The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA)

Guidelines for Ornamental Fish Sampling, Data Collection and Analysis of the Aquarium Fish Trade

Jeddah, 9-15 April 2002

Trainer: Dr. Alasdair Edwards

PERSGA Training Workshop Report

2002 **Number 2**

PERSGA, "The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden", is an intergovernmental organisation dedicated to the conservation of the coastal and marine environments in the region. The Organization was officially established in 1995.

Since December 1998, PERSGA has been the executing agency for The Strategic Action Programme for the Red Sea and Gulf of Aden (SAP). This Programme is funded jointly by the member countries of PERSGA, the Global Environment Facility (GEF) and the Islamic Development Bank. The GEF implementing agencies include the United Nations Development Programme, the United Nations Environment Programme, and the World Bank.

Acknowledgements

This training course was executed under the PERSGA/SAP LMR component and was organised by Dr. Mohamed Abdallah, LMR Lead Specialist who collaborated closely with Dr. Alasdair Edwards in the preparation of the course agenda and in setting up and actively participating in the field visits and practical monitoring exercises.

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ABSTRACT

This report provides a summary of a PERSGA Training Workshop that focussed on suitable guidelines for ornamental fish sampling, data collection and analysis of the aquarium trade in the Red Sea and Gulf of Aden region. The main objectives of the course were to train participants in methods of sampling, data collection and analysis of ornamental fish populations and to introduce them to the methods used and the regulations affecting the collection and trade of ornamental fish. The training included lectures, field studies (including visits to a company dealing in ornamental fish), and data analysis.

Printed in October 2002

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EXECUTIVE SUMMARY

Dr. Alasdair Edwards conducted a participatory training workshop to teach techniques for ornamental fish sampling, data collection and analysis of the aquarium fish trade. It was held at the Second Sub-regional Research and Training Centre at the Faculty of Marine Science of King Abdul Aziz University, Jeddah from 9-15 April 2002.

The workshop objectives were to:

1. Collect data from ornamental fish exporting companies in the Jeddah area on fish collection, holding facilities and export practices.

2. Train participants in the identification of marine aquarium fish species in the Red Sea and Gulf of Aden with special consideration to biological factors which make species vulnerable to over collection or contribute to poor survivorship in captivity.

3. Train participants in methodologies for the collection and analysis of export data on aquarium fish.

4. Train participants in sampling methodologies suitable for the collection and analysis of field data that can be used to monitor the impacts of the aquarium fish trade.

Twenty-three participants from Djibouti, Egypt, Jordan, Saudi Arabia, Somalia, Sudan and Yemen attended the workshop. Country reports from Egypt, Jordan, Saudi Arabia and Yemen were presented (Annexes 7-10).

Participants were trained in identification of marine aquarium fish species in the Red Sea and Gulf of Aden through a series of illustrated presentations accompanied by self-test quizzes (Annex 5). They were also alerted to issues of endemism, survivorship in captivity, ecology, rarity, etc, which influence the suitability of fish species for the aquarium trade.

In order to develop participants' understanding of the marine aquarium fish trade, they were taken to Thowal to see fish being collected by trained collectors, to visit holding facilities and given a demonstration on methods used to pack fish for export. An illustrated slide presentation from the Issham International aquarium fish exporting company was also given to show the high technology and labour-intensive husbandry required to maintain optimal health of the fish in the holding facilities.

The Marine Aquarium Council (MAC) approach to certification of the marine aquarium trade, and their Core Standards (Annex 6) on:

1. Ecosystem and Fishery Management (EFM)
2. Collection, Fishing and Holding (CFH) and
3. Handling, Husbandry, and Transport (HHT)

were introduced to the participants. Each core standard was discussed within a regional context and the workshop made three recommendations to MAC:

1. That a requirement to provide annual collector/fisher effort data for each collection area is included as a component of the Collection Area Management Plan,

2. That the Dead on Arrival (DOA)/Dead After Arrival (DAA) 1 % level requirement be reviewed,

3. "Optimal health" is redefined in a manner consistent with reality and current best practice.

Use of upcoming MAC Full Standards and Best Practice Guidance, and MAC certification of companies involved in the marine aquarium trade are advocated as the optimum approach to management of the trade in the region.

To train participants in methodologies for the collection and analysis of export data on aquarium fish, they were given export data to study from three sources: the Global Marine Aquarium Database (GMAD) of the World Conservation Monitoring Centre (UNEP-WCMC) and from two Saudi Arabian exporting companies. The inconsistencies and errors in scientific and common names between different sources were emphasised and the need for standard *pro forma* lists of species for each country was outlined. A specimen p*ro forma* list was developed for recording annual export data from the Red Sea and Gulf of Aden.

Training in sampling methodologies for collection and analysis of field data, and reporting for monitored impacts of aquarium fish trade was divided into two parts. Each part addressed a different scientific question. The two questions were:

1. Are populations (numbers) of those fish species targeted by the aquarium trade declining in an unsustainable way as a result of collection for the aquarium trade?

2. Are collecting activities of the aquarium trade adversely impacting the coral reef ecosystem in other ways?

Overall design and sampling methodologies for monitoring aquarium fish

A stratified sampling scheme with replication at all levels was developed which involves three pairs of sites in each country (each pair consisting of one collected site and one comparable uncollected site). For each site a minimum of three 100 m transects (length determined after pilot monitoring study by participants) are laid and then a sample of approximately 40 key aquarium fish species (list developed in a workshop session) are counted in a 2.5 m band either side of the transect. This allows numbers/1000 m^2 of each key fish species present to be assessed in the collected and comparable uncollected sites so that deleterious impacts on fish stocks can be detected. Three approaches were described that can be used to assess sustainability or detect declines in target fish numbers.

Sampling methodologies for monitoring the impacts on coral reefs resulting from fish collection activities were trialed by the participants. A random quadrat methodology was adopted which involves laying 20 x 1 m^2 quadrats randomly throughout each 5 m wide fish monitoring transect. This allows percentage cover of live hard coral, specifically live branching coral cover and other principal substrates to be assessed reproducibly at each site. This methodology allows both potential impacts of aquarium fish collection on live coral cover and comparability of paired sites to be assessed. Pilot monitoring showed that the methodology works well with training and delivers robust data.

INTRODUCTION

The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA) is executing a Strategic Action Programme (SAP) funded by the World Bank, United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP) and other donor organisations.

The SAP was prepared following an extensive analysis of regional environmental issues and has been endorsed by the PERSGA Council of Ministers. The SAP provides a co-operative framework for the longterm conservation and management of the coastal and marine resources of the Region. A programme of activities is being carried out through a number complementary components including:

1. Sustainable use of living marine resources

2. Conservation of habitats and biodiversity

3. The establishment of marine protected areas

4. The promotion of integrated coastal zone management

5. The enhancement of public awareness and participation (HARIRI et al., 2000).

This training course was conducted through the Living Marine Resources (LMR) component. The aim of the course was to teach local specialists to be able to conduct surveys on the status of ornamental fish collecting activities and assess the impact of the aquarium fish trade on the coral reefs of the region. Preliminary studies on the aquarium fish trade have been conducted by ABDALLAH (2000), ABDUL GHANI & GAZZAZ (2000) and BARRANIA (2000).

Course Objectives

The Participatory Training Workshop on Guidelines for Ornamental Fish Sampling, Data Collection and Analysis of the Aquarium Fish Trade was conducted by Dr Alasdair Edwards at the Second Sub-regional Research and Training Centre at the Faculty of Marine Science of King Abdul Aziz University, Jeddah on 9-15 April 2002.

The objectives were:

1. To collect data on ornamental fish collection practices, holding facilities and export practices from ornamental fish exporting companies in the Jeddah area of Saudi Arabia.

2. Train local participants in:

    2.1. Identification of marine aquarium fish species in the Red Sea and Gulf of Aden with special consideration of biological factors which make species vulnerable to over collection or contribute to poor survivorship in captivity

    2.2. Methodologies for the collection and analysis of export data on aquarium fish

2.3. Sampling methodologies for the collection and analysis of field data, for monitoring the impacts of the aquarium fish trade.

The ultimate goal of the training course was to promote sustainable use of marine aquarium organisms. Twenty three participants from Djibouti, Egypt, Jordan, Saudi Arabia, Somalia, Sudan and Yemen attended the workshop (Annex 1). The workshop schedule is included as Annex 2.

Course Description

The workshop consisted of formal lectures, laboratory sessions on identification of fish species (including self–test quizzes), data analysis training, field work, a field trip to Thowal to see collecting, holding and packing facilities and a slide presentation to demonstrate husbandry methods.

WORKSHOP

TRAINING SESSIONS

The international context for management, and structure of the report

The international status of the marine aquarium trade was outlined as this has a bearing on future management. The total annual import value of marine aquarium organisms is estimated at around US$28-44 million with some 14-30 million fish being caught each year (WOOD 2001). In individual countries however, the marine aquarium trade tends to be economically insignificant compared to other marine resource based sectors such as food fisheries and tourism. Thus governments are unlikely to divert significant resources to monitoring and regulating the trade. This makes the trade vulnerable to environmental concerns. The trade itself is generally positive about efforts at self-regulation.

The Marine Aquarium Council (MAC) has been set up with the support of international conservation agencies and the aquarium industry as an independent non profit making NGO. The aim of MAC is to conserve coral reefs by creating standards and certification for those involved in the collection and care of ornamental marine life.

MAC has produced three *Core Standards* that cover all aspects of the marine aquarium trade. These *Core Standards* will be followed in 2003-2004 by *Full Standards* and *Best Practice Guidance* documents. These documents, if developed properly and in a realistic manner, will provide a clearly defined management framework for the marine aquarium trade. Essentially the management and regulation will be undertaken by MAC. If collectors and exporters are required to be MAC certified the theory is that the authorities in each country can rest assured that best practice is being followed and the trade is sustainable. This minimises the government resources that need to be deployed to regulate this relatively insignificant economic sector, whilst achieving the goal of sustainable use of the marine resources being collected for the aquarium trade.

Support for the MAC approach, use of upcoming MAC *Full Standards* and *Best Practice Guidance,* and MAC certification of companies involved in the marine aquarium trade are advocated as the optimum approach to management of the trade in the region.

Three sessions were held to ensure that participants in the workshop were fully aware of the *MAC Core Standards* and the MAC approach to certification. The three *Core Standards* were presented to participants and discussed with particular attention to their applicability in a regional context. The results of these sessions are outlined in the *Marine Aquarium Council* section below.

To support MAC activities the World Conservation Monitoring Centre (UNEP-WCMC) is developing a Global Marine Aquarium Database (GMAD) with data on the world trade in marine aquarium organisms. As of March 2002 the database held limited data from Saudi Arabia and Egypt (Annex 3). This was developed during the workshop with the help of the representatives of the Saudi Arabian ornamental fish companies. A list of scientific, trade and English common names of the principal fish species targeted by the marine aquarium trade in the Red Sea and Gulf of Aden was produced (Annex 4). Details of the development of this *pro-forma* list of species exported from the region are given in the section on *Methodologies for the collection and analysis of export data on aquarium fish.*

At the root of monitoring, both from the export data and the field data, is the ability to be able to identify the fish species being traded with confidence and to know aspects of their ecology that may influence their suitability for maintenance in aquaria. Thus a key aim of the training workshop was to develop the fish identification skills of the participants with a focus on those species exported for the marine aquarium trade. To this end four fish identification sessions were held each followed by a quiz to reinforce the knowledge gained. Details of these sessions are given in the section *Identification of marine aquarium fish species in the Red Sea and Gulf of Aden*.

As a basis for managing an industry, one must have a good understanding of how it operates. So another key aim of the workshop was to develop the participants' understanding of the aquarium fish industry from collection on the reef to export from the airport. To this end representatives from the four main ornamental fish companies in the Jeddah area (Issham International, Softa Marine Export, Red Sea Secret, and Coral Reef Company) were invited to the workshop.

These representatives were very helpful, allowing participants

1. To witness fish collection methods in the field at Thowal

2. To visit holding facilities of the Coral Reef Company at Thowal

3. To have a demonstration on methods of fish packing for export

4. To attend an illustrated lecture on the activities of Issham International from collection to export, showing the high technology involved in holding facilities, and the best practice followed to ensure good husbandry and thus survivorship of collected fish.

These sessions and the inputs from the ornamental fish industry representatives were central to the success of the workshop. Further details of these sessions are given in the section *Understanding the marine aquarium fish trade*.

Once participants had developed their fish identification skills and had an understanding of those species that are important to the ornamental fish trade, it was possible to discuss how one might select key species for a monitoring programme. In a workshop session, some 40 key species were selected for monitoring. Pilot monitoring was conducted by more experienced participants using the full 40 species, less experienced participants used a subset of 10 species. Once the key species to be monitored had been selected, a robust monitoring strategy for the region could be developed. The details of the development of this field monitoring strategy are described in the section *Sampling methodologies for collection, analysis and reporting of field data for monitoring the impacts of the aquarium fish trade*.

Identification of marine aquarium fish species in the Red Sea and Gulf of Aden

Four sessions were carried out to train participants in the identification of fish species that are important to the marine aquarium trade. Each session consisted of a presentation of photographs of the principal species involved in the trade. Fish were arranged in families with pointers being given to key identification features and aspects of ecology which might influence whether the species should be traded (diet e.g. obligate corallivore, cleaner, piscivore; size e.g. grows rapidly to large size; endemism and rarity). Each participant was provided with a copy of *Red Sea Reef Fishes* (RANDALL 1983) which remains the best overall reference for Red Sea and Gulf of Aden reef fishes, although the nomenclature is slightly out of date. See - Presentations on fish identification (Annex 5).

Identification of aquarium fishes 1:

Discussion of endemism in the region which approaches 20 % for coral reef fish species; identifying 34 species of damselfishes (Pomacentridae), butterflyfishes (Chaetodontidae), angelfishes (Pomacanthidae), triggerfishes (Balistidae) prevalent in the marine aquarium trade. (Quiz 1: identification of the 12 most important species in the aquarium trade from these 4 families).

Identification of aquarium fishes 2:

Identifying 27 species of surgeonfishes (Acanthuridae), dottybacks (Pseudochromidae), pufferfishes (Tetraodontidae), moray eels (Muraenidae), boxfishes (Ostraciidae), blennies (Blenniidae), Groupers and anthias (Serranidae) prevalent in the marine aquarium trade. (Quiz 2: identification of the 12 most important species in the aquarium trade from these 7 families).

Identification of aquarium fishes 3:

Identifying 28 species from the wrasse family (Labridae) prevalent in the marine aquarium trade. (Quiz 3: identification of the 9 most important wrasse species in the aquarium trade).

Identification of aquarium fishes 4:

Identifying 21 species of parrotfishes (Scaridae), scorpionfishes (Scorpaenidae), goatfishes (Mullidae), gobies (Gobiidae), cardinalfishes (Apogonidae), eel catfishes (Plotosidae), etc. prevalent in the marine aquarium trade. (Quiz 4: identification of the 9 most important species in the aquarium trade from these 12 families).

Species which need special consideration:

Some species may require special consideration owing to:

1. Poor survivorship in captivity (e.g. easily stressed, obligate corallivores, release toxins)
2. Easy over-exploitation (rare, endemic)
3. Collateral damage caused by collection (species which shelter in branching coral)
4. Ecological concerns (cleaners)

The types of special treatment that might be envisaged are:

1. Exports being banned
2. Species-specific quotas
3. Export only being allowed to public aquaria
4. Careful monitoring of either numbers collected, collection effort, or numbers per unit area on the reef in collected and comparable uncollected areas

The Marine Aquarium Council (MAC) has a sub-committee of its MAC Standards Committee which will identify species which are inappropriate to be collected, handled, or transported by anyone seeking MAC certification. Export of such species should be banned.

Species in the region identified as not suitable for normal marine aquaria:

1. Exquisite butterflyfish, *Chaetodon austriacus*
2. Arabian butterflyfish, *Chaetodon melapterus*
3. Chevroned butterflyfish, *Chaetodon trifascialis*
4. Bluetail trunkfish, *Ostracion cyanurus*

The first three species are corallivores that tend to die after a few months in captivity unless they are kept in large aquaria containing live corals on which they can feed. Many responsible companies already refuse to import such species unless specially ordered for large public aquaria where they can survive. The final species apparently releases potent toxins into the water killing any other species in the same aquarium. There seems to be significant export of *Chaetodon austriacus* from the region despite its unsuitability. MAC certification would presumably not allow export of this species.

Species in the region where some concern has been expressed about suitability for normal marine aquaria:

1. Orange-faced butterflyfish, *Chaetodon larvatus*
2. Regal/Royal angelfish, *Pygoplites diacanthus*

Chaetodon larvatus feeds largely on branching coral polyps and is a difficult species to keep in aquaria. It is likely to have low survivorship in the average marine aquarium and is a species that needs to be carefully assessed by MAC. One of the ornamental fish companies indicated that they had reports of poor survivorship of *Pygoplites diacanthus* and did not recommend this species to customers despite the demand for it. This species should also be assessed carefully by MAC for its suitability for aquaria.

Certain species, such as lionfishes/turkeyfishes (*Pterois*), some angelfishes (*Pomacanthus imperator, P. maculosus*), and some triggerfishes (*Rhinecanthus assasi, Balistoides viridescens*), although quite common in that one is likely to encounter them on most dives, are present at relatively low densities. They could be over-collected locally by the marine aquarium trade. Numbers of such species need to be monitored in some way (catch and effort data or direct observation) to ensure that over-collection does not occur.

Evidence presented by the Egypt Country Report (Annex 7) suggests over-collection of two angelfish species by the Egyptian Company for Fishing (government-owned sole-licensed collector for the country) may be occurring in the Gulf of Aqaba. Where species are endemic to the Red Sea and Gulf of Aden, or the Arabian peninsula as a whole (see *Concerns* column in Annex 4), the over-collection is potentially more serious. It is highly unlikely however, that a significant percentage of the species range is likely to be subject to aquarium fish collection.

Ecosystem health and ecological issues focus primarily on the collection of cleaner wrasse. If cleaner wrasse such as *Labroides dimidiatus* and *Larabicus quadrilineatus* are over-collected, the parasitism loads on larger fish (many of them commercial importance as food fish) could potentially increase with adverse consequences. Thus levels of these species need to be monitored to ensure they are not over–collected.

Another potential, lesser worry centres on triggerfishes, some species of which are known to feed on the Crown-of-thorns starfish, *Acanthaster planci*. Any significant decrease in the populations of these predators of Crown-of-thorns is seen as likely to be detrimental. However, other factors are considered to trigger Crown-of-thorns outbreaks which occur equally in places without any aquarium fish collection.

A highly unlikely impact of aquarium fish collection which some have expressed concern over is the over-collection of herbivores (e.g. Acanthuridae, surgeonfishes) leading to algal dominance on reefs which are already damaged by coral bleaching. This seems a far-fetched scenario given the density of grazers in the wild and the relatively low numbers of such species collected for the marine aquarium trade.

The final issue raised is collateral damage to the coral reef. This centres on destructive fishing practices. MAC certification should prevent such practices if their ban is properly enforced. The main problem relates to the collection of small fishes such as *Dascyllus, Chromis*, and *Pseudanthias* that take shelter in branching corals when under threat. As indicated by WOOD (1985), some collectors destroy the corals to get the fish out. Yemeni participants indicated that collectors there would blow a jet of air into such corals to eject the fish into dip-nets. They suggested that air jets could be of such force as to strip the soft tissues from the coral skeleton causing at least partial death of the colony. Such impacts could be detected by long-term monitoring. Again the impacts of coral bleaching and Crown-of-thorns outbreaks are likely to far exceed any from aquarium fish collection, but the latter impacts are needless and should not be allowed.

Marine Aquarium Council

The Marine Aquarium Council (MAC) *Core Standards* were introduced to the participants, as was the concept of *Chain of Custody* that permeates MAC certification.

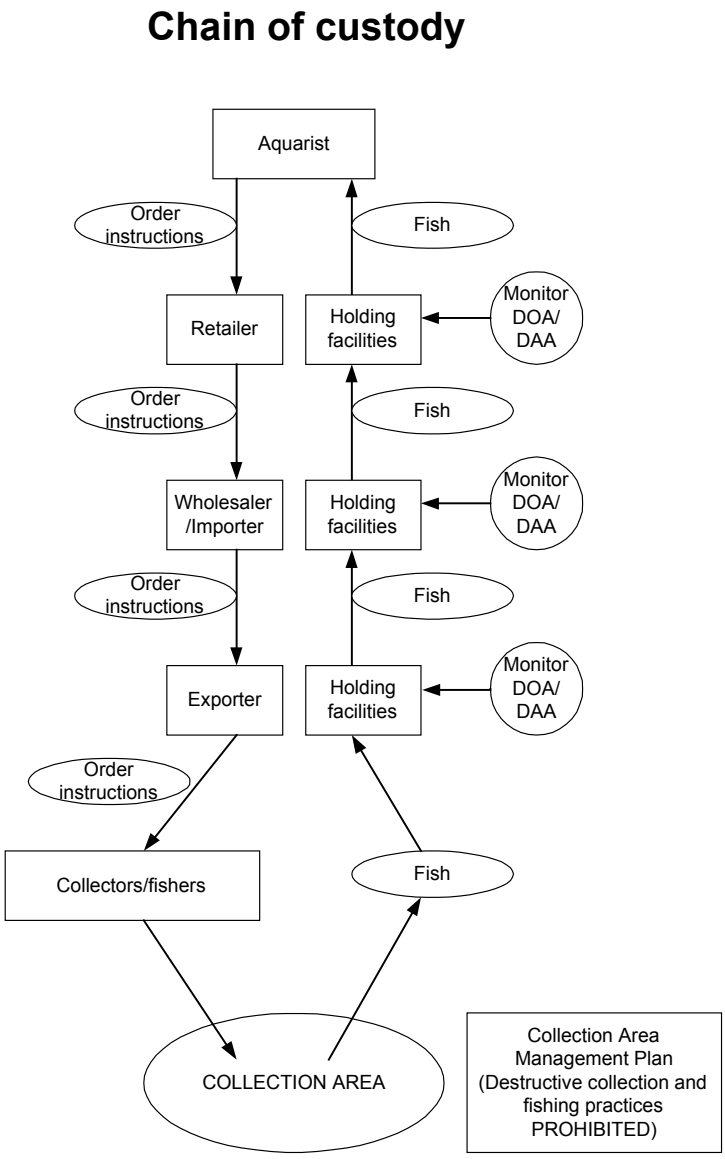

Figure 1. Diagram to show concept of a simple MAC Chain of Custody.

Each of the three MAC Core Standards were introduced and discussed. They are:

1. **Ecosystem and Fishery Management (EFM):** including collection, area ecosystem management and conservation.

2. **Collection, Fishing and Holding (CFH):** including fish, coral, live rock, other coral reef organisms, and associated harvesting and related activities, e.g. field handling and holding practices, etc.

3. **Handling, Husbandry, and Transport (HHT):** including holding, husbandry, packing, transport, etc. at wholesale, retail, and all other components of the industry not covered by EFM and CFH standards.

The first two Core Standards essentially cover aquarium fish collecting, holding and export activities that occur in the region. The third relates to the chain of custody from exporter to retailer but is still relevant in that MAC certified fish must complete the full chain of custody under MAC certification requirements.

Each Core Standard (Annex 6 to this document) contains identical sections on: MAC Standards Review and Committees Responsible for this Standard, Foreword, Introduction, Scope, Terminology, Definitions, Bibliography, Annex 1 – Contents of a Collection Area Management Plan, Annex 2 – MAC Approved Training Courses, Annex 3 – MAC Approved Chemical Detection Methods and Providers, and Annex 4 – MAC Unsuitable Species.

Some 2–6 pages of additional information define each core standard. The definitions section is crucial in terms of evaluating the feasibility of the proposed standards.

MAC Core Standard I: Ecosystem and Fishery Management (EFM):

Purpose: To verify that the collection area is managed according to principles of ecosystem management in order to ensure ecosystem integrity and the sustainable use of the marine aquarium fishery.

Collection area: for MAC certification purposes, is the physical space covered by the Collection Area Management Plan.

Sustainable use: collection of marine aquarium organisms does not lead to long-term decline of biological diversity.

Particularly relevant to the training workshop was the concept of defined collection areas for which defined Collection Area Management Plans (CAMPs) are implemented. These CAMPs seek to ensure sustainable use of the aquarium fish resources. Ornamental fish companies are already granted permits to collect in certain designated areas in Saudi Arabia, MAC certification would extend the information made available from collection sites as well as improving the management of those sites. The MAC aims and management principles of promoting sustainable use of marine aquarium resources were fully supported by the workshop participants. The need to define precisely what monitoring was required was noted. How the monitoring required would be paid for remains unclear. Overall, Core Standard I was considered relatively uncontentious with broad support for making sure collectors were properly trained and recognition that there was a need to demonstrate that the industry was environmentally responsible.

The workshop identified that item 3.1.4 in the CAMP ("basic annual catch data for the marine aquarium organisms collected or fished in the collection area") would produce data of little value unless accompanied by effort data such as number of collector hours spent collecting in each collection area.

Recommendation to MAC*:* that a requirement to provide annual collector/fisher effort data for each collection area is included as a component of the Collection Area Management Plan.

MAC Core Standard II: Collection, Fishing and Holding (CFH):

Purpose: To verify that the methods of collection, holding, pre-export handling, packing, and transporting of marine aquarium organisms do not impinge on the ecosystem integrity in the collection area, and to ensure optimal health of the harvested organisms.

Optimal health: Dead On Arrival (DOA) and Dead After Arrival (DAA) at each and every stage in chain of custody <1 %.

Discussion of Core Standard II centred on the definition of optimal health. There was some surprise that dead on arrival (DOA) and Dead after arrival (DAA) rates of less that 1 % were considered feasible. Almost all previous data from the industry has suggested that mortality rates through the chain of custody were at least an order of magnitude greater (e.g. WOOD 1985, 2001).

Dr Edwards pointed out that many of the species concerned have instantaneous natural mortality rates (M) in the order of 0.2-1.0 (EDWARDS & SHEPHERD, 1992; PAULY, 1980). Consequently during the 1-3 months species are held in the chain of custody one might expect some mortality if those same individuals had been in the wild and subject to predation and other vagaries of life (Table 1). For example, the life expectancy (age which 50 % of individuals would expect to attain having successfully established themselves on the reef) of a fish with M=0.2 would be 3-4 years. For such a population one would expect 5 % of individuals to attain an age of 15 years. Larger fish might be held in the chain of custody for up to 3 months whilst smaller species might go through the chain in 4 weeks. In such periods in the wild mortality rates might be expected to exceed 1 %. Thus MAC appears to be requiring better survivorship of some fish species in holding facilities than might be expected in the wild.

Natural mortality rate (M)	Age to which 5 % survive	Age to which 50 % survive	Percentage dying in 1 month	Percentage dying in 2 months	Percentage dying in 3 months
0.1	30 years	7 years	1	2	2
0.2	15 years	3.5 years	2	3	5
0.5	6 years	1.4 years	4	8	12
1.0	3 years	0.7 years	8	15	22

Table 1. **Estimated expected survivorship for 5 % and 50 % of population and expected mortalities of young reef fishes over 1-3 month periods in the wild given instantaneous rates of natural mortality (M) of 0.1-1.0.**

Larger fish that reach greater ages have much greater life expectancies in the wild than smaller fish with life spans of just a few years. From Table 1 it is difficult to see how

MAC can justify a blanket DOA/DAA level of 1 % at the species level. Some species are clearly more stressed by collection than others and do not survive well in aquaria. Such species need to be placed on the MAC Unsuitable species list if DOA/DAA rates with best practice being followed are considered unacceptable. Other species (e.g. Pseudochromidae) are much hardier and DOA/DAA rates of 1 % may be achievable because fish are not normally subject to natural predation in holding facilities (except for stray cats). However, for many species routinely traded it is clear that DOA/DAA levels of 1 % are not realistic with current technology even if best practice is followed. Thus although the DOA/DAA levels represent a laudable goal, the companies represented at the meeting felt that if this was a stated criteria for MAC Certification then the whole process was likely to be brought into disrepute with DOA/DAA figures being massaged to give "paper" compliance.

The ornamental fish collecting and exporting companies were in total agreement with MAC goals and principles. They felt that certification of collectors, CAMPs, certification of holding facilities; standards for transport and packing were all areas that they could support. However they felt that, the proposal that any species which suffered a DOA/DAA of over 1 % at any stage in the chain of custody could not be MAC certified would make a mockery of the whole certification process. The companies also wondered how the prohibition on "co-mingling" could be enforced.

Recommendation to MAC*:* that DOA/DAA 1 % level requirement be reviewed as it threatens to make the whole MAC certification process into a "paper exercise". Redefine "optimal health" in a manner consistent with reality and best practice. Concentrate on Collection Area Management Plans, ensure that collectors are properly trained, ensure that destructive fishing practices are prohibited, ensure that holding facilities employ best practice in terms of both technology and husbandry, ensure that packing is of an appropriate standard.

MAC Core Standard III: Handling, Husbandry, and Transport (HHT):

Purpose: To verify that the handling, husbandry, packing and transport of marine aquarium organisms ensures the "optimal health" of organisms.

This standard largely applies to the chain of custody from exporter to retailer. The prime concern voiced by the ornamental fish companies related to the definition of "optimal health" as discussed above. They indicated that their customers also considered DOA/DAA rates of 1 % or less unrealistic.

In summary, the MAC certification process was seen as a sensible way forward towards regulating the ornamental fish industry in the region but some aspects were considered in need of change if the process was to be workable in the region. The idea that "market forces" would drive self-regulation of the industry via the MAC process was appealing given the limited resources in the region available to monitor the industry.

Visit to a Coral Reef Company collection area and holding facilities at Thowal

Once workshop participants had completed the fish identification training and studied the MAC Core Standards, a field visit was made to a collection area and to holding facilities at Thowal (approximately one hour's drive north of Jeddah) and a presentation

given by Issham International. The aim was to develop participants' awareness and understanding of the marine aquarium trade from collection to export.

Collection of marine aquarium fish

Participants went out with two highly skilled Sri Lankan fish collectors to see how fish were collected. The two collectors used SCUBA equipment and worked as a pair, both seeking target species for collection and then one working to lay a barrier net and the other to drive target fish into the net using a "tickler" (long metal rod) to coax fish towards the net. The pair caught 16 fish in a 40 minute dive at depths of around 4-8 m in an area of mixed sand and coral outcrops. The catch included *Chaetodon fasciatus, C. auriga, C. larvatus, Heniochus intermedius, Acanthurus sohal* and *Zebrasoma veliferum*. The barrier net (about 2.5 m deep) with floats at the top and weights along the bottom was deployed in sandy areas and did not appear to cause any environmental damage. Non-target fish caught in the fine mesh net were carefully untangled and released. Target fish were caught by hand (each collector wore string gloves) and carefully transferred to a large plastic laundry basket where they appeared fairly relaxed and swam around slowly.

Following collection, the captured fish were transferred to individual holding boxes with holes to allow water circulation and these were placed in a net which was anchored to bottom in calm water a few metres deep in the outer harbour. They would be held there for two days and if showing no ill effects would then be transferred to tanks in the holding facilities less than 1 km away.

Visit to holding facilities

The workshop participants visited the holding facilities, which consisted of a semi-closed system of large and small tanks with water being filtered but without UV sterilisation or protein skimmers. The fish in the holding facilities at the time of the visit are listed in Table 2.

Of the some 1500 fish from 30 species in the facilities, there were about five *Paracheilinus octotaenia* which appeared to be dying or dead and two large *Dascyllus trimaculatus*, which appeared unwell.

A demonstration of packing was given to the participants. Fish are placed in aerated seawater in individual multiple polythene bags with oxygen before being packed in styrofoam containers within cardboard boxes for export.

The slide presentation given by Issham International covered the collection process and holding facilities and showed the company's high technology facilities. This is a large operation and exposed participants to the range of types of facilities in use. The key message was that a combination of high technology, highly trained staff and labour intensive husbandry practices are needed to maintain fish in optimal health.

Species	Nos	Species	Nos
Acanthurus sohal	36	*Ostracion cubicus*	1
Arothron diadematus	5	*Paracheilinus octotaenia*	6
Bodianus anthioides	4	*Pomacanthus asfur*	20
Chaetodon auriga	23	*Pomacanthus imperator*	2
Chaetodon fasciatus	28	*Pseudanthias squamipinnis*	350
Chaetodon larvatus	10	*Pseudochromis fridmani*	70
Chaetodon mesoleucos	8	*Pterois miles*	3
Chaetodon paucifasciatus	32	*Pterois radiata*	1
Chaetodon semilarvatus	28	*Pygoplites diacanthus*	20
Cheilinus lunulatus	2	*Rhinecanthus assasi*	1
Chromis viridis	800	*Taeniura lymma*	7
Dascyllus marginatus	50	*Thalassoma klunzingeri*	12
Dascyllus trimaculatus	3	*Thalassoma purpureum*	8
Genicanthus caudovittatus	3	*Zebrasoma veliferum*	3
Larabicus quadrilineatus	15	*Zebrasoma xanthurum*	3
Total	**1047**	**Total**	**507**

Table 2. **Fish being held in holding facilities at Thowal; compiled by Dr Maroof Khalaf**

On average small fish might spend a week or so in holding facilities whilst large fish might spend up to a month. Small fish might thus complete the chain of custody from collector to being bought from retailer within a month and large fish might be in the chain for up to 2-3 months.

Methodologies for the collection and analysis of export data on aquarium fish

Participants were exposed to the Global Marine Aquarium Database (GMAD) being developed by the World Conservation Monitoring Centre (UNEP-WCMC), Cambridge and were given export data sheets to examine from two Saudi Arabian companies (ABDUL GHANI & GHAZZAZ, 2000).

The key points being made to the participants were that such data are collected in inconsistent ways by different companies and agencies, contains identification errors, and is thus difficult to collate. Several common names may be in use for the same species and both scientific and common names may be applied to the wrong species. This makes it difficult to assemble reliable figures on fish collection and export.

To overcome these problems and ease the burden of data collection, a solution, which has been tried successfully in the Maldives, is to introduce *pro forma* species lists in collaboration with the industry. These use an agreed set of common and scientific names in an agreed order. The lists can be made available to exporters as Excel spreadsheets on which the numbers being exported can be entered on a consignment by consignment basis and then summarised on a monthly or annual basis for reporting purposes. In terms of MAC certification and Collection Area Management Plans, collectors/exporting companies would be required to provide annual summaries.

Table 3 provides a *pro forma* list of aquarium fish species utilised in the region. Some additional species are listed as being rarely traded by Issham International. Such lists should be reviewed annually by companies and monitoring authorities with species never collected being deleted and additional species being incorporated onto the main list. This is easily done if the list is kept as a spreadsheet.

Table 3. ***Pro forma*** **list of fish species utilised by the marine aquarium fish trade in the Red Sea and Gulf of Aden region. Three butterflyfish species that are likely to be on the MAC Unsuitable species list are given in boldface. Only three columns for entering numbers caught are shown but if data were to be collected on each visit to each collection area then many such columns would needed in the spreadsheet (which allows 256 columns).**

Genus	**Species**	**Common names**	**No.**	**No.**	**No.**
Acanthuridae					
Acanthurus	*gahhm*	Black/Whitetail surgeon(fish)			
Acanthurus	*nigrofuscus*	Brown surgeon(fish)			
Acanthurus	*sohal*	Sohal (tang), Red Sea surgeon(fish)			
Ctenochaetus	*striatus*	Lined/Brown bristletooth			
Naso	*brevirostris*	Long-nose/Spotted unicornfish			
Naso	*hexacanthus*	Sleek unicornfish			
Naso	*lituratus*	Orangespine/Lipstick unicornfish, Blonde naso			
Naso	*unicornis*	Short-nose/Bluespine unicornfish			
Zebrasoma	*veliferum*	Sailfin tang			
Zebrasoma	*xanthurum*	Yellowtail/Purple tang			
Apogonidae					
Apogon	*aureus*	Golden cardinalfish			
Balistidae					
Balistapus	*undulatus*	Orange-striped/Undulate triggerfish			
Balistoides	*viridescens*	Titan triggerfish			

Odonus	*niger*	Red-tooth/Niger triggerfish			
Pseudobalistes	*fuscus*	Yellow-spotted/Blue-lined triggerfish			
Rhinecanthus	*assasi*	Picasso triggerfish, Assasi			
Sufflamen	*albicaudatus*	Bluethroat triggerfish			
Blenniidae					
Ecsenius	*aroni*	Aron's blenny			
Ecsenius	*frontalis*	Smoothfin blenny			
Ecsenius	*gravieri*	Red Sea mimic blenny			
Exallius	*brevis*	Short-bodied blenny			
Istiblennius	*periophthalmus*	Red algae/Red-dotted blenny			
Meiacanthus	*nigrolineatus*	Blackline fangblenny			
Chaetodontidae					
Chaetodon	*auriga*	Threadfin butterfly(fish)			
Chaetodon	***austriacus***	**Exquisite/Melon butterfly(fish)**			
Chaetodon	*fasciatus*	Red Sea racoon/Striped butterfly(fish)			
Chaetodon	*larvatus*	Orangeface butterfly(fish)			
Chaetodon	*lineolatus*	Lined butterfly(fish)			
Chaetodon	*melannotus*	Blackback butterfly(fish)			
Chaetodon	***melapterus***	**Arabian butterfly(fish)**			
Chaetodon	*mesoleucos*	Whiteface/Red Sea butterfly(fish)			
Chaetodon	*paucifasciatus*	Redback butterfly(fish)			
Chaetodon	*semilarvatus*	Golden/Redlined/Masked butterfly(fish)			
Chaetodon	***trifascialis***	**Chevroned butterfly(fish)**			
Heniochus	*diphreutes*	Schooling bannerfish			
Heniochus	*intermedius*	Red Sea bannerfish			
Cirrhitidae					
Paracirrhites	*forsteri*	Blackside/Forster's hawkfish			
Dasyatidae					
Himantura	*uarnak*	Spotted longtail ray			
Taeniura	*lymma*	Blue-spotted stingray			

Ephippidae					
Platax	*orbicularis*	Circular spadefish			
Gobiidae					
Amblygobius	*albimaculatus*	Tailspot goby			
Amblygobius	*hectori*	Hector's goby			
Crypotcentrus	*caeruleopunctatus*	Blue-and-red-spotted goby			
Crypotcentrus	*lutheri*	Luther's goby			
Valenciennea	*puellaris?*	Blue-band goby			
Haemulidae					
Plectorhinchus	*gaterinus*	Black-spotted sweetlips, Yellow grunt			
Holocentridae					
Myripristis	*murdjan*	Crimson soldierfish			
Neoniphon	*sammara*	Bloodspot/Spotfin squirrel(fish)			
Sargocentron	*caudimaculatum*	Tailspot/Silver squirrel(fish)			
Sargocentron	*spinifer*	Longjaw squirrel(fish)			
Labridae					
Anampses	*caeruleopunctatus*	Bluespot wrasse			
Anampses	*meleagrides*	Spotted/Yellowtail wrasse			
Anampses	*twistii*	Yellow-breasted wrasse			
Bodianus	*anthioides*	Lyretail hogfish			
Bodianus	*axillaris*	Axilspot hogfish			
Bodianus	*diana*	Diana's hogfish			
Cheilinus	*abudjubbe*	Abudjubbe			
Cheilinus	*fasciatus*	Red-breasted Maori wrasse			
Cheilinus	*lunulatus*	Broomtail wrasse			
Cheilinus	*mentalis*	Mental wrasse			
Cheilinus	*undulatus*	Humphead wrasse			
Cheilio	*inermis*	Cigar wrasse			
Coris	*africana*	African coris			
Coris	*aygula*	Clown/Twin-spot coris/wrasse			

Coris	*caudimacula*	Spottail (sand) coris			
Coris	*variegata*	Dapple/Variegated coris			
Epibulus	*insidiator*	Slingjaw/Yellow-longjaw wrasse			
Gomphosus	*caeruleus*	Red Sea bird/Greenbird/Brownbird wrasse			
Halichoeres	*hortulanus*	Checkerboard/Chequered wrasse			
Halichoeres	*marginatus*	Dusky wrasse			
Halichoeres	*scapularis*	Zigzag wrasse			
Hemigymnus	*fasciatus*	Barred (thicklip) wrasse			
Hologymnosus	*annulatus*	Ring wrasse			
Labroides	*dimidiatus*	(Bluestreak) Cleaner wrasse			
Larabicus	*quadrilineatus*	Arabian/Four-line cleaner (wrasse)			
Macropharyngodon	*bipartitus*	Divided/Vermiculate wrasse			
Novaculichthys	*taeniourus*	Rockmover/Dragon wrasse			
Oxycheilinus	*digrammus*	Cheek-lined Maori wrasse			
Paracheilinus	*octotaenia*	Eight-stripe/Eight-line wrasse			
Pseudodax	*moluccanus*	Chiseltooth wrasse			
Stethojulis	*albovittata*	Blue-lined wrasse			
Stethojulis	*interrupta*	Cutribbon wrasse			
Thalassoma	*klunzingeri*	Klunzinger's/Rainbow wrasse			
Thalassoma	*lunare*	Moon/Lunare wrasse			
Thalassoma	*purpureum*	Surge wrasse			
Lutjanidae					
Lutjanus	*kasmira*	Blueline/Bluestripe snapper			
Microdesmidae					
Ptereleotris	*evides*	Twotone dartfish, Scissortail goby			
Ptereleotris	*zebra*	Zebra dartfish/goby			
Monacanthidae					
Amanses	*scopas*	Broom filefish			
Cantherhines	*pardalis*	Wire-net filefish			
Monodactylidae					

Monodactylus	*argenteus*	Mono			
Mullidae					
Parupeneus	*cyclostomus*	Yellow-saddle/Yellow goatfish			
Parupeneus	*forsskali*	Forsskal's/Dot-dash goatfish			
Parupeneus	*macronema*	Pink and black goatfish			
Parupeneus	*rubescens*	Redstriped/Rosy goatfish			
Muraenidae					
Gymnthorax	*undulatus*	Undulated moray			
Siderea	*grisea*	Grey/Peppered/Geometric moray			
Ophichthidae					
Myrichthys	*colubrinus*	Ringed snake eel			
Ostraciidae					
Ostracion	*cubicus*	Yellow boxfish			
Pinguipedidae					
Parapercis	*hexophtalma*	Spotted sandperch			
Plotosidae					
Plotosus	*lineatus*	Striped eel catfish			
Pomacanthidae					
Centropyge	*multispinnis*	Manyspined/Red Sea dwarf angel(fish)			
Genicanthus	*caudovittatus*	Zebra angel(fish)			
Pomacanthus	*asfur*	Arabian angel(fish)			
Pomacanthus	*imperator*	Emperor angel(fish)			
Pomacanthus	*maculosus*	Yellow-bar/Bluemoon angel(fish)			
Pygoplites	*diacanthus*	Royal/Regal angel(fish)			
Pomacentridae					
Abudefduf	*sexfasciatus*	Scissor-tail/Stripetail sergeant			
Amphiprion	*bicinctus*	Two-banded anemonefish, Red Sea clown			
Chromis	*dimidiata*	Half-and-half/Chocolate-dip chromis			
Chromis	*viridis*	Blue-green chromis			
Chrysiptera	*annulata*	Footballer demoiselle			

Dascyllus	*aruanus*	Humbug/Threestripe dascyllus/damsel			
Dascyllus	*marginatus*	Black-banded dascyllus, Half-moon damsel			
Dascyllus	*trimaculatus*	Three-spot/Domino dascyllus/damsel			
Paraglyphidodon	*melas*	Royal damsel(fish)			
Pomacentrus	*sulfureus*	Sulphur damsel			
Pomacentrus	*trilineatus*	Three-line damsel			
Pseudochromidae					
Pseudochromis	*flavivertex*	Yellow-back/Sunrise dottyback			
Pseudochromis	*fridmani*	Orchid/Fridman's dottyback			
Pseudochromis	*olivaceus*	Olive dottyback			
Pseudochromis	*springeri*	Springer's dottyback			
Scaridae					
Cetoscarus	*bicolor*	Bicolor parrotfish			
Scarus	*ferrugineus*	Rusty parrotfish			
Scarus	*fuscopurpureus*	Purple-brown parrotfish			
Scarus	*ghobban*	Blue-barred parrotfish			
Scarus	*gibbus*	Steep-headed parrotfish			
Scarus	*niger*	Swarthy/Dusky parrotfish			
Scarus	*psittacus*	Palenose parrotfish			
Scorpaenidae					
Pterois	*miles*	Soldier turkeyfish, Lionfish			
Pterois	*radiata*	Clearfin turkeyfish, Tailbar lionfish			
Scorpaenopsis	*barbatus*	Bearded scorpionfish			
Synanceia	*verrucosa*	Stonefish			
Serranidae					
Cephalopholis	*argus*	Peacock grouper			
Cephalopholis	*hemistiktos*	Half-spotted grouper			
Cephalopholis	*miniata*	Coral grouper			
Cephalopholis	*oligosticta*	Vermilion grouper			
Cephalopholis	*sexmaculata*	Sixspot grouper			

Diploprion	*drachi*	Yellowface soapfish			
Epinephelus	*summana*	Whitespot/Summana grouper			
Pseudanthias	*squamipinnis*	Scalefin/Lyretail anthias			
Variola	*louti*	Lunartail grouper			
Tetraodontidae					
Arothron	*diadematus*	Masked puffer			
Arothron	*hispidus*	White-spotted puffer/Stars and stripes puffer			
Canthigaster	*coronata*	Crown toby, Longnose puffer			
Canthigaster	*margaritata*	Pearl toby			
Torpedinidae					
Torpedo	*panthera*	Leopard torpedo			
Additional species					

For MAC Certification, numbers of each species taken annually from each collection area would need to be recorded. These could be entered after each day's collection and summed up on a monthly or annual basis for reporting purposes. Once a system is in place it should not be burdensome.

Recommendation: that each country should establish *pro forma* lists of exported species, in collaboration with exporting/collecting companies. These lists should eventually be used to record catch data from each collection area (preferably also effort data) but in the interim be used to record export data.

The type of analyses that can be carried out depends on what data are collected. If only annual export data are collected for each species then only the broad levels of collection can be judged. These do not allow the sustainability or otherwise to be known unless the sizes of the collection areas are known. If the area of coral reef which is being utilised by collectors is known or can be estimated and surveys are undertaken to assess the density (e.g. numbers/1000 m^2) of key aquarium fish species present (see next section), then the method outlined by EDWARDS & SHEPHERD (1992) can be used. The method assesses whether key species may be at risk of overexploitation by comparing potential yields from the collected areas to the export data. If numbers being exported significantly exceed estimated potential yields then there might be concerns about the sustainability of collection of the species concerned. A copy of the paper in which this method is described was made available to all workshop participants and the method outlined.

Sampling methodologies for collection, analysis and reporting of field data for monitoring the impacts of the aquarium fish trade

Field monitoring of the impacts of the aquarium trade seeks to address two scientific questions:

1. Are populations (numbers) of those fish species targeted by the aquarium trade declining in an unsustainable way as a result of collection for the aquarium trade?

2. Are collecting activities of the aquarium trade adversely impacting the coral reef ecosystem in other ways?

Trying to answer either scientific question satisfactorily is not a trivial matter and monitoring designs that will allow either of them to be answered in a meaningful way requires significant resources deployed annually over at least three years. Weaker survey designs will yield less information, which is likely to be vague and less robust to analysis.

Overall design and sampling methodologies for monitoring aquarium fish

The key point stressed to workshop participants is that whatever is done in terms of monitoring must be done in a completely consistent manner for all surveys at each site. The recommended design involves selecting three pairs of comparable areas of reef with one of each pair of sites known to be subject to aquarium fish collection and one (control site) known not to be utilised by the aquarium trade. Ideally for logistic reasons and to increase the likelihood that environmental conditions are similar, each pair of sites should be fairly close to each other geographically (within about 2 km). The sites should also be reasonably separated from each other (at least 200-500 m apart) so that collecting activities in the one site are unlikely to be impacting the other. Local considerations will determine what is feasible and what a reasonable degree of separation is. The collected sites do not necessarily need to be similar (comparable) to each other. The types of sites available will be dictated by the locations that ornamental fish companies use to collect specimens in each country.

The reason for pairing each collection area with a comparable uncollected site is that one needs a control for other factors, e.g. environmental factors such as coral bleaching, Crown-of-thorns outbreaks or global/local environmental change, that might be impacting the area. If changes in abundances of aquarium fish species are recorded at the collected site but not observed at the control site then one may attribute them with some confidence to aquarium fish collection. If similar changes occur at both sites then impacts of other environmental factors are suggested. Also the paired control sites provide a benchmark against which any decline can be compared, to judge whether the collection is sustainable or not.

A recommended list of approximately 40 species to be included in monitoring in the Red Sea and Gulf of Aden was drawn up on the basis of the species being utilised by the trade, endemism, ecological rarity, ease of identification and demand criteria (Table 4). Two species that should not be collected by the aquarium trade (e.g. *Chaetodon austriacus, C. trifascialis*) are included as internal controls. It was recognised that it might be appropriate to exclude a few species in some countries or include a few extra in other countries due to biogeographical differences or differences in collection pressure within the

region. Pilot monitoring in Obhur Creek, Jeddah indicated that the minimum length of transect which might be useful for monitoring most of these species was 100 m with all individuals 2.5 m either side of the transect being counted. Thus each transect would sample 500 m^2 of reef. Of the species sampled in Obhur Creek, *Dascyllus aruanus* could clearly have been adequately sampled in a 50 m transect. For any species which is normally present in numbers of 100+ per 50 m transect, the option to save time and only count such species for the first 50 m of each transect should be considered. Schooling species such as *Chromis viridis* and *Pseudanthias squamipinnis* might fall into this category at many sites.

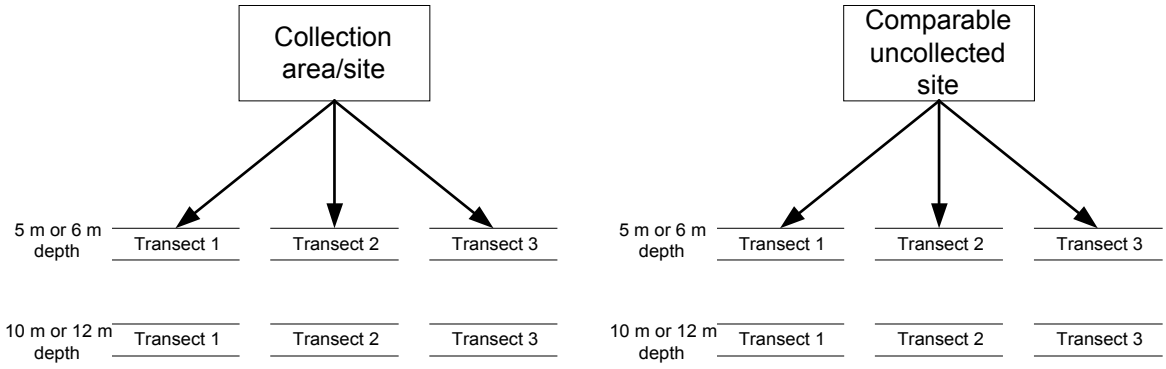

Figure 2**. Recommended minimum survey design for a pair of collected and comparable uncollected sites on a reef slope. Recommended transect length is 100 m and width 5 m (2.5 m either side of transect).**

For sites where depth changes slowly or haphazardly, such as the collection area visited at Thowal where depth fluctuated between about 4 m and 8 m over a reef with no clear slope, one set of transects need to be laid. Three parallel transects across the collection area would be a minimum requirement. For sites on the reef slope where depth changes rapidly, it is recommended that transects are laid parallel to the reef crest at two depths to sample the range of aquarium fish species present at the sites adequately (Figure 2). Transects should follow the topography of the reef along the depth contour so that the tape remains fairly close to the substratum. The recommended depths are 5 m or 6 m for the shallower depth and 10 m or 12 m for the deeper depth. The minimum number of transects per depth should be three (sampling 1500 m^2). Each transect took approximately 40 minutes to survey.

Increasing the number of transects increases the sensitivity of the sampling i.e. smaller differences/changes/impacts are likely to be detectable. For example, if the variability in the numbers of individuals of a species remains constant between transects, then sampling five as opposed to three 100 m transects per depth will roughly halve the size of the differences that can be detected between sites. With three transects per depth/site, relatively large changes in numbers/1000 m^2 would need to occur for a significant difference between two surveys to be detected. However, if monitoring is conducted annually over three or more years, as recommended, then regression analysis should allow trends of smaller magnitude to be detected. At sites where two depths do not need to be sampled it is recommended that 5 transects be surveyed if possible.

Table 4. **List of species selected for underwater monitoring**

Family	**Genus**	**Species**	**Common names**
Acanthuridae	*Acanthurus*	*sohal*	Sohal, Red Sea surgeon(fish)
Acanthuridae	*Naso*	*lituratus*	Orangespine/Lipstick unicornfish
Acanthuridae	*Zebrasoma*	*veliferum*	Sailfin tang
Acanthuridae	*Zebrasoma*	*xanthurum*	Yellowtail/Purple tang
Balistidae	*Balistapus*	*undulatus*	Orange-striped/Undulate triggerfish
Balistidae	*Balistoides*	*viridescens*	Titan triggerfish
Balistidae	*Rhinecanthus*	*assasi*	Picasso triggerfish
Chaetodontidae	*Chaetodon*	*auriga*	Threadfin butterfly(fish)
Chaetodontidae	*Chaetodon*	*austriacus*	Exquisite/Melon butterfly(fish)
Chaetodontidae	*Chaetodon*	*fasciatus*	Red Sea racoon/Striped butterfly(fish)
Chaetodontidae	*Chaetodon*	*larvatus*	Orangeface butterfly(fish)
Chaetodontidae	*Chaetodon*	*mesoleucos*	Whiteface/Red Sea butterfly(fish)
Chaetodontidae	*Chaetodon*	*paucifasciatus*	Redback butterfly(fish)
Chaetodontidae	*Chaetodon*	*semilarvatus*	Golden/Redlined/Masked butterfly(fish)
Chaetodontidae	*Chaetodon*	*trifascialis*	Chevroned butterfly(fish)
Chaetodontidae	*Heniochus*	*intermedius*	Red Sea bannerfish
Cirrhitidae	*Paracirrhites*	*forsteri*	Blackside/Forster's hawkfish
Labridae	*Anampses*	*twistii*	Yellow-breasted wrasse
Labridae	*Bodianus*	*anthioides*	Lyretail hogfish
Labridae	*Cheilinus*	*lunulatus*	Broomtail wrasse
Labridae	*Coris*	*aygula*	Clown/Twin-spot coris/wrasse
Labridae	*Gomphosus*	*caeruleus*	Red Sea bird/Green-bird wrasse
Labridae	*Labroides*	*dimidiatus*	(Bluestreak) Cleaner wrasse
Labridae	*Larabicus*	*quadrilineatus*	Arabian/Four-line cleaner (wrasse)
Labridae	*Novaculichthys*	*taeniourus*	Rockmover/Dragon wrasse
Labridae	*Paracheilinus*	*octotaenia*	Eight-stripe/Eight-line wrasse
Labridae	*Thalassoma*	*klunzingeri*	Klunzinger's/Rainbow wrasse
Labridae	*Thalassoma*	*lunare*	Moon/Lunare wrasse
Ostraciidae	*Ostracion*	*cubicus*	Yellow boxfish
Pomacanthidae	*Pomacanthus*	*asfur*	Arabian angel(fish)
Pomacanthidae	*Pomacanthus*	*imperator*	Emperor angel(fish)

Pomacanthidae	*Pomacanthus*	*maculosus*	Yellow-bar/Bluemoon angel(fish)
Pomacanthidae	*Pygoplites*	*diacanthus*	Royal/Regal angel(fish)
Pomacentridae	*Amphiprion*	*bicinctus*	Two-banded anemonefish
Pomacentridae	*Dascyllus*	*aruanus*	Humbug dascyllus
Pomacentridae	*Dascyllus*	*marginatus*	Black-banded dascyllus
Pomacentridae	*Dascyllus*	*trimaculatus*	Three-spot/Domino dascyllus
Pseudochromidae	*Pseudochromis*	*fridmani*	Orchid/Fridman's dottyback
Scorpaenidae	*Pterois*	*miles*	Soldier turkeyfish, Lionfish
Scorpaenidae	*Pterois*	*radiata*	Clearfin turkeyfish, Tailbar lionfish
Tetraodontidae	*Arothron*	*diadematus*	Masked puffer
Schooling species			
Pomacentridae	*Chromis*	*viridis*	Blue-green chromis
Serranidae	*Pseudanthias*	*squamipinnis*	Scalefin/Lyretail anthias

Transect starting points should be permanently marked underwater and if possible located near prominent natural features of the reef which can be detected using GPS co-ordinates once a boat is in the vicinity. Hand drawn maps indicating topography around the start of each transect to allow them to be located in repeat surveys need to be made and stored with the GPS locations. Compass bearings of transects laid in relatively flat monitoring areas need to be noted so transects can be re-laid in the same or similar positions on subsequent visits. Ideally both ends of each transect would be permanently marked but this is not often feasible as useful markers tend to be found and removed by fishermen or divers.

Ideally each country should select three pairs of sites, thus allowing any general statistical trends of decline resulting from collection to be detected or, if collection effort were available for the collected sites, any correlations between fishing effort and fish density to be detected. If such a strategy were not feasible, a weaker alternative would be to select one pair of sites in at least three countries and restrict monitoring to these.

This monitoring strategy, if carried out annually for several years, would allow one to ascertain whether numbers of key species targeted by the marine aquarium fish trade were in decline at collecting sites. If similar trends were not observed at uncollected control sites then these declines could be attributed to collection by the trade. However, in any fishery one expects declines in fish densities with increased fishing effort. To ascertain whether the level of collection and decline in numbers is sustainable or unsustainable requires other data. Fishery theory based around the logistic equation using surplus yield models would suggest that declines of up to 50 % in numbers from those found at uncollected sites might be sustainable (although a safer maximum level of decline in numbers/1000 m^2 might be 40 %).

The other critical information which is provided by annual monitoring is the current trend in numbers, i.e. are they continuing to decline or have numbers per unit area levelled out at some sustainable level in collected areas. For example, if numbers/1000 m^2

of certain target species in collection areas are significantly lower (say 30-40 % less) than in comparable uncollected sites, but over several years these numbers do not decline further, then the collection can be considered sustainable. However, if numbers are over 40 % less than on comparable uncollected sites one would be justified in having concerns that collection was at unsustainable levels.

To assess sustainability unequivocally one would ideally carry out monitoring surveys twice a year, once after the main collection period (around March/April) and once after the summer lull in collection pressure (around September/October). If numbers/1000 m^2 were found to recover between the two surveys, that would be incontrovertible evidence that collection was sustainable.

Sampling methodologies for monitoring collateral impacts of collection

To monitor impacts of collecting activities one needs do decide what these might be. The most likely impact will be damage to branching coral colonies as a result of collection of species which shelter in them (e.g. *Dascyllus* spp*., Chromis* spp. and *Pseudanthias*), so monitoring should focus on detecting changes in live coral cover or even live branching coral cover. This requires monitoring of the substrate composition. The recommended method is to sample the whole 5 m wide belt transects using randomly laid 1 m^2 quadrats. Two methods were presented to workshop participants and each was evaluated.

The substrate categories chosen for pilot monitoring were:

1. Live hard coral
2. Live soft coral
3. Dead coral (corallite structure still visible)
4. Coral rock (corallite structure not visible)
5. Sand
6. Rubble (particle size > 5 mm)
7. Macroalgae (e.g. *Padina, Sargassum, Turbinaria, Valonia*)
8. Algal turf
9. Sponge
10. Others

<u>A Point Intercept Transect Method</u>

The first method was to use the 100 m fish monitoring transect and record the substrate directly below it every 0.5 m. This meant that for each transect, 200 points would be recorded. The number of points for each substrate category were then summed and divided by two to give percentage cover for each category.

A Random Quadrat Method

The second method was to use random quadrats to sample throughout the 5 m wide belt transect used for fish monitoring. Again the 100 m transect laid for fish monitoring provided the baseline. A method using an Excel spreadsheet to generate three sets of random numbers to select positions of quadrats was demonstrated to workshop participants who then each set up their own spreadsheets as an exercise. The second column (Table 5) uses the RAND() function and multiplies this by 100 to generate random numbers between 0 and 100. The third column uses the RAND() function and multiplies it by 2 to generate random numbers between 0 and 2, and the fourth column uses the RAND() function alone to generate numbers between 0 and 1. All columns are formatted to zero decimal places to give integer (whole number) values. These determine the distance along the transect, the distance to either side of the transect and whether this is to the right or left of the transect (Table 5). If the distance either side column contains a zero, the 1 m^2 quadrat is laid directly on the transect with 0.5 m width either side; if it is a 1, the quadrat is laid 0.5 m away (0.5-1.5 m from the transect); if it is a 2, the quadrat is laid 1.5 m away (1.5-2.5 m from the transect). The spreadsheet cells containing the random numbers are copied and then the Paste Special option is used to paste them as values so they can be sorted by distance along the transect. The sorted random sampling regime is then transcribed to an underwater slate so that each surveyor can progress along the transect in an ordered way. A sorted list for three surveyors, each covering part of a 100 m transect is shown in Table 6.

Table 5. **Method for positioning quadrats randomly along fish monitoring transects. Output for 10 quadrats is shown.**

	Random distance along 100 m transect	Distance either side (+/- 2 m)	Right (0) / Left (1)
1	64	1	1
2	29	1	1
3	76	1	0
4	44	1	1
5	70	1	0
6	68	1	1
7	92	0	1
8	36	0	0
9	16	2	1
10	94	2	1

Table 6. **Sorted list of random quadrat positions with R (right) substituted for 0 and L (left) substituted for 1 (this can be done automatically in the spreadsheet).**

AJE			**Yasser**			**Mustaffa**		
4	1	L	32	2	R	59	0	R
6	1	L	39	0	L	61	1	L
12	2	R	41	1	L	62	1	R
12	1	L	44	0	L	65	1	R
15	1	L	46	1	R	65	1	L
16	1	L	47	1	R	68	2	L
17	1	L	51	1	R	68	1	L
24	2	L	54	1	L	74	1	L
31	1	R	55	1	R	77	1	L
32	1	L	59	2	L	81	1	R

In this example from the pilot survey, each surveyor samples approximately one third of the 100 m transect. Surveyor AJE must proceed to the 4 m mark on the transect and place the first quadrat 0.5 m to the left of the transect line, then proceed to 6 m mark and place the second quadrat 0.5 m to left of the transect, then proceed to the 12 m mark and place the third quadrat 1.5 m to the right of the transect, etc.

Each 1 m^2 quadrat is divided by fishing line or nylon/polypropylene line into one hundred 10x10 cm^2 squares. To assess percentage cover, the number of squares occupied by each substrate category is assessed and recorded. The total number should approximate 100. Any missing percentage cover is normally assigned to the "others" category. There is a tendency to underestimate cover for major categories so percentage cover values for key substrate categories are normally rounded up to the nearest 5 %. The "others" category should not normally exceed 10 %. If it does then some other named category should be added.

Results from random quadrats and point-intercept-transect (PIT) methods using the fish monitoring transects were compared by participants in a pilot monitoring study in Obhur Creek, Jeddah. Due to the way the fish monitoring transects were laid, (not in a straight line but following the contours of the reef and thus snagging on coral outcrops,) the PIT method gave consistently higher values for live coral cover than the random quadrat method did (2.5-5 times more live coral cover being recorded in the PIT method). This bias means that this method was not appropriate for the monitoring objectives here.

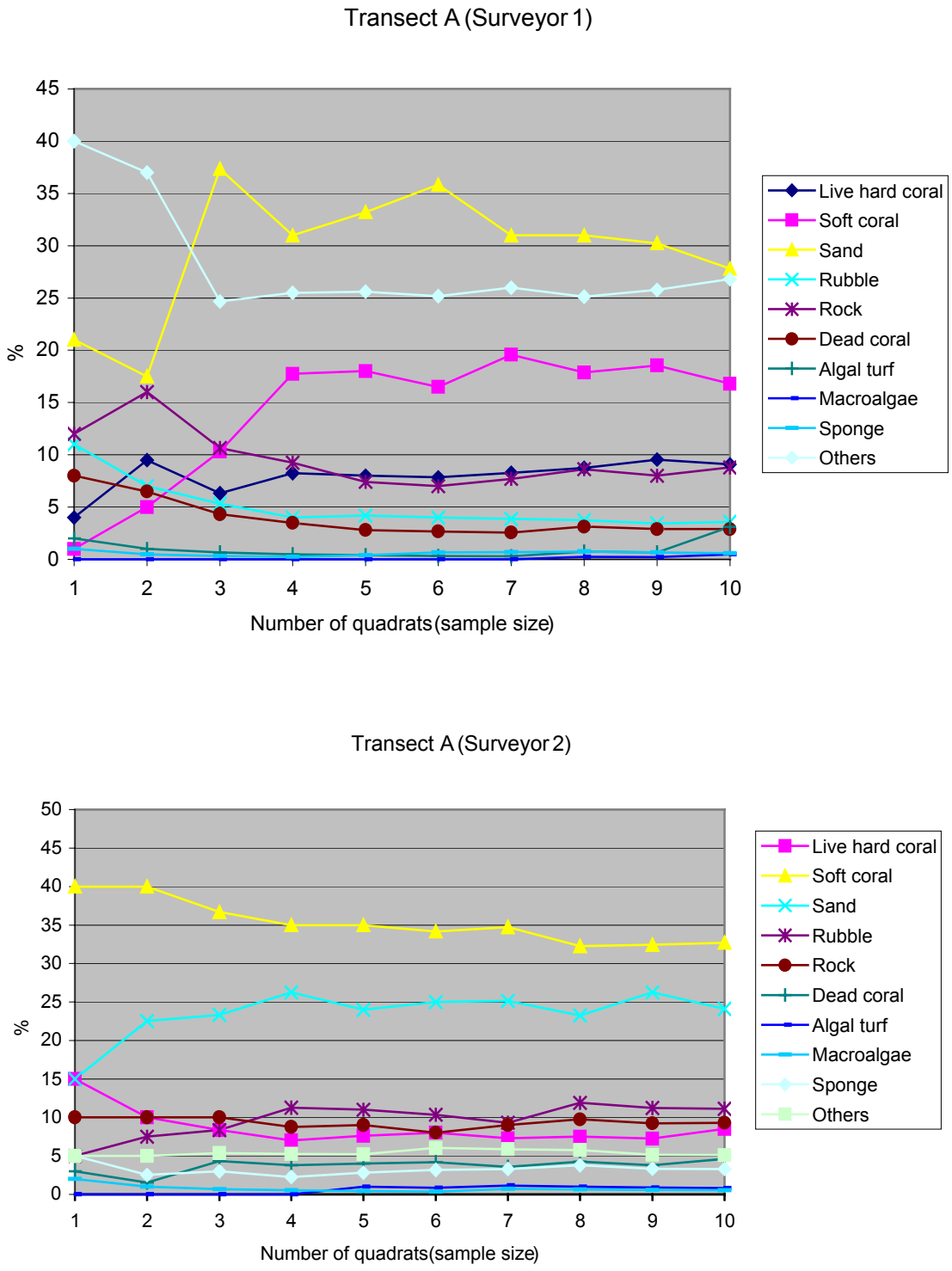

Figure 3. **Results of pilot monitoring using random quadrat method from two surveyors, each covering approximately one third of a 100 m long 5 m wide fish monitoring transect. Each graph shows the mean percentage cover estimated after 1, 2, 3 … quadrats. It indicates that very poor estimates are likely to be obtained with anything less than 5 quadrats. In each case for the area surveyed, 10 quadrats appear to give stable reproducible results.**

The pilot monitoring indicated that for the full 100 m transect, 20 quadrats would provide robust and reproducible estimates of percentage cover (if 50 m transects were being used then the pilot monitoring suggest one could use only 10 quadrats). The time taken to survey 20 quadrats was approximately 70 minutes allowing one transect to be surveyed in one dive. If only 15 quadrats/transect could be completed then fairly robust results should still be obtainable based on analysis of the Obhur Creek pilot monitoring data. This method allows the fish monitoring transect to be laid just once and then used as the basis for both fish and substrate monitoring. If the PIT method (or the much more time-consuming line – intercept-transect (LIT) method) was to be used, then separate straight-line transects would need to be laid for the substrate surveys to avoid sampling bias. This does not seem logistically feasible given time constraints.

The results in Figure 3 show very similar estimates of live coral cover and sand between surveyors 1 and 2 and mainly differ in the percentage cover assigned to the "others" category. Further training to ensure that a greater percentage of the substrate is assigned to key categories (using the rounding-up approach stated earlier) would lead to greater consistency.

Based on the experience of the pilot monitoring by the workshop participants it was considered that the substrate categories might be modified. Not having to differentiate between sand and rubble or decide whether one has algal turf growing on coral rock or just coral rock would allow more focus on the marine aquarium fish impact issues and facilitate faster survey. The modified substrate categories are as follows:

1. Live hard branching coral (e.g. *Acropora, Stylophora, Pocillopora*)
2. Other live hard coral
3. Live soft coral (e.g. *Xenia*)
4. Dead coral (corallite structure still visible)
5. Coral rock (corallite structure not visible) and algal turf
6. Sand and rubble
7. Macroalgae (e.g. *Padina, Sargassum, Turbinaria, Valonia*)
8. Sponge
9. Others

The benthic substrate surveys allow one to monitor whether declines in live coral cover or increases in macroalgal cover are occurring over time and provide an objective measure of whether pairs of collected and uncollected sites are really comparable in terms of habitat.

The critical importance of initial pilot monitoring of the same fish transects and the same quadrats by *each* member of a survey team to ensure that each is monitoring in the same way was stressed to participants. Discrepancies between surveyors need to be sorted out before monitoring starts, to eliminate surveyor bias. Once a methodology is agreed at each pair of sites then it must be followed CONSISTENTLY for each annual survey.

EVALUATION

Participants from Egypt, Jordan, Yemen and Saudi Arabia showed a clear understanding of the issues involved with good underwater survey skills and satisfactory to excellent fish identification skills. The country reports from each country showed fish monitoring already in place in Jordan, collection and collation of export data already underway in Egypt, Saudi Arabia and Yemen, and underwater surveys which demonstrated loss of two out of ten key aquarium fish species at heavily collected sites in Egypt. With input and technical field assistance from the PERSGA/SAP LMR project these countries have the trained personnel and the capacity to carry out the recommended monitoring. However, due to prioritisation constraints, funding for such activities may not be available locally. The local capacity (trained manpower and resources) for monitoring the marine aquarium trade did not appear to be currently available in Djibouti, Somalia or Sudan. Although the Sudanese delegate participated fully in all underwater survey activities, a diving team of at least three trained people is required for safe underwater survey work.

The fish identification training appeared to benefit all participants. Most will require further practice even for the 40 key species chosen for monitoring. The day and a half spent in developing an understanding of how the trade works from collection to export was well spent. It was both informative and enjoyed by the participants. Study of the MAC Core Standards was necessary to alert participants to what MAC has to offer in terms of ensuring sustainable use of marine aquarium organisms, and broadened awareness of an alternative route to management other than local regulation.

The detailed discussion of sampling methodologies and the practice of these in the field during the pilot monitoring exercises was particularly useful to participants. It made them aware that monitoring is not a trivial task and requires substantial planning, careful design as well as resources. If the recommended survey designs are followed then robust and useful data should be obtainable from those countries with the capacity to carry out the monitoring.

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ANNEX 1

List of Workshop Participants

Name	Country	Address
Dr. Ahmed Osman Mal	Saudi Arabia	Marine Science Faculty, KAAU
Kamal K. Al-Dahoudi	Saudi Arabia	Marine Science Faculty, KAAU
Yasser Mohamed Awadallah	Egypt	Ras Mohammed Marine Park yawadalla@hotmail.com
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Tellk Reenjar	Saudi Arabia (Red Sea Secret)	P.O. Box 9084, Jeddah Tel.: 6672939
Nasser Shawali	Saudi Arabia (Coral Reef Co.)	

ANNEX 2

Workshop Schedule

Date		Activity
Tuesday 9 April	Opening ceremony	Welcome and introduction (Dr Mohamed Abdallah PERSGA/SAP); The training course, Mr Madani Gazzaz, (Working Group member); The role of research institutions in ensuring sustainable use of living marine resources, Dr Ikram Mohamed Amin (President of the National Institute of Oceanography and Fisheries, Egypt); Objectives of the Course, Dr Alasdair Edwards
		Tea/coffee break
	Session 1	Introduction to the marine aquarium trade and objectives of the training workshop
	Session 2	Identification of aquarium fishes 1: Endemism in the region, damselfishes (Pomacentridae), butterflyfishes (Chaetodontidae), angelfishes (Pomacanthidae), triggerfishes (Balistidae) (Quiz 1: identification of 12 most important species in the aquarium trade from these 4 families)
		Lunch break
	Session 3	Identification of aquarium fishes 2: Surgeonfishes (Acanthuridae), dottybacks (Pseudochromidae), pufferfishes (Tetraodontidae), moray eels (Muraenidae), boxfishes (Ostraciidae), blennies (Blenniidae), Groupers and anthias (Serranidae). (Quiz 2: identification of 12 most important species in the aquarium trade from these 7 families)
	Session 4	Marine Aquarium Council standards 1 (Introduction and Core Standard III. Handling, Husbandry, and Transport-HHT)
		Tea/coffee break
	Session 5	Country report: Yemen. Zaher Abdo Ali
Wednesday 10 April	Session 6	Identification of aquarium fishes 3: the wrasse family (Labridae). (Quiz 3: identification of the 9 most important wrasse species)
		Tea/coffee break
	Session 7	Marine Aquarium Council standards 2 (Core Standard I. Ecosystem and Fishery Management - EFM). Discussion: Feasibility of Marine Aquarium Council approach
	Session 8	Fish species which may need special consideration
		Lunch break
	Session 9	Country report: Jordan. Dr Maroof Khalaf
	Session 10	Marine Aquarium Council standards 3 (Core Standard II. Collection, Fishing and Holding - CFH)
		Tea/coffee break
	Session 11	Identification of aquarium fishes 4: Parrotfishes (Scaridae), scorpionfishes (Scorpaenidae), goatfishes (Mullidae), gobies (Gobiidae), cardinalfishes (Apogonidae), eel catfishes (Plotosidae), etc. (Quiz 4: identification of the 9 most important species in 12 families)
Thursday 11 April	Session 12	Visit to Coral Reef Company, Thowal (study of aquarium fish collectors at work in the field using barrier nets to capture aquarium fish species, tour of holding facilities to assess species held, demonstration of packing techniques)
		Lunch break
	Session 13	Monitoring the aquarium trade (export data)

	Session 14	Workshop exercise: producing a *pro-forma* export list for Red Sea and Gulf of Aden
Friday 12 April	Session 15	Trial monitoring of 40 marine ornamental fish species in Obhur Creek and analysis of collected data (Dr Maroof Khalaf, Dr Mohamed Abdallah, Kamal Aldahoudi, Dr Alasdair Edwards, Dr Ahmed Mal)
Saturday 13 April	Session 16	Presentation by Issham Company, Jeddah of collection, holding facilities, husbandry and packing techniques
	Session 17	Review of workshop, overview of the aquarium fish trade industry in Saudi Arabia
		Tea/coffee break
	Session 18	Introduction to monitoring of aquarium fish: preparing a list of those species which should be included in a monitoring programme for impacts of aquarium trade
	Session 19	Country report: Egypt. Yasser Mohamed Awadallah
		Lunch break
	Session 20	Final planning for field monitoring of 10 species of aquarium fish by workshop participants along 100 m transects at laid at 6 m depth (in two teams)
	Session 21	Pilot monitoring by workshop participants of aquarium fish at 6 m depth in Obhur Creek adjacent to King Abdul Aziz University Marine Station
		Tea/coffee break
	Session 22	Compilation of field data collected in Obhur Creek
Sunday 14 April	Session 23	Review of fish monitoring data collected by workshop participants.
		Tea/coffee break
	Session 24	Determining potential yields of aquarium fish using fish density data and lessons learnt from aquarium fish management in the Maldives.
	Session 25	Final planning of monitoring strategies for benthic cover, using quadrats and point-intercept transect methodologies.
		Lunch break
	Session 26	Benthic monitoring exercise in Obhur Creek to assess percentage cover of live coral and other substrata comparing point-intercept transect and random quadrat methodologies
		Tea/coffee break
	Session 27	Compilation of field data collected in Obhur Creek
Monday 15 April	Session 28	Review of benthic monitoring data collected by workshop participants from Obhur Creek with lessons learnt from monitoring exercise and comparison of results obtained from two methodologies. Use of rarefaction curves to estimate the number of quadrats required to obtain statistically robust estimates.
		Tea/coffee break
	Session 29	Review of training workshop and lessons learnt from field monitoring activities
	Closing ceremony	Speakers: Dr Mohamed Abdallah (PERSGA/SAP LMR - Lead Specialist); Dr Mohamed Hariri (Dean of Marine Science Faculty, King Abdul Aziz University); Dr Maroof Khalaf (PERSGA/SAP, LMR - Working Group member); Dr Nizar Ibrahim Tawfiq (Secretary-General, PERSGA), Dr Mustafah Al-Edreisy (Vice-President, King Abdul Aziz University). Presentation of PERSGA Certificates of Appreciation to course participants
		Final Conference Lunch

ANNEX 3

Data on the marine aquarium trade in the Red Sea and Gulf of Aden available from the Global Marine Aquarium Database of the World Conservation Monitoring Centre.

Table 1: Data extracted from World Conservation Monitoring Centre Global Marine Aquarium Database (GMAD) on species Exported (E) or Imported (I) into the Kingdom of Saudi Arabia with indication of quantities and percentage or total numbers for each species. Species are ranked in order of abundance in trade. For species listed as both imported and exported, only export data are listed. Likely misidentifications are underlined.

Type	Genus	Species	Quantity	Total
E	*Chromis*	*viridis*	4067	19.162
E	*Dascyllus*	*marginatus*	1297	6.111
E	*Pseudanthias*	*squamipinnis*	1255	5.913
E	*Pseudochromis*	*fridmani*	1160	5.466
E	*Acanthurus*	*sohal*	711	3.350
E	*Amphiprion*	*bicinctus*	657	3.096
E	*Larabicus*	*quadrilineatus*	600	2.827
E	*Zebrasoma*	*xanthurum*	589	2.775
E	*Pomacanthus*	*asfur*	509	2.398
E	*Zebrasoma*	*veliferum*	505	2.379
E	*Chaetodon*	*larvatus*	469	2.210
E	*Naso*	*lituratus*	448	2.111
E	*Chaetodon*	*fasciatus*	421	1.984
E	*Chaetodon*	*paucifasciatus*	413	1.946
E	*Pseudochromis*	*flavivertex*	410	1.932
E	*Pseudochromis*	*springeri*	299	1.409
E	*Rhinecanthus*	*assasi*	295	1.390
E	*Chromis*	*dimidiata*	291	1.371
E	*Pygoplites*	*diacanthus*	277	1.305
E	*Gomphosus*	*caeruleus*	267	1.258
E	Cobitis	*lutheri*	247	1.164
E	*Chaetodon*	*mesoleucos*	243	1.145
E	*Pomacanthus*	*maculosus*	236	1.112
E	*Chaetodon*	*auriga*	205	0.966
E	*Odonus*	*niger*	205	0.966
E	*Dascyllus*	*trimaculatus*	182	0.858
E	*Chaetodon*	*semilarvatus*	181	0.853
E	*Anampses*	*twistii*	175	0.825
E	*Heniochus*	*intermedius*	156	0.735
E	*Thalassoma*	*lunare*	151	0.711

E	*Valenciennea*	*strigata*	141	0.664
E	*Thalassoma*	*rueppellii*	132	0.622
E	*Paracheilinus*	*octotaenia*	131	0.617
E	*Pterois*	*radiata*	121	0.570
E	*Pomacanthus*	*imperator*	117	0.551
E	*Halichoeres*	*hortulanus*	113	0.532
E	*Arothron*	*diadematus*	112	0.528
E	*Meiacanthus*	*nigrolineatus*	112	0.528
E	*Chaetodon*	*trifasciatus*	111	0.523
E	*Bodianus*	*anthioides*	108	0.509
E	*Pseudochromis*	*olivaceus*	108	0.509
E	*Ostracion*	*cubicus*	100	0.471
E	*Coris*	*aygula*	94	0.443
E	*Parupeneus*	*cyclostomus*	91	0.429
E	*Thalassoma*	*klunzingeri*	88	0.415
E	*Scarus*	*ghobban*	86	0.405
E	*Parupeneus*	*forsskali*	83	0.391
E	*Dascyllus*	*aruanus*	81	0.382
E	*Labroides*	*dimidiatus*	78	0.368
E	*Chrysiptera*	*annulata*	71	0.335
E	*Chaetodon*	*lineolatus*	66	0.311
E	*Cheilinus*	*lunulatus*	64	0.302
E	*Cephalopholis*	*miniata*	64	0.302
E	*Halichoeres*	*scapularis*	64	0.302
E	*Ptereleotris*	*evides*	61	0.287
E	*Pterois*	*volitans*	59	0.278
E	*Novaculichthys*	*taeniourus*	57	0.269
E	*Acanthurus*	*mata*	55	0.259
E	*Cephalopholis*	*argus*	52	0.245
E	*Cheilinus*	*fasciatus*	51	0.240
E	*Chaetodon*	*lunulatus*	50	0.236
E	*Epibulus*	*insidiator*	49	0.231
E	*Variola*	*louti*	48	0.226
E	*Halichoeres*	*marginatus*	48	0.226
E	*Diploprion*	*drachi*	47	0.221
E	*Pseudobalistes*	*fuscus*	46	0.217
E	*Amblygobius*	*hectori*	46	0.217
E	*Scarus*	*niger*	44	0.207
E	*Abudefduf*	*sexfasciatus*	43	0.203

E	*Scarus*	*forsteni*	41	0.193
E	*Scarus*	*ferrugineus*	40	0.188
E	*Paracirrhites*	*forsteri*	38	0.179
E	*Centropyge*	*multispinnis*	38	0.179
E	*Thalassoma*	*purpureum*	38	0.179
E	*Genicanthus*	*caudovittatus*	35	0.165
E	*Macropharyngodon*	*bipartitus bipartitus*	32	0.151
E	*Oxycheilinus*	*digrammus*	32	0.151
E	*Monodactylus*	*argenteus*	28	0.132
E	*Taeniura*	*lymna*	27	0.127
E	*Plectorhinchus*	*gibbosus*	25	0.118
E	*Pomacentrus*	*sulfureus*	25	0.118
E	*Ecsenius*	*frontalis*	20	0.094
E	*Siderea*	*grisea*	20	0.094
E	*Scarus*	*schlegeli*	20	0.094
E	*Balistapus*	*undulatus*	20	0.094
I	*Crypotcentrus*	*caeruleopunctatus*	19	0.090
I	*Ctenochaetus*	*striatus*	16	0.075
E	*Gymnthorax*	*undulatus*	11	0.052
E	*Apogon*	*aureus*	8	0.038
E	*Torpedo*	*marmorata*	8	0.038
E	*Sicyopterus*	*griseus*	7	0.033
E	*Platax*	*pinnatus*	7	0.033
E	*Coris*	*gaimard africana*	6	0.028
E	*Gomphosus*	*varius*	5	0.024
I	*Ecsenius*	*gravieri*	3	0.014
E	*Canthigaster*	*margaritata*	3	0.014
I	*Pomacentrus*	*trilineatus*	3	0.014
E	*Myrichthys*	*colubrinus*	1	0.005
E	*Balistoides*	*viridescens*	1	0.005

Table 2: Data extracted from World Conservation Monitoring Centre Global Marine Aquarium Database on species Exported (E) or Imported (I) into the Egypt with indication of quantities and percentage or total numbers for each species in database. Species are ranked in order of abundance in trade.

Type	Genus	Species	Quantity	Percentage Total
I	*Pseudochromis*	*fridmani*	105	22.6
I	*Pseudochromis*	*springeri*	104	22.4
I	*Pseudochromis*	*flavivertex*	80	17.2
I	*Acanthurus*	*sohal*	60	12.9
I	*Ecsenius*	*gravieri*	30	6.5
I	*Amblygobius*	*hectori*	26	5.6
I	*Zebrasoma*	*xanthurum*	20	4.3
I	*Pygoplites*	*diacanthus*	18	3.9
I	*Chaetodon*	*semilarvatus*	15	3.2
I	*Arothron*	*diadematus*	4	0.9
I	*Bodianus*	*anthioides*	2	0.4

ANNEX 4

List of scientific, trade and English common names of principal fish species exploited by the marine aquarium trade in the Red Sea and Gulf of Aden.

Table compiled and edited from GMAD database and records of Saudi Arabian ornamental fish companies attending the workshop using Randall (1983) and Khalaf and Disi (1997). *Price range:* H = ≥$10; M = $2 – $10; L = <$2. *Status:* O = only occasionally collected by the trade, C = Commonly collected by the trade (although often in very low numbers). Annex 3 indicates relative numbers taken for most commonly collected species. The price range data is from one ornamental fish company and mean (average) price data from another company. Prices for a species will vary with the size of the fish.

Family	Genus	Species	Common names	Concerns	Price range	Mean Price	Status
Acanthuridae	*Acanthurus*	*gahhm*	Black/Whitetail surgeon(fish)	Endemic	M		O
Acanthuridae	*Acanthurus*	*nigrofuscus*	Brown surgeon(fish)		M		O
Acanthuridae	*Acanthurus*	*sohal*	Sohal (tang), Red Sea surgeon(fish)	Endemic	H	$10.00	C
Acanthuridae	*Ctenochaetus*	*striatus*	Lined/Brown bristletooth		M		C
Acanthuridae	*Naso*	*brevirostris*	Long-nose/Spotted unicornfish			$10.00	C
Acanthuridae	*Naso*	*hexacanthus*	Sleek unicornfish			$10.00	O
Acanthuridae	*Naso*	*lituratus*	Orangespine/Lipstick unicornfish, Blonde naso		M - H	$8.00	C
Acanthuridae	*Naso*	*unicornis*	Short-nose/Bluespine unicornfish			$10.00	C
Acanthuridae	*Zebrasoma*	*veliferum*	Sailfin tang		M	$6.00	C
Acanthuridae	*Zebrasoma*	*xanthurum*	Yellowtail/Purple tang	Endemic	M	$12.00	C
Apogonidae	*Apogon*	*aureus*	Golden cardinalfish		M		O
Balistidae	*Balistapus*	*undulatus*	Orange-striped/ Undulate triggerfish		M	$8.00	C
Balistidae	*Balistoides*	*viridescens*	Titan triggerfish		M - H		C
Balistidae	*Odonus*	*niger*	Red-tooth/Niger triggerfish		M	$10.00	C
Balistidae	*Pseudobalistes*	*fuscus*	Yellow-spotted/Blue-lined triggerfish		M		C
Balistidae	*Rhinecanthus*	*assasi*	Picasso triggerfish, Assasi	Endemic	M	$8.00	C
Balistidae	*Sufflamen*	*albicaudatus*	Bluethroat triggerfish	Endemic	M	$8.00	C
Blenniidae	*Ecsenius*	*aroni*	Aron's blenny	Endemic		$3.00	O
Blenniidae	*Ecsenius*	*frontalis*	Smoothfin blenny		L		C
Blenniidae	*Ecsenius*	*gravieri*	Red Sea mimic blenny	Endemic	L	$3.00	C
Blenniidae	*Exallius*	*brevis*	Short-bodied blenny			$5.00	O
Blenniidae	*Istiblennius*	*periophthalmus*	Red algae/Red-dotted		L		O

			blenny				
Blenniidae	*Meiacanthus*	*nigrolineatus*	Blackline fangblenny	Endemic	L	$2.50	C
Chaetodontidae	*Chaetodon*	*auriga*	Threadfin butterfly(fish)		M	$5.00	C
Chaetodontidae	*Chaetodon*	*austriacus*	Exquisite/Melon butterfly(fish)	Endemic, Low survival		$6.00	C
Chaetodontidae	*Chaetodon*	*fasciatus*	Red Sea racoon/ Striped butterfly(fish)	Endemic	M - H	$6.00	C
Chaetodontidae	*Chaetodon*	*larvatus*	Orangeface butterfly(fish)	Endemic	M	$4.00	C
Chaetodontidae	*Chaetodon*	*lineolatus*	Lined butterfly(fish)		M - H	$8.00	C
Chaetodontidae	*Chaetodon*	*melannotus*	Blackback butterfly(fish)		M	$8.00	C
Chaetodontidae	*Chaetodon*	*melapterus*	Arabian butterfly(fish)	Endemic			C
Chaetodontidae	*Chaetodon*	*mesoleucos*	Whiteface/Red Sea butterfly(fish)	Endemic	M	$4.00	C
Chaetodontidae	*Chaetodon*	*paucifasciatus*	Redback butterfly(fish)	Endemic	M	$9.00	C
Chaetodontidae	*Chaetodon*	*semilarvatus*	Golden/Redlined/ Masked butterfly(fish)	Endemic	H	$16.00	C
Chaetodontidae	*Chaetodon*	*trifascialis*	Chevroned butterfly(fish)	Low survival		$7.00	C
Chaetodontidae	*Heniochus*	*diphreutes*	Schooling bannerfish		M - H		C
Chaetodontidae	*Heniochus*	*intermedius*	Red Sea bannerfish	Endemic	M - H	$5.00	C
Cirrhitidae	*Paracirrhites*	*forsteri*	Blackside/Forster's hawkfish		M	$3.00	C
Dasyatidae	*Himantura*	*uarnak*	Spotted longtail ray			$20.00	C
Dasyatidae	*Taeniura*	*lymma*	Blue-spotted stingray		M - H	$18.00	C
Ephippidae	*Platax*	*orbicularis*	Circular spadefish		M		C
Gobiidae	*Amblygobius*	*albimaculatus*	Tailspot goby		M	$7.00	C
Gobiidae	*Amblygobius*	*hectori*	Hector's goby		L - M		C
Gobiidae	*Crypotcentrus*	*caeruleopunctatus*	Blue-and-red-spotted goby	Endemic	M	$4.00	C
Gobiidae	*Crypotcentrus*	*lutheri*	Luther's goby	Endemic	M		C
Gobiidae	*Valenciennea*	*puellaris?*	Blue-band goby		M		C
Haemulidae	*Plectorhinchus*	*gaterinus*	Black-spotted sweetlips, Yellow grunt			$8.00	C
Holocentridae	*Myripristis*	*murdjan*	Crimson soldierfish				O
Holocentridae	*Neoniphon*	*sammara*	Bloodspot/Spotfin squirrel(fish)			$5.00	C
Holocentridae	*Sargocentron*	*caudimaculatum*	Tailspot/ Silver squirrel(fish)			$7.00	C
Holocentridae	*Sargocentron*	*spinifer*	Longjaw squirrel(fish)				O
Labridae	*Anampses*	*caeruleopunctatus*	Bluespot wrasse				O
Labridae	*Anampses*	*meleagrides*	Spotted/Yellowtail wrasse		M		O
Labridae	*Anampses*	*twistii*	Yellow-breasted wrasse		M	$5.00	C
Labridae	*Bodianus*	*anthioides*	Lyretail hogfish		M	$6.00	C

Labridae	*Bodianus*	*axillaris*	Axilspot hogfish			$10.00	C
Labridae	*Bodianus*	*diana*	Diana's hogfish		M		C
Labridae	*Cheilinus*	*abudjubbe*	Abudjubbe	Endemic	M	$10.00	C
Labridae	*Cheilinus*	*fasciatus*	Red-breasted Maori wrasse		M	$13.00	C
Labridae	*Cheilinus*	*lunulatus*	Broomtail wrasse	Endemic	M - H	$15.00	C
Labridae	*Cheilinus*	*mentalis*	Mental wrasse		M	$8.00	C
Labridae	*Cheilinus*	*undulatus*	Humphead wrasse		M		O
Labridae	*Cheilio*	*inermis*	Cigar wrasse		M	$10.00	C
Labridae	*Coris*	*africana*	African coris		M	$5.00	C
Labridae	*Coris*	*aygula*	Clown/Twin-spot coris/wrasse		M	$10.00	C
Labridae	*Coris*	*caudimacula*	Spottail (sand) coris		M	$5.00	C
Labridae	*Coris*	*variegata*	Dapple/Variegated coris				O
Labridae	*Epibulus*	*insidiator*	Slingjaw/Yellow-longjaw wrasse		M	$6.00	C
Labridae	*Gomphosus*	*caeruleus*	Red Sea bird/Greenbird/ Brownbird wrasse		M	$4.00	C
Labridae	*Halichoeres*	*hortulanus*	Checkerboard/Cheque red wrasse		M	$6.00	C
Labridae	*Halichoeres*	*marginatus*	Dusky wrasse		M	$7.00	C
Labridae	*Halichoeres*	*scapularis*	Zigzag wrasse		M	$5.00	C
Labridae	*Hemigymnus*	*fasciatus*	Barred (thicklip) wrasse			$10.00	C
Labridae	*Hologymnosus*	*annulatus*	Ring wrasse			$17.00	C
Labridae	*Labroides*	*dimidiatus*	(Bluestreak) Cleaner wrasse		M	$2.50	C
Labridae	*Larabicus*	*quadrilineatus*	Arabian/Four-line cleaner (wrasse)	Endemic	M	$2.50	C
Labridae	*Macropharyngodon*	*bipartitus*	Divided/Vermiculate wrasse		M	$5.00	C
Labridae	*Novaculichthys*	*taeniourus*	Rockmover/Dragon wrasse		M	$7.00	C
Labridae	*Oxycheilinus*	*digrammus*	Cheek-lined Maori wrasse		M		C
Labridae	*Paracheilinus*	*octotaenia*	Eight-stripe/Eight-line wrasse	Endemic	M	$3.00	C
Labridae	*Pseudodax*	*moluccanus*	Chiseltooth wrasse				C
Labridae	*Stethojulis*	*albovittata*	Blue-lined wrasse		M	$3.00	C
Labridae	*Stethojulis*	*interrupta*	Cutribbon wrasse		M		C
Labridae	*Thalassoma*	*klunzingeri*	Klunzinger's/ Rainbow wrasse	Endemic	M	$4.00	C
Labridae	*Thalassoma*	*lunare*	Moon/Lunare wrasse		M	$3.00	C
Labridae	*Thalassoma*	*purpureum*	Surge wrasse		M		C
Lutjanidae	*Lutjanus*	*kasmira*	Blueline/Bluestripe snapper		M	$6.00	C
Microdesmidae	*Ptereleotris*	*evides*	Twotone dartfish, Scissortail goby		M	$5.00	C
Microdesmidae	*Ptereleotris*	*zebra*	Zebra dartfish/goby		M	$4.00	C
Monacanthidae	*Amanses*	*scopas*	Broom filefish				C

Monacanthidae	*Cantherhines*	*pardalis*	Wire-net filefish			$10.00	C
Monodactylidae	*Monodactylus*	*argenteus*	Mono		M		C
Mullidae	*Parupeneus*	*cyclostomus*	Yellow-saddle/Yellow goatfish		M	$7.00	C
Mullidae	*Parupeneus*	*forsskali*	Forsskal's/Dot-dash goatfish	Endemic	M	$7.00	C
Mullidae	*Parupeneus*	*macronema*	Pink and black goatfish				O
Mullidae	*Parupeneus*	*rubescens*	Redstriped/Rosy goatfish			$9.00	C
Muraenidae	*Gymnthorax*	*undulatus*	Undulated moray		M		C
Muraenidae	*Siderea*	*grisea*	Grey/Peppered/Geometric moray		M		C
Ophichthidae	*Myrichthys*	*colubrinus*	Ringed snake eel		M		C
Ostraciidae	*Ostracion*	*cubicus*	Yellow boxfish		M		C
Pinguipedidae	*Parapercis*	*hexophtalma*	Spotted sandperch		M	$3.00	C
Plotosidae	*Plotosus*	*lineatus*	Striped eel catfish		M		C
Pomacanthidae	*Centropyge*	*multispinnis*	Manyspined/Multi-spinnis/ Red Sea dwarf angel(fish)		M	$10.00	C
Pomacanthidae	*Genicanthus*	*caudovittatus*	Zebra angel(fish)		M - H	$12.00	C
Pomacanthidae	*Pomacanthus*	*asfur*	Arabian angel(fish)	Endemic	H	$11.00	C
Pomacanthidae	*Pomacanthus*	*imperator*	Emperor angel(fish)		H	$35.00	C
Pomacanthidae	*Pomacanthus*	*maculosus*	Yellow-bar/Bluemoon angel(fish)		H	$20.00	C
Pomacanthidae	*Pygoplites*	*diacanthus*	Royal/Regal angel(fish)	Low survival	M - H	$8.00	C
Pomacentridae	*Abudefduf*	*sexfasciatus*	Scissor-tail/Stripetail sergeant		L		O
Pomacentridae	*Amphiprion*	*bicinctus*	Two-banded anemonefish, Red Sea clown		M	$3.00	C
Pomacentridae	*Chromis*	*dimidiata*	Half-and-half/ Chocolate-dip chromis		L	$1.00	C
Pomacentridae	*Chromis*	*viridis*	Blue-green chromis		L	$1.00	C
Pomacentridae	*Chrysiptera*	*annulata*	Footballer demoiselle		L		C
Pomacentridae	*Dascyllus*	*aruanus*	Humbug/Threestripe dascyllus/damsel		L	$1.00	C
Pomacentridae	*Dascyllus*	*marginatus*	Black-banded dascyllus, Half-moon damsel		L	$1.00	C
Pomacentridae	*Dascyllus*	*trimaculatus*	Three-spot/Domino dascyllus/damsel		L	$1.00	C
Pomacentridae	*Paraglyphidodon*	*melas*	Royal damsel(fish)			$2.00	O
Pomacentridae	*Pomacentrus*	*sulfureus*	Sulphur damsel		L		C
Pomacentridae	*Pomacentrus*	*trilineatus*	Three-line damsel		L		O
Pseudochromidae	*Pseudochromis*	*flavivertex*	Yellow-back/Sunrise dottyback	Endemic	M	$4.00	C
Pseudochromidae	*Pseudochromis*	*fridmani*	Orchid/Fridman's dottyback	Endemic	M	$4.00	C
Pseudochromidae	*Pseudochromis*	*olivaceus*	Olive dottyback	Endemic	M		C

Pseudochromidae	*Pseudochromis*	*springeri*	Springer's dottyback	Endemic	M		C
Scaridae	*Cetoscarus*	*bicolor*	Bicolor parrotfish		M	$8.00	O
Scaridae	*Scarus*	*ferrugineus*	Rusty parrotfish		M	$8.00	C
Scaridae	*Scarus*	*fuscopurpureus*	Purple-brown parrotfish		M	$8.00	C
Scaridae	*Scarus*	*ghobban*	Blue-barred parrotfish		M		C
Scaridae	*Scarus*	*gibbus*	Steep-headed parrotfish		M		O
Scaridae	*Scarus*	*niger*	Swarthy/Dusky parrotfish		M	$8.00	C
Scaridae	*Scarus*	*psittacus*	Palenose parrotfish		M	$8.00	C
Scorpaenidae	*Pterois*	*miles*	Soldier turkeyfish, Lionfish		M	$17.00	C
Scorpaenidae	*Pterois*	*radiata*	Clearfin turkeyfish, Tailbar lionfish		M	$14.00	C
Scorpaenidae	*Scorpaenopsis*	*barbatus*	Bearded scorpionfish				O
Scorpaenidae	*Synanceia*	*verrucosa*	Stonefish				O
Serranidae	*Cephalopholis*	*argus*	Peacock grouper		M - H	$8.00	C
Serranidae	*Cephalopholis*	*hemistiktos*	Half-spotted grouper	Endemic		$8.00	C
Serranidae	*Cephalopholis*	*miniata*	Coral grouper		M - H	$8.00	C
Serranidae	*Cephalopholis*	*oligosticta*	Vermilion grouper			$8.00	O
Serranidae	*Cephalopholis*	*sexmaculata*	Sixspot grouper			$8.00	O
Serranidae	*Diploprion*	*drachi*	Yellowface soapfish		M		C
Serranidae	*Epinephelus*	*summana*	Whitespot/Summana grouper			$8.00	O
Serranidae	*Pseudanthias*	*squamipinnis*	Scalefin/Lyretail anthias		M	$2.50	C
Serranidae	*Variola*	*louti*	Lunartail grouper		M		O
Tetraodontidae	*Arothron*	*diadematus*	Masked puffer	Endemic	M	$6.00	C
Tetraodontidae	*Arothron*	*hispidus*	White-spotted puffer/ Stars and stripes puffer		M		C
Tetraodontidae	*Canthigaster*	*coronata*	Crown toby, Longnose puffer		L - M		C
Tetraodontidae	*Canthigaster*	*margaritata*	Pearl toby	Endemic	L - M	$3.00	C
Torpedinidae	*Torpedo*	*panthera*	Leopard torpedo		M		C

ANNEX 5

Presentations on the identification of fish of importance to the marine aquarium fish trade

Identification of aquarium fishes 1: Discussion of endemism in the region which approaches 20 % for coral reef fish species; identifying 34 species of damselfishes (Pomacentridae), butterflyfishes (Chaetodontidae), angelfishes (Pomacanthidae), triggerfishes (Balistidae) prevalent in the marine aquarium trade. (Quiz 1: identification of 12 most important species in the aquarium trade from these 4 families).

Identification of aquarium fishes 2: Identifying 27 species of surgeonfishes (Acanthuridae), dottybacks (Pseudochromidae), pufferfishes (Tetraodontidae), moray eels (Muraenidae), boxfishes (Ostraciidae), blennies (Blenniidae), Groupers and anthias (Serranidae) prevalent in the marine aquarium trade. (Quiz 2: identification of 12 most important species in the aquarium trade from these 7 families).

Identification of aquarium fishes 3: Identifying 28 species in the wrasse family (Labridae) prevalent in the marine aquarium trade. (Quiz 3: identification of the 9 most important wrasse species in the aquarium trade).

Identification of aquarium fishes 4: Identifying 21 species of parrotfishes (Scaridae), scorpionfishes (Scorpaenidae), goatfishes (Mullidae), gobies (Gobiidae), cardinalfishes (Apogonidae), eel catfishes (Plotosidae), etc. prevalent in the marine aquarium trade. (Quiz 4: identification of the 9 most important species in the aquarium trade in these 12 families).

Species that need special consideration: discussion of those species that require special consideration owing to:

1. Poor survivorship in captivity (e.g. easily stressed, obligate corallivores, release toxins)
2. Easy overexploitation (rare, endemic)
3. Collateral damage caused by collection (species which shelter in branching coral)
4. Ecological concerns (cleaners)