Pathway Risk Analysis for Exotic Ornamental Marine and Estuarine Species

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ABSTRACT
The Florida Department of Agriculture and Consumer Services, Florida Fish and Wildlife Conservation Commission, and University of Florida cooperatively responded to a state Comprehensive Wildlife Conservation Strategy which called for a risk assessment on all commercially available exotic marine/estuarine animals in Florida's pet trade by organizing and managing a pathway risk analysis. The agencies recruited an expert panel consisting of 18 import, wholesale, retail, producer, harvester, research, extension, and agency representatives to implement the methodology described in *Generic Nonindigenous Aquatic Organisms Risk Analysis Review Process*. The participants produced a literature review, marine ornamental trade pathway description, assessed the ecological risks to Florida associated with marine ornamental species, determined the level of risk at each link and node in the trade pathway, and suggested risk mitigation actions. Annual global trade in marine ornamentals has an estimated retail value in the hundreds of millions of U.S. dollars per year with approximately 20 million fish specimens, 10 million invertebrate specimens (excluding coral), and 10 million coral pieces. These major groups are composed of approximately 1,500 fish species, 200 coral species, and 500 invertebrate species (excluding coral). The United States, European Union, Japan and China are the largest consumers. Source regions (in descending order of importance) are Indonesia, Philippines, South Pacific, Red Sea, Caribbean, South Atlantic, and Indian Ocean. Currently, 22 exotic ornamental marine fish species have been observed in Florida waters. One of the 22 species is established as a reproducing population in the South and mid-Atlantic outside of State of Florida waters. Participants described a marine ornamental pathway of links and nodes from sources to consumers and examined the potential for economic, environmental or perceived (social or political) effects as a consequence of marine ornamental species being established in Florida waters. They were very certain the potential economic costs were low and the economic benefits high based upon literature and general knowledge. Potential and real environmental effects were also judged to be low based upon literature and the combined observations of the marine life fishers that participated. However, the participants were very certain the perceived consequences, social and political, were high based upon concerns identified in the scientific literature and the use of emotive language when nonindigenous species are discussed. This could result in the implementation of stricter state regulations, on-site inspections, and reporting. A variety of risk mitigation activities were suggested for the unlicensed retail sale link and the consumer node of the marine trade pathway.

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SPECIAL NOTE
A limitation to the project was that Congressionally authorized State Wildlife Grant money administered by the U.S. Fish and Wildlife Service may not be used to pay for the establishment, publication and dissemination of regulations that a State issues pertaining to the protection and utilization of fish and wildlife resources. This includes laws, orders, seasonal regulations, bag limits, creel limits, license fees, etc. This does not prohibit the scientific collection of information needed to support management recommendations.

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Florida Pathway Risk Analysis for Nonindigenous Marine and Estuarine Aquarium Species

INTRODUCTION

Introductions of nonindigenous marine species into marine environments by humans may occur via unintentional or intentional aquarium or aquaculture releases, transport in ballast water, movement through canals, or stocking marine species to improve fisheries (Hare and Whitfield 2003). Nonindigenous marine species that become established have been characterized as causing "…fundamental impacts on fisheries resources, industrial development and infrastructure, human welfare, and ecosystem resources and services." (Carlton 2001: 1).

The trade in ornamental species (production, marketing and ownership) is a potential pathway[1] of biological invasion composed of human practices and attendant institutions which transport organisms outside their native ranges, intentionally or not (Courtenay 1997; Benson and Boydstun 1999; Ruiz and Carlton 2003). Scientists have expressed concern about the ecological risks associated with the marine ornamental trade (Hare and Whitfield 2003; Padilla and Williams 2004; Jacoby et al. 2004; Ruiz-Carus et al. 2006; Calado and Chapman 2006). Myrick (2002) discusses the potential ecological impacts of introduced cultured species including (1) genetic – congeneric interbreeding can cause genetic dilution and loss of genetic diversity; (2) disease – introduction of pathogens; (3) competition – create or intensify interspecific or intraspecfic competition for habitat, food or mates; (4) predation – predation by escapees on native species; hypothetically, large or frequent escape events may lead to localized predator abundance that would increase predation pressure in the immediate vicinity; (5) habitat alteration – direct or indirect habitat alteration that may negatively affect native species; (6) colonization – establishment and subsequent cumulative effects by a spreading population that may be detrimental to native biota.

In contrast to coastal states subject to cold water temperatures, Florida's tropical and subtropical climate and its role as a gateway for international trade seem to offer opportunities for the establishment of nonindigenous marine ornamental species. Marine ornamental species are primarily subtropical or tropical in distribution, and many are associated with coral reefs. The specific ecological and socio-economic features favoring successful colonization of marine ornamentals in Florida include: 1) temperate to subtropical climates, 2) two long coastlines shared with the warm Gulf of Mexico and South Atlantic Ocean that supplies abundant moisture to create a variety of estuarine aquatic habitats, 3) diverse coastal marine ecosystems ranging from salt marsh to mangrove forest that are associated with mud, sand, rock, or coral near-shore benthic substrates, 4) tremendous range of landscape ages from 25 million to a few thousand years, 5) long term, extensive and on-going aquatic habitat disturbance and alteration, 6) a growing population of 18 million residents and 84 million annual visitors, and 7) importance as a transportation hub for people and international economic trade (Simberloff 1997; Myers and Ewel 1990; Abell et al. 2000; Enterprise Florida, Inc. 2007).

In light of the potential risks of introduction, establishment, spread, and economic or ecological effects of marine ornamental species, authors of Florida's Comprehensive Wildlife Conservation Strategy advised the research community to "Conduct a risk assessment on all

[1] Pathway – The means by which aquatic species are transported between ecosystems (ANSTF 1996).

commercially available exotic marine/estuarine animals in Florida's pet trade" as a high priority research issue (FWC 2007: 438).

Marine and estuarine aquarium species (ornamentals) include fish, invertebrates, and plants for display in home, office, or public aquaria. Marine ornamentals are either caught from the wild or raised in aquaculture operations. Marine life fishing occurs primarily in shallow reef ecosystems throughout the tropics. While aquaculture of marine ornamentals is increasing, it is estimated that 90% of the supply remains from wild-harvested specimens (Cato and Brown 2003: xix).

Representatives from the Florida Department of Agriculture and Consumer Services, Florida Fish and Wildlife Conservation Commission (FWC), and University of Florida cooperatively responded to the high priority research action item with a proposal to implement a risk analysis of the marine ornamental fish pathway in Florida using the *Generic Nonindigenous Aquatic Organisms Risk Analysis Review Process* (hereafter referred to as Generic Analysis) (ANSTF 1996). They successfully made the case that it was technically infeasible to assess hundreds of species individually, and that a pathway risk analysis would be useful as an analytical tool that would yield risk mitigation options.

METHODS

The Generic Analysis pathway risk analysis consists of three steps:

(1) **Initiation** by an appropriate authority to evaluate a specific pathway. In this case, the analysis was initiated by a high priority research action item within the FWC statewide wildlife conservation plan.

(2) **Risk Assessment** consists of a process to: (a) identify interested parties and solicit their participation; (b) list the nonindigenous organisms of concern, (c) collect information about the pathway (literature and investigation); (d) assess the probability of establishment by examining the likelihood that an organism(s) is in the pathway and the potential for release, establishment, and spread; and (e) assess consequences of establishment by examining the potential for economic, environmental, and perceived (social and political) impacts.

(3) **Risk Management** requires creation of: (a) a risk mitigation matrix consisting of policies, regulations and operational measures and (b) a realistic risk management operational plan that includes a monitoring system to revise and update mitigation over time (ANSTF 1996).

A group of 18 knowledgeable stakeholders was assembled to conduct the risk assessment and risk management. Stakeholders represented various interests in the marine ornamental trade including state (4) and federal (1) agencies; academia (2); commercial aquaculturists (2); marine ornamental fish import (3), wholesale and retail businesses (5); and marine hobby aquarists (1). (see Appendix I).

Risk assessment and risk mitigation were conducted in two intensive workshops. Prior to the first workshop, a review of marine ornamental trade literature was conducted as a basis for

developing a description of the marine ornamental pathway at the global, national and state level. The first workshop focused on refining the pathway description (e.g., species, sources, infrastructure, and value) and a Generic Analysis presentation to familiarize the participants with pathway risk analysis methodology. Workshop participants volunteered or offered additional information to complete the pathway description including searching the International Nonindigenous Species Database Network (Steves et al. 2006), contacting the Marine Aquarium Council http://www.aquariumcouncil.org/ for additional information, acquiring the current American Pet Products Manufacturers Association consumer survey (American Pet Products Manufacturers Association 2007), and preparing the pathway diagrams that were developed through member discussion during the workshop (Figures 1 and 2). The second workshop consisted of a follow-up review of the pathway description, assignment of risk ratings to the nodes (i.e., locations where marine ornamentals were held) and links (methods of transfer between nodes, e.g., air freight) within the pathways and recommendations to mitigate risk. The workshops were held at the University of Florida, Tropical Aquaculture Laboratory, in Ruskin, Florida on February 16 and April 27, 2007.

RESULTS

Marine Ornamental Pathway Information

Global Perspective –

Marine ornamental species are currently the highest valued products that can be harvested from tropical marine ecosystems, and trade in ornamentals supports employment in predominantly rural, low-income coastal communities, as well as providing a strong economic incentive for coral reef conservation (Olivier 2003; Wabnitz et al. 2003). Quantifying the number, value or taxonomy of marine ornamental species in trade is difficult. Marine and freshwater species are frequently combined as a single category in governmental statistics, there are few countries with regulations that require marine ornamental trade reporting, and considerable variation exists among the published estimates (see Appendix II). Peer-reviewed and gray literature reports were reviewed including 20 published books, 14 peer-reviewed journal articles, 13 websites, 12 government/university reports, five on-line databases, one survey and one fact sheet. Combined with knowledge of the workshop participants, key findings were:

- Annual global trade in marine ornamentals has a retail value in the hundreds of millions of U.S. dollars.
- Approximately 1,500 fish species, 200 coral species, and 500 invertebrate species (excluding coral) are traded.
- Approximately 20 million fish specimens, 10 million coral pieces, and 10 million invertebrate specimens (excluding coral) are traded annually.
- United States, European Union, Japan, and China are the largest consumers.
- Source regions (in descending order of importance) are Indonesia, Philippines, South Pacific, Red Sea, Caribbean, South Atlantic, and Indian Ocean.

Fish in Trade.-

Although there is a huge diversity of fish species in the aquarium trade, a large portion is concentrated on certain families and species. Wabnitz et al. (2003) examined data from the

Global Marine Aquarium Database (GMAD 2007) during the period 1997 to 2002 and found that damselfishes (Pomacentridae) dominated the trade, accounting for 43 percent of all fish traded. This was followed by angelfish (Pomacanthidae), surgeonfish/tangs (Acanthuridae), wrasse (Labridae), gobies (Gobiidae), butterflyfish (Chaetodontidae), blennies (Blenniidae and Callionymidae), wormfishes (Microdesmidae), and grouper/rock cod/basses (Serranidae) (see Appendix III). Import data indicated 10 species accounted for 36 percent of all fish traded. Wood (2001) offered a similar observation that was supported by an analysis of fish families in trade and trade volume (see Appendix IV).

Coral in Trade.-

Coral trade is governed under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Wabnitz et al. (2003) used 1997-2002 GMAD information to estimate that 61 soft coral and 140 hard coral species are in trade, and 1999-2001 CITES export/import data to identify commonly traded genera: staghorn, cluster, bluetip, bush, cat's paw or bottlebrush corals (*Acropora spp.*), elegance coral (*Catalaphyllia spp.*), anchor or hammer corals (*Euphyllia spp.*), flowerpot coral (*Goniopora spp.*), mushroom coral (*Heliofungia spp.*), lobed brain coral (*Lobophyllia spp.*), bubble or grape corals (*Plerogyra spp.*), open brain coral (*Trachyphyllia spp.*), cup coral (*Turbinaria spp.*) and unidentified stony corals (*Scleractinia spp.*) and live rock. As noted by Wabnitz et al. (2003) and Wood (2001), coral information should be accepted with caution because of uncertainty in coral taxonomy.

Invertebrates in Trade.-

Approximately 500 invertebrate species, other than coral, are in the marine aquarium trade. Key genera include cleaner shrimp (*Lysmata spp.*), sea anemone (*Heteractis spp.*), banded coral shrimp (*Stenopus spp.*), turbo snail (*Turbo spp.*), giant clam (*Tridacna spp.*), snail (*Tectus spp.*), and topshell snail (*Trochus spp.*). Of these genera, the most popular species (*Tectus spp.*, *Trochus spp.*, and *Turbo spp.*) feed on algae, parasites, or dead animals to maintain aquarium quality (Wabnitz et al. 2003). Invertebrate information should be accepted with caution because of taxonomic uncertainty (Wabnitz et al. 2003 and Wood 2001).

Socio-Economic Effects

As can be inferred from the global and national marine ornamental species trade data, jobs and income are created and sustained by the marine aquarium hobby because of the biological and technical demands of handling delicate, live species imported from tropical locales around the world. Unfortunately, definitive economic impact analysis is unavailable. However, the creation of jobs and income in coastal regions of countries that have low incomes or limited employment opportunities has been recognized as a rationale to support the trade and improved harvesting and handling practices to conserve marine reef species (Green 2003; Olivier 2003; Wabnitz et al. 2003).

Sri Lanka is recognized as one of the first nations to catch and export tropical marine fish during the 1930s, and today most, if not all, of the countries that border tropical and subtropical seas (western Atlantic and Caribbean, Red Sea, Arabian Gulf, East Africa, Indian Ocean, Southeast Asia and Australian area, and Pacific Ocean) export marine aquarium species (Wood 2001). In some instances, the value of the trade and products are of considerable importance.

Philippine ornamental marine life fishers have few employment alternatives (Tlusty 2002). Philippine marine ornamentals have a significantly higher value ($500 per kilogram) versus food species ($6 per kilogram) (Green 2003). Similarly, live coral as an aquarium item is of much greater value ($7,000 per tonne) versus its value as a source of limestone ($60 per tonne) (Wabnitz et al. 2003). These economic effects have been directly or indirectly influenced through government regulation to sustain marine ornamental life fishing and used as an incentive to protect or conserve reefs (Bowden-Kerby 2003).

The 2007-2008 annual consumer survey conducted by the American Pet Products Manufacturers Association, Inc. (APPMA) lists socio-economic motivations for keeping marine ornamentals. Rank order benefits recognized by marine aquarists were: fun to watch/have in household (91%), appearance (88%), relaxation/relieves stress (72%), hobby (69%), conversation piece (64%), quiet (46%), educational (45%), good for children/teach responsibility (35%), convenience/easy to maintain (31%), good for health or my family's health (30%), enjoy designing systems/work with equipment (24%), and inexpensive/good value for the money (19%) (APPMA 2007).

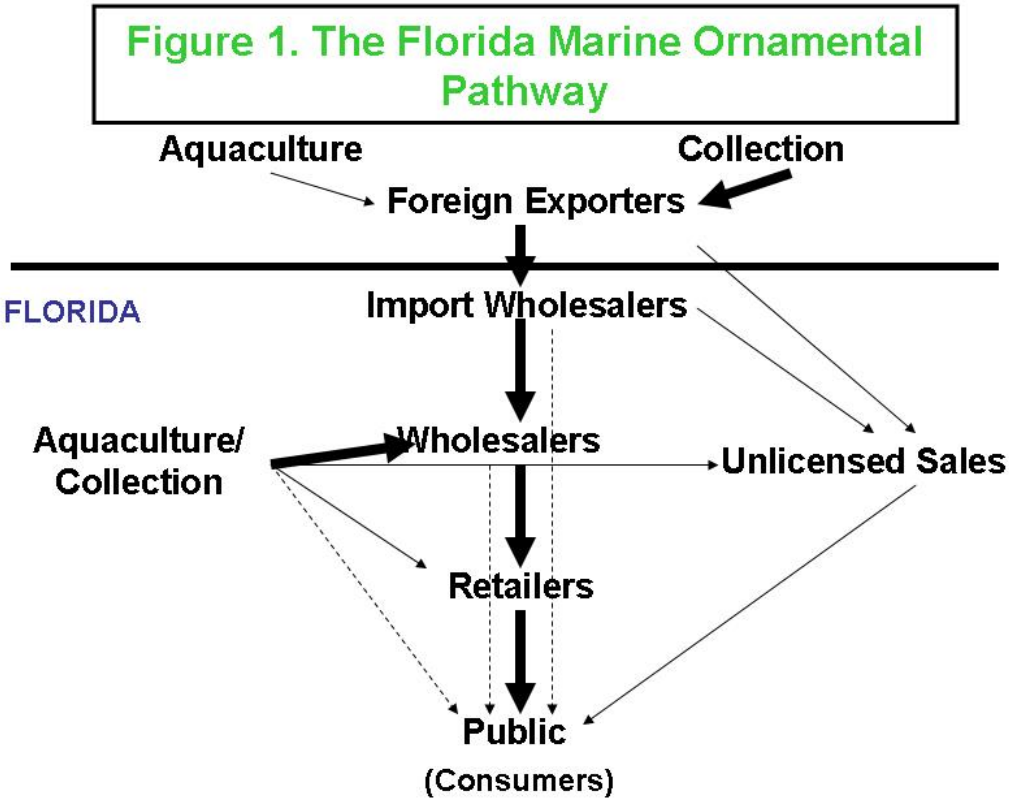
The American Pet Products Manufacturers Association also estimated that 800,000 U.S. households contained an average of 12 marine fish with a total of nearly 10 million fish owned nationwide (freshwater aquaria were estimated to be in 14.5 million households containing an average of 10 fish each for a total of more than 151 million fish). Compared with other pet owners (71.1 million households nationwide), fish owners reported higher household income, lived in mid-sized cities, had young children at home, are married, and are of larger household size. Marine aquarists reported obtaining their fish from fish/aquarium stores (60%), pet store (33%), pet superstore (16%), internet/online (10%), mass merchant (9%) or friend/relative (9%) (APPMA 2007).

Beyond the socio-economics effects are additional research, educational, and conservation benefits. As stated by Causey (2003: 354), "Public and private marine aquariums are important in promoting marine conservation values and ethics." Educational opportunities provided to and via marine aquarists can assist natural resource managers to instill in the public the understanding that anthropogenic activities hundreds of miles from the coast can negatively affect estuarine and reef systems, and the need for creative solutions for environmental problems can be vividly illustrated through the display of living corals, fish, and invertebrates (Causey 2003; Wabnitz et al. 2003). In addition, the biological and ecological knowledge gained to successfully keep marine ornamentals can be put to use in culturing corals, echinoderms, fish, and other species to restore species or physical damage to reef tracts (Causey 2003; Moe 2003).

U.S. Marine Ornamental Trade Pathway

There are many entities involved in the marine ornamental trade, other than the importer and exporter. These entities consist of marine life fishers, breeders, wholesalers, transshippers, retailers, federal and state government officials, airline companies, port authorities, veterinarians, and consumers.The direct handling of live species (harvest or culture, packing, selling, or possession) is limited to marine life fishers, breeders, primary and secondary wholesalers, retailers, and consumers (Larkin 2003; Weigle et al. 2005).

Except for very short trips, standard packaging for live marine species consists of two boxes, one inside the other, made of paperboard and plastic foam, respectively, or air-inflated plastic film liners within a paperboard box. The paperboard box has approximate dimensions of 50 cm x 50 cm x 28 cm. Commercial shippers print the outside of boxes with advisory language warning that live animals are contained therein, requesting expedited handling, and may, depending upon the country and/or state of origin, include a variety of license or permit numbers. Fish and invertebrates are packaged in sealed, oxygenated, partially water-filled plastic bags. Live rock and, sometimes snails and colonial polyp rocks, are wrapped in damp material (i.e., paper), enclosed in a plastic bag, and placed in a waxed, cardboard box. The number of animals in each bag or box varies depending upon the species, size, and travel time (i.e., the longer the estimated travel time, the fewer the animals in a bag or box). A shipment may consist of a single box or multiple boxes. All marine species wild-harvested or cultured out-of-state arrive into Florida via air cargo. Intrastate shipments are by truck, and interstate shipments are, depending upon time and distance, by air cargo or truck. Federal and state regulations pertinent to the marine ornamental trade, culture and harvest; industry standards for the marine ornamental collection, and handling; and trade statistics are summarized in Appendix V. Florida marine ornamental production history and cultural practices are summarized in Appendix VI.



Notes: Dashed lines indicate infrequent movement/sales. Thick lines indicate primary movement/sales. Few Florida companies farm marine ornamentals and those that do may also act as wholesalers. Wholesale and retail distribution includes internet sales and hobbyist shows. Marine aquarists (public/consumers) also sell and trade amongst themselves.

Florida Marine Ornamental Pathway

The principal pathway (indicated by the thick directional lines in Figure 1) is from a foreign source (wild-harvested or cultured) to an importer located near an international airport (e.g., Miami, Tampa, and Orlando) to a wholesaler to a retailer to the consumer. Trade does occur at a lesser extent from sources and buyers throughout the pathway as indicated by the thin black line. Much of this movement occurs through a node identified as “unlicensed sales” which could be internet sites or hobbyists. At a lesser frequency species move from farms or wholesalers to consumers (indicated by a dashed directional line in figure 1). As a general statement, the number of specimens per box is greater at the import node and the farmer-to-wholesaler link, than at any other locations of the pathway.

The importer accepts an air freight shipment after it has been inspected and released by U.S. Department of Homeland Security, Customs and Border Protection; and the U.S. Fish and Wildlife Service. At the importer, specimens are unpacked, examined and placed into holding tanks for acclimation. The importer repacks specimens upon order from a wholesaler and ships via truck or air freight. Florida wholesalers frequently are importers and are located near international airports. Similar to the handling practice at the importer, the wholesaler unpacks, inspects, acclimates, and regroups species for packaging and truck shipment to retailers. Acclimatization can take hours or a day or two depending upon the species, but as soon as possible specimens are moved into the importer-wholesaler link.

Retailers receive, unpack, inspect, and acclimatize specimens to display tanks. Retail purchasers are provided live specimens in water-filled plastic bags for the trip to the home aquarium.

Farmers package and deliver live specimens to wholesalers via truck, or package specimens for farmgate pickup by a wholesaler-owned vehicle. Farmers may use reusable plastic foam boxes (larger volume and with thicker lids, sides and bottoms) or the same type of packaging used in the rest of the pathway (paperboard and plastic foam box combination). They also inject oxygen into water-filled bags and seal those bags.

Very infrequently live species can be transferred from importer to farmer (i.e., broodstock), or from Florida marine life fisher to farmer (i.e., broodstock). Consumers infrequently return specimens to a retailer to exchange for another species or to surrender specimens for a variety of reasons (e.g., size, lack of interest).

Marine species sales or exchange between individuals, termed unlicensed direct consumer-to-consumer sales, has rapidly expanded over the past seven years. Internet search engines and chat sites connect global buyers and sellers. Rapid communication of text and images facilitate the process. Hobbyists sell and trade species with each other. There are also retail "cyber stores," some of which have extensive lists of species, while others are small sites set up by breeders and marine life fishers. Species movement is by overnight package delivery services. These packages are not inspected by federal agencies.

Marine Ornamental Introductions

A search of the International Nonindigenous Species Database Network[2] completed during September 2007 returned 177 records from the U.S. Geological Survey Nonindigenous Aquatic Species database (http://nas.er.usgs.gov/) and 127 records from the Gulf States Marine Fisheries Commission's Non-Native Aquatic Species Summaries (Steves et al. 2006). Of those records, 17 were identified by workshop participants and five species were identified by Dr. Ramon Ruiz-Carus, Ichthyology Collection Manager, FWC Fish and Wildlife Institute, as marine ornamental fish species.

The U.S. Geological Survey Nonindigenous Aquatic Species database (USGS-NAS) fact sheets and collection records for the 22 species were examined and condensed into Table 1 to list the number of fish observed or collected, locations, and original information source(s). The 22 species consisted of nine species observed as one individual fish at one location, one species observed as single fish at two locations, one species observed as three fish at three locations, one species observed as five individual fish at one location, and nine species observed as an unreported number of fish at one or more locations. Of the latter nine species, one of them, the fairy basslet (*Gramma loreto*), was first reported by Courtenay (1995) and is native to the western Central Atlantic: Bermuda, Bahamas, Cuba, and Greater and Lesser Antilles to Tobago.

[2] This resource allows users to search five data providers in the United States and Australia for marine and aquatic nonindigenous species records.

Table 1. The 22 marine ornamental fish records listed among 177 records from the U.S. Geological Survey Nonindigenous Aquatic Species database and 127 records from the Gulf States Marine Fisheries Commission database, accessed September 2007.

Family	Species	Common Name	Number of Observed Locations	Number of Observed Fish	Information Source
Acanthuridae	*Acanthurus sohal*	Sohal surgeonfish	1	not reported	Semmens et al (2004)
	Naso lituratus	orangespine unicornfish	1	not reported	Semmens et al (2004)
	Zebrasoma desjardinii	sailfish tang	1	1	REEF, USGS-NAS
	Z. flavescens	yellow tang	1	1	REEF, USGS-NAS
	Z. veliferum	sailfish tang	1	1	REEF, USGS-NAS
	Z. xanthurum	yellowtail tang	1	1	REEF, USGS-NAS
Balistidae	*Rhinecanthus verrucosus*	bursa triggerfish	coastal SE Florida	not reported	Courtenay (1995)
Chaetodontidae	*Chaetodon lunula*	raccoon butterfly fish	1	"seen a few times"	REEF, USGS-NAS
	Heniochus intermedius	Red Sea bannerfish	1	1	USGS-NAS
Ephippidae	*Platax orbicularis*[1]	orbiculate batfish	1	5	USGS-NAS
Grammatidae	*Gramma loreto*[2]	fairy basslet	coastal SE Florida	"numerous reports"	USGS-NAS
Pomacanthidae	*Pomacanthus annularis*	blue ringed angelfish	1	1	REEF, USGS-NAS
	P. asfur	Arabian angel	3	3	REEF, USGS-NAS
	P. imperator	Emperor angelfish	6	not reported	Semmens et al (2004), USGS-NAS
	P. maculosus	yellowbar angelfish	1	1	REEF, USGS-NAS
	P. semicirculatus	semicircle angelfish	3	not reported	Semmens et al (2004), USGS-NAS
	P. xanthometopon	bluefaced angelfish	coastal SE Florida	not reported	Courtenay (1995)
Serranidae	*Cephalopholis argus*	peacock hind	2	2	USGS-NAS
	Chromileptes altivelis	humpback grouper	4	several individuals	USGS-NAS
Scatophagidae	*Scatophagus argus*	scat	1	1	USGS-NAS
Scorpaenidae	*Pterois volitans/miles*[3]	red lionfish	Numerous – Mid and South Atlantic, 1 – Gulf of Mexico		USGS-NAS
Zanclidae	*Zanclus cornutus*	Moorish Idol	1	1	REEF, USGS-NAS

[1]Individual fish collected and delivered to public aquariums.
[2]May represent a natural range expansion from its native range.
[3]Established in federal waters in the Mid and South Atlantic.

These sightings may represent a natural range expansion. Two closely related species of similar appearance, commonly called the red lionfish (*Pterois volitans/miles*), appears to be established in federal waters of the South and mid-Atlantic (Ruiz-Carus et al 2006).

The Reef Environmental Education Foundation (REEF) has organized recreational SCUBA diver trips to complete reef fish surveys and organized the sighting reports collected into a database that can be accessed via the web (www.reef.org). They also offer the opportunity for divers to report exotic marine fish through their website. The REEF data was the basis for the paper written by Semmens et al (2004) and is a reference consistently utilized by USGS-NAS. In an attempt to fill in the gaps concerning numbers of individual fish of any particular species and the locations where they have been sighted, Dr. Christy Semmens, Director of Science, Reef Environmental Education Foundation was contacted via e-mail December 4, 2007 for assistance in interpreting the output from the website. She responded by e-mail on December 12th with an explanation concerning the missing information.

> "The data reports that were in the Semmens et al paper were primarily those that REEF members and other recreational divers reported to REEF through our Exotic Species Sighting Form through the REEF website over the years. A few of these sightings were also reported on REEF survey sheets, but only if the diver was doing a REEF survey at the time. We created the web report form (http://www.reef.org/programs/exotic) after getting reports from folks that weren't doing REEF surveys as a way to capture the information. This database is mostly in Excel and raw data files at the moment and isn't represented at all in the larger REEF database. The REEF database summary reports on the REEF website only include data from REEF surveys."
>
> "I have been in contact with [Dr.] Pam [Schofield, USGS-NAS], and working with Lad [Akins] (REEF's Director of Special Projects and our primary non-native species person), we will ultimately be adding all of REEF's sightings (both from the form and from REEF surveys) into the larger USGS NAS database. I am hoping that we will have the data ready for Pam by the end of the year. This should then provide you with the level of detail that I believe you are looking for, in terms of when and where each sighting was reported."

Risk Assessment

In a forum of open discussion, risk analysis participants weighed the following risk:

The introduction and subsequent establishment of a marine ornamental species and associated species may cause ecological, economic, or perceived (social or political) effects.

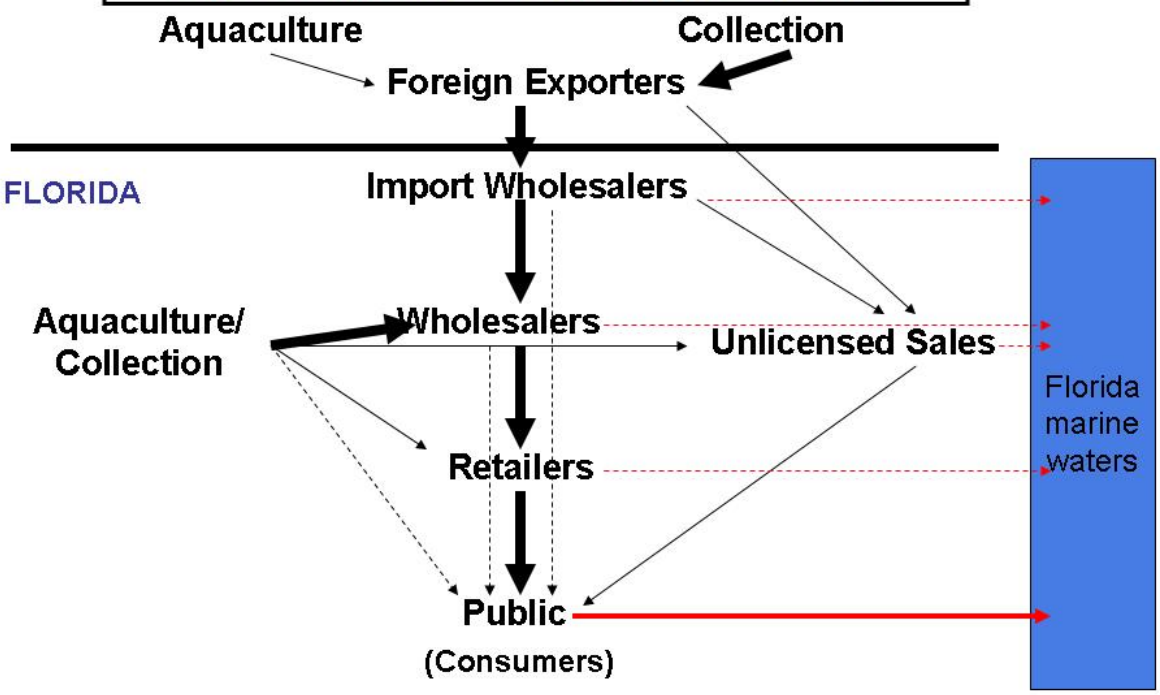
To evaluate this risk, participants examined the probability of establishment and consequences of establishment at each link (e.g., foreign source to importer) and at each node (e.g., wholesaler) of the Florida Marine Ornamental Pathway. High, Medium or Low risk ratings were assigned, along with the participants' certainty of each risk

assignment. Reference codes were used to support each decision. Risk ratings represent a group consensus following appropriate discussion. Risk ratings, uncertainty codes, and reference codes were taken from the Generic Analysis (see Appendix VIII).

Likelihood of Introduction and Establishment -

Red directional lines, dashed or solid, depicted in Figure 2 indicate where the risks to the Florida marine and estuarine environments (depicted as a blue box) were considered.

Figure 2. Likelihood of Release from the Florida Marine Ornamental Pathway



Notes: Dashed lines indicate infrequent movement/sales. Thick lines indicate primary movement/sales. Likelihood of escape or release in red.

The likelihood of marine ornamentals present in nodes and links in the principal pathway (specimens collected from the wild and imported) was judged to be High (Table 2). The participants were very certain of this assessment based on their considerable personal experience as well as by statistics cited in the literature (Wabnitz et al. 2003, Wood 2001 and others cited in this analysis). By contrast, participants were very certain that, for all nodes but the Consumer, the probability of introduction to Florida marine and estuarine environments was Low. This assessment was based on design and operation of holding tanks, importer locations (not in immediate proximity to estuarine or coastal waters), existing regulatory programs, and that the release of live specimens represented an economic loss to the business. One particular scenario that might result in the introduction of a large number of specimens, a truck shipment overturning on a bridge crossing a southern Florida estuary, was discussed. This was deemed not to alter the Low risk assessment because of improbability that: 1) specimens would escape the truck or sealed boxes, 2) the life stage and numbers of specimens would be sufficient to establish a population, or 3) the environment would be suitable.

For the Consumer node, participants were reasonably certain that the probability of introduction to Florida marine and estuarine environments was Medium, based on their general knowledge that hobbyists grow tired of specimens, specimens outgrow hobbyist tank systems, or of socio-cultural beliefs that to release an animal benefits the species and the liberator. However, based on our literature and nonindigenous species database search, participants were very certain the probability of establishment was low, resulting in an overall rating of Low for this node.

At the links, the Low risk of introduction was based upon packaging and shipping practices and existing regulatory programs. Following the Generic Analysis methodology, Overall Risk Potential is determined by the element (i.e., presence, survival, introduction, colonization and spread) with the lowest risk rating, because each of the elements must occur, in-turn, for the organism to become established. Accordingly, the Overall Risk Potential for each node and link was determined to be Low.

For the secondary pathway link, Florida marine life fishers to Florida importers or wholesalers, probability of organisms in these nodes or links was judged to be Low. Participants representing marine life harvesting were very certain of this assessment, because organisms in this pathway link are regulated on a species-specific basis, and harvesters do not, or very infrequently, observe nonindigenous species. Notably, exotic marine ornamental species are considered an oddity rather than a product to market.

For unlicensed direct consumer-to-consumer sales, participants were very certain of a High probability of live organisms in the link, and a High probability of survival. Introduction to Florida marine and estuarine environments was judged to be Medium. Participants were very uncertain of their risk estimation because this trade is not routinely monitored. Participants were very certain that shipping and packaging practices were similar to the other pathway links, but the size and scope of this part of the marine ornamental trade, and the identity or location of pathway participants are not well known. Notwithstanding these uncertainties, participants were very certain the probability of establishment from this link was Low.

Table 2. Participants assessment of the probability of introduction, certainty, and supporting evidence for nodes and links in the Florida Marine Ornamental Pathway.

Pathway Link or Node	**Probability of Introduction**					**Overall Risk Potent-ial**
	Organisms present in the link or node	**Organisms survive in the link or node**	**Introduction from each link or node**	**Colonization following introduction**	**Spread after colonization**	
1. Non-Florida marine life fishers or foreign wholesalers to Florida importers	High Very Certain GK, LR	High Very Certain GK, LR	Low Very Certain GK, LR	Low Very Certain GK, LR	Low Very Certain GK, LR	Low
2. Florida	Low	Low	Low	Low	Low	

marine life fishers to Florida Importers or wholesalers	Very Certain GK, LR	Very Certain GK, LR	Very Certain GK, LR	Very Certain GK, LR	Very Certain GK, LR	Low
3. Florida Importers	High Very Certain GK, LR	High Very Certain GK, LR	Low Reasonably Certain GK, LR	Low Very Certain GK, LR	Low Very Certain GK, LR	Low
4. Importers to Florida fish farmers or wholesalers	High Very Certain GK, LR	High Very Certain GK, LR	Low Very Certain GK, LR	Low Very Certain GK, LR	Low Very Certain GK, LR	Low
5. Florida farmers	High Very Certain GK, LR	High Very Certain GK, LR	Low Very Certain GK, LR	Low Very Certain GK, LR	Low Very Certain GK, LR	Low
6. Florida wholesalers	High Very Certain GK, LR	High Very Certain GK, LR	Low Very Certain GK, LR	Low Very Certain GK, LR	Low Very Certain GK, LR	Low
7. Wholesalers to retailers	High Very Certain GK, LR	High Very Certain GK, LR	Low Very Certain GK, LR	Low Very Certain GK, LR	Low Very Certain GK, LR	Low
8. Retailers	High Very Certain GK, LR	High Very Certain GK, LR	Low Very Certain GK, LR	Low Very Certain GK, LR	Low Very Certain GK, LR	Low
9. Retailers to consumers	High Very Certain GK, LR	High Very Certain GK, LR	Low Very Certain GK, LR	Low Very Certain GK, LR	Low Very Certain GK, LR	Low
10. Consumers	High Very Certain GK, LR	High Very Certain GK, LR	Medium Reasonably certain GK, LR	Low Very Certain GK, LR	Low Very Certain GK, LR	Low
11. Unlicensed direct sales to consumers	High Very Certain GK	High Very Certain GK	Medium Very Uncertain GK	Low Very Certain GK, LR	Low Very Certain GK, LR	Low
Reference Code: GK – General Knowledge LR – Literature Review						

Consequences of Establishment -

Participants examined the potential for economic, environmental or perceived (social or political) effects as a consequence of marine ornamental species being established in Florida

waters. Economic costs and environmental effects were judged to be Low with great certainty (Table 3). This was supported by the literature that indicated no established marine ornamental species in Florida waters proper, and the combined observation by the marine life fishers. However, the participants were very certain the perceived consequences, social and political, were High based upon concerns identified in the scientific literature which are frequently interpreted as actualities in the media through the use of emotive terms when nonindigenous species are discussed (i.e., aggressive, dangerous, deadly, devastate, destroy, menace, siege, threat). Which may lead to implementation of stricter state regulations, on-site inspections, and reporting.

Table 3. Participants assessment of the consequences of establishment of marine ornamental species, certainty, and supporting evidence.

Consequences of Establishment			
Economic	**Environmental**	**Social or Political**	**Pathway Risk Potential**
Low – Very Certain GK, LR	Low – Very Certain GK, LR	High – Very Certain GK, LR	Medium
Reference Code: GK – General Knowledge LR – Literature Review			

The conservative risk evaluation method of the Generic Analysis argues that Low economic effects, Low environmental effects, and High perceived effects yield an overall Pathway Risk Potential rating of Medium, which justifies risk mitigation and management.

Risk Management

The participants recommended the following public education action items directed at the unlicensed direct consumer-to-consumer sales pathway link and the consumer node. The affected agencies, FWC, University of Florida, and the Florida Department of Agriculture and Consumer Services, will distribute this final report to advisory groups (i.e., aquaculture and marine life) that they coordinate to trigger consideration and adoption of these recommendations.

Unlicensed Direct Consumer Sales Pathway Link.-

1. FWC public outreach:
    a) Nonindigenous species educational efforts at hobbyist and trade pet shows.
    b) Nonindigenous species educational efforts with the Florida Marine Aquarium Society.
    c) Develop a Florida-oriented marine ornamental species PowerPoint presentation describing the potential ecological and economic effects and the responsible keeping and disposal of aquarium marine species.
    d) Utilize web-based means to communicate via popular web sites (e.g., YouTube).
    e) Create a public service announcement (audio and video) educating the public not to release unwanted pets.
2. FWC regulatory efforts:

   a) Create a program to monitor Internet sales.
   b) Spot check retail stores for appropriate saltwater products licensure and species permits.
3. Include in the University of Florida, Institute of Food and Agricultural Sciences, Florida Master Naturalist Program a nonindigenous species educational component.
4. State agency support and promotion of the Habitattitude™ message for the public to not release exotic species.
5. Encourage businesses that hold a Wholesale/Retail Saltwater Products licenses issued by the FWC to display nonindigenous species educational information in their retail stores.

Consumer Node.-

1. Utilize species suitability information for marine aquarium (i.e., habitat or food requirements, maximum size) as a component of public education efforts (Michael 2001; Borneman 2004; Shimek 2004; Michael 2006).
2. Utilize the resources available through Florida Agriculture in the Classroom, Inc. to develop a marine aquaria educational curriculum that includes responsible disposal methods (FAITC 2007).
3. Encourage retailers to:
   a. Complete the PIJAC Animal Care educational program (PIJAC 2007).
   b. Join the Habitattitude™ campaign and utilize the educational materials available that ask consumers to not release exotic species (Habitattitude 2007).
   c. Use Habitattitude™ fish bags imprinted with the “do not release” message.
4. Florida Department of Agriculture and Consumer Services should develop public education message supporting the Habitattitude™ “do not release” message.
5. Create an educational partnership between the Florida Department of Agriculture and Consumer Services, FWC, University of Florida, and the public aquaria to communicate the responsible nonindigenous species ownership and handling message.

DISCUSSION

The introduction and establishment of nonindigenous marine ornamental species are relatively rare when compared to freshwater ornamental species (Courtenay 1997; Wood 2001; Whitfield et al. 2002; Wabnitz et al. 2003; Hare and Whitfield 2003; Ruiz-Carus et al. 2006). Examination of nonindigenous species databases for Florida observations corroborates this: 22 species in the marine ornamental trade have been observed, none established, in State of Florida waters with a few individuals for each species sighted (i.e., in the majority of instances one individual fish for each recorded sighting). This may be surprising because of (1) the number of individual specimens of a species that are traded (Padilla and Williams 2004; Semmens et al. 2004); (2) the taxonomic diversity found in the marine ornamental trade (Weigle et al. 2005); (3) aquarium species are usually traded as "hardy" adults that survive the stress of wild-harvest and transportation (Padilla and Williams 2004); and (4) the variety of species contained in the shipping water or interstitial spaces of live rock (Padilla and Williams 2004; Bolton and Graham 2006; Calado and Chapman 2006; Walters et al. 2006).

In terms of the increased risk of establishment due to the hardiness of specimens in transport, Wood (2001) and Wabnitz et al. (2003) differ from Padilla and Williams (2004) and state that the marine ornamental trade consists primarily of juvenile specimens (except for small species such as gobies, blennies and dottybacks) because young fish have attractive color patterns, are easier to ship and maintain, and are small enough for a wide variety of tank sizes. However, Wood (2001) notes that a selective harvest of mature males exists for some species because of their flamboyant colors. Risk analysis participants familiar with the trade stated during the second workshop that, in addition to the reasons identified in the literature, primarily juvenile fish are in trade because they better adapt to captivity with higher survivability and demonstrate a faster acceptance of marine aquarium feeds.

Bolton and Graham (2006) reported the transport of Indo-Pacific-derived live rock to Florida that included large numbers of upside-down jellyfish (*Cassiopea spp.*) scyphistoma that yielded juvenile medusa. They recommended that "regulatory bodies recognize the threat that international trade in live rock presents (page 653)."

Although there are no documented marine ornamental fishes established in State of Florida waters[3], two closely related Indo-Pacific red lionfish species (*Pterois volitans* predominates with some species genetically identified as *P. miles*) are considered established and expanding their range in neighboring federal waters. The current lionfish distribution is from south Florida to North Carolina and confined to a favorable temperature gradient (> 11° C) in waters 35 to 45 meters deep (Ruiz-Carus et al. 2006; Whitfield et al. 2007). Although it has been suggested that these species are present as a result of accidental or intentional release of aquarium specimens (Whitfield et al. 2002; Ruiz-Carus et al. 2006), there are no conclusive data to pinpoint their origin (Robins 2007). The National Center for Coastal Ocean Science, Center for Coastal Fisheries and Habitat Research, is engaged in a long term investigation to estimate lionfish population abundance in offshore habitats, characterize their ecology and biology, better understand lionfish effects on native communities, assess human interactions and impacts,

[3] State of Florida boundaries encompass "…three geographic miles from the Atlantic coastline and three leagues distant from the Gulf of Mexico coastline…"[Constitution of the State of Florida, Article II, Section 1(a)]

evaluate control options, and predict its geographic distribution (NCCOS 2007; Whitfield et al. 2007).

Specific explanations for the lack of established nonindigenous marine species were suggested by Courtenay (1997), Tlusty (2002), Semmens et al. (2004), Weigle et al. (2005), and the risk analysis participants. Complex life histories of marine fishes and invertebrates may preclude successful colonization; insufficient numbers of individual species are introduced (i.e., low propagule pressure); or the biological, physical, or chemical attributes of the recipient location are unfavorable for colonization. In addition, to these specific potential aspects, Fuller and Drake (1999) recognize a multitude of abiotic, biotic, temporal and spatial factors that affect species establishment. In addition to these biological and ecological barriers to species establishment, our assessment found that the risk of introduction and establishment were low due to escape prevention facility designs and management practices required by state regulation; an economic incentive for buyers, sellers and consumers to prevent escape; and propagule pressure that is very likely to be low at all nodes and links in the Florida Marine Ornamental Pathway.

Ultimately, risk analysis should consider benefits as well as costs. A review of the global, national and Florida marine ornamental literature revealed substantial socio-economic (jobs and income) and environmental benefits (habitat and species conservation/protection). Risk analysis participants concluded that these benefits outweigh the ecological risks to Florida. In their experience as marine ornamental importers and wholesalers that interact personally with foreign marine life fishers and exporters, participants recognized that the socio-economic value of the marine aquarium trade necessitates reef and reef species conservation and management. There is a lack of socio-economic studies on marine life harvest and marketing activities, with little recognition in the literature of the positive and constructive influence by the Marine Aquarium Council and other non-governmental organizations to retrain marine life harvesters and handlers.

Concerns over marine ornamentals expressed by the scientific community and amplified in public media communicate a degree of alarm that is not supported by evidence discovered during this risk analysis. However, the expert panel is aware that two exotic, non-ornamental marine species are established in Florida waters and have caused localized negative economic effects. The green mussel (*Perna viridis*) clogs power plant intakes in the Tampa Bay region (Benson et al. 2001; Baker et al. 2006) and the Charru mussel (*Mytella charruana*) affected a Jacksonville power plant cooling system during the summer of 1986. This population disappeared during the winter months but later appeared in Mosquito Lagoon during 2004 and may be established (Boudreaux and Walters 2006). A comparison of the introduction pathways of these species to those of the ornamental trade may shed light on the reasons for their establishment.

Few observations of corals or other marine invertebrates were found in nonindigenous species databases. This may represent a bias among reporting sources, particularly the dive industry, or the lack of systematic reporting of non-native invertebrates in the course of other scientific surveys. On the other hand, it may further support marine ornamental fish data that established populations in Florida are unlikely. Additional research is recommended to clarify the status of marine invertebrates in the ornamental pathway.

SUMMARY

> "We need to educate the public regarding the potential danger from handling this fish [Indo-Pacific lionfish] and the potential harm to Florida ecosystems that can be caused by the introduction of exotic species" (Ruiz-Carus et al. 2006: 388).

An expert panel concluded that the risk of introduction and establishment of marine ornamental species in Florida is generally low, although two specific pathway elements (consumer node and unlicensed direct consumer-to-consumer sales) may present moderate risks of introduction. Because of this, general and focused public education efforts are needed to minimize the risk of introduction of exotic marine species to Florida waters from these sources. The negative social or political effects associated with exotic marine ornamental species can be mitigated through improved and expanded: (1) integration of a "do not release nonindigenous species" message by the state agencies (educational and regulatory) and marine ornamental pathway participants; and (2) communication of biological and ecological information to the general population. The charismatic nature of marine ornamentals (color, shape, variety, and life history) lends itself to capturing public attention with a constructive, simple message that will result in greater appreciation for the complex blend of events, species, location, biology, and ecology that make up the aquatic environments that surround Florida.

GLOSSARY

Established – an introduced organism with a permanent population(s) (i.e., one unlikely to be eliminated by man or natural causes) (Shafland and Lewis 1984).

Exotic – an organism introduced from a foreign country (i.e., one whose entire native range is outside the country where found) (Shafland and Lewis 1984).

Introduced – a plant or animal moved from one place to another by man (i.e., an individual, group, or population of organisms that occur in a particular locale due to man's actions) (Shafland and Lewis 1984).

Nonindigenous species – Any species or other viable biological material that enters an ecosystem beyond its historic range, including any such organism transferred from one country to another (includes exotic or transplanted species) (ANSTF 1996).

Pathway – Means by which aquatic species are transported between ecosystems (ANSTF 1996).

Propagule pressure – A composite measure of the number of individuals released into an ecosystem to which they are not native (Reaser, et al 2007)

Risk – Likelihood and magnitude of an adverse event (ANSTF 1996).

Risk analysis – Process that includes risk assessment and risk management (ANSTF 1996).

Risk assessment – Estimation of risk (ANSTF 1996).

Risk Management – Pragmatic decision-making process concerned with what to do about the risk (ANSTF 1996).

Species – A group of organisms, all of which have a high degree of physical and genetic similarity, can generally interbreed only among themselves, and show persistent differences from members of allied species. Species may include subspecies, populations, stocks, or other taxonomic classifications less than full species (ANSTF 1996).

Transplanted – an organism moved outside its native range but within a country where it occurs naturally (i.e., one whose native range includes at least a portion of the country where found) (Shafland and Lewis 1984).

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APPENDIX I
Risk Analysis Participants

G. Christopher Buerner
President
Quality Marine
www.Qualitymarineusa.com

Bachelor of Arts, University of California at Irvine
20 year association with the Marine Aquarium hobby and Industry,
12 years as an industry professional.

In 1997, Mr. Buerner founded Ocean-2-Ocean to organize and facilitate trans-shipment of imported marine ornamental species to wholesale distributors throughout North America, became Managing Director of Quality Marine in 2000, one of the largest, longest established marine ornamental wholesale distributors worldwide. From 1998, during the early stages of Marine Aquarium Council formation, Chris participated with and served on the Certification Standards Setting Sub-committee, and has subsequently encouraged and facilitated the certification of overseas tropical fish collectors, collection areas and exporters. As president of Quality Marine, one of the first North American importers to achieve MAC certification, Chris was named to the MAC Board of Directors in 2003 as North American Industry Representative, and as Vice Chair of the Board in 2006. To date he works actively to support sustainable harvest of ornamental reef animal species, poverty alleviation in fishing communities, indigenous species mariculture efforts, and toward greater industry responsibility for a healthy, sustainable hobby and trade.

Dustin Dorton
Vice President and Chief Operating Officer
Oceans, Reefs & Aquariums
http://www.orafarm.com

Thirteen years of professional involvement in the marine aquarium industry including retail, wholesale, collection, small and large-scale aquaculture. Dustin is currently the Vice President and COO of Oceans, Reefs & Aquariums, the largest marine ornamental aquaculture facility in the world. In 2001 he started the live coral production facility at ORA and has since established the company as the industry leader in captive propagated corals. Currently he is responsible for overseeing production and operations for ORA and its Tridacnid Clam farm located in the Marshall Islands.

Thomas M. Edling, DVM, MSpVM
Director, Veterinary Medicine
PETCO Animal Supplies, Inc.
http://www.petco.com/

Residency - North Carolina State University, Raleigh, NC. Residency in Companion and Wild Avian Medicine and Surgery. June 2001; Master of Specialized Veterinary Medicine (MSpVM) - North Carolina State University, College of Veterinary Medicine. Raleigh, NC. June 2001;

DVM - Colorado State University, College of Veterinary Medicine and Biomedical Science. Fort Collins, CO. May 1995; Bachelor of Science - Industrial Engineering, Texas A&M University, College Station, TX. December 1981.

Director, Veterinary Medicine - PETCO Animal Supplies, Inc. San Diego, CA. (2003 -present). Owner - Avian and Exotic Mobile Veterinary Clinic. Full service mobile veterinary clinic specifically for avian and exotic animals. Dallas/Ft. Worth. (2002 – 2003). Avian/Exotics Associate Veterinarian – Metroplex Veterinary Centre. Initiated and developed exclusive avian and exotic 24 hour specialty practice. Irving, TX (2001 – 2002). Resident - North Carolina State University, ABVP approved Residency program in Companion and Wild Avian Medicine and Surgery. Raleigh, NC. (1999 – 2000). Clinical Instructor - University of Wisconsin Veterinary Medical Teaching Hospital, Special Species Service. Madison, WI. (1999). Veterinary Services and Avian Research Center Manager - Kaytee Avian Research Center. Chilton, WI. (1997 – 1999). Veterinary Intern - Kaytee Avian Research Center. Chilton, WI. (1996 - 1997). Associate Veterinarian - Sheep Draw Animal Hospital. (1995 – 1996).

Henry Feddern. Ph.D.

Bachelor of Science, Master of Science in Marine Biology, Doctor of Philosophy in Ichthyology, University of Miami, Florida.
Work Experience: 1956-present -- Marine Life Fishing, 1992-present -- Biological Consulting, 1973-1975 -- open-system culture of various ornamental marine fishes and pompano, 1968-1973 -- development of marine aquarium equipment, and laboratory culture of various marine ornamental fishes, 1965-1968 -- Assistant, then Principal Investigator, developing equipment to test effects of pesticides on tarpon, then initiating and monitoring the tests.

Governmental Service: about 1980 to present -- Advisory Panel member for the Coral Fishery Management Plan for the Gulf of Mexico and South Atlantic Fishery Management Councils, 1980-1983 -- Vice-Chairman of the Advisory Panel for the Tropical Reef Fish Fishery Management Plan (ornamental fishes) for the Gulf of Mexico Fishery Management Council. (Plan shelved in 1983.)

Dr. Feddern has been active for many decades during the evolution of the marine aquarium hobby from “fish tanks” to “minireefs,” in applying his expertise in harvesting marine life together with his scientific background, to educate regulators about the fishery and to propose and document harvest and licensing regulations that are both fair to the fishermen and ecologically sound.

Scott Hardin
Section Leader
Exotic Species Coordination
Division of Habitat Conservation and Species Conservation
Florida Fish and Wildlife Conservation Commission

B.S. Zoology, University of Georgia; M.S. Fisheries Science, Auburn University and M.S. Statistics, The Florida State University.

2004–present Section Leader, Exotic Species Coordination, Division of Habitat and Species Conservation. 1995-2004 Chief, Bureau of Fisheries Services, Division of Freshwater Fisheries (oversaw urban fisheries projects, aquatic education, non-native fish lab, Chemistry lab, fisheries statistics, Richloam Fish Hatchery). Prior to that, Scott worked in the Bureau of Fisheries Research primarily on data analysis, statistical methods, creel surveys, experimental design.

Jeffrey E. Hill, Ph.D.
Assistant Professor
Tropical Aquaculture Laboratory
Department of Fisheries and Aquatic Sciences
Institute of Food and Agricultural Sciences
University of Florida
http://tal.ifas.ufl.edu/

Bachelor of Science in Biology (minor in Geography), University of North Alabama.
Master of Science and Doctorate of Philosophy in Fisheries and Aquatic Sciences, University of Florida.
Four years of experience in commercial ornamental aquaculture prior to graduate work. Current research and teaching program in non-native aquatic species and aquaculture in the Department of Fisheries and Aquatic Sciences, University of Florida, where Dr. Hill conducts research on life history, physiological tolerances, predator-prey relations, ecological effects, and other aspects of the biology and ecology of non-native aquatic species as well as teaching a graduate course in invasion ecology. Dr. Hill has studied non-native species as a graduate student, post doctoral associate, and faculty member since 1996. He is a member of various state and national committees and working groups on non-native aquatic species.

Timothy A. Hovanec, Ph.D.
Consulting Biologist
Associate Faculty, Saddleback College, Mission Viejo, CA

Bachelor of Science in Biology, San Diego State University. Masters of Science in Biology, San Diego State University. Doctorate of Philosophy in Ecology, Evolution and Marine Biology, University of California, Santa Barbara.

Seventeen years management experience as the Chief Science Officer of Marineland Aquarium Products researching the phylogenetics of nitrifying bacteria, microbial ecology of closed aquatic systems, developing research strategies and overseeing a staff of 15 biologists/chemists. Ten years experience as manager of the commercial hybrid striped bass aquaculture facility in charge of hatchery operations and research on ammonia toxicity in finfish. Five years as president of the Pet Industry Joint Advisory Council (board member for 12 years). Member of several national and international scientific societies. Organizing member of Marine Ornamentals 2006 and 2008 and Aquality Symposia. Author of numerous scientific and popular articles on tropical fish, water quality, systems filtration, ecology of nitrifying bacteria and closed coral reef systems. Holder of nine US and foreign patents.

Jessica McCawley
Fishery Management Analyst
Division of Marine Fisheries Management
Florida Fish and Wildlife Conservation Commission (FWC)

Bachelor of Science in Marine Biology, Spring Hill College
Masters of Science in Marine Science, University of South Alabama, thesis research on red snapper and artificial reefs.
Approximately five years of experience developing fisheries management plans for Florida's marine resources. Four years of experience working with the management of Florida's Marine Life Fishery (tropical ornamental trade). This fishery includes primarily the wild harvest of over 600 fish and invertebrates in Florida waters. Ms. McCawley worked with the stakeholders in this business to create a tiered management program for the industry via FWC rulemaking. Created the Marine Life Workgroup, which is made up of members of the industry, a NGO, and other interests groups, to advise the FWC on issues associated with the fishery. She is the main member of the Division of Marine Fisheries Management working with this fishery and its related issues. She works with staff at the agency's research institute on issues relating to the harvest and sustainability of this fishery, as well as advising other agencies on issues relating to FWC rules associated with this fishery.

N. Marshall Meyers
Executive Vice President and General Counsel
Pet Industry Joint Advisory Council
http://www.pijac.org/

Martin Moe
Marine Biologist, Author, Publisher,
Marine Ornamental Fish Aquaculture

Bachelor of Arts, Biology, Education, Florida State University 1960
Master of Arts, Zoology, University of South Florida 1967
Fishery Biologist, Florida State Board of Conservation Marine Laboratory, 1961 – 1969. Published on pompano mariculture 1968. Spawned and reared pompano with a private company, 1970. Spawned and reared clownfish in commercial numbers 1972. Founded Aqualife Research Corporation 1972. Spawned and reared Atlantic Grey and French Angelfish 1977. Founded Green Turtle Publications 1982. Published numerous books and papers on fishery biology, marine aquarium topics, and marine natural history. Including The Marine Aquarium Handbook (1982), The Marine Aquarium Reference (1989), and Lobsters: Florida, Bahamas, and the Caribbean (1991). Retired to the Florida Keys 1999. Adjunct Scientist, Mote Marine Laboratory. Built and now operate small marine culture laboratory. Now developing technology for Diadema sea urchin culture and rearing various species of marine ornamental fish.

Jamie K. Reaser, Ph.D.
Senior Science and Policy Advisor
Pet Industry Joint Advisory Council
http://www.pijac.org/

Bachelor of Science in Field Biology (minor in Studio Art), The College of William and Mary. Doctorate of Philosophy in Biology, Stanford University. Certified Trainer and Master Practitioner of Neuro-linguistic Programming (a field of communication psychology). Dr. Reaser's work frequently integrates the fields of ecology and psychology with policy development. For much of the last ten years, invasive species issues have been her primary area of focus. Prior to joining PIJAC as its Senior Science and Policy Advisor, she was the lead negotiator on invasive species issues for the U.S. Department of State; National Invasive Species Council's Assistant Director for International Policy, Science, and Cooperation; and the Executive Director of the Global Invasive Species Programme. She has also served as Vice Chair of the Board of the Global Invasive Species Programme and is currently a member of the IUCN Invasive Species Specialist Group.

Elwyn Segrest
Segrest Farms, Inc.
http://www.segrestfarms.com/

Bachelor of Arts 1961
Masters of Psychology 1969
Mr. Segrest has been associated with the tropical fish business for 46 years. He began Segrest Farms in 1961 as a production and wholesale distributor of ornamental fish direct to retail stores. He owns or has constructed 11 marine life collection stations around the world. Mr. Segrest has served on the Board of Directors for the Florida Tropical Fish Farms Association for 10+ years and was the Association's President for three years. He has served on advisory boards for the Marine Aquarium Council for three years and the Pet Industry Joint Advisory Council for 12 years and is currently PIJAC's President.

Paul Shafland
Biological Administrator III
Director, Non-Native Freshwater Fish Laboratory
Florida Fish and Wildlife Conservation Commission
http://myfwc.com/Fishing/offices/boca.html

Mr. Shafland received a Bachelor of Arts degree from Luther College and Master of Science degree from Southern Illinois University. He joined the Florida Fish and Wildlife Conservation Commission in 1975, and is now the Senior Fisheries Scientist at the Commission's Non-Native Fish Laboratory in Boca Raton. Paul's primary activities involve studying life histories and associations of Florida's exotic freshwater fishes with native species. He has published more than thirty scientific articles; and he is a Past-President of the American Fishery Society's Introduced Fish Section and Florida Chapter, a Fellow of the American Institute of Fishery Research Biologists, and recipient of several awards including the Chevron Conservation Award,

Florida Wildlife Federation's Wildlife Conservationist of the Year Award, and Wildlife Foundation of Florida's Louise Ireland-Humphrey Achievement Award.

J. Marty Tanner
President
Aquatica Tropicals, Inc.
Florida Marine Aquaculture Inc.

Twenty years in the ornamental aquaculture industry. Current President - Florida Aquaculture Association; Member - Aquaculture Review Council, and Co-Chair – Industry Advisory Committee for the Southern Regional Aquaculture Center.

Wm. Jay Troxel
Fishery Biologist/Regional Aquatic Nuisance Species Coordinator
U.S. Fish and Wildlife Service
Southeastern United States Region 4
http://www.fws.gov/contaminants/ANS/ANSSpecies.cfm

Bachelor of Science, University of California, Davis
Fish and Wildlife professional with the U.S. Fish and Wildlife Service since 1974. Field experience included inland and anadromous fishery work in California working for California Game and Fish. In 1974 Mr. Troxel relocated with the Service to Panama City, Florida. The Southeast experience expanded his fishery work into the estuarine and marine systems as well as inland stream and reservoirs. Supervisory responsibilities at the Panama City Field Station included the fishery management staff responsible for large river work and the Ecological Services staff. After sixteen years in the coastal areas he moved to the Service's Southeast Regional Office, Atlanta, Georgia. As Senior Staff Biologist, his responsibilities ranged from inland and interjurisdictional fisheries management to State and Tribal coordination and aquatic nuisance species. In 1993 he relocated the Division of Fisheries, Fish and Wildlife Management Assistance, Washington, D.C. His responsibilities were FWS Nonindigenous Species Coordinator and for three years the Executive Secretary for the Aquatic Nuisance Species Task Force. In 2001, Jay returned to the Fisheries Program in the Southeast Region as the Aquatic Nuisance Species Coordinator.

Craig Watson
Director and Research Coordinator
Tropical Aquaculture Laboratory
Department of Fisheries and Aquatic Sciences
Institute of Food and Agricultural Sciences
University of Florida
http://tal.ifas.ufl.edu/

Craig has an undergraduate in Biological Sciences from Florida State University and a Masters of Aquaculture from Auburn University. His current research priorities include pond production technologies, and reproductive strategies for aquatic organisms. As Director of the Tropical

Aquaculture Laboratory, he is also responsible for establishing and funding several programs, including a current faculty, focused on non-native aquatic species and aquaculture.

Mr. Watson has worked for the University of Florida since 1988, serving as a multi-county aquaculture extension agent until 1996 when he took on the role of Director and Research Coordinator for the Tropical Aquaculture Laboratory located in Ruskin. In 2006 he was also appointed as Associate Director for Aquaculture Programs for the Department of Fisheries and Aquatic Sciences.

His experience in aquaculture dates back to 1974 and includes working on a production farm in Miami, selling ornamental fish at the retail level in Tallahassee, managing a wholesale shipping operation in Riverview, and three years in Peace Corps Tunisia where he worked in a marine hatchery. Craig serves as a board member to the National Aquaculture Association, and is Vice President of Conservation and Research programs for the Florida Aquarium.

Forrest A. Young, MS 1978
Director, Dynasty Marine Associates, Inc.
http://www.dynastymarine.net/

Mr. Young first entered the industry working with Martin Moe in 1977 and co-developed techniques for breeding 25 species of marine tropical fish. He began Dynasty Marine Associates in 1983 and developed many new and novel transport techniques for pelagic sharks, including being the first to ever successfully transport sub adult hammerhead sharks by air. Dynasty Marine Associates was a member of the Aquamarine Fukushima's team to research and eventually capture a coelacanth for public display. They have developed a deep sea diving team mission capable to 150m. Mr. Young has 26 publications (3 of them in-press) ranging in topics from new species descriptions to shark physiology.

Paul W. Zajicek
Natural Resource Manager Level II
Division of Aquaculture
Florida Department of Agriculture and Consumer Services
http://www.FloridaAquaculture.com

Mr. Zajicek received a Bachelor of Science in Marine Biology from the Florida Institute of Technology in 1977 and a Master of Science in Agriculture from the University of Florida in 1986. He is a technical specialist dedicated to environmental impact and mitigation and economic development for Florida's $100 million aquaculture industry. Originator, author, project coordinator or co-operator for $1.08 million in market analysis, industry development, environmental monitoring grants over the last ten years. Editor or co-editor of industry-directed newsletters. Author of in-house industry analysis, web site, and articles for popular and peer-reviewed publications. Member of the National Aquaculture Association's Ocean Policy Committee. Ex officio member of the Aquatic Nuisance Species Task Force representing the National Association of State Aquaculture Coordinators. Conference chair for Aquaculture America 2008.

APPENDIX II

Marine Ornamental Trade Data
Estimated Value
• Global value: $200 - $330 million (Wabnitz et al. 2003). • E.U. import value of marine species during 1998: $12 million (Green 2003). • Global import value: $28 – 30 million (Wood 2001). • Fish: U.S. import $8.9 million (Wood 2001 citing Basleer 1994). • Fish: E.U. import $8.9 million during 1992 (Wood 2001). • Fish: Japan import $3 million (Wood 2001). • Total: global retail value $90 – 300 million (Wood 2001). • Approx. global import value of marine species during 1996: $24 to $34 million (Dawes 2001). • U.S. retail value: $103.2 million during 1995 (MAC 2007b). • Retail value in the U.S. and E.U. of fish from Southeast Asia: $200 million. Retail value of fish from Indonesia: $32 million (Baquero 1999).
Estimated Taxonomic Composition
• 1,471 fish species, 140 stony coral species, 61 soft coral species, 516 invertebrate species (Wabnitz et al. 2003). • 1,196 fish species from 406 genera, 102 coral species from 52 genera, 293 invertebrate species from 113 genera (Green 2003). • U.S. imports consisted of 1,038 fish species from 95 families during October 2000 (Balboa 2003). • 1,000 fish species from ~50 families (Wood 2001). • 700 fish species and 300 invertebrate species (Moe 2001). • Fiji exported 56 coral species (Baquero 1999).
Estimated Quantities
• 10 million individual marine specimens sold in U.S. pet stores in 1995 (MAC 2007b). • Fish make up 85% of the trade (MAC 2007b). • 3,000 tons of coral in global trade (MAC 2007b). • Fish: 20 – 24 million specimens (Wabnitz et al 2003). • Coral: 11 – 12 million pieces (Wabnitz et al 2003). • Invertebrates: 9 – 10 million specimens (molluscs, shrimps, and anemones) (Wabnitz et al 2003). • Fish: 27 million specimens annually (Green 2003). • Invertebrates: 16 million specimens annually (Green 2003). • Coral: 10 million pieces annually (Green 2003). • Total: 11 – 40 million specimens (Wood 2001). • Coral imported into Canada: 3,604 pcs (1995) and 7,764 pcs (1996) (Baquero 1999). • Fish: 35 million (Baquero 1999).
Estimated Consumption (Imports)
• The United States imports nearly half of the marine aquarium organisms. Other major importers are Germany, France, Netherlands, Italy, United Kingdom and Japan (MAC 2007b).

- The U.S. imported 80% of all live coral in trade which represented at least 350,000 pcs in 1995 (MAC 2007b).
- Primary markets: United States and the European Union and, to a lesser extent, Japan (Wabnitz et al 2003).
- 80% of the stony corals and 50% of the marine fish sold to the U.S. (Wabnitz et al. 2003).
- 1.5 to 2.0 million people keep marine aquariums, approximately half in the U.S. and a quarter in Europe (Green 2003; Wabnitz et al. 2003.)
- 600,000 U.S. marine aquarium households (Wabnitz et al. 2003).
- All organisms: U.S. 66%, E.U. and Southeast Asia 13% each (Green 2003).
- Fish: U.S. 68%, E.U. and Southeast Asia 11% each (Green 2003).
- Fish: U.S. 50 to 60% (Balboa 2003).
- Coral: North America 66%, E.U. 18%, and Southeast Asia 11% (Green 2003).
- Invertebrates: North America 59%, E.U. 18% and Southeast Asia 20% (Green 2003).
- Fish: U.S. 4 million specimens (Wood 2001).
- 44 importing countries (Green 2003).
- 700,000 U.S. marine aquarium households (Baquero 1999).
- 95,000 Canadian marine aquarium households with 900,000 fish (Baquero 1999).
- Coral: U.S. represents 70 – 90 % of the coral market (Baquero 1999).

Estimated Sources (Exports)

- Southeast Asia, Pacific Islands, South Asian and Indian Ocean islands, Australia, Hawaii, Mexico, Florida, Caribbean, Brazil, East Africa, and the Red Sea (MAC 2007b).
- Indonesia and the Philippines supply more than half of the marine fish; Indonesia and Fiji are the largest coral suppliers (MAC 2007b).
- Primary sources: Southeast Asia and the island nations of the Indian and Pacific Oceans (Wabnitz et al. 2003).
- Fish: Western Pacific 85% and Caribbean 8% (Green 2003).
- Coral: Western Pacific 99.5% (Green 2003).
- Invertebrates: Western Pacific 75%, North America 17%, Southeast Asia 4%, and Caribbean 3% (Green 2003).
- 30 exporting countries (Green 2003).
- Total: $22 million (Wood 2001).
- Important suppliers are Indonesia and the Philippines with Brazil, Maldives, Vietnam, Sri Lanka and Hawaii as other significant suppliers (Wood 2001).
- 85% of the marine fish exported to the U.S. and E.U. originate from the Philippines and Indonesia. The remaining 15% come from Pacific Islands, Hawaii, Caribbean, Florida, Red Sea, Sri Lanka, Indian Ocean and East Africa (Baquero 1999).

APPENDIX III

Fish Families in the Marine Ornamental Trade (Wabnitz et al. 2003)		
Family	Export Data (%)	Import Data (%)
Pomacentridae	47	43
Labridae	7	6
Acanthuridae	6	8
Gobiidae	7	5
Pomacanthidae	6	8
Chaetodontidae	4	4
Serranidae	3	2
Blenniidae	3	2
Callionymidae	2	3
Microdesmidae	2	2
Others	13	17

APPENDIX IV

Fish Families in Trade (modified from Wood 2001)				
		Approximate number of species in trade		
Common name	Family	1-10	11-20	21+
Damselfish	Pomacentridae			xxx
Wrasse	Labridae			xxx
Angelfish	Pomacanthidae			xxx
Gobies	Gobiidae			xxx
Butterflyfish	Chaetodontidae			xxx
Surgeonfish/tangs	Acanthuridae		xxx	
Blennies	Blenniidae		xxx	
Clownfish	Pomacentridae		xxx	
Grouper, rock cod, basses	Serranidae		xxx	
Triggerfish	Balistidae		xxx	
Cowfish/trunkfish/boxfish	Ostraciidae		xxx	
Pufferfish	Tetradontidae		xxx	
Pipefish and seahorses	Syngnathidae		xx	
Lionfish, scorpionfish	Scorpaenidae		xx	
Hawkfish	Cirrhitidae		xx	
Cardinalfish	Apogonidae		xx	
Sweetlips, grunts	Haemulidae		xx	
Moray eels	Muraenidae	xx		
Frogfish/anglerfish	Antennariidae	xx		
Anthias, fairy/flag basslet	Serranidae	xx		
Soapfish	Serranidae	xx		
Hamlets	Serranidae	xx		
Basslets; grammas	Grammatidae	xx		
Dottybacks; pygmy basslets	Pseudochromidae	xx		
Parrotfish	Scaridae	xx		
Moorish idol	Zancliidae	xx		
Porcupinefish	Diodontidae	xx		
Sharks	Ginglymostomatidae, Hemiscyllidae	x		
Rays	Dasyatidae	x		
Snake eels	Ophichthidae	x		
Catfish	Plotosidae	x		
Cusk eel	Ophidiidae	x		
Soldierfish/squirrelfish	Holocentridae	x		
Flashlightfish	Anomalopidae	x		
Trumpetfish	Aulostomidae	x		
Cornetfish	Fistularidae	x		
Prettyfins	Plesiopidae	x		

Big eyes	Priacanthidae	x		
Tilefish	Malacanthidae	x		
Remoras	Rachycentridae	x		
Snappers	Lutjanidae	x		
Trevally, jacks	Carangidae	x		
Remoras	Echeneididae	x		
Fusiliers	Caesionidae	x		
Bream, porgies	Sparidae	x		
Threadfin bream	Nemipteridae	x		
Drums	Sciaenidae	x		
Goatfish	Mullidae	x		
Sweepers	Pempheridae	x		
Stripey	Microcanthidae	x		
Grubfish	Pinguipedidae	x		
Jawfish	Opistognathidae	x		
Rabbitfish	Siganidae	x		
Flounder	Bothidae	x		
Key: x = low level of trade; xx = moderate level of trade; xxx = high level of trade				

APPENDIX V

Species, Trade, Culture, and Harvest Regulations or Standards

Federal.-

The U.S. Fish and Wildlife Service regulates the trade of shellfish, fish, and fishery products as authorized by the Endangered Species and Lacey Acts and through the requirements imposed by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). These Acts and treaty require the Service to examine shipments for the purpose of preventing the sale of injurious, endangered, or threatened species. The Service requires a $100 annual license for businesses that import or export live animals. Businesses are required to report each shipment imported or exported by using a document entitled, "Declaration for Importation or Exportation of Fish or Wildlife" (USFWS Form No. 3177). The form requires the business to report the information displayed in the following table.

Information required to complete USFWS Form No. 3177	
Date	Foreign supplier or receiver contact info
Import/export license number	Customs broker
Port of clearance	Agent or freight forwarder contact info
Purpose code	Species scientific and common name
Customs entry number	Foreign or U.S. CITES Permit Number
Name of carrier	Description code (live or specific part or piece)
Waybill or bill of lading number	Quantity (number, weight or volume)
Transportation code	Monetary value
Number of cartons	Country of origin for the animal
Live species carton markings	

Currently, in the United States there are 17 U.S. Fish and Wildlife Service designated ports of entry. For those businesses that use one of the 37 non-designated ports of entry, a "Designated Port Exception Permit" is required. The cost of a new permit or permit renewal is $100. The permit is valid for two years. The cost of shipment inspections may vary depending on whether the port is designated or non-designated as well as whether the shipment is received after working hours, on weekends, or holidays (Wm. Jay Troxel, U.S. Fish and Wildlife Service, personal communication, 2007).

There are three exemptions to providing a USFWS Form 3177 to the Service and undergoing inspection: 1) Live shellfish and fishery products taken commercially or recreationally for the purposes of human or animal consumption, 2) live species of the Class Pelecypoda (oysters, clams, mussels and scallops) and their eggs, larvae or juvenile forms exported for research, and 3) domestically produced live farm-raised fish and fish egg exports (including ornamentals) (USFWS Director's Order Number 48 dated June 11, 1992).

The coral trade is governed under the CITES and Endangered Species Act which are enforced by the U.S. Fish and Wildlife Service. CITES lists as Appendix II species: Blue corals (*Helioporidae spp.*), organ-pipe corals (*Tubiporidae spp.*), black corals (*Antipatharia spp.*), stony corals (*Scleractinia spp.*), fire corals (*Milleporidae spp.*), and lace corals (*Stylasteridae spp.*).

International trade in Appendix II species may be authorized by the granting of an export permit or re-export certificate. No import permit is necessary for these species under CITES (although a permit is needed in some countries that have taken stricter measures than CITES requires).

Under the provisions of the Endangered Species Act of 1973, as amended, two coral species, staghorn (*Acropora cervicornis*) and elkhorn (*Acropora palmate)*, are listed as threatened species, and two coral species, ivory bush *(Oculina varicosa)* and Hawaiian reef *(Montipora dilitata)* are listed as Species of Special Concern (NOAA 2007).

In addition to coral species, the United States has included fish and abalone under the Endangered Species Act. Two fish species are listed as Species of Special Concern: bumphead parrotfish *(Bolbometopon muricatum)* and humphead wrasse *(Cheilinus undulatus)*. One abalone species is listed as Endangered: white *(Haliotis sorenseni).* Three abalone species are listed as Species of Special concern: green *(Haliotis fulgens)*, pink *(Haliotis corrugata)*, and pinto *(Haliotis kamtschatkana)*. One abalone species is a candidate for listing as a Species of Special Concern: black *(Haliotis cracherodii)* (NOAA 2007).

The Federal Water Pollution Control Act, amended in 1972 and 1977, (commonly called the Clean Water Act) provides for federal regulation of aquacultural facilities if annual production of warm water species exceeds 45,454 kilograms and waste water is discharged 30 days or more per year (40 CFR 122.24 Appendix C). This authority was delegated to the State of Florida in the late 1990s. No marine ornamental aquaculture Florida facility exceeds the live weight production threshold (K. Knickerbocker, Florida Department of Agriculture and Consumer Services, personal communication).

State of Florida.-

Two agencies are responsible for regulating nonindigenous species: Florida Fish and Wildlife Conservation Commission (FWC) and the Florida Department of Agriculture and Consumer Services. The FWC regulates and manages Florida's fish and wildlife resources as authorized within Article IV, Section 9, of the Constitution of the State of Florida:

> "The commission shall exercise the regulatory and executive powers of the state with respect to wild animal life and fresh water aquatic life, and shall also exercise regulatory and executive powers of the state with respect to marine life…" (Online Sunshine, 2007).

The FWC prohibits the release of non-native fish and other aquatic organisms without a permit. Certain saltwater species are listed in Chapter 68-5, Non-Native Species, Florida Administrative Code (F.A.C.), as prohibited and may not be imported into the state, sold, possessed, or transported live: mitten crab (*Eriocheir spp.*), sea snakes (Hydrophiidae), weeverfishes (Trachinidae), and stonefishes (*Synanceia spp.*). Prohibited non-native species are considered to be dangerous to the ecology and/or the human health and welfare. These species cannot be personally possessed alive. Non-native prohibited species may be killed by legal means and possessed dead for the purpose of reporting to the FWC. Special permits for possession of prohibited species may be issued for public exhibition by Association of Zoos and

Aquariums or American Association of Museums accredited institutions or for research under an approved scope of study.

Non-native marine species that are not prohibited may be caught alive and personally possessed in private aquaria without a permit. However, once caught, they may not be released. The FWC allows the unrestricted take of these marine non-native species by legal methods. In order to catch non-native marine fish, a recreational fisher would need a recreational saltwater fishing license, unless marine life fishing is done by a Florida resident using cast nets or bait seines less than 100 feet in length and that have mesh that is 3/8 inch or less. Non-native marine fish may be taken by the following: rod and reel; hook and line; while free diving; by spearfishing except where prohibited; with landing or dip nets; with cast nets; with a bait, beach, or haul seine; or with blue crab or stone crab traps.

There are certain methods of harvesting non-native marine fish that are strictly prohibited: gill or entangling nets; bangsticks and powerheads; diving by means of a rebreather, and poisons, drugs, or chemicals unless permitted to do so. The FWC regulates the wild harvest of marine ornamental species, which includes over 600 fish, invertebrates, and plants listed in Chapter 68B-42, Marine Life, F.A.C. The rules for this fishery have been in place since 1988, and landings data collection began in 1990. In order to harvest these species recreationally, a recreational saltwater fishing license is needed. Commercial harvest of these marine species with the intent to sell requires a commercial saltwater products license, a restricted species endorsement, and a tiered marine life endorsement. A commercial special activity license is also required to use quinaldine to harvest these species (68B-8.014, F.A.C.). Some species, such as sharks, require additional federal permits to harvest. Bag limits, size limits, and gear restrictions apply for both recreational and commercial harvest. A Florida wholesale saltwater products dealer license is necessary to purchase these species from a licensed Florida fisher. The commercial landings of these species are reported using the Marine Fisheries Trip Ticket system.

The FWC's Exotic Species Coordination Section (ESC) organizes non-native Pet Amnesty Days to allow unwanted exotic pets, including marine species, to be surrendered without penalty. Every effort is made to place these surrendered animals with qualified caregivers. The ESC is also developing a statewide adoption network that would allow these unwanted non-native pets to be surrendered year-round to FWC-certified adopters.

The Florida Department of Agriculture and Consumer Services, Division of Aquaculture, regulates all aquaculture facilities as authorized by Chapter 597, Florida Aquaculture Policy Act, Florida Statutes. Each facility must be inspected to be in compliance with a published manual of Best Management Practices and possess an annual Aquaculture Certificate of Registration. A unique certification number must be included on all pertinent records associated with the shipment or sale of aquaculture products (e.g., invoices, receipts, and bills of lading). There are general and species-specific Best Management Practices (BMP) that include management and production practices or farm design and construction to prevent escape or prohibit release of nonindigenous aquatic species (Chapter 5L-3, Aquaculture Best Management Practices, F.A.C.). Aquaculture facilities are annually inspected a minimum of two times to insure BMP compliance (Hill 2006, FDACS 2007; K. Knickerbocker, Florida Department of Agriculture and Consumer Services, personal communication).

Industry.-

The Marine Aquarium Council (MAC), which represents a global effort to organize the many stakeholders associated with the marine ornamental trade, is an international, multi-stakeholder, not-for-profit, non-governmental organization established by conservation organizations, the aquarium industry, public aquariums and hobbyist groups. Its mission is to conserve coral reefs and other marine ecosystems, and to preserve the livelihoods of fishing communities that depend upon the harvest of marine ornamental species by promoting sustainable harvest and creating standards and certification for those engaged in marine life fishing and care of ornamental marine life from reef to aquarium. MAC intends to accomplish this mission through the following activities:

- Establishing independent certification of best practice standards;
- Raising public awareness of the conservation role of the marine aquarium industry and hobbyists;
- Providing objective, accurate data on the marine ornamental trade;
- Promoting the sustainable use of coral reefs and other marine ecosystems though the responsible collection of marine ornamental life;
- Working with fisher communities to create understanding of long-term value and importance of sustainable harvest of the resource for livelihoods of future generations.
- Ensuring the health and quality of marine ornamental life through responsible collection, handling, and transporting practices; and
- Encouraging responsible husbandry through education and training (MAC 2007a).

The Marine Aquarium Council has grown to become a unique global partnership to resolve arguments for and against marine ornamental trade. Previously, regulations were implemented in a near vacuum of information on their impact on the aquarium trade. The debate at times has been vociferous and contentious, and progress remains constrained by the lack of quantitative and unbiased information. At stake is the employment of thousands of people, especially in source nations, and the high incentives for coral reef stewardship which the marine aquarium trade is capable of providing. Since April 2000 the United Nations Environmental Program-World Conservation Monitoring Centre and the MAC have collaborated with members of trade associations such as Asosiasi Koral Kerang dan Ikan Hias Indonesia (AKKII) **(**Indonesia Coral, Shell and Ornamental Fish Association), Philippines Tropical Fish Exporters Association (http://ptfea.org/), Singapore Aquarium Fish Exporters' Association (http://www.safea.org/), Ornamental Fish International (http://www.ornamental-fish-int.org/) and Ornamental Aquatic Trade Association (http://www.ornamentalfish.org/) to establish the Global Marine Aquarium Database GMAD 2007) as a freely available source of information on the global aquarium industry. Their objective is to centralize, standardize and provide fast and easy access to information on the aquarium trade, so that the magnitude and taxonomic composition of the international trade can then be calculated. This allows debate concerning the trade in marine life to be based on global data (GMAD 2007).

APPENDIX VI

Florida Marine Ornamental Production

Ornamental aquaculture in Florida began in the 1930's and continues today. In 2005, tropical fish and aquatic plants destined for the aquarium and outdoor pond hobbies were the largest segment of the state's aquaculture industry, with a combined farm gate value of $50,792,000, produced on 152 farms (NASS 2006). While not completely differentiated by the survey tool used, this production continues to be primarily freshwater species.

However, the culture of marine ornamentals is a growing segment of Florida aquaculture due to an increased demand from the hobby, recent advances in reproductive strategies, larval rearing, and recirculating water technologies. Added to this is the belief that aquaculture can serve as a relief valve on the pressures being placed on tropical reef systems due to marine life fishing, which is driving investments in aquaculture research and technology development in the private and public sector.

Live Rock.-

Live rock aquaculture became competitive and economically viable when state and federal agencies banned the harvest of "wild" live rock in both State of Florida and federal waters during 1992 and 1995, respectively. In 2005, there were six live rock producers culturing rock in federal and state waters with a combined farm gate sales value of $341,000 for their product (NASS 2006). Permits are issued by the Army Corps of Engineers and National Marine Fisheries Service in federal waters, and live rock submerged sovereignty land leases are granted by the State of Florida in state waters. Federal permits and state leases are restricted to areas where the placement of rock by the producer will have a minimal impact on existing hard bottom, sea grass, navigation, or other natural resources (K. Knickerbocker, Florida Department of Agriculture and Consumer Services, personal communication).

One of the requirements for live rock aquaculture is that the base rock must be from a land-based source, and geologically distinct from naturally occurring coralline rubble in the area. This requirement allows for simple and rapid distinction between aquacultured rock, and illegally harvested "wild" rock. The rocks must also be placed on the site by hand, to avoid inadvertent damage to any existing resources (FDACS 2007).

The rock is left on the site for anywhere between six months to greater than two years, depending on the quality of rock desired, and site location. The desired product will be colonized with nitrifying (and denitrifying) bacteria, coralline algae, and other organisms which assist in serving as the foundation for marine reef aquaria. Any organisms, including stony corals, which settle and colonize on aquacultured live rock are the property of the aquaculturists and can be sold in the trade.

Problems with live rock aquaculture include vulnerability to weather and harmful algal blooms, and the costs and hardship of working the sites, especially during winter months. In addition, the main competition in the market is "wild" live rock harvested from Indo-Pacific regions, which are encrusted with a wide assortment of colorful, and highly valuable

invertebrates. In response to these issues, production of live rock in inland facilities is growing, where not only are the issues with working in the open water removed, but the cultures can also include the addition of select invertebrate species. This practice is known as value-added live rock, and in at least one case has resulted in almost a total abandonment of the off-shore operation. These inland live rock producers are also licensed and regulated by the FDACS Division of Aquaculture, and must agree to adhere to a set of Best Management Practices, including specific guidelines for discharge, biosecurity, and species.

Other Invertebrates.-

Other invertebrate culture includes a wide variety of soft and stony corals which can be reproduced by simple, forced division (i.e. cuttings), or spontaneous divisions. Culture facilities are typically greenhouse-like structures, as most of the species in production rely on symbiotic zooxanthellae for growth. Soft corals are primarily Indo-Pacific species, but there is some aquaculture of soft corals from parent colonies that are legally harvested from Florida waters (e.g., Gorgonian species, Ricordea species, etc.). Stony coral production is currently limited to rapidly growing Indo-Pacific species, as parental stock is available from non-CITES countries such as Fiji. Research is occurring to develop similar techniques for Atlantic and Caribbean species, but due to regulatory restrictions is not being conducted for commercial purposes.

Fish.-

Fish are grown exclusively in closed system, recirculating water systems, often using artificial sea salts. Fish species in commercial production include many species of the clown fish (*Amphiprion spp.*), and several species of the dottybacks (*Pseudochromis spp.*), blennies (Blenniidae), gobies (Gobidae), basslets (Grammatidae), seahorses (Syngnathidae), and the Banggai cardinalfish (*Pterapogon kauderni*). Much research in both the private and public sector is focused on developing reproductive strategies for additional marine species, especially high-valued ones such as the marine angelfish (*Pomacanthus spp., Centropyge spp.)*. It is expected that within the near future, spawning, larval rearing, and husbandry practices will allow for the captive production of several dozen marine ornamental fish species (C. Watson, UF-Tropical Aquaculture Laboratory, personal communication).

APPENDIX VII

Risk Ratings

Low = acceptable risk – organism(s) of little concern (does not justify mitigation).
Medium = unacceptable risk – organism(s) of moderate concern (mitigation justified).
High = unacceptable risk – organism(s) of major concern (mitigation justified).

Uncertainty Codes

Very Certain	VC	Sufficient data to support certainty
Reasonably Certain	RC	Reasonably certain
Moderately Certain	MC	More certain than not
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Reference Codes

General knowledge, no specific source	G
Judgmental evaluation	J
Extrapolation; information specific to a species no available; however, information available on similar organisms applied	E
Literature cited	(Author Year)

Please note:
The Risk Ratings, Uncertainty Codes and References Codes are taken directly from the Generic Nonindigenous Aquatic Organisms Risk Analysis Review Process (ANSTF 1996).