5. REVIEW OF POTENTIAL AREAS OF CONFLICT WITH SUGGESTED SOLUTIONS AND PROPOSED RESEARCH PROGRAMS

Some research has been carried out on the effect of collecting specific aquarium fishes on reef populations, but this discussion will be limited to the areas of concern which have most relevance to the Great Barrier Reef.

5.1 Areas of conflict

5.1.1 Effects on target species

- Collection in certain areas may deplete numbers of a species in a localised region (Walsh, 1978). Lubbock and Polunin (1975) cite examples of supposed extinctions along the Sri Lankan and Kenyan coasts where collection has been confined to small areas.

- Collection of fish from accessible depth ranges may deplete numbers in this range. Although they may still be common at greater depths, to the diver and sightseer however, the species is as good as extinct (Walsh, 1978). Local depletion of Blue Tang (Paracanthurus hepatus) has been reported at Arlington Reef as a result of collection (Ian Croll, pers comm.).

- Even though the diversity of fish in reef ecosystems is great, not all species are particularly abundant and some may be greatly depleted in abundance by collection. 35 percent of the Hawaiian aquarium fish catch is composed of species rated between 'scarce' and 'rare' (Walsh, 1978).

- de Boer (1981) voiced concern over the collection of species that undergo a sex change. He used an example Gamma loreto, a protogynous species (changes from female to male). If the larger fish were caught continually and there was no compensating reduction in the size of sex

change, the population would be all female, resulting in no breeding. The same may well apply to protandrous species (those which change from male to female).

5.1.2 Effects on the reef community

- Destruction of shelter while collecting (Walsh, 1978) will decrease utilizable reef fish living space. This may lead to a reduction in the number of reef fish (and other organisms).

- de Boer (1981) was concerned that removal of cleaner fish may result in an increase in fish parasites on previously 'clean' fish, with possible deleterious effects.

- Removal of herbivorous species may lead to a significant increase in algal coverage, which may result in decreased settlement of coral planulae, hence reduced coral coverage and less habitat for fish (de Boer, 1981; Dart _in_ Lubbock and Polunin, 1975).

- The wrasse (_Cheilinus undluatus_), Pufferfish (_Arothron hispidus_) and Tiggerfish (_Balistoides vindiscens_ prey upon _Acanthaster planci_ (Crown of thorns starfish) (Roads and Ormond _in_ Lubbock and Polunin, 1975).

- Collection of aquarium fish may disadvantage predator species if numbers of the small reef fish are severely depleted. _Abudeduf spp_., _Acanthurus spp_. and _Pomacentrus spp_. have been found in the stomach contents of coral trout (Goeden, 1978; Choat, 1968), although coral trout appear to be opportunistic feeders. The relative absence of these and other large predatory fish may affect reproductive strategies and density dependant aspects of the life histories of prey fishes such as the smaller aquarium fishes, although there is no information to support or refute this view (Russ, 1984).

- Although illegal, the use of chemicals to capture aquarium fish in the Great Barrier Reef Region is reported to occur, but the extent of this is unknown (McKay, pers comm.). Cyanide is reported to be employed widely in the Philippines, whilst in other countries, both overseas and in Australia, the most widely used chemicals are quinaldine and rotenone (Robinson, 1981). Jaap and Wheaton (1975) report that there is minimal or no long-term damage to coral exposed to test quinaldine solution, however the commercial rotenone preparation causes severe damage to coral colonies, killing many species. Cyanide, although having an anaesthetizing effect on fish, lingers in the fish's digestive system and erodes the intestinal lining (Bellwood, 1981), premature death often resulting. To date its use has not been reported in the GBRR.

5.2 Suggested solutions

- Creation of artificial habitats/reefs in some areas (Nolan, 1978) in order to increase living space and thus abundance of reef fish.

- Species of reef fish which are particularly rare may require total protection (Walsh, 1978; Lubbock and Polunin, 1975) from collecting pressures.

- A review of collecting techniques and elimination of those harmful to the reef environment (Walsh, 1978; Lubbock and Polunin, 1975).

- Close heavily collected areas periodically in order to permit revitalization of collected stocks (Walsh, 1978). This idea is similar to the Temporary Reserve idea (Lubbock and Polunin, 1975; Siri and Barnett, 1980) whereby areas of permitted collection are rotated continually.

- Control over numbers of collectors in an area and over numbers and types of fish collected (Walsh, 1978; de Boer, 1981).

- The declaration of sanctuary areas (Randall, 1978; Taylor, 1978; Siri and Barnett, 1980; Nolan, 1978) would have many advantageous characteristics in addition to the protection of reef fish species within the sanctuary confines:

  - enhance collecting in adjacent areas through larval production

  - provide study areas for comparison.

- Lubbock and Polunin (1975) voiced concern over the wastage between capture and retail distribution, due to lack of control over exporters and importers, resulting in inexperience entering the trade. This inexperience results in unnecessarily high mortality which is an inefficient utilization of the natural resource. They feel that competition and free trade are not necessarily beneficial to the coral reef fish trade and that such competition leads to unnecessary exploitation to compensate for the inefficiency of exporters and importers. The following proposals were made:

  - requirements of proficiency in the trade (licences)

  - catch reports

  - in countries bordering temperate/tropical seas, aquarists should be made aware of the ecological dangers of releasing exotic species.

- Mariculture, considered below in some detail, involves a new approach to the aquarium fish trade; a farming approach rather than a hunting approach as presently practised.

Mariculture is a recent marketing development in the marine aquarium fish industry and is in its infancy compared to its freshwater counterpart. The development of this technique offers an alternative to, but not a replacement for, collecting from the wild. It provides some control over the product, which may be managed more efficiently, thus providing a higher yield. Through genetic selection, faster growing and more tolerant varieties may be produced. While the prices are lower per unit, a larger volume is possible, along with the hybrids and varieties which increase the desirability and demand for the product (Madden, 1978).

Very few marine aquarium fishes have been bred sucessfully in captivity and there seems to have been little documented research on rearing of coral reef fishes. While a number of fishes have been observed to spawn in aquaria, filtration may destroy eggs unless precautions are taken.

Other limitations have been the difficulty in keeping marine fish in conditions good enough to allow gonad development and spawning, the specialised requirements of larval fish for food and environment, and a proclivity for disease in captive fish (Moe, 1981).

Madden (1978), of the Oceanic Institute of Hawaii reports that generally marine fish will not spawn in captivity and spawning must be manipulated through environmental changes and/or hormone injections.

Fish that lay demersal eggs (on the substrate) are better prospects for mariculture since the young do not require pelagic conditions of food and space, which are difficult to reproduce in the aquaria (Siri and Barnett, 1980). In some instances it will not be possible, practical or economical to breed certain species, and collecting from the wild will still be necessary (Madden, 1978). Already however, there has been some degree of success in the mariculture of some aquarium fish:

- The White Tailed Puller (*Acanthochromis polyacanthus*) broods it's eggs and breeds successfully in aquaria (Watson, *pers comm*.).

- Some successful breeding of clownfishes in Germany (*Amphiprion akailopisas* and *A. ephippium*) and Australia has apparently been achieved (Nequebauer *in* Allen, 1975; McKay, *pers comm*.).

- Clownfish (*Amphiprion spp.*) have also been hatched at Taronga Zoological Aquarium (West, *pers comm*.).

- The Mandarin fish (*Synchiropus splendidus*) and Australian Orange Tail Blue Damsel (*Glyphidodontops hemicyaneus*) are also believed to have spawned in captivity (Brown, *pers comm*.).

- Martin Moe Jnr, from Aqualifi Research Corporation in Florida has been involved with the development of culturing ornamental fish since the early 1970's and presently markets small numbers of cultured clownfish (*Amphiprion*), Neon Gobies (*Gobiosoma oceanops*), angelfish (*Pomacanthus*) and a hybrid angelfish. He has also spawned and reared to the juvenile stage a number of other species as listed in Table 2.

Table 2. Species of fish reared to the juvenile stage under artificial conditions by M. Moe, Jnr.

Scientific Name	Common Name
Amphiprion akallopisos	Skunk Clownfish
A. chrysopterus	Gold Fin Clownfish
A. clarkii	Clarkii Clownfish
A. ephippium	Black Backed Clownfish
A. frenatus	Brindled Clownfish
A. melanopus	Black Clownfish
A. ocellaris	Orange Clownfish
A. percula	Percula Clownfish
A. perideraion	Pink Skunk Clownfish
A. polymnus	White Saddled Clownfish
A. rubrocinctus	Richardson's Clownfish
A. sandaracinos	Allen's Clownfish
A. tricinctus	Three Band Clownfish
Premnas biaculeatus	Maroon Clownfish
Gramma loreto	Royal Gramma
Apogon nematopterus	Cardinal fish
Trachinotus carolinus	Florida Pompano
Lutjanus griseus	Grey Snapper
Anisotremus virginicus	Parkfish
Haemulon plumieri	White Grunt
Equetus acuminatus	High-hat
E. lanceolatus	Jackknife fish
Chaetodipterus faber	Atlantic Spadefish
Pomacanthus arcuatus	Grey Angelfish
P. paru	French Angelfish
Abudefduf saxatilis	Sergeant Major (Black)
Hypsypops rubioundus	Garibaldi
Pomacentras flavicauda	Yellowtail Damsel (Jewel fish)
Lachnolaimus maximus	Hogfish
Opistognathus aurifrons	Yellowhead Jawfish
Gobiosomus multifasciatum	Greenband Goby
G. evelynae	Sharknosed Goby
G. oceanops	Neon Goby

Gobiesox strumosus	Skilletfish
Hippocampus erectus	Lined Seahorse
H. zosterae	Dwarf Seahorse
Sphoeroides maculatus	Northern Puffer

In the short term, culture of tropical fish will not be widely adopted, as it is currently not competitive with collecting and there is little economic incentive to do so because of imports, and the preliminary research required. Thus it may fill only an alternative role, when divers cannot collect either through inclement weather or due to other causes. In the long term however, raising ornamentals from the egg stage may prove to provide less expensive and healthier specimens, while reducing the pressure on heavily collected reef areas.

5.3 Proposed research programs

One of the primary themes of this report was to indicate those areas where knowledge is lacking. Considered below are appropriate research programs that may fill this gap in knowledge and allow future management decisions to be made regarding aquarium fish collecting.

5.3.1 Biological studies

- Basic biology and population dynamics of individual species:

  including distribution, larval duration, growth, age at maturity, mortality, fecundity, recruitment, life-histories, territoriality, home ranges and population densities.

- Effects of collecting on target and non-target communities.

- Environmental effects on individual species:
  effects of temperature and salinity changes as well as other biotic and abiotic factors.

- Mariculture:
  breeding of stock aquarium fishes.

- Survival in captivity:
  longevity - does this differ from the natural environment.

Such biological information is specific however, to the species studies and to the region where the study was conducted. Hence, it will be a long time before a thorough knowledge of the detailed effects of aquarium fish collecting on an environment may be obtained.

5.3.2 Economics of the industry

- The collectors:
  what is the value of locally caught fish (compared with the value of other fisheries, imported aquarium fishes, cost of aquarium fish research etc.).

- The industry:
  import costs and values
  wholesale/retail sales
  potential for Australian caught fish in market terms.

This information will indicate how important the industry is in economic terms and will give some hint as to the extent of collection and the possible future growth in the industry.

5.3.3 Fishing activities

- The fishery:
  - catch and effort data
  - localities collected from
  - fishing methods.

- Environmental effects:
  - what damage is done by fishing activities compare with anchor damage, tourists, Acanthaster planci, cyclones, chemicals.

As biological information will be obtained only very slowly, the abovementioned information would provide useful guidelines for the monitoring of the industry in the meantime. This type of information might best be collected by introducing a log book. This could enable the collection of useful, long-term data, allowing the monitoring of individual species at specific reefs.