest deep-water corals. In addition to the damage caused by trawls, there is also a substantial by-catch, which is usually discarded.

Traditional medicines

A number of traditional medicine raw materials are harvested from coral reefs and inshore areas, the best known of which is the seahorse; this is dried and mainly used in traditional Asian medicine. It is estimated that 95% of seahorses harvested are used for traditional medicine (Thornhill 2012). There used to be a trade in wild-caught seahorses for the ornamental trade but this has declined in recent years and now it is thought that farmed sources now supply about 80% of live seahorses (Thornhill 2012). Based on CITES trade data between 2004 and 2012, in terms of numbers of live individuals, there has been a decline in those coming from the wild, with an increase in those traded under source code F (F1 or subsequent generations that are captive bred but do not fulfil the definition of ‘bred in captivity’) (Annex D). The majority of individuals in trade are listed as being from F (c. 42,500 in 2012), followed by captive bred (c. 13,500 in 2012) and then wild (c. 3,200 in 2012). In term of trade of dried individuals, all but a few were listed as wild-collected. The trade in dried wild collected seahorses appears to have declined from a high of over 13,000 kg in 2005 to just over 2,000 kg in 2012; although in the previous year over 8,000 kg was traded. While there is a targeted seahorse fishery in some areas, a significant source is from by-catch, mainly from trawlers, which suggests that they are using very small mesh sizes that are bound to have a negative impact on coastal resources and ecology by removing a lot of juvenile fishes. To allow comparison between the live and dried seahorse trades it is possible to convert dried seahorse from kg into number of individuals; 1 kg of seahorses was equivalent to 200 to 500 individuals. Between 2004 and 2014 trade in dried seahorses was 765% to 36,394% greater than the live trade depending on the year and if 200 or 500 individuals/kg is used (Annex D). Within a local fishery by-catch was estimated to be c. 72,000 individuals (Baum et al. 2003). The change in production from wild to farmed sources means that off-take from the wild for the aquarium trade is now trivial compared to that for traditional medicine. Finally in a study of the seahorse trade in Brazil, Rosa et al. (2011) found that the dried

trade was largely unregulated, poorly recorded, and destined for domestic trade, therefore not recorded in the analysis of CITES trade data. Live seahorses on the other hand was mainly destined for exports, and regulated through national quotas. Further, per individual, live had the greatest value (USD 1.06-USD 2.78 compared with USD 1.13-USD 10.08).

The live reef food fish trade

While the aquarium trade and the food fish trade both harvest fish from reefs, the stocks targeted and the amounts removed differ significantly. The aquarium trade targets a wide range of species of very low average weight whereas the food fish trade targets a much smaller number of species, which are usually of much higher average weight. In addition, while the aquarium trade removes a fish with a wide range of feeding habits, the food fish trade focuses mainly on top predators. Even as long ago as 2000, the main market for live reef fish for the food trade, Hong Kong imported 30-35,000 mt of live reef fish with a wholesale value of about USD 490 M (Chan 2000). By contrast Wabnitz et al. (2003) reported that the worldwide trade in marine ornamentals was worth about USD 200-330 M annually and with about 9.4 M marine organisms traded in 2003 for the ornamental trade. Assuming a weight per fish of not more than 5g that 9.4 M would equate to about 47 mt, a fraction of the biomass removed for the live food fish trade. In some places, the food fishery has largely collapsed due to removal of high value live fish such as on the reef on the north coast of Bali where favoured food fish such as groupers are now so rare that the fishers no longer bother to fish for them.

Loss of coral reefs

There are a number of causes of coral reef loss and some of these are at least partly the result of the ornamental fish trade but the major impacts come from other sources. Some of the causes are attributable to human activity but a few are the result of natural occurrences.

The impact of nature

Natural events can have a major impact on coral reefs, causing widespread and extensive damage. Tsunamis can cause extensive damage to the corals and to the reef structure. The 2008 Samoa tsunami caused extensive and widely reported damage on shore but it also caused extensive damage on the shallow, inshore reefs. By 2010/11 the area was littered with dead coral fragments with little sign of live coral and very few reef fishes to be seen (IW pers. obs.). The Palolo Deep marine reserve also showed signs of damage attributed to the tsunami but these may also be due to the recent changes to the harbour wall, which were reported to have caused changes in currents and the distribution of sediments locally. The island of Niue was badly affected by Hurricane Heta in 2004, which led to what were probably the strongest winds recorded hitting the island. Extensive damage was caused on land by waves reportedly 40m high hitting the cliffs but these also caused major damage to the reef by moving around large rocks which broke up the reefs which were reported to still not have recovered by 2008 (IW pers. obs.). Such events have hit coral reef areas in recent years and must have caused widespread damage to areas used by the ornamental fish collectors but, apart from the loss of fishing vessels, not much has been reported on the impact on the trade. Edwards et al. (2011) found that the capability of coral reefs to recover from hurricane damage was higher where herbivorous fish populations are sufficiently high to prevent over-growth of the coral by algae. In combination with coral bleaching, recovery was less likely and took longer. Coral reef recovery in general may be improved where herbivorous fish populations are present which may impose restrictions on both the food fish and aquarium industries, both of which harvest herbivorous fishes.

Destructive fishing methods

Arguably, any fishing method is likely to cause damage to a reef if for no other reason than that it will cause a change in the fish population, either in the average size of a species, the population of that species or changes to the species composition on the reef. The methods that have most impact will be those that damage the reef in addition to harvesting fish. Many methods cause damage but

some are of greater concern as they lead to extensive coral reef loss, which may not be recoverable. Cyanide is used by both the ornamental and live food fish industries, in the latter case for local consumption and for export. Widespread and repeated use can cause extensive coral death and loss of the reef functionality. However, as the reef can recover, cyanide fishing is not always the cause of loss of reef structure. As was seen at Les village in Bali, it is possible to rehabilitate a reef as long as the use of cyanide ceases. However, this is not possible with blast fishing as it causes extensive and permanent damage to the reef with the coral being reduced to rubble and sand.

Tourism development

Tourism development can have significant impacts on reef areas, through direct or indirect effects. Indirect effects are more difficult to link to coral reef loss. An example would be the high carbon dioxide footprint of long distance tourism, which is linked to global warming and ocean acidification but it would be hard to pin this to any particular tourism development. Direct impacts can be traced more easily such as coral breakage by snorkel and SCUBA divers and by the dropping of anchors by dive boats. A major impact can come from the onshore developments associated with tourism such as hotels and restaurants. Hotel construction has led to coral mining in the past although this is less likely to happen now. Construction often proceeds ahead of the development of associated infrastructure such as a sewage treatment and effluent disposal system. Raw sewage or sewage which has only been subject to primary treatment is often discharged onto the reef or near to a reef leading to eutrophication and sediments having an adverse impact on the reef. The very thick soils on some tropical islands can support lawns for amenity or grass for golf courses. However, the sandy soil that tends to underlie the organic layer is often very permeable, leading to leaching of fertilisers and agro-chemicals that have been applied and these too lead to eutrophication and adverse impacts on the reef.

The effect of recreational diving on coral reefs has been the subject of a number of studies. Tratalosa and Austin (2001) studied the impact of diving around Grand Cayman in the Caribbean. They found damage associated with dive sites which was greater at high use sites than at low use sites and decreased away from mooring buoys used by dive boats. Dead coral was found to increase and there was more coral rubble at heavily used sites implying physical damage (e.g. breakage) and there was also a trend towards lower cover of large and massive hard corals at sites with high usage. By contrast soft corals (which are generally faster growing than hard corals) tended to be more common at high use sites suggesting that the coral reef community was disrupted. The authors also considered the possibility that anchoring rather than diving caused reef damage but were able to exclude this as anchoring had been prohibited at the study sites and all boats were required to use the mooring buoys. Hawkins et al. (1999) also studied the impact of recreational diving on coral reefs in the Caribbean at sites around the island of Bonaire. They too compared damage to corals at high and low use sites and at varying distances from mooring buoys. They found a lesser effect of diving intensity at the study sites with little difference between high and low use sites in coral damage although there was a higher incidence of abraded and partially dead corals at the high use sites. Coral damage overall was assessed as low with 2.5% of corals being broken and combining broken and abraded corals only took the total to 2.7% but to put this in context (see section on CITES, Corals of significance to the ornamental aquatics trade) it has been estimated that removal of corals for the aquarium trade in Fiji is 0.0085% of total estimated colonies on the reef with a living cover reduction of 0.0014%.

Egypt is a country which relies heavily on Red Sea tourism and the effect of diving has been studied by Zakai et al. (2002) who found generally higher levels of impact than the two Caribbean studies. The main impacts on the study sites at Eilat were from disturbed sediments and to a lesser extent, by breakage. The authors noted that diver skills and experience varied greatly as some sites were used for training novice divers while others (typically deep-dive sites) were used by experienced divers only. They observed a high frequency of diver contact with the reef which leads to abrasion or breakage of corals. The percentage of damaged branching corals observed at dive sites was high

at 15-60% but there was little difference in branching coral cover between sites. In contrast, massive coral cover varied considerably between sites although the rates of damage were slightly less varied at 11-57%. Overall damage to some sites was assessed as high and was associated with high dive frequency. Most of the damage was caused by inexperienced divers with damage typically being caused by contact with divers' fins and by divers stirring up sediments which may settle on the reef. The authors estimated that as many as 400,000 incidents of direct contact occurred annually and up to two million sediment clouds may be kicked up. In view of the very high percentage of sites showing damage (possibly as high as 100%) the authors suggest that the present level of use by recreational divers at the study sites is not sustainable and needs to be reduced. The damage appears to be very high compared to that caused by the harvest of reef organisms for the ornamental trade.

Coral diseases

There appears to be an increase in reports of coral diseases and while the cause and the vectors for spreading such diseases are not well understood, this does appear to be linked to human activity. If nothing else, stressed corals (e.g. by bleaching events) will be more vulnerable to disease. Diseases can be spread by fishes (e.g. corallivorous angelfish), however there is evidence that they can also be spread by humans. The incidence of coral diseases has increased recently, probably linked to corals being stressed by various factors such as high sea surface temperature, sediments, and eutrophication (Muller and Woesik 2012, Pollock et al. 2014, Vega Thurber et al. 2014). A number of coral disease syndromes have been observed, which have been linked to bacterial, fungal or viral infections. There is evidence that the diseases that occur and the stressors that make corals prone to disease may vary with location; the Caribbean for example has a particularly high incidence of coral disease, probably linked to increased sediments caused by land use changes (Muller and Woesik 2012). Pollock et al. (2014) found that sediments from dredging caused a significant increase in "white syndrome" coral disease compared to areas where there was not dredging sediment. There may be multiple impacts such as an increase in coral disease and an increase in coral bleaching both caused by excess nutrients reaching the reef (Vega Thurber et al. 2014). Stressors may combine with other influences to increase the level of damage to the reef. There is also evidence that humans can spread coral diseases directly through contact. Lamb et al. (2014) found that the prevalence of coral disease and other impacts such as physical damage was linked to SCUBA diving with low use sites having much less incidence of disease and damage than high use sites. Reef-based tourism is often regarded as a low impact and sustainable use of coral reefs (unlike the aquarium industry which is usually portrayed as having a negative impact), however evidence is gathering that this is far from low impact and, where dive concentrations are high, significant damage may be caused. LINI observed that at some of the sites they monitor, there are often so many divers present that they get in each other's way.

Shipping

There are numerous reports of damage to coral reefs by shipping usually due to navigation errors. No satisfactory way exists of converting damage by shipping, which is reported in m², to allow comparison with extraction for the ornamental industry, so the two cannot be compared directly. However, as the examples below show, the damage caused by any single incident can be substantial and is likely to lead to long-lasting effects on the reef.

Tubbataha Reef is a UNESCO World Heritage site and a marine reserve off the Philippines. It has suffered from a number of ship grounding incidents and persistent illegal fishing. Some examples include:

- USS Guardian grounded in 2013 causing at least 1,000 m² of coral damage. The [Tabbataha Reefs National Park](#) claims that up to 3,903 m² was damaged. It was not possible to remove the Guardian and it had to be broken up on the reef.

- The Chinese fishing vessel F/V Min Long Yu grounded in 2013, however the amount of coral damage was not reported ([Inquirer Global Nation](#)) although it was found to be carrying 400 frozen pangolin carcasses indicating that illegal fishing is not the only activity of concern.
- The Greenpeace vessel Rainbow Warrior also grounded in Tubbataha in 2005 after a navigation error, causing 100 m² of damage.

A further example is that of the [Carnival Magic](#) cruise ship that ran aground in the Cayman Islands. It caused substantial damage as reported in the Cayman Compass, “It was a significant area of destruction that is not easily repairable, and will take a very long time to recover naturally,” said Timothy Austin, deputy director of the Department of Environment. Divers spent two hours conducting an environmental impact assessment, collecting underwater video footage of the damage, and found the coral impacted from moderate degrees to near complete destruction. “Our early estimate based on a reconnaissance dive [Tuesday] and video analysis of data collected on that dive puts the total impact footprint at approximately 1,100 square meters (11,840 square feet). Within that footprint, approximately 500 square meters is severely impacted with near complete destruction. The remaining 600 square meters (6,458 square feet) has varying degrees of impact from severe to moderate,” said Mr. Austin in an email

To put this in context, the typical loss from blast fishing would have been about 41 m² in that year (assuming a destruction rate of 3.75 m² per 100 m² per year) and cyanide fishing (at 0.06 m² per 100 m² per year) would have caused less than 1 m² of damage. Even blast fishing would have taken over 290 years to cause the level of damage caused by the grounding of the Carnival Magic.

Other examples include:

- MV Island Explorer ran aground in Apo Reef National Park, Philippines damaging 2,720 m² reef.
- MV Wellwood ran aground on the Florida Keys damaging 1,282 m² of damage.

The number of ship groundings per year has not been assessed, however from the above it can be assumed that every year, ship grounding causes damage to reefs around the tropics. If it is assumed that each grounding causes at least 1,000 m² damage to a depth of at least 0.5 m that would equate to about 500 m³ coral damaged equivalent to about 740 tonnes of coral (based on 1480 kg/m³ Harney and Fletcher 2003) or the removal of about 2.96M coral frags (at 250g each). In practice damage to live coral would be less than this; however this does at least provide an indication of the scale of damage from ship grounding.

Many countries rely on sea transport for trade and delivery of essential supplies and need to maintain facilities capable of handling modern container ships. Additionally, many countries rely on tourism for a substantial part of their national income and this in turn relies on access for tourists from visiting cruise ships. Where a country has port access restricted by the presence of a reef, extensive dredging may be needed to allow vessel access. This can be illustrated by a proposal for dredging to improve access to the port in North Caicos, Turks and Caicos Islands where the [bid proposal](#) outlines the anticipated works, and includes the dredging of 87,000 m³ of off-shore reef to facilitate better vessel access. That is equivalent to about 128,760 tonnes of coral, an amount equivalent to more than all the live corals ever traded by the ornamental trade. The dredging would remove not just live corals, but also material equivalent to raw coral (as defined by CITES) and live rock; clearly this single dredging proposal would be capable of causing more damage to a reef in one operation than the ornamental industry can cause in many years.

Over-fishing and competition for resources

Production from capture fisheries worldwide has remained static at about 90 million tonnes in recent years (FAO 2014) despite increases in catching technology and efficiency. Whether this level of catch can be sustained is questionable as the proportion of fisheries, which are classed as being

fished at biologically sustainable levels has decreased from 90% in 1974 to 71.2% in 2011; with the other 28.8% described as being fished at biologically unsustainable levels (FAO 2014). Many NGOs have a far less optimistic outlook, especially for marine fisheries. One consequence of over-fishing is that, as stocks decline and catch rates falls, fishers have to compensate by increasing effort (fish more often, use more or larger nets) or by changing gear, especially where the overall size of the fish has declined. A familiar pattern was followed on the African Rift Valley Lakes where the introduction of industrial fishing (usually trawling) and the introduction of new gear (especially monofilament gill nets) has led to over-fishing and severe depletion of stocks on some areas. In most cases, communities around the Lakes have no choice but to carry on fishing to earn money and feed their families and have even resorted to using seine nets made from mosquito netting in an attempt to catch anything (IW pers. obs.).

Naturally, this has led to impacts on the ornamental fish industry, as fishers are now targeting what was previously a resource only used by ornamental fish collectors. Increasing populations and civil disturbance have added to the problem as displaced people often have little opportunity for employment and may have to resort to fishing for food and income. The tendency to replace traditional fishery management systems with a centralised science-based approach has often not helped as local controls and inhibitions on fishing are often abandoned as a result, ending up with a 'free for all' approach to the resource.

In many countries, there is little difference to most people between food fish and ornamental fish and pretty much anything caught may be eaten, unless it is toxic. Even the smallest fish and shrimp may be eaten, often by being transformed into a relish such as fish sauce (e.g. Thailand, Vietnam, Philippines). The composition of many fermented fish products is not important and any small fish may be used. Larger fish are usually cooked and eaten and even small fish are eaten. For example, small cyprinids and cichlids popular in the aquarium trade are often fried up and served as "relish" (i.e. to add taste) with meals (see Figure K.1). From observation (IW) it seems clear that there can be conflict with the ornamental fish collectors but there is little in the way of firm evidence on this (but see section of Stuart M Grant Cichlid Conservation Fund). Observation in a number of local markets in the South Pacific shows that what might be regarded as "aquarium fishes" often appear in food markets (see Figure K.2).



Figure K.1: A beach landing on Lake Malawi. (a) Competition is fierce for buying fish. (b) The bucket of mixed small fish is a typical catch.

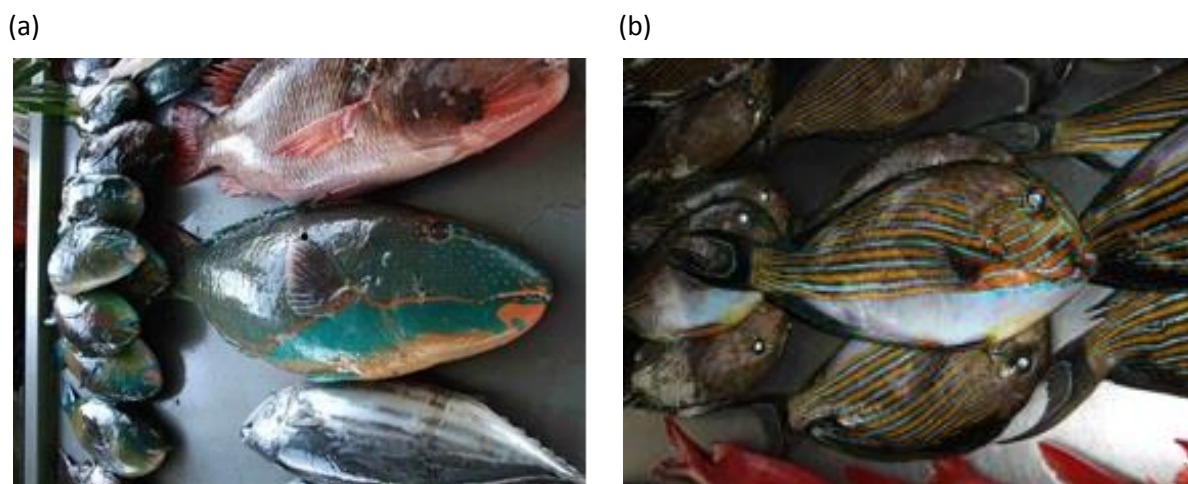


Figure K.2: Fish for sale in Apia market, Samoa. Practically anything caught can be sold.

There is also competition for the resource from bait fishing. The Banggai cardinalfish is known to be easy to catch and this is now being exploited by fishermen who catch it for bait (LINI pers. comm. Interview Nov 2015); the scale of this trade is not known but it is believed to be substantial. The Maldives provide an example of multiple conflicts over resource use, Saleem and Islam (2008) reported that the ornamental fish industry exported 358,578 fishes for the ornamental trade in 2007. This contrasts with the live reef fish food trade where they state that “*Variola louti* (Lunar tailed grouper) and *Cephalopholis miniata* (Vermillion rock cod) which are eaten locally or targets of the live food fish trade are also collected by the aquarium fishery. However, the quantity exported through this trade is insignificant compared to the amount landed at the fish market or exported as live food fish. For example, 23 juveniles of *C. miniata* and none of *V. louti* were exported in the aquarium trade between May and September of 2003. During the same period, 11,888 individuals of *C. miniata* and 12,992 of *V. louti* were exported in the live food fish trade”. The weight of the fishes exported for the live fish trade is not reported but is likely to be in the range of 1 to 2 kg. The combined trade in these two fish is likely to total about 25-50 tonnes compared to the ornamental trade where fishes usually weigh about 2-3 g giving a total export weight of about 717-1,075 kg. This compares with about 3,000-10,600 tonnes of baitfish used annually by the Maldives tuna industry ([FAO Maldivian Tuna Livebait Fishery](#)), which dwarfs any catch by the ornamental industry. FAO also reported extensive damage caused by livebait collection activities. Baitfishing itself can cause damage to the coral reefs, as reported by FAO “*The collection of species, such as Cardinalfishes and Damselfishes, that are closely associated with the corals can be particularly destructive. In such cases the net may be spread over the corals with which the livebait are associated. Any livebait remaining under the net may be chased out using poles, or a 'scarer' (such as a palm frond or a steel chain) on the end of a rope. The livebait are then chased back onto the net. This can result in much coral damage, and in particular branching corals in which livebait shelter may be smashed. In the case of essentially pelagic varieties such as Fusiliers, Sprats and Anchovies the net is generally kept off the bottom, and the livebait are lured into the required position with fish paste, so reef damage is minimal.*”

“Another cause of reef degradation associated with baitfishing is anchor damage. Each pole and line vessel deploys at least two heavy steel anchors while baitfishing. Vessels may move positions several times during the course of one baiting operation. Depending on wind and current directions, the anchors may be deployed on the sandy lagoon bottom or on the coral reef itself. The extent of damage caused in such cases is unknown. However, sometimes many boats from a single island concentrate on one reef to collect bait over a period of days or even weeks. At such times anchor

damage must be significant. Since tuna fishing is becoming concentrated on fewer islands, and vessels are getting larger, this problem may be getting worse."

It should be noted that cardinalfishes and damselfishes are both used in the ornamental fish trade and while the catching of some damselfishes (e.g. *Chromis viridis*) for ornamental use is restricted, substantial numbers are still removed for bait (c. 15 tonnes in 1994).

The livebait industry was explored in more detail by IPNLF (2012) but very little information was given on competition with the ornamental aquarium trade. Generally, the tuna industry uses livebait only for the pole and line fishery and the great majority of fishes used are small, pelagic fishes such as sardines. However, in some places, a wider range of fishes is used which may include some reef fishes of interest to the aquarium trade. The extent of the use of such species varies considerably from one location to another. IPNLF (2012) state that the tuna pole and line fisheries worldwide use in the region of 19-48,000 tonnes of live baitfish per annum and on average, 25,000 tonnes. While this figure is clearly much larger than the global harvest of marine fishes for the ornamental aquarium trade the report does not provide sufficient data to be able to state to what extent the two uses are in conflict. The report only notes two species where conflicting use may occur and both of those are cardinalfishes. The use of these may be significant in some locations, such as Fiji but it is not possible to quantify use based on the information provided.

Ornamental fisheries and their impact

While the ornamental industry, and the marine sector in particular, come in for a lot of criticism, this is often not justified, and the impact of the ornamental trade on natural populations is often exaggerated. In addition, negative changes for habitats and fish populations may be attributed to the collection of organisms for the ornamental trade whereas there may be multiple factors involved for which the ornamental trade may be at most a minor contributor.

Rhine et al. (2012) examined the trade in marine ornamental fish through an analysis of US trade data. A great many species were found to be in trade and they estimated that 11 million marine aquarium fishes comprised over 1,802 species from 125 families were imported from May 2004 to May 2005. However, a relatively small number of species accounted for the bulk of this trade. They also noted inconsistencies between documentation which suggested the actual number of fishes shipped was less than the 11 million indicated on shipping documents and that the actual number might be over-estimated by as much as 27%. The authors used a combination of the number of a species exported and the country from which they were exported (to the US) and concluded that for only a small number of species was the number per country in excess of 1,000 indicating that for the majority of species, the numbers exported from each country are low. In some cases, numbers exported were very low (10 or fewer). While the paper did not make direct comparison to offtake and its impact on the reef, the data indicate that for the majority of species in trade to the US, the numbers are very low and unlikely to make any significant impact on reef populations. It should be noted that some of the species traded in high volume are now provided from aquaculture although this could not be identified from the paperwork examined.

The fishery for the Banggai cardinalfish has been criticised for the impact that it has had on the populations of the fish in its native range. However, recent developments show that the ornamental fish trade is not the only factor involved, with its use as bait having been noted. A recent survey by LINI (Reksodihardja-Lilley 2015) showed an unexpected drop in the population near Lumbia-Lumbia. The sudden decrease in numbers was found to be due to a new initiative in the area for the farming of fish such as groupers in cages and the Banggai cardinal fish were being harvested as food. There is no collection for the ornamental trade in the area and so the reduction in population is assumed to be mainly down to the cage farming development.

Other threats to the Banggai cardinalfish are being discovered. Surveys by LINI showed the almost total destruction of a reef by blast fishing for food fish. LINI also observed over-harvesting of sea urchins and anemones that are important habitats for juvenile Banggai cardinalfish.

Elsewhere in Indonesia, the status of the Banggai cardinalfish is not clear. While it has reduced in numbers in part of its natural range due to a number of factors, including over-harvesting for the ornamental trade, in other parts of Indonesia its numbers have increased. In part, this is due to releases, either deliberately or accidentally. Fish lost or discarded during grading by the ornamental fish collectors and traders appear to be one source of new populations but it was also reported (LINI pers. comm. Interview Nov 2014) that it had been released in some areas popular with tourists, as it is a popular focal species for snorkelers and SCUBA divers due to its habit of not fleeing when approached, making it easy to observe and photograph. Due to these new populations, the Indonesian Institute for Science considers the Banggai cardinalfish to no longer be endangered.

The yellow tang (*Zebrasoma flavescens*) has come in for considerable attention, partly as a result of a campaign to close the ornamental fishery in Hawaii. The yellow tang has a very wide distribution but is abundant in Hawaii, and so features strongly in the ornamental trade there. Over collection for the ornamental trade has been blamed for perceived declines in yellow tang populations. However, the yellow tang, in common with some other reef fish often experiences very poor years for recruitment where an entire spawning class may effectively be missing from the population. In contrast to years when recruitment is low, there can be years when super-abundant recruitment can take place see <http://www.reef2rainforest.com/2014/08/29/biblical-spawning-event-on-hawaiian-reefs/>). This can occur with other reef fishes and can even take place when the spawning stock is relatively low. The conditions required for high recruitment will vary from species to species but the recent very high recruitment of yellow tangs in Hawaii was accompanied by high recruitment of a number of reef fishes of value to the ornamental industry. Any fish that has a prolonged pelagic stage is at risk from adverse currents and adverse environmental conditions. The two-month pelagic phase usually results in very high mortality before settlement on a reef, although it does have the benefit of providing dispersion and thus genetic mixing of populations together with the potential for colonisation of new sites. Yellow tang spawn twice per year and recruitment is variable. While very poor recruitment is seen in some years there may also be bumper recruitment such as was observed in 2014 when super-abundant recruitment was seen. Given the very variable recruitment of such species, it would be difficult to try to pin poor or good recruitment on any single factor.

The Hawaii ornamental fishery was recently reviewed by DLNR (2014) to assess the effectiveness of fishery protection measures that has been put in place, such as the 40 spp. “white list” and the establishment of no take zones, which take up about a third of the coastline. The report notes:

“The Hawai’i marine aquarium fishery is currently the most economically valuable commercial inshore fishery in the State with FY 2014 reported landings greater than \$2.3 million. The West Hawai’i aquarium fishery has undergone substantial and sustained expansion over the past 38 years. Total catch and value have increased by 22% and 45% respectively since FY 2000. Approximately 70% of the fish caught in the State and 67% of value presently comes from West Hawai’i.”

The question was whether this fishery was actually sustainable or whether some species, and the yellow tang in particular, were declining due to over-exploitation by the ornamental fish collectors. The report notes that the yellow tang fishery is particularly important:

“Of the 40 collected aquarium species, Yellow Tang comprise 84.3% of the total and Kole 8.3%. Since the FRAs were established the value of Yellow Tang has increased 79% while Kole have increased 10%. On a price per pound basis, Yellow Tang is the most valuable marine organism in Hawai’i caught in relatively large numbers, exceeding \$250/lb” (IW USD 550/kg).

There is a substantial amount of data on the fishery, collected over a long period of time. This does not indicate that the population is in decline; in fact the reverse appears to be happening:

“The FRAs (Fish Replenishment Areas) have been very successful in increasing Yellow Tang populations. Fifteen years after closure, the population of Yellow Tang has increased 64.5% in the FRAs while its abundance in the Open Areas has not declined significantly. Overall Yellow Tang

abundance in the 30'-60' depth range over the entire West Hawai'i coast has increased by over 1.3 million fish from 1999/2000 to 2012-2013 to a current population of 3.6 million fish."

The FRAs appear to have been very successful not only in providing a refuge for the yellow tang, but by providing excess stock to recruit into areas where the ornamental trade is allowed to collect, have also resulted in an improvement in the resource available to the ornamental industry. Similarly, the FRAs have been shown to result in a substantial increase in the population of Kole. By contrast, the report notes:

"Long-term West Hawai'i studies have found Kole populations to have decreased from 31% in South Kona to 71% in South Kohala. Given the length of protection at these sites and the overall decline in habitat quality and fish populations in South Kohala it seems unlikely that the declines are due primarily to aquarium collecting."

The Achilles tang has declined both in the FRAs and in the areas open to the ornamental fishery, although that fish is also taken as a food fish, which will lead to greater pressure on the population by targeting the larger, spawning fishes. While it is unwise to generalise about such issues due to major variations in population dynamics and ecological conditions in different areas, it can be concluded that the Hawaii ornamental fishery is sustainable and can provide a model that could be adapted and used elsewhere.

An older assessment of the Hawaii fishery by Tissot et al. (2004) showed mixed results for the establishment of Fish Replenishment Areas (FRAs) that are no-take zones. Overall, they found that the number of aquarium fishes seen in transects in the FRAs increased after two years and was much higher than in comparable areas outside the FRAs, especially for the main collected species, the yellow tang. By comparison, fishes not collected for the aquarium trade showed little difference in density either before or after the establishment of the FRAs or inside out outside the RFAs. The authors also noted that there is considerable year to year variation in recruitment and abundance of yellow tangs which suggests that it would be unwise to base assessments on short-term data runs and that a population may recover very quickly as the result of a good recruitment year. In addition, no take zones can increase populations of some aquarium fishes, however year-to-year results can be variable and populations in areas adjacent to RFAs may not necessarily increase at the same time.

The role of marine protected areas (MPAs), such as the FRAs, in boosting recruitment is not as clear as might be expected. While MPAs do generally lead to an increase in fish density both within the MPA and in the surrounding area, the means and extent of this may vary with location and species. Harrison et al. (2012) studied this on MPAs established on the Great Barrier Reef, using genetic tracers to determine the dispersal of larvae from MPAs to the surrounding reef. While their results refer to two species not generally found in the aquarium trade, coral trout, *Plectropomus maculatus* (Serranidae), and stripey snapper, *Lutjanus carponotatus* (Lutjanidae), it is reasonable to assume that the results would apply to any species that have a similar larval dispersal process. Their study showed that the MPA provided larval dispersal up to 30 km away, although they also noted that about 30% of the larvae settled within 1-2 km of the natal MPA. This dispersal is rather less than might have been expected from a dispersal phase lasting several weeks and suggests that the impact of MPAs might be rather local.

Alcala et al. (2005) studied food fisheries in and around two MPAs in the Philippines. Both showed an increase in fish population inside the MPA, however while catches tended to increase outside the MPA, fish populations did not, presumably in response to continued fishing pressure. They concluded that the MPAs supplied excess recruitment, which dispersed outside the MPA and increased fishery yield in adjacent areas.

Jones et al. (1999) pointed out that, while larval dispersal for reef fishes had been assumed, there was actually little evidence either for or against this assumption. The existence of genetically isolated populations and the persistence of populations of fishes with a prolonged larval phase were

taken to indicate that larval dispersal may actually be limited and that at least some fish populations will be self-recruiting rather than relying on recruitment at a distance. They used marked individual of *Pomacentrus amboinensis* to study larval dispersal. The number of marked individuals recaptured was small and most were found near to the area where they had been released indicating that dispersal was limited.

The overall lessons from the above are not obvious. On the one hand the establishment of no-take zones, such as MPAs, can have a positive impact on the ornamental trade by providing additional recruitment for harvesting. An analysis of the conservation and economic benefits would help to show whether harvest foregone by the establishment of MPAs is at least compensated for or even exceeded by increases in catch in adjacent areas. On the other hand, the role of MPAs in boosting recruitment in areas not adjacent to the MPA seems to be at least questionable. If local dispersal is common in reef fishes harvested for the ornamental trade, management at the local level may make sense if populations are likely to be locally recruited.

The ornamental industry is well established in Fiji and has exported fish, corals, invertebrates and live rock for many years. A number of changes have occurred over time but the fishery is still mainly based on small-scale collectors who harvest marine organisms under the traditional *qoliqoli* system of management. This is where sustainability is encouraged by the use of a community-based approach to the allocation of resources and the use of peer pressure to bring any offenders into line if they use illegal methods or overuse a resource. The fishery has been subject to independent evaluation on a number of occasions (e.g. Lovell and Tumuri, 1999, Lovell and Whippy-Morris, 2008, MAC, 2004) and has been found to be sustainable. Lovell and Tumuri (1999) concluded that the collection of live coral products (taken to mean all coral reef organisms) and the collection of live rock were both sustainable, although in some places, the collection of live rock had led to environmental damage. Further work by Lovell and Whippy-Morris (2008) showed that the removal of corals for the aquarium trade was very low accounting for the removal of only 0.0085% of colony numbers and 0.0014% of coral cover, well within the limited of recovery. Lovell and Tumuri (1999) did recommend better management of the fishery and this has to some extent been taken on by the exporters who now operate a stricter programme of self-management (see for example [the Walt Smith sustainable harvest programme](#)). There has also been a shift towards cultured organisms, especially with [coral farming](#) which has not only helped to keep the industry sustainable but has also ensured that the benefits are retained in local communities in Fiji. The MAC (2004) study also concluded that the live rock trade from Fiji is sustainable with adequate management measures in place.

To put this in context, the off-take from the Fiji ornamental fishery can be compared to the artisanal and subsistence fisheries. Wabnitz et al. (2003) estimated that 237,875 marine ornamental fish were exported from Fiji. Assuming each weighed not more than 5g, this would give a total biomass of about 1.1 tonnes. This is tiny compared to the off-take from the subsistence fishery reported by Zeller et al. (2015) of 18,413 tonnes and of 8,973 tonnes for the artisanal fishery. Even the larger quota of about 800 tonnes for live rock appears very low by comparison.

In a report otherwise critical of the aquarium industry, Bruckner (2000) notes *“that Instead of banning coral collection, Australia has developed an effective management strategy designed to ensure sustainability of the resource. Coral reef habitats have been zoned for different uses, including no-take areas. Collectors are licensed, and the collection of coral is permitted only in selected areas that amount to less than 1 per cent of the reefs in a region. Collectors have harvested 45 to 50 metric tons of coral per year for 20 years, with no noticeable impact on the resource.”* There is no reason to assume that the Great Barrier Reef is fundamentally different from other reefs utilised for the aquarium trade and so it may be generally assumed that there is no reason why the aquarium trade should be inherently unsustainable.

The resilience of reef fish populations to withstand fishing pressure is often reported and is related to the relatively high reproductive capacity of some species. Data relating to this is given in Table K.1.

It should be noted that the data in Table K1 are not all current as changes in aquarium technology and especially in breeding have meant some of the species are now easier to maintain and more species are now being bred and reared both privately and commercially. In addition, recent understanding of reef fish breeding and recruitment indicates that recruitment may be more localised than previously thought. However, as a general indication of the ability of reef fishes to withstand collecting pressure, the data still stand as, even where recruitment is localised, the short doubling times ought to ensure that populations recover relatively quickly from any depletion. This may be in contrast to more widespread events such as coral bleaching which are likely to have a longer-lasting, greater impact on reef fish populations.

The Puerto Rico marine aquarium fishery

This fishery has a mixed history and at one time a complete ban was introduced due to a perceived problem of unsustainable use. This was reviewed by Hardin and LeGore (2005). Using the Fisheries Law authorized the Department of Natural and Environmental Resources (DNER) to introduce a ban on the harvesting and export of ornamental aquatic organisms from marine areas around Puerto Rico but, as this was carried out without consultation and was also perceived to not be based on scientific evidence, the collectors challenged this decision in the courts and the courts found in their favour. Subsequent efforts by DNER to enforce the new regulations and introduce a new licensing scheme were also deemed to be unlawful and, in the end, a review of policy towards the industry was commissioned. New quotas and regulations were imposed by the courts that were more in the fishermen's favour. The policy review was conducted and reported by LeGore et al. (2005) who stated:

"Two primary issues can therefore be described, the first of which provides the immediate objective for the recently completed Phase I characterization study of this fishery."

"Issue 1: The DNER lacks data on the subject resource, as well as basic understanding of the ornamental capture and export business, needed to evaluate the real impact of this activity, to make decisions on the wisest and sustainable use of this marine resource, and in general to develop effective management policy for this marine resource given to its care by law. Despite its lack of information, the DNER, believing that reef fish and invertebrate populations and their habitats were under significant threat from the ornamental trade, and acting within its understanding of existing law and fisheries management policy, prohibited the activity without the stakeholder consultation that might have led to greater acceptance of its actions by the affected groups, and leading to the second issue."

"Issue 2: Trust and communication between the DNER and fishermen is at such a low state that the consultation and dialogue needed for effective policy will not take place without some practical remedy."

Table K.1: Data on the ability of reef species to withstand fishing pressure and adapt to aquarium life.

Species	No. individuals imported into the EU (2001)	No. range states (distribution)	Minimum population doubling time	Species resilience	Captivity	Comments
<i>Pseudanthias squamipinnis</i>	7,424	31	1.4 – 4.4 yrs	Medium	Durable and hardy in captivity	Spawned but not reared in public aquaria.
<i>Pterapogon kauderni</i>	8,209	1	1.4 – 4.4 yrs	Medium	Species thrives in captivity	Limited distribution. Status in the wild is precarious due to heavy collection. There have been reports of <i>P. kauderni</i> being collected to feed food fish in its natural habitat and use of explosives for food fish collection ¹ . It is also worth noting that, in recent years, imports for the ornamental industry in the UK in this species is mostly sourced from aquaculture (i.e. captive-bred) ²
<i>Amphiprion clarkii</i>	2,551	25	1.4-4.4 yrs min	Medium	Very hardy in captivity, readily acclimating to aquaria.	One of the most common and durable anemonefishes in trade. Being propagated in public aquaria for research.
<i>Aphiprion ocellaris</i>	23,248	14	< 15 months	High	Captive-bred individuals due well in aquaria	Abundantly bred in captivity. Being propagated in public aquaria for research.
<i>Chromis viridis</i>	38,437	33	< 15 months	High	Durable and hardy	In the Maldives, this fish is primarily used as bait ³

¹ Reksodihardjo-Lilley, G. February 2015. What has happened to the Banggai Cardinalfish in the Banggai Islands, Sulawesi? OFI Journal 77: 8-11pp.

² Reference pending – comment submitted by TMC Feb 17, 2015 in response to NOAA proposed rule: Endangered and Threatened Wildlife and Plants: 12- Month Finding for the Eastern Taiwan Strait Indo-Pacific Humpback Dolphin, Dusky Sea Snake, Banggai Cardinalfish, Harrison’s Dogfish and Three Corals.

³ Saleem and Islam (2008)

<i>Chrysiptera cyanea</i>	13,563	20	< 15 months	High	Very hardy	
<i>Chrysiptera hemicyanea</i>	2,315	8	< 15 months	High		
<i>Chrysiptera parasema</i>	14,490	6	< 15 months	High	Very hardy	
<i>Chrysiptera taupou</i>	4,167	5	< 15 months	High	Very hardy	
<i>Dascyllus trimaculatus</i>	9,937	52	1.4-4.4 yrs	Medium	Very hardy	
<i>Pomacentrus coelestis</i>	2,971	24	< 15 months	High	Very hardy	Probably the most common and widespread damsel.
<i>Labroides dimidiatus</i>	11,642	50	1.4-4.4 yrs	Medium	Do not acclimate to home aquaria. Extremely sensitive to transport. High mortality rate in captivity.	Important for productivity of fishing grounds centred in tropical coral reefs.
<i>Pseudocheilinus hexataenia</i>	4,893	47	< 15 months	High	Very hardy	
<i>Salarias fasciatus</i>	3,040	25	1.4-4.4 yrs	Medium	Durable and hardy	
<i>Synchiropus splendidus</i>	6,924	10	< 15 months	High	Do not acclimate to home aquaria.	
<i>Valenciennesa puellaris</i>	3,834	29	1.4-4.4 yrs	Medium	Difficult to keep in aquaria	

<i>Valenciennea strigata</i>	6,565	36	1.4-4.4 yrs	Medium	Do not acclimate to home aquaria.	
<i>Nemateleotris magnifica</i>	7,597	32	< 15 months	High	Very hardy	
<i>Acanthurus leucosternon</i>	3,305	19	< 15 months	High	Moderately hardy. Relatively sensitive to aquarium conditions.	
<i>Paracanthurus hepatus</i>	8,583	33	1.4-4.4 yrs	Medium	Moderately hardy. Relatively sensitive to aquarium conditions.	

Data adapted by OATA from Review of Marine Ornamental Species (UNEP/WCMC, Dec. 2004)

LeGore et al. (2005) also described the current state of the aquarium fishery. They found only 16 licensed operators of whom two were inactive; four more permits were in the process of being approved which would have brought the total to 20. The fishermen estimated that there were 20-25 fishermen involved in the industry. The fishermen tended to not operate on the reef for several reasons. They found the nets they used tended to tangle on the reef and get damaged and they also sought to avoid conflict with tourist boat operators taking divers to the reef. The nets used are fine-meshed barrier nets into which small fish can be driven and temporarily entrapped, enabling them to be caught. Fish are then transferred to bags or buckets for transport to the surface or shore. All these activities can be judged as being low-impact. The authors reported that they saw no evidence of intoxicants being used. Fish and other organisms were collected to order. The authors reported exports of 88,404 fish over a period of three years with a value of USD 202,000 so the fishery is small-scale. Interestingly, the authors concluded that *“interviews conducted with stakeholders in potentially conflicting resource uses such as other fishermen, dive tourism operators, recreational divers, and relevant NGOs revealed few if any real conflicts. The single report of destructive collecting practices was unclear, and cannot be attributed to operators of the marine ornamentals export fishery.”*

The first stages of the development of better policy and management options for the aquarium fishery were outlined in LeGore et al. (2006) who reported on the populations of target organisms for the aquarium trade and the impact of the fishery on those populations. Based on surveys of the two main collecting areas and recorded catches by the fishermen, the authors concluded that off-take was generally less than 1% of the population for fish and was at sustainable levels. For invertebrates the off-take was also generally much less than 1% with two exceptions, neither of which was thought to be in danger of over-exploitation. The authors provided a *caveat* that their surveys may have underestimated population levels and that some areas not surveyed would also hold populations of the target organisms and thus the effective exploitation rates would be even lower. They recommended that quotas be based on surveys in the future.

Rio Negro cardinal tetra fishery

Approximately 12-13 million cardinal tetras are exported annually from Manaus at the moment. The figure was higher in the past, possibly as high as 30 million per annum at the peak, although export statistics are not reliable for some years. This might appear to be an extremely large number of cardinal tetras, which may lead to the sustainability of the fishery being brought into question. However, the fishery shows no sign of depletion and in only one instance has a reduction in catches been observed and that was resolved by a voluntary suspension of harvesting. The cardinal tetra is a small but fecund fish, which is capable of producing as many as 1,000 eggs in the spawning season. It appears to act as an annual fish with the great majority of fishes dying each year as the floodwaters retreat, leaving many fishes stranded in drying streams and small ponds in the forest. Exactly where adult cardinals go in years of extreme drought is not known, but they must find refuge somewhere as the population rebounds very quickly once flooding occurs. The catching cycle follows the reproductive cycle with most cardinals being caught as the floodwaters recede, concentrating the new cohort of fish. At the peak of the floods, the fish are highly dispersed in the forest and difficult to catch. A rough calculation suggests that a relatively small amount of the cardinal tetra biomass is removed by the ornamental fishery in any year.

- The Rio Negro basin has an area of 691,000 km²
- The Rio Negro floods from Manaus for about 650km upstream, a distance not far upstream from Santa Isabel. The river floodplain extends to about 30km in width at its peak. Obviously, not all of this creates cardinal tetra habitat, but much of it will be available to them for growth and recruitment;

- This leads to a floodplain of 19,500 km² at the peak;
- The average weight of a cardinal tetra at the sizes exported is about 0.2 g; thus 12 million cardinals would weight about 2,400 kg. This represents an off-take of only 0.12 kg/km² over the whole floodplain.

Even if the actual area available to the cardinal tetra is far less than 19,500 km² and even if mortality is taken into account, the actual biomass removed is clearly very small compared to the total population. It should also be taken into account that much of the cardinal tetra population is not available to *piabeiros* for logistical reasons (e.g. too remote, too difficult to reach, no buyers in easy reach).

Despite many years of study, little is known about the population dynamics of the cardinal tetra. However, it is likely to be similar to that of *Hyphessobrycon eques*, which was studied by Penha et al. (2015). In a way similar to the cardinal, this tetra lives in an area subject to an annual flood/drought cycle and breeds in the early flood season. This leads to a rapidly expanding population that spreads out with the floodwaters onto the surrounding floodplain and into small lakes, rivers and streams. Penha et al. (2015) found that the species suffers high mortality in the drought season as the waters recede and food becomes limiting. This was viewed as being density-dependant survival (i.e. the number of fish that survive the drought is more dependent on the number of fish and the area remaining under water than on other factors). Typically, more than half the fish failed to survive the drought. Furthermore, fish often suffered 100% mortality in some areas and yet neither factor seemed to have much effect on the next wet season population. Populations of these types of fish that are subject to extreme environmental fluctuations and which have (for their size) relatively high fecundity seem to have great resilience and there is a substantial surplus population available for harvesting.

Comparison with the catches of the food fish industry are hard to make due to lack of data and there appears to be no information on how much communities on the Rio Negro rely on subsistence fishing (Figure K.3). There is some information about landings at Manaus, which provide some indication of the biomass removal from the Rio Negro. However, it should be borne in mind that these total exclude fish landed at major towns along the Rio Negro, such as Barcelos and Santa Isabel, and exclude any catches at villages and the household level (Table K.2).



Figure K.3: A selection of the freshwater fish on sale at Manaus fish market. The quantity of fish sold on any day at Manaus fish market dwarfs anything taken for the ornamental fish trade.

Table K.2: Fish landings at Manaus. Data adapted from Batista and Petrere (2003).

	Year		
	1994	1995	1996
Total landings at Manaus (tonnes)	25,054	22,322	23,589
% of catch from Rio Negro	4.9%	3.2%	4.7%
Landings from Rio Negro (tonnes)	1,127	714	1,104

No data are available for cardinal tetra exports in 1994 and 1996, however 17,506,800 were exported in 1995 (Chao, 2001). Using the previous conversion rate of 0.2g per cardinal that equates to about 3,500 kg or only c. 0.5% of the biomass extracted as food fish.

The clown loach

Although the data are somewhat dated, Kottelat and Whiten (1996) reported on the long-term stability of the clown loach fishery in Indonesia. This is a dual use fish besides being used as food and some species are collected for the aquarium fish trade. *The main species in this trade in Indonesia is the clown loach Botia macracanthus.* According to Aglionby (1995) “*This is possibly the most important wild-caught pet fish of the world, in terms of biomass, with an estimated 10,000,000 exported per year (pers. data). Field surveys in Danau Sentarum indicate that some 2,400,000 are caught annually; until 1995 provincial statistics report only about 50,000 to 300,000 individuals. Obviously, the economic viability of this massive pet trade depends upon the stability of biodiversity and the integrity of the ecosystem.*” Much of this trade is now supplied from farmed sources but, as reported elsewhere (see Fishing Methods, Traps), the species is still abundant in the wild indicating that even the previous higher level of off-take had no long lasting impact on the population.

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