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Review of Trade in Ornamental Coral, Coral Products and Reef Associated Species to the United States

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Executive Summary

The United States is the world's largest consumer and importer of coral reef associated species for ornamental purposes, including aquaria, jewelry, curio and home décor. Analysis indicates that the U.S. market share of global imports is 63% and North America, as a whole, imports on average two thirds of all organisms involved in the marine ornamental trade. This report analyses the trade of coral reef associated species imported to the U.S. for ornamental purposes and examines issues and concerns related to the harvest, supply chain, and overall trade of some of the most threatened species in the trade. The analysis in this report covers the past decade of trade records from 2000 to 2009 and reveals, among other data, that:

- Records of imports of coral products in the U.S. have shown a five-fold increase over the past ten years;
- The most important genus of coral in terms of total import volume is *Corallium* species, with imports over two and-a-half times greater than any other genus of coral.
- Imports of marine tropical fish imports have remained fairly steady with approximately 15 million marine fish imported each year;
- The imports of invertebrates, specifically for items such as jewelry, unlike that for corals and marine tropical fish, have seen significant fluctuation in the ten-year period from 1999 to 2009, with a clear downward trend since peaking in 2004;
- The area known as the Coral Triangle, (Indonesia, the Philippines, Malaysia, Solomon Islands, Timor-Leste, and Papua New Guinea) continues to be the primary source countries for corals, coral products and reef-associated species exported to the U.S.
- In terms of exports, the U.S. is a fairly small player, exporting just over 1% of the total international trade in exports of coral reef associated species.

The collection of specimens for the ornamental trade can involve the use of destructive practices, such as the use of cyanide, for collection of fish and invertebrates and the coral structures themselves. Many of the target species live amongst the rocks and corals, which can be indiscriminately destroyed for the collection of their inhabitants. Some species collected for trade are locally threatened species or the catch rates, given the biology and status of the population of the species are indicative that the trade is unsustainable. The collection practices involved in acquiring coral reef species for trade raise concerns, including the use of toxins, overfishing, and survivability rates after being caught, among other issues.

Furthermore, there remain significant concerns surrounding the legal trade of threatened and/or endangered species, such as Banggai cardinalfish, a popular species in the aquarium trade that lacks international protections despite being listed as an endangered species by the IUCN Red List. The trade in some species for traditional medicines, such as seahorses (*Hippocampus* spp.), as well as the illegal trade of species, such as the giant clam (*Tridacna gigas)* and black and gold corals, also raise concerns regarding the effectiveness of governments and international agreements, such as CITES, to ensure adequate protections for vulnerable species.

These concerns suggest that governments, industry, and consumers, need to play a more active role in ensuring that the trade in coral reef species does not continue to drive declines in vulnerable species. Efforts to establish new import and export standards in the U.S., based on sustainability criteria, for collection, handling, and transport activities should be developed, including strengthening and supporting CITES as an instrument for effective regulation. Additionally, the U.S. government should establish additional data collecting requirements to improve the level of specificity of the species appearing in trade to provide a more accurate picture of the animals in trade. Industry, too, should make greater efforts to

source the coral reef species they sell more responsibly, including through the establishment of independent standards and certification for best practices to assist consumers wanting and willing to make informed purchasing decisions regarding the origin and sustainability of coral reef species.

There is an opportunity and responsibility for the United States, through its purchasing power, to ensure that the trade is conducted in a responsible manner. The U.S. role as the largest global consumer should compel the government, the industry, and the consumers to become more active participants in the chain governing the trade in coral reef species to ensure that the species harvested are done so both legally and sustainably.

Introduction

Coral reefs are among the most complex ecosystems on the planet. They form some of the most intricate and varied marine habitats in the world, providing a home to a vast and dazzling array of marine organisms. Fish, seabirds, sponges, jellyfish, worms, crustaceans, mollusks, sea snakes, sea turtles and hosts of other marine life make their homes on coral reefs. A third of the world‘s marine fish species (over 4,000 species), approximately 800 species of reef-building corals, and numerous marine invertebrates, live in, on, or around coral reefs (Paulay 1997). Despite this biological richness, coral reefs account for less than one quarter of 1% of the marine environment. Totaling an estimated 284,300 square kilometers (109,800 sq. mi.), coral reefs around the globe occupy an area just half the size of France, with coral reefs in the seas of Southeast Asia accounting for almost 30% of this total and those in Australia and the Pacific accounting for roughly 37% (UNEP 2001).

Coral reef associated species include species that form the reef structure and species that live in and around reefs. They rely on the reef for their existence. Reef-building species include corals, sea fans, sponges and clams. Stony corals, or scleractinians, deposit hard calcium carbonate exoskeletons that form the building blocks of coral reefs and provide habitat for thousands of reef associated species (Harrison 2011). Reef inhabitants include a multitude of invertebrate species, crabs, lobsters, shrimp, clams, conch, snails, sea slugs, starfish, urchins etc. The fish living in and around the reef range from the tiniest blenny to the largest of reef sharks. Reptiles such as sea turtles and sea snakes inhabit the reef as well. Coral reefs are also vital to the world's fisheries. They form nurseries for about a quarter of the ocean's fish, providing a source of food and livelihood for local communities and world markets (Paulay 1997). An estimated one billion people depend on coral reefs for food and income, with direct and indirect benefits of reefs estimated to value $375 billion each year (Costanza *et al.* 1997).

Scientists have documented that tropical coral reefs are being lost at a rate of two percent per year, which is approximately twice as fast as rainforest destruction (Bruno *et al.* 2007). The causes of coral reef decline can be as complex as the coral reefs themselves. Mass tourism, unregulated coastal development, overfishing, land based pollution, coral bleaching resulting from global climate change, and ocean acidification are all primary threats to coral reefs (Burke et al. 2011). Illegal, unregulated and poorly-managed legal trade in coral reef species and destructive collection methods are also impacting the resilience and survival of coral reefs. The degradation of coral reefs has been calculated to cost nearly US$ 30 billion annually in net benefits that these ecosystems provide in goods and services to the global economy – including tourism, fisheries, and coastal protection (Cesar 2003). By helping to prevent coastal erosion, flooding, and the loss of property on shore, reefs save additional billions of dollars each year by reducing insurance and reconstruction costs, eliminating the need for costly coastal defenses, as well as reducing the costs of human displacement and loss of life.

The breathtaking beauty of coral reefs makes them natural works of art that capture the imagination. But this quality is both a boon and a curse for reefs. Reefs are treasured for their biodiversity and economic potential to encourage tourism. They also suffer from sometimes damaging extractive practices to meet the demand by people who want to capture the essence of the reef's beauty to adorn their own home or business and some do not mind if the harvest was unsustainable or destructive.

Trade and Use

This report analyses trade to the U.S. of coral reef associated species imported for ornamental purposes. The incredible diversity of these species and their uses in trade for ornament are typically grouped under the following categories:

- **<u>Aquaria industry</u>**: live reef fish, invertebrates (corals, mollusks such as clams and snails, etc.) and live rock.

- **<u>Ornaments/home décor</u>**: dried and preserved dead stony (hard) corals and mollusk shells (clams,conch, etc.).

- **<u>Jewelry</u>**: precious corals (black, red, pink, gold corals) and polished mollusk shells, some stony corals.

- **<u>Curios</u>**: dried specimens of fish (seahorses, porcupine fish, etc.) and mollusk shells.

The **aquaria industry** often uses the generic term ornamental fish to describe aquatic animals kept in the aquarium hobby, which includes fish, invertebrates such as corals and crustaceans, and live rock. Live rock is a general term for any type of rock encrusted with, and/or containing within its crevices a wide variety of marine organisms, like algae and colorful sessile invertebrates.

Although the majority of people in the ornamental fish hobby keep freshwater aquariums, saltwater and coral reef aquariums have become increasingly popular. Improvements in husbandry technology and knowledge on captive husbandry have contributed to the growth in the number of hobbyists and therefore supply of the marine ornamental fish trade. A rise in U.S. consumers' ability to afford and maintain this hobby has increased demand. Both have resulted in the growth of the marine aquaria industry. Between 1.5 and 2 million people have marine aquariums worldwide, with half in the United States and a quarter in Europe (Green 2002). There is a lack of recent data on the size of the global trade in coral reef species, with the most comprehensive assessment carried out more than eight years ago. However, according to the 2003 data from the Global Marine Aquarium Database (GMAD), the most accurate approximation of annual global trade encompassed 20-25 million marine ornamental fish, 11-12 million corals, and 9-10 million marine ornamental invertebrates (Wabnitz *et al.* 2003). At the time of the most comprehensive review of incomes from the aquaria industry, the industry represented US$200-330 million annually (Wabnitz *et al.* 2003). However, this growing industry has conservationists, scientists, policy makers, business interests, and hobbyists concerned about its impact on the health and sustainability of coral reef ecosystems around the world.

The demand for live corals for ornamental use has been growing as have the development of technologies for keeping corals alive in aquaria. Because coral identification is difficult and requires expertise in coral taxonomy, species in trade are more difficult to identify than marine fish and other invertebrates. However, in trade data for CITES listed coral species is required by law and has to be as accurate as possible, preferably to species level. In contrast, there are few trade regulations and trade data are requirements for the vast majority of fish and invertebrate species in trade). Some estimates of the composition and volumes of trade in marine ornamental species have been published and these include:

- 140 species of stony coral (almost entirely Scleractinia) in trade with 12 million pieces traded annually, accounting for 56% of the total trade in coral (Wabnitz *et al.* 2003).

- 61 species of soft coral in trade with 400,000 pieces traded annually (Wabnitz *et al.* 2003).

- Drastic increases in the use of live rock due to the rise in popularity of reef tanks. Live rock is traded in three varieties: Pacific, Atlantic and aquacultured (Wabnitz *et al.* 2003).

- Approximately 20-25 million marine ornamental fish are caught annually from over 50 taxonomic families and encompass 1,500 species (Monticini 2010).

- 516 invertebrate species in the aquarium trade, mostly mollusks, shrimps and anemones (Wabnitz *et al.* 2003).

- Live giant clams constituting an increasing proportion of the invertebrate trade for the purpose of aquaria due to the crucial role they play in removing nitrates, nitrites and ammonia from tank water, which are poisonous in high quantities to other aquarium animals (Wabnitz *et al.* 2003). Consequently, wild populations of giant clams have considerably deteriorated over the past 20-30 years even with the advent of aquacultured giant clams.

Marine curiosities (curio), **ornaments, home décor and jewelry** include a wide variety of dead marine animals or plants, whether in part or whole, used for decoration. Coral and reef-related species that are imported as curios are sold as a range of things from souvenirs to jewelry to arts and crafts and ornaments (Grey *et al.* 2005). Mollusk shells and corals make up the majority of the invertebrate portion of the trade, while preserved sharks, porcupine fish and seahorses make up the majority of the marine fish groups encompassed in the trade (Grey *et al.* 2005). Corals used for jewelry command high prices due to limited supply and are called precious corals because they are one of the most highly valuable marine resources (Tsounis *et al.* 2010). This has led to major booms in the demand for coral jewelry, particularly for red and pink corals (Coralliidae) (CITES 2010). Specific amounts of a given species are hard to classify because when coral is sold as polished, finished product, such as beads, it is difficult to identify the species (Tsounis *et al.* 2010).

Impacts of Trade

The collection of specimens for the ornamental trade can involve the use of destructive practices for collection of fish and invertebrates and the coral structures themselves. Many of the target species live amongst the rocks and corals, which can be indiscriminately destroyed for the collection of their inhabitants. Some species collected for trade domestically and even internationally are locally threatened species or the catch rates, given the biology and status of the population of the species are indicative that the trade is unsustainable. The collection practices involved in acquiring coral reef species for trade raise concerns, including the use of toxins, overfishing, and survivability rates after being caught, among other issues. It is possible to consistently harvest sustainably and in ways that are far less detrimental to the species' and reefs survival. However, these concerted efforts to manage reefs are not comprehensively applied and the cheaper option for the quick profit more often prevails. Some of the main problems with unsustainable and destructive practices are detailed here:

Cyanide Use

The use of cyanide in coral reef fish collection began in the 1960s in Taiwan and the Philippines. Cyanide pellets are crushed and mixed with seawater in squirt bottles. Fishermen then squirt the mixture into small openings in the reefs where fish frequently hide, stunning the fish and making them easy to capture. By the mid-1980s some estimates suggested that at least 80% of all fish harvested in the Philippines for the aquaria trade were caught using cyanide; by the 1990s use spread to Indonesia, where over 90% of boats transporting live fish had cyanide on board (Wabnitz *et al.* 2003). Cyanide use continued to spread to Thailand, Papua New Guinea, Malaysia, Vietnam, the Maldives and Yemen, and it is estimated that at one time approximately 150,000 kg were used every year (Monticini 2010). The use of cyanide weakens fish and results in high mortality rates of fish post capture (Rubec 1987). Cyanide also destroys coral ecosystems and causes accidental deaths of non- target specimens. The rate of death within hours of collection of fish caught using the toxins is estimated at the high end to be 75% mortality; 20% to 50% die after a couple of hours, and an additional 25% to 30% die before export (Wabnitz *et al.* 2003). Furthermore, retail outlets commonly report a 30% to 50% mortality rate upon arrival (Wabnitz *et al.*

2003). While fishing with cyanide is now illegal in most countries – in Indonesia for example, it is punishable by fines up to US$12,000 (Wabnitz *et al.* 2003) – in much of the world those tasked with enforcing these laws are easily avoided due to the fast acting nature of cyanide, or bribes can be paid, resulting in the widespread use of cyanide throughout the Asia-Pacific region (Donnelly *et al.* 2000).

Over Exploitation

A study on the effects of collecting fish for the aquarium trade showed that 8 of the 10 most commonly traded species declined in abundance from as much as 57% to as low as 38% compared to an area where no fishing took place (Tissot 1999). Unsustainable fishing results in shifts in fish size and species composition within coral communities, which may precipitate large-scale ecosystem changes alone or when combined with other threats (Burke 2011). For example, unsustainable fishing of large predatory and herbivorous fishes is blamed (or pointed to) as the beginning of the end for some Caribbean reefs (Mumby 2006). In the absence of predators and competing herbivores, the long-spined sea urchin became the primary control of macro algae levels on these reefs. Their increased population density left the sea urchins extremely susceptible to an unknown disease that killed off over 90% of the species in the Western Atlantic in 1982. This in turn led to algal overgrowth and the decline of reefs in the region (Cesar 2003).

Poor Maintenance of Live Animals in Trade

One estimate of the rate of mortality of tropical fish prior to reaching the aquarium market is estimated at 80% (Monticini 2010). However, it is hard to accurately quantify these results as the mortality rates post-import are largely not systematically quantified or made public "due to the sensitivity of such information", which could portray the industry in a bad light if high mortality rates are recorded (Wabnitz *et al.* 2003). The mortality is due to physiological damage, use of chemicals (such as cyanide), disease, and inadequately following procedures of stocking and shipping. Approximately 15% of fish die immediately upon being caught, 10% during transport and 5% while in stocking stations (Monticini 2010). Once at a stocking facility, fish are quarantined for anywhere between a few hours to a few months. Some fish are starved for a minimum of 48 hours prior to shipment, to prevent regurgitation of food and decrease fecal excretion to avoid fouling of the water. (Wabnitz *et al.* 2003, Monticini 2010). Depending on the species, fasting may last up to 10 days upon arrival (Monticini 2010). Because the mortality rate is so high, significantly more fish are caught than become part of the trade. Post-harvest mortality levels are lower for corals and invertebrates than fish, yet more coral and live rock is harvested and therefore killed, than go into trade, as some pieces are ultimately deemed unsatisfactory and don't enter international trade.

Source Countries and Consumer Markets

The number of countries participating in the trade of coral reef species includes about 45 importing and exporting nations. The most current estimate show that the majority of organisms – fish, corals, live rock, and other invertebrates – captured for the global marine aquarium trade originate from the Western Pacific (85%), with smaller contributions originating from the Caribbean (6%), and from the United States (6%) (Green 2002). More specifically, previous reports have shown that:

- In 2002, 99.5% of the trade in coral originated from the Western Pacific (Green 2002). The majority of the trade is collected from an area known as the Coral Triangle, which refers to a roughly triangular area of the incredibly biologically diverse tropical marine waters of Indonesia, Malaysia, Papua New Guinea, Philippines, Solomon Islands and Timor-Leste and that contains at least 500 species of reef-building corals in each ecoregion. Tonga, Vanuatu, and Bali also participate in the trade within the region. Since the late 1980s, Indonesia has been the largest coral exporting country with 71% of global trade for all coral species (Wabnitz *et al.* 2003).

- Fiji and Indonesia are currently the world‘s largest suppliers of live rock (Livengood 2011). However, since much of the harvested rock is deemed unsuitable for trade and thrown back, true collection figures are undoubtedly much higher than reported trade (Wabnitz *et al.* 2003).

- 85% of fish in the marine ornamental trade are from the West Pacific (Green 2002). The Philippines, Indonesia, the Solomon Islands, Sri Lanka, Australia, Fiji, the Maldives and Palau represent 98% of the total number of fish exported between 1997 and 2002 (Wabnitz *et al.* 2003).

- By 2002 75% of marine invertebrates for the aquaria trade originated from the West Pacific (Green 2002).

The marine aquarium trade is a fairly large industry in some of the source countries, in Sri Lanka, for example, it is estimated that over 50,000 people are directly involved in the export of marine ornamentals (Wabnitz *et al.* 2003).

There have been several studies looking at the trade flows of coral reef species internationally, particularly the report by the United Nations Environment Program (UNEP) World Conservation Monitoring Centre in 2003 (Wabnitz *et al.* 2003). The UNEP report identified the U.S. as the largest single global consumer market for coral reef associated species. The report stated that the U.S. imported more than two thirds of global supply and the E.U. was the second largest importer, with a small number of other countries importing. UNEP estimated that the United States imported 3.9 million specimens of live corals each year (73% of total live coral trade globally). The report also cited that the U.S. imported 80% of the total market share of stony corals, and 64% of the total trade in soft corals (Wabnitz *et al.* 2003). The specific break down of primary importers of hard/stony corals by country was the United States, Japan, Germany, France, China, Canada, the Netherlands and the United Kingdom; importing over 95% of all live corals traded globally (Wabnitz *et al.* 2003). According to this 2003 UNEP report, the United States accounted for 73% of total live coral imports; with 14% by the EU, 7% by Japan, 2% by Canada and 1% by the Republic of Korea (Wabnitz *et al.* 2003). A study by TRAFFIC in 2007 that analyzed global wildlife trade showed that, with the trade in ornamental corals only, the U.S. and the E.U. continued to dominate imports. However, this more recent analysis by TRAFFIC indicated that the U.S. market share had declined to 63%, even though the overall volume of U.S. imports increased (Engler and Parry-Jones 2007).

The absence of updates in information on the levels of trade and the changes in data that have been observed with more recent examinations, highlight the need for a new analysis of trade data. The information in the main results section of this report updates the data for the U.S. trade in coral reef associated ornamental species to provide the latest insights into the trade dynamics.

Description of the Supply Chain

The supply chain for the marine ornamental trade is organized in a complex and extremely variable manner, involving a series of collectors/fishers, wholesalers, middlemen, trans-shippers, manufacturers, artisans, exporters and importers, wholesalers, and finally retailers. The majority of collectors are small-scale fishermen who either work alone or in small groups and are either self-employed or work for wholesalers and exporters. Techniques vary based on the organisms, but rudimentary, artisanal equipment such as hand nets and fishing lines are most often used in the harvesting of live species (Wabnitz *et al.* 2003). For deeper water, precious corals dredging may be used or scuba collection where depths are not prohibitive.

Upon capture, corals, fish and invertebrates are separated. Where facilities exist, and where the supply chain is longer and more involved, the catch is typically brought back to a stocking area on the same day it is captured. However, this is less important for species that are traded as dead specimens like precious corals that are used for jewelry or corals and mollusks that are used as curios. The corals are sorted into groups based on their growth form and wrapped securely and packaged depending on whether their use is for live trade or dried home décor, jewelry etc. The corals and live animals are boxed, loaded into an on-site container and taken to the wharf or airport for overseas dispatch. Live fish and corals have to be sent by airfreight or express air courier to avoid undue mortality caused by lengthy transit times. Large bulk shipments of dried stony corals may be shipped by sea freight as it is cheaper than air freight and time sensitivity does not apply. Within the importing country, the shipments pass clearances and checks by border agencies such as customs to check permits such as CITES where relevant and deal with import duties, tariffs, and other documentary requirements. The corals, invertebrates, and fish are sent to the wholesaler‘s warehouse, often using a broker to facilitate shipments. From the wholesaler the wildlife is then distributed to various retailers.

The Role of the United States

The United States is the world's largest consumer and importer of coral reef associated species for the aquarium, home décor, and jewelry industries (Tissot *et al.* 2010). Most research and estimates in the literature agree that North America imports on average two thirds of all organisms involved in the marine ornamental trade (e.g. Green 2002). Through its purchasing power, there is an opportunity and responsibility for the United States to ensure that the trade is conducted in a responsible manner. The following trade analysis aims to generate greater understanding of the U.S. trade, and in doing so, to provide indicators for the trends in the harvest in marine ornamental species from source country coral reefs.

The U.S. Market for Corals and Reef-Associated Species

It is clear that the United States is the most significant consumer market globally for corals and reef associated species, across the broad spectrum of use for these species ranging from aquaria, ornamentation, pharmaceutical and household purposes (see the Introduction and references therein). The U.S. is the top importer of corals, with almost 65% of all global imports in 2005 (Engler and Parry-Jones 2007).

The following section of the report covers new trade data analysis regarding imports of coral reef species into the U.S. This is to compare with the literature review summarized earlier in the report and to provide the latest assessment of the trade volumes, flows and trends in the U.S.

Aquarium fish prepared for live fish export.

Trade Analysis: Method and Data Sources

The volumes and frequency of imports are very large; the records held by the USFWS show on average nearly half a million import records per year of coral reef associated species. Data was requested from the USFWS Law Enforcement Management Information System (LEMIS) through the Freedom of Information Act (FOIA). Data obtained included all wildlife trade records for the years 2000-2009, which totaled approximately four million records. The analysis began by eliminating all records that were clearly not corals or species that inhabit coral reefs (mammals, reptiles, etc.). Then, by focusing on records where a genus was listed (including where genus was a category such as “Other live invertebrates”), each genus was reviewed to determine its relevance as a reef-associated species. For the purpose of this analysis, the term “associated” means that the species (or vast majority of species in a genus where only genus was specified) lives in or on the reef and/or collection of the species could have an impact on the reef. While numerous records are reported by weight rather than number of specimens, this analysis only included those reports recorded by number of specimens. This preliminary work resulted in approximately 800,000 remaining records to be used for the final trade analysis.

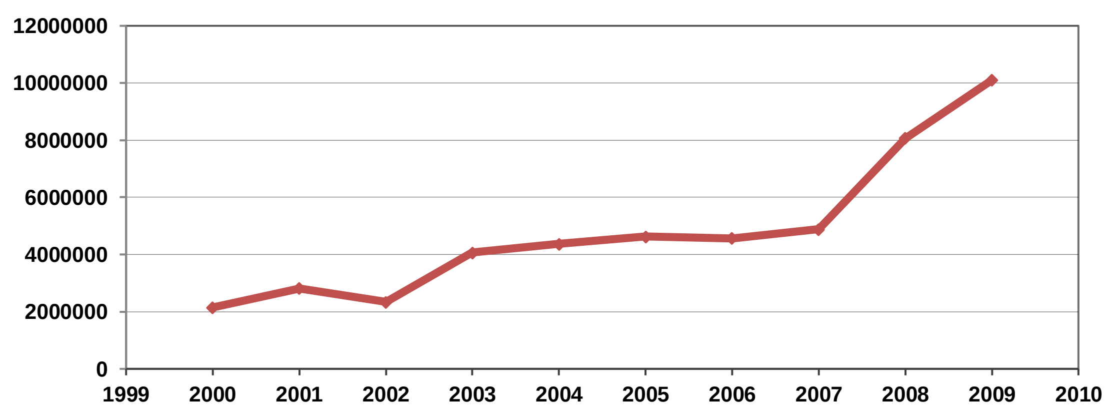
One of the difficulties with LEMIS data is the lack of consistency in the units used in recording shipments; shipments may be recorded by number of items or by weight. The vast majority of corals and reef-associated species imported to the U.S. are accounted for by number of items, therefore any shipments recorded in units other than number (kilogram, etc.) were not counted in this analysis. In consideration of the two factors listed above, namely the subjectivity of species/genera included in the analysis and the elimination of all shipments measured in units other than number, any actual numbers listed in the report for total imports and/or exports (such as total imports, imports of corals, number of shipments from a particular country, etc.) for a given year or period of years should be considered a conservative estimate. *Rather than focus on absolute number, the value of the analysis is in gauging the relative differences among groups/years and trends in trade.*

Imports to the United States

In reviewing imports of corals, coral products and reef-associated species, it is useful to break total imports into the three primary categories of corals, fish, and invertebrates other than corals. CITES regulates trade in stony corals and therefore there are systems in place to monitor and manage trade and permits are required for international trade. Most other marine species from coral reefs that are in trade for ornamental use are not controlled under CITES. Thus, there are reporting requirements under CITES that are upheld by the USFWS, and the data for CITES species such as stony corals are much more detailed, and data can be considered to be more reliable is available for a longer time-scale. Thus, the trade analysis regarding corals and coral products addresses trade for the years 2000-2009. Trade in invertebrates reflects data from the same time period, 2000-2009, while marine tropical fish imports were reviewed for five years of data, 2005-2009. The U.S. Fish and Wildlife Service changed the way in which they record imports of tropical fish between the years 2003-2004. Previously, the vast majority of tropical fish imports were held under a generic "tropical fish" category; however, after 2004 the records were separated to identify marine and freshwater fish as different groupings for the purposes of recording import and export data.

Volume of Imports

Figure 1: U.S. Imports of Corals and Coral Products (No. of specimens), 2000-2009

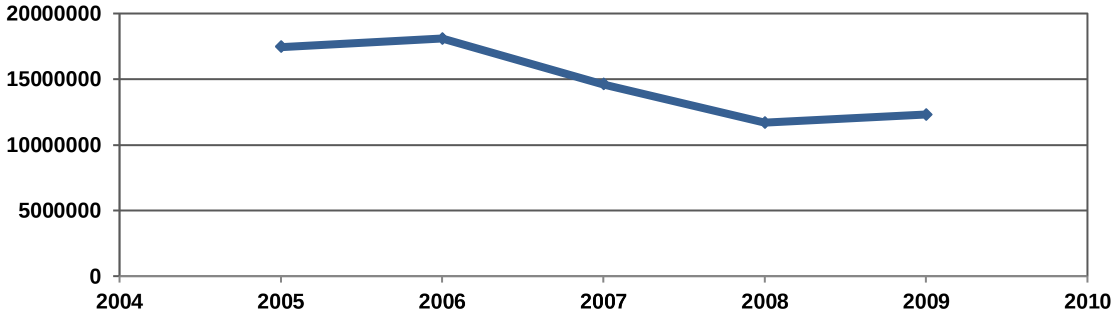


Source: TRAFFIC analysis of USFWS LEMIS data, 2011

In the United States, records of imports of coral products have shown a five-fold increase over the past ten years (Figure 1). From 2003 through 2007 the import volume was fairly steady, with a sudden jump in 2008 and 2009. This increase can largely be attributed to a growth in exports from China; whether that increase is an actual one or simply reflects a change in data reporting will be discussed in more detail in the section regarding countries of origin.

Over the past decade, the most important genus of coral in terms of total import volume is *Corallium* species, with imports over two and-a-half times greater than any other genus of coral. *Corallium*, otherwise commonly known as "red/pink" or "precious" coral, is primarily used for jewelry. While most *Corallium* imports originate in the tropical waters of the Coral Triangle, the most important species for trade purposes (preferred, more valuable) in the genus, *C. rubrum*, is found in the colder, deeper waters of the Mediterranean (Göthel 1992).

Figure 2: U.S. Imports of Marine Tropical Fish (No. of specimens), 2005-2009



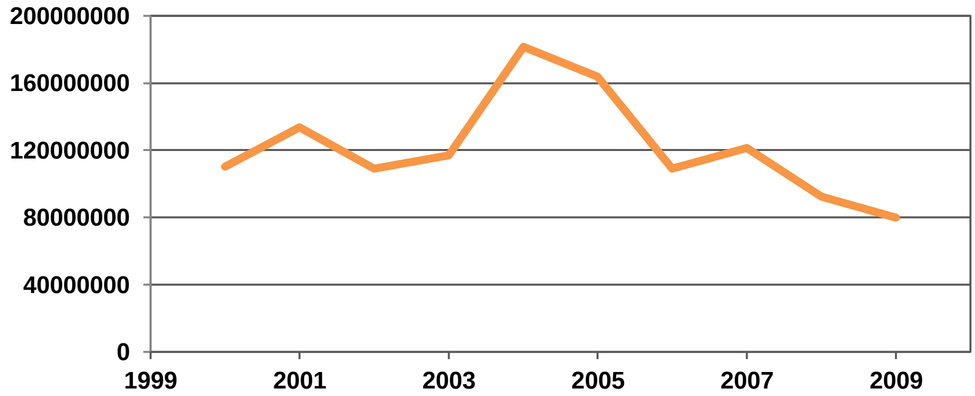
Source: WWF analysis of USFWS LEMIS data, 2011

Since reporting of marine tropical fish imports became more specific and consistent in 2005, import numbers have remained fairly steady with approximately 15 million marine fish imported each year, although the overall trend is showing a decline (Figure 2). Because the majority of marine tropical fish imports are simply identified as "Tropical Fish, Marine Spp." rather than by genus and/or species, it is not possibly to accurately identify the top imported species by the import records alone. Information regarding species imports is provided in the industry overviews, highlighting those genera and species of particular importance to the various industries that depend on trade in reef-associated species.

Tropical reef fish collector using cyanide to capture deep water species, Indonesia. Copyright naturepl.com/David Fleetham/WWF-Canon

Particularly with fish and invertebrates, numbers in trade should be considered relative rather than absolute as numerous shipments of these species are recorded by weight rather than number of specimens, yet only those shipments recorded by number of specimens have been included in this analysis. In the case of marine tropical fish it is important to note that, while many fish products may be recorded by weight, the vast majority of products associated with coral reefs are imported live for the marine aquarium trade and are recorded by number of individuals. This is evidenced by the number of products overall imported live, which tracks closely with imports of marine tropical fish. Those fish products recorded by weight are generally less relevant for the purposes of this analysis as they are primarily not reef-associated species or are imported in very small quantities.

Figure 3: U.S. Imports of Other Live Invertebrates (No. of specimens), 2000-2009

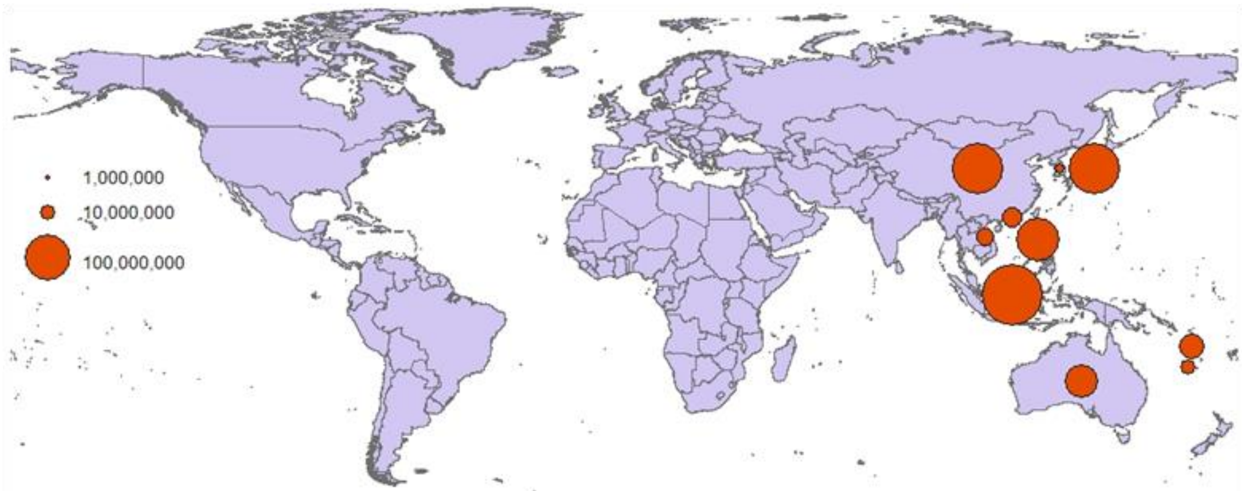


Source: WWF analysis of USFWS LEMIS data, 2011

Unlike the data for corals and marine tropical fish that show clear trends in import volume, the imports of invertebrates has seen significant fluctuation in the ten year period from 1999 to 2009, with a clear downward trend since peaking in 2004 (Figure 3). Interestingly, imports of items listed as “jewelry” have seen fluctuation over the years, corresponding with a high degree to the fluctuation in invertebrate imports, particularly the shelled species that are utilized in jewelry. As with fish, the majority of invertebrate imports are not identified by their specific genus or species but are rather lumped into a broad category of “Other Live Invertebrates;” thus making it virtually impossible to identify those genera or species imported in the greatest volume.

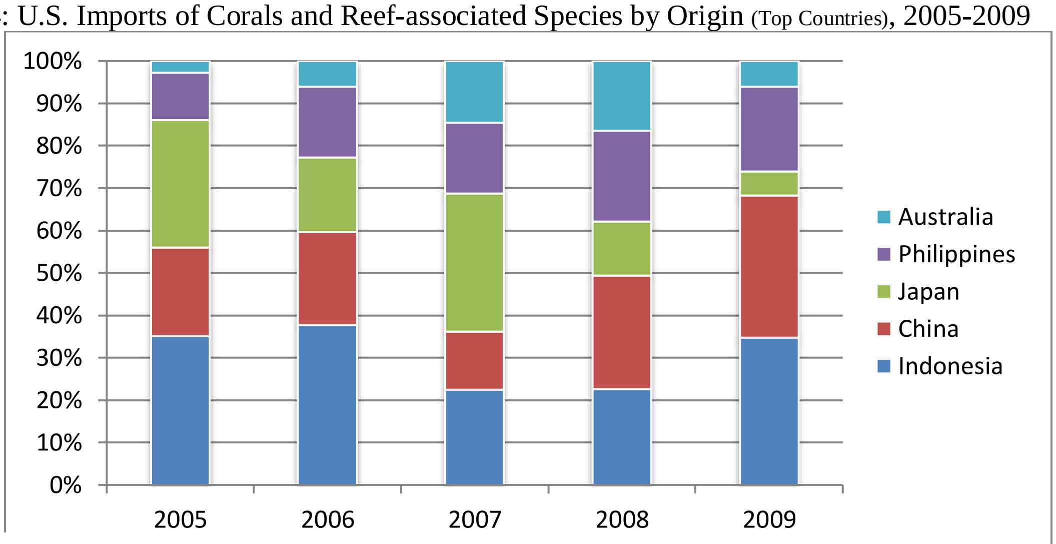
Origin of Imports

Map 1: Imports of Corals and Reef-associated Species by Origin, 2005-2009



Source: WWF analysis of USFWS LEMIS data, 2011

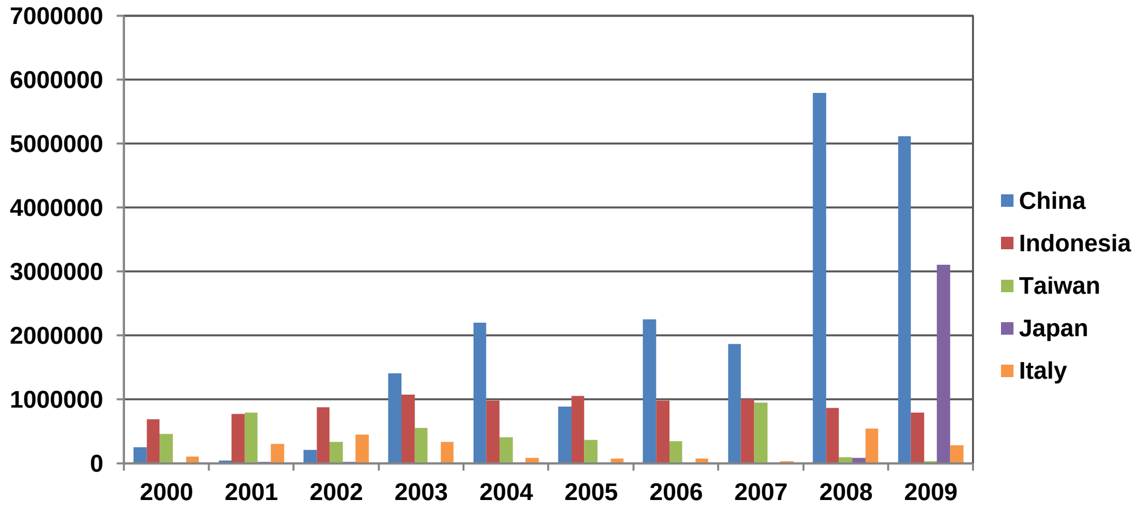
Figure 4: U.S. Imports of Corals and Reef-associated Species by Origin (Top Countries), 2005-2009



Source: WWF analysis of USFWS LEMIS data, 2011

Asia, and specifically the Coral Triangle, continues to be the primary area from which corals, coral products and reef-associated species imported to the U.S. originate. For all products combined, the top countries of origin for the period examined are Indonesia, China, the Philippines, Japan, and Australia (Figure 4).

Figure 5: U.S. Imports of Corals by Origin (No. of specimens), 2000-2009

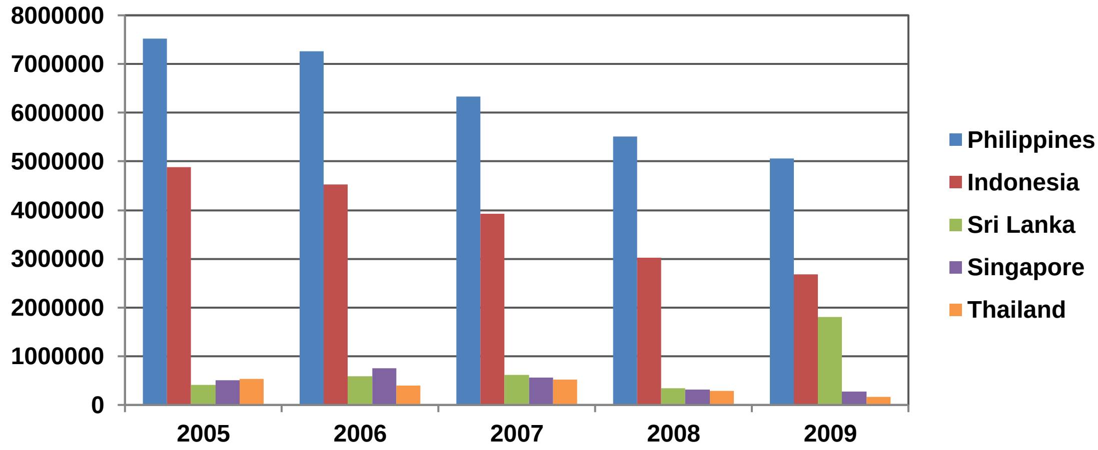


Source: WWF analysis of USFWS LEMIS data, 2011

For coral products, a few countries in particular play a key role. Indonesia has remained a steady source of coral and coral product imports to the U.S. throughout the period 2000-2009, with imports hovering around 1 million items per year. However, in recent years China has become a significant player. The years 2004, 2006, and 2007 saw spikes of imports from China up over 2 million items in each of those years; then, from 2007 to 2009, import numbers have jumped tremendously to between 5 and 6 million items per year, with 2008 as the peak year (Figure 5).

It is important to note that China is likely not the primary country of origin for all of the coral products exported. Rather, China is a major center for processing of coral products into finished items such as jewelry or items for home décor. The question raised by import data is why exports from China to the U.S. increased so dramatically from 2007 to 2009; a question for which there are a number of potential explanations. In 2008, China requested that a number of species of *Corallium* be listed in Appendix III of CITES, resulting in the requirement of appropriate CITES documentation for all exports of these species from China (FWS, 2008). It is plausible that this increase in paperwork resulted in an improvement in documentation for many of the coral products exported by China, thereby ensuring that coral jewelry products in particular are now identified as wildlife products and accounted for in wildlife trade data.

Figure 6: U.S. Imports of Marine Tropical Fish by Origin (No. of specimens), 2005-2009



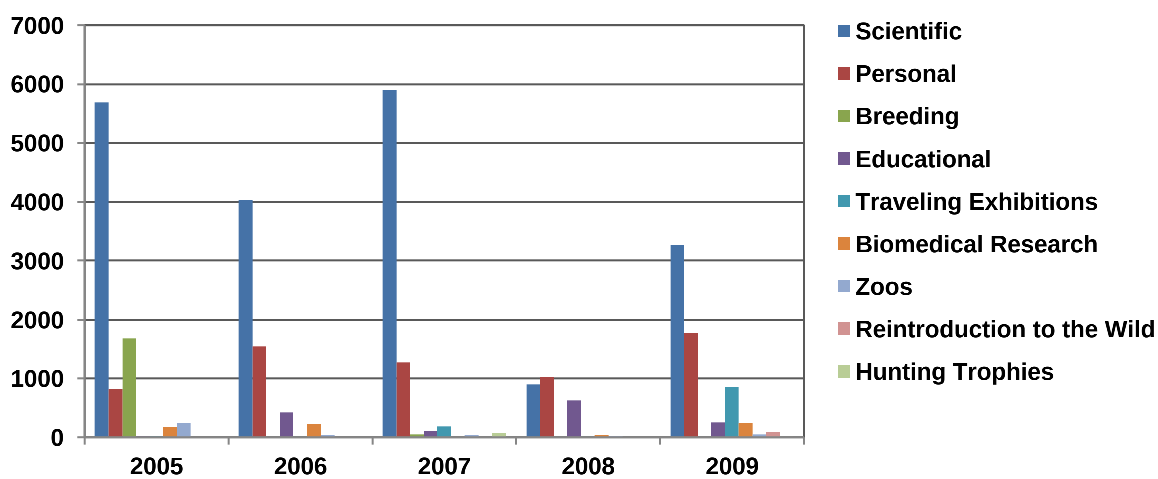
Source: WWF analysis of USFWS LEMIS data, 2011

The primary countries of origin for imports of marine tropical fish have been more consistent from 2005 to 2009. Since 2005, the top two countries of origin for marine tropical fish have been the Philippines and Indonesia, with the Philippines consistently the top country of origin for exports to the U.S.

Purpose of Imported Products

When wildlife products are imported to the United States, the exporter must state the purpose for which the products will be used. While there are a wide range of purpose categories ranging from use in botanic gardens to hunting trophies to traveling exhibitions, the primary purpose for coral products and reef-associated species is commercial trade. This broad category simply identifies the product as having commercial value and that it will be sold to an end-user in the U.S. or re-exported. Over 99% of all corals, coral products and reef-associated species that enter the U.S. are identified as items for commercial trade. Among the remaining imports, the identified purpose varies by product type.

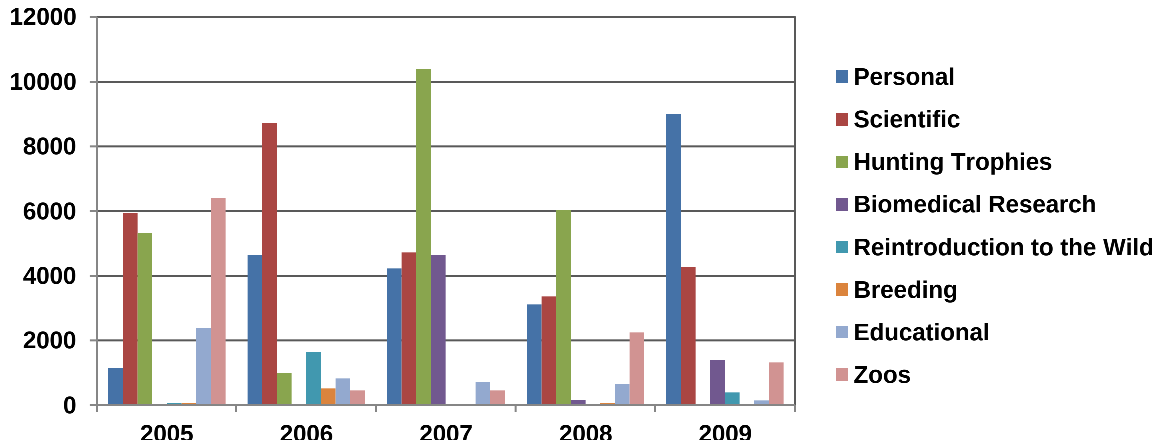
Figure 7: Stated purpose, other than commercial trade, for U.S. coral imports (No. of specimens), 2005-2009



Source: WWF analysis of USFWS LEMIS data, 2011

For coral imports from 2005 to 2009, 99.9% of imports were for commercial trade. The most frequently stated purposes other than commercial trade for importation are scientific and personal use . Although imports for captive breeding operations were relatively high in 2005, no imports for breeding purposes were recorded in 2008 and 2009.

Figure 8: Stated purpose, other than commercial trade, for marine tropical fish imports (No. of specimens), 2005-2009



Source: WWF analysis of USFWS LEMIS data, 2011

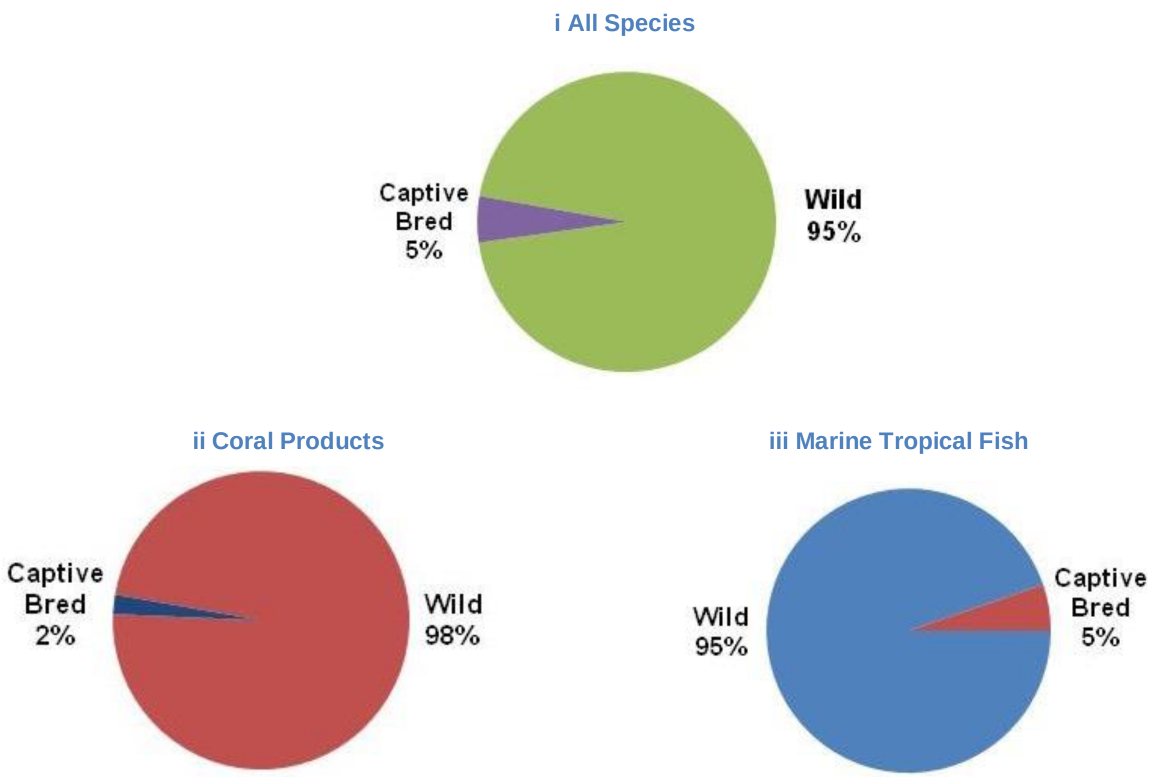
As with coral products, 99.9% of marine tropical fish imports from 2005 to 2009 were for commercial trade. The remaining trade was for a variety of purposes, primarily personal use, scientific purposes and hunting trophies. Notably, there were no imports hunting trophies in 2009. Also notable is the increase in imports for biomedical research; while there were almost no imports for this purpose in 2005 and 2006, 2007 saw a dramatic increase with still significant, although lower, import numbers in 2008 and 2009.

Source of Imported Products

Along with information regarding purpose, origin and other aspects, exporters must also report on the source of their products. The two broad categories for source are specimens taken from the wild and animals bred in captivity. For the purpose of this analysis, the latter category includes all of the primary definitions used by the U.S. Fish and Wildlife Service: 1) animals bred in captivity, parts and derivatives; 2) species listed in CITES Appendix-1 animals bred in captivity for commercial purposes; and 3) animals born in captivity that do not fulfill the definition of "bred in captivity" under CITES rules (Resolution Conf. 10.16) (USFWS-OLE, 2009).

The vast majority of corals, coral products and reef-associated species imported to the U.S. are taken from the wild. From 2005-2009, approximately 95% of all imported items were from wild sources.

Figure 9: Captive and Wild Sourcing of U.S. Imports, 2005-2009



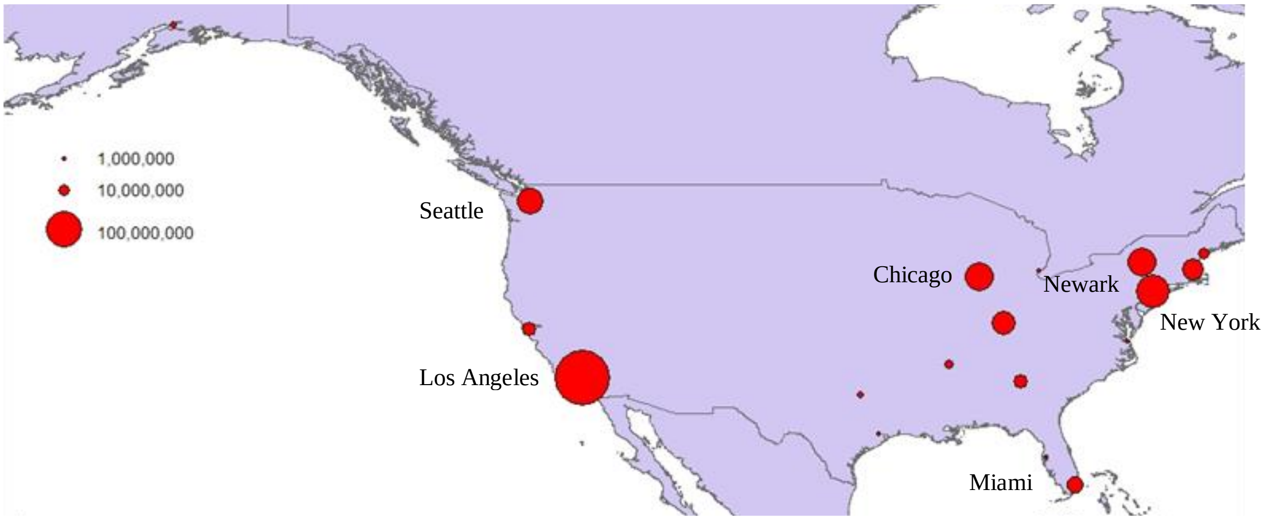
WWF analysis of USFWS LEMIS data, 2011

As demonstrated previously, the total imports of coral products have seen a dramatic increase in the past two years. However, the increase in imports, average for the period of 2005-2009 has primarily been met with products from the wild, as imports from captive-bred operations have remained fairly stable (Figure 9).

For marine tropical fish, percentages have remained fairly consistent since 2005, with the majority of products originating in the wild. On average, only 5% of marine tropical fish imports are captive-bred, while the remaining 95% are taken from the wild. However, it is worth noting that there is no legally consistent way to label non-CITES species of captive bred fish, corals or invertebrates, which could be preventing the data from accurately reflecting the true volume of captive bred species in trade.

Primary Ports of Entry to the United States

Map 2: Primary Ports of Entry for Corals and Reef-Associated Species, 2005-2009



Source: TRAFFIC analysis of USFWS LEMIS data, 2011

Los Angeles is overwhelmingly the most important point of entry overall for shipments of corals, coral products and reef-associated species. Los Angeles accounts for over 50% more imported product than the ports of New York and Newark combined, which together make up the second most important port of entry for these products. Perhaps unsurprisingly, the ports of New York and Newark combined make up the primary port for products that are re-exported, followed by Chicago, Anchorage and Miami.

The picture changes slightly when looking at individual product categories. Los Angeles remains the primary port in all cases; however, although Miami is not high in relative significance for imports of coral products it is the second biggest port for imports of marine tropical fish.

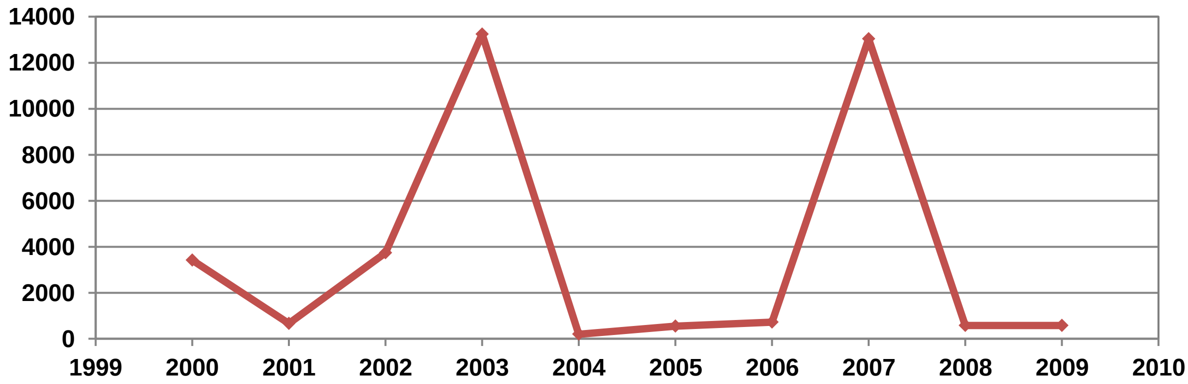
Exports from the United States

Although the major role of the United States in the market for corals and reef-associated species is as an importer, the U.S. also plays a role in the export market, albeit a very small role, particularly when compared to the major exporting nations of the Coral Triangle. For the years 2005-2009, trade records for exports from the United States were just over 1% of the total international trade in coral reef associated species; with the remaining records consisting primarily of import records with a small percentage of re-export records.

As with the analysis of import data, the trade analysis regarding the exports of corals and invertebrates will address trade for the years 2000-2009, while marine tropical fish exports will only be reviewed for the five years of data, 2005-2009.

Volume of Exports

Figure 10: U.S. Exports of Corals and Coral Products (No. of specimens), 2000-2009

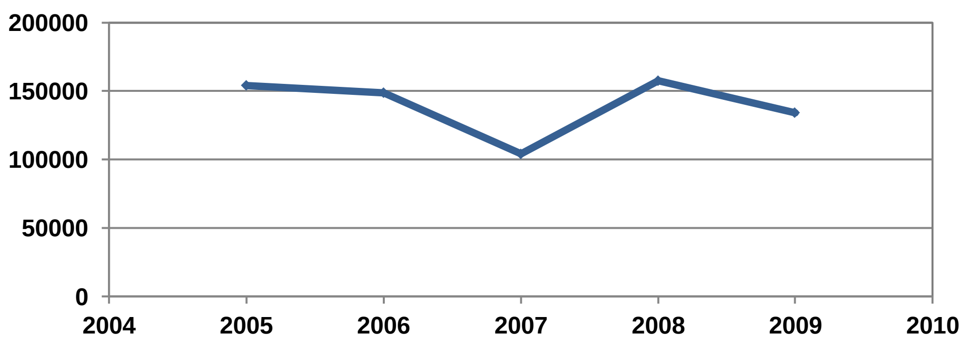


Source: WWF analysis of USFWS LEMIS data, 2011

As demonstrated in Figure 10 above, coral exports have been generally very low over the past ten years, with the exception of 2003 and 2007 in particular. Over 85% of shipments of coral and coral products from the U.S. contain fewer than ten items, with almost 60% of shipments only containing one item. In 2003, there were three particularly large shipments, two of which had over 5,000 specimens of cultivated (captive bred) live bubble coral (*Physogyra* spp.) destined for Ireland. The peak in 2007 can be largely attributed to a single shipment of 10,000 specimens of live, wild elkhorn coral larvae (*Acropora palmata*) collected after spawning. This species is critically endangered and has been listed on CITES Appendix II since 1985, which means that permits are required for export; this particular shipment was for scientific purposes and was shipped to the Rotterdam Zoo in the Netherlands.

In the LEMIS trade records, corals are, for the most part, identified by genus and are not lumped into broad categories like the majority of fish and invertebrates. For this reason, it is possible to look at the particular genera most prevalent in the U.S. trade. In the last ten years, the genera that have seen the highest exports are *Physogyra* and *Acropora*, which is not surprising given the few high-volume shipments noted above.

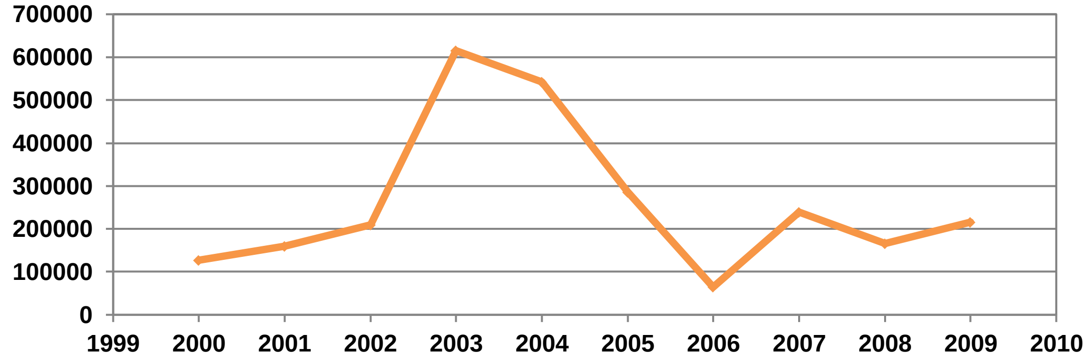
Figure 11: U.S. Exports of Marine Tropical Fish (No. of specimens), 2005-2009



Source: WWF analysis of USFWS LEMIS data, 2011

Export volumes of marine tropical fish have held fairly steady for the past five years, with a dip in 2007. As noted previously, the majority of trade records for marine tropical fish are classified in the broad category “Tropical Fish, Marine Spp.” so it is not possible to comment on the primary species exported from the United States. The vast majority are exported live for commercial trade.

Figure 12: U.S. Exports of Other Invertebrates (No. of specimens), 2000-2009

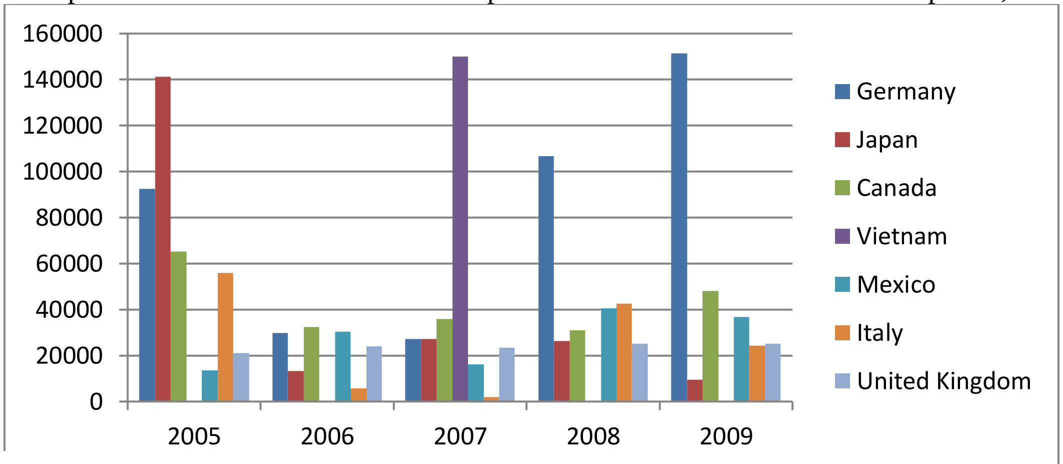


Source: WWF analysis of USFWS LEMIS data, 2011

Similar to the import volumes of marine invertebrates and unlike either the import or export data for corals and marine tropical fish, export volumes of invertebrates have seen significant fluctuation over the past ten years (Figure 12). As with fish, the majority of invertebrate imports are not identified by their specific genus or species but are rather lumped into a broad category of “Other Live Invertebrates;” thus making it virtually impossible to identify those genera or species imported in the greatest volume. Approximately 69 % of export shipments contained fewer than 100 items, although the number of shipments per year has been declining while the quantity per shipment has increased. The peak years of 2003 and 2004 were primarily due to a few very large shipments; in 2003 there was a single shipment of 100,000 live, captive-bred invertebrates to Vietnam and two shipments of 30,000 wild invertebrates to Italy, and in 2004 there were again two shipments of 30,000 wild invertebrates to Italy.

Destination for Exports

Figure 13: Top Destination Countries for U.S. Exports of Corals and Reef-associated Species, 2005-2009

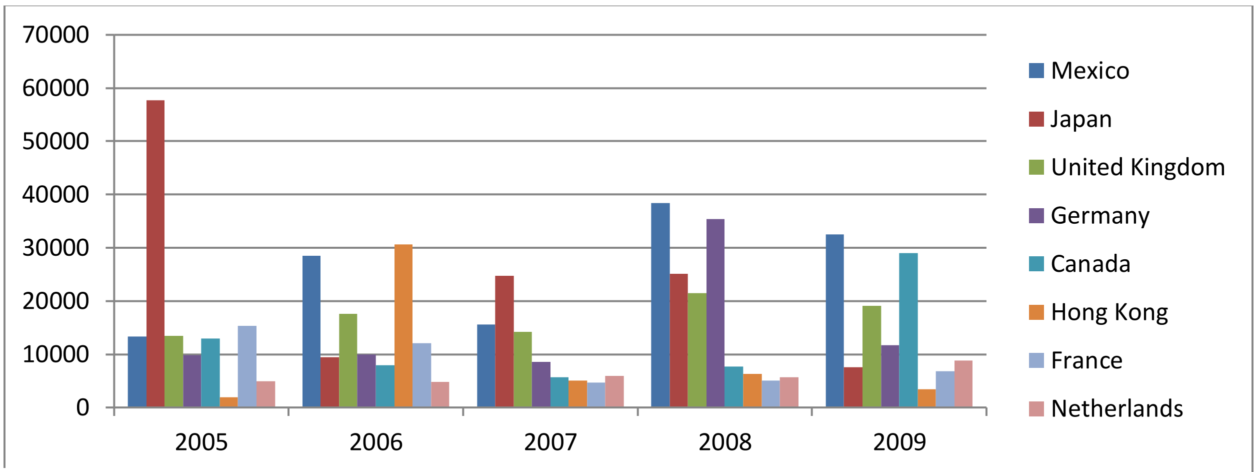


Source: WWF analysis of USFWS LEMIS data, 2011

Germany, Japan, Canada and, Mexico, are the primary destination countries for U.S. exports of corals and reef-associated species (Figure 13) with relatively negligible amounts exported elsewhere. Vietnam appears as a top country in the last five years of the analysis even though they have only received one shipment from the U.S. because that single shipment contained 150,000 items – live, captive-bred marine invertebrates.

For corals and coral products specifically, export volumes have been relatively low in the last decade, as noted previously, with the exception on the large shipments in 2003 and 2007 that caused peaks in volumes for those years. Canada has more consistently been a destination country for U.S. coral exports, although volumes have decreased from a few thousand items in 2000 and 2002 down to less than 100 items per year for the most recent six years of data. The other consistent destination country over time has been Japan; there were peak years in 2001 and 2007 where Japan imported over 500 items, but numbers have more steadily held around 50 items per year. The majority of shipments of coral products to Canada consisted of jewelry, although by volume Canada imported more live specimens than jewelry. Japan primarily imports coral jewelry items from the United States.

Figure 14: Top Destination Countries for U.S. Exports of Marine Tropical Fish, 2005-2009



Source: WWF analysis of USFWS LEMIS data, 2011

As with imports, the primary destination countries for U.S. exports of marine tropical fish have been more consistent from 2005 to 2009. Mexico and Japan are the top two destinations in terms of total imports of U.S. product over the past five years, although the United Kingdom, Germany and Canada consistently import relatively high volumes each year.

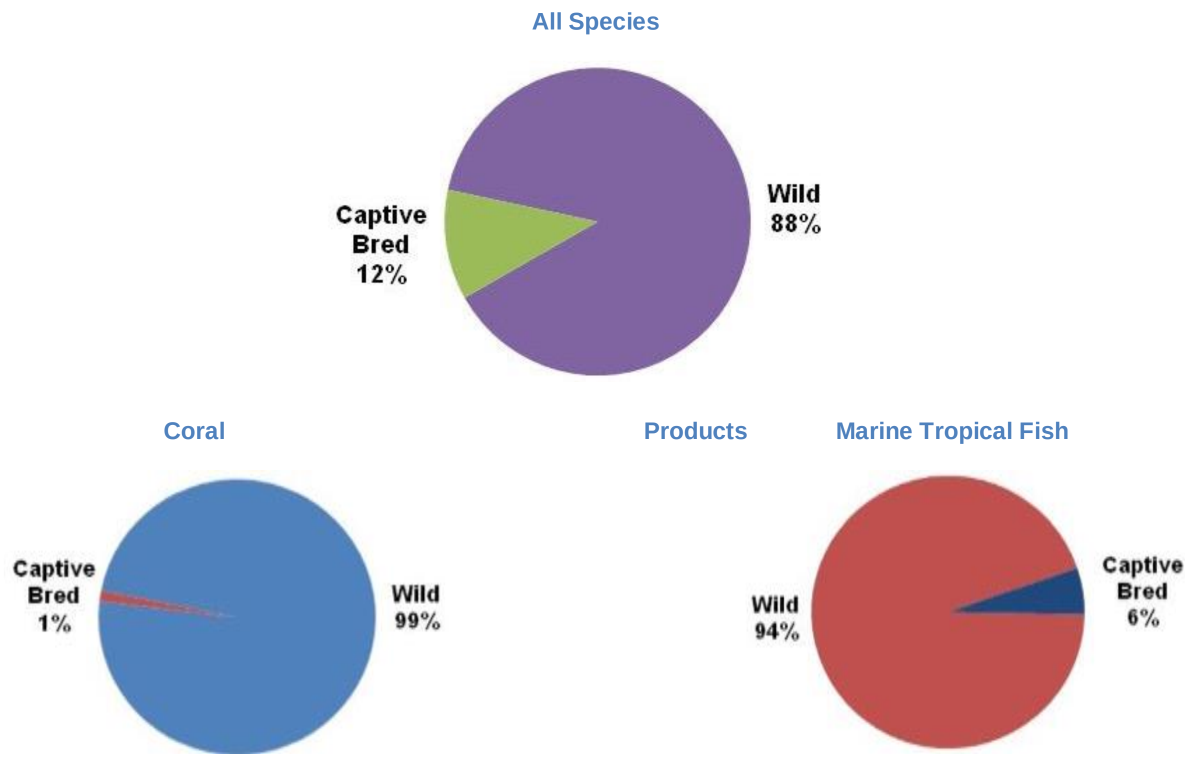
Source of Exported Products

Along with information regarding purpose, origin and other aspects, imports and exports must also report on the source of their products. The two broad categories for source are specimens taken from the wild and animals bred in captivity. As in the analysis of imported products, for the purpose of this analysis, the latter category includes all of the primary definitions used by the U.S. Fish and Wildlife Service:

1) animals bred in captivity, parts and derivatives;
2) CITES Appendix I animals bred in captivity for commercial purposes; and
3) animals born in captivity that do not fulfill the definition of "bred in captivity" in CITES Resolution Conf. 10.16 (USFWS-OLE, 2009).

The majority of corals, coral products and reef-associated species exported from source countries to the U.S. are taken from the wild. From 2005-2009, approximately 88% of all exported items were from wild sources.

Figure 15: Source of Exports, 2005-2009



Source: WWF analysis of USFWS LEMIS data, 2011

Overall, as with imports, the vast majority of exported corals, reef-associated species and their products are of wild origin. The figures above (Figure 15) show an average for the five years; captive-bred coral exports have been steady through those years, although captive-bred marine tropical fish exports in 2009 were nearly double those of each of the previous four years.

Key Species in Trade

This part of the report provides specific examples of harvest and trade in some key species that are the main coral reef associated species used for ornamental purposes in the United States.

Ornamental fisheries are highly selective and focus their efforts on species that are easily harvested or caught, or exhibit high market values. For example, species selected for trade for ornamental purposes for aquaria are live reef fish, corals and invertebrates that are desirable esthetically or exhibit interesting behaviors. With all ornamental use of reef species there are specific factors that make particular species more desirable and profitable to trade. Often trends fluctuate to a degree based upon fashion, demand dynamics and availability of quality supply.

Ornamental Fish Species in Trade

Globally the main marine fish groups that have dominated the aquarium market are: Pomacentridae, Acanthuridae, Blastidae, Labridae, Pomacanthidae, Chaetodontidae, and Syngnathidae. *Amphiphrion* spp., *Dascyllus* spp., and *Chaetodon* spp. are among the favored genera (Olivier 2001).

Looking at the most commonly traded families internationally, species of Pomacentridae (damselfishes) dominate, (Green 2003). The Pomacentridae genus consists of over 360 species, and is characterized by small, colorful, and commonly found fish, throughout tropical seas. Damselfishes, live throughout coral reef ecosystems, are oftentimes highly territorial, and inhabit the branches of coral colonies. This family also includes the highly popularized relative the clownfish. Throughout the hobby this particular family is known for its affordability, and is usually marketed towards beginners.

The following families of marine fish species are listed in order of popularity in international trade:

Pomacentridae	damselfishes, see above;
Pomacanthidae	represent the relatively delicate, large angelfish;
Acanthuridae	a large, herbivorous family commonly known as tangs or surgeonfish;
Labridae	which consists of an extensive array of colorful reef species known as wrasses;
Gobiidae	gobies which are characteristically small fishes found commonly in association with coral colonies;
Chaetodontidae	or the butterfly fish are colorful relatives of the angelfish, many members of this family have specific dietary requirements (coral polyps, sponges) making the majority of species unsuitable for aquarium life;
Callionymidae	commonly known as dragonettes, are also poorly adapted to aquarium life. They display striking coloration, small size, and a notoriously specific dietary habit consisting of (microorganisms/micro fauna). A vast majority of this species slowly starve to death despite hobbyist efforts. [However, it should be noted that in 2010, ORA (Oceans Reefs and Aquariums) began to successfully mass produce, and wean this species onto commercially available frozen foods].
Microdesmidae	the dartfish are another small, colorful and active family;
Serranidae	the sea basses;

Blenniidae	blennies, a small reef dweller, similar in size, and behavior to gobies.

Trade trends can change over time and demand for certain species will vary depending on fashion, availability and price. For data provided by exporters and importers for the years 1997-2002 for example, the most commonly traded marine ornamental fish species for aquaria were (Wabnitz *et al.* 2003):

- Blue-Green Damselfish (*Chromis viridis*)
- Clown Anemonefish (*Amphiprion ocellaris*)
- Whitetail Dascyllus (*Dascyllus aruanus*)
- Sapphire Devil (*Chrysiptera cyanea*)
- Threespot Dascyllus (*Dascyllus trimaculatus*)

Elegant and Endangered: The Banggai Cardinalfish from Indonesia

Trade Concerns

Since its rediscovery in 1994 the Banggai cardinalfish (*Pterapogon kauderni*) has become highly prized in the aquarium trade. Its rapid rise in popularity is due to a number of factors, namely its striking spotted and striped pattern and elegant, elongated fins, ease of capture as it inhabits shallow coastal waters (typically found between 1.5 and 2.5 m), and a low market price that is not reflective of this species' increasing scarcity (Allen and Donaldson 2007, ARKive 2009, Blundell 2010).

Banggai cardinalfish are endemic to Indonesian coastal waters, with suitable habitat along just 32 islands in the Banggai Archipelago, limiting the species range to 34 km^2, or 13 square miles (see map) (CITES 2007, Vagelli *et al.* 2008). The Banggai Archipelago is located in the center of the Coral Triangle, which contains the most biologically diverse expanse of coral reefs anywhere in the world, but is also one of the most vulnerable marine ecosystems in the world due to both direct human pressures and the indirect impacts of human-induced climate change (CITES 2007, Hoegh-Guldberg *et al.* 2009).

Banggai cardinalfish live in small groupings, the majority contain less than ten individuals, while the largest recorded community had several hundred members. The sedentary nature of Banggai communities, paired with unique reproductive traits (the species lacks a pelagic larval phase) and local geomorphology (strong currents and deep trenches between islands) make it virtually impossible for groups to disperse to new potential habitats or interact with sister populations. Due to the isolation of Banggai communities these fish assemblages exhibit high levels of genetic diversity between groups separated by extremely short distances – often just a few kilometers; even populations occurring on reefs of the same islands are genetically distinct, and makes them extremely vulnerable to any form of fishing pressure (Allen and Donaldson 2007, ARKive 2009, CITES 2007, Vagelli 2008, Vagelli *et al.* 2008).

Overfishing and environmentally destructive fishing practices – primarily dynamite fishing – have led to extinctions of at least two local populations and brought the Banggai cardinalfish to an IUCN designated endangered status in little more than a decade after commercial trade began. In 2007, the IUCN Red List of Threatened Species completed an assessment of *Pterapogon kauderni* and listed the species as endangered, meaning the species is "considered to be facing a very high risk of extinction in the wild" (Vagelli 2008). Early in the Banggai aquarium trade hobbyists reported that wild sourced Banggai individuals were hardy and resilient, but as capture and trade rapidly expanded these cardinalfish have become more and more fragile and vulnerable, with survivability described as "pitiful at best" (Blundell 2010). Some traders state that only captive bred specimens should be purchased in spite of the premium paid for captive fish due to its endangered species status.

Population Viability and Conservation Controversy

There is no debate within the scientific world about the overexploitation of Banggai cardinalfish. As research biologist Adam Blundell states, "For all scientific efforts, studies, and data that exist the outlook is bad. It is an acknowledgment that the Banggai Cardinal are in dire need of help." But there is a debate within the political community, with some Indonesian officials, traders, and aquarium hobbyists claiming harvests are sustainable.

The estimated total number of Banggai cardinalfish living in the Banggai region is 2.2 million individuals, while a conservative estimate of the rate of capture of *P. kauderni* is about 1 million specimens per year, meaning half of their population is removed annually (Blundell 2010, Vagelli 2008). The capture estimate is considered conservative because there are high rates of mor11tality during holding and shipping, with a reported 25 percent loss in the first 24 hours, and a similar percentage frequently rejected at export hubs due to poor condition. Consequently, it is difficult t1o reconcile the number of fish sold with the amount harvested (Allen and Donaldson 2007, CITES 2007, Vagelli 2008). The historic average abundance of *P. kauderni* is uncertain as Banggai populations did not become the subject of research until after they became a rising star in the aquarium industry.

However, one *de facto* protected area (a bay off-limits to all fishing since before trade began) contains an undisturbed subpopulation that provides insights into the historical baseline abundance of the species. This bay is privately owned by a pearl farm business and contains the typical microhabitats and oceanographic characteristics associated with other Banggai populations. In 2004 the density of this subpopulation was 0.63 individuals per m^2, while the mean density for eight censuses completed in unprotected sites was 0.07 individuals per m^2 (highest density = 0.21; lowest density = 0.028). In addition, a census of a subpopulation located just 300 m from the protected bay revealed a density of just 0.071 individuals per m^2 (Allen and Donaldson 2007). Scientists infer that the density of the protected subpopulation is representative of the historic mean density for the species, meaning that Banggai cardinalfish have been reduced to just 10 percent of their historical abundance and range (ARKive 2009, Vagelli 2008). One of the most prominent experts on Banggai cardinalfish, Dr. Vagelli, has stated, "The non-regulated capture of selected species for the international aquarium trade is so severe that it is threatening at least one species with extinction – the endemic apogonid [cardinalfish] *Pterapogon kauderni.*" When coral researcher Eric Borneman was president of the Marine Aquarium Societies of North America he proposed an ethical ban on purchasing Banggai cardinalfish (Blundell 2010).

In combination with statistics indicating huge annual harvests and plummeting populations, Banggai cardinalfish have very low fecundity, considerable energy investment in reproduction, paternal oral incubation of both eggs and free-living embryos, and are reliant on local recruitment, with juvenile settlement in parental habitat (Allen and Donaldson 2007, ARKive 2009, CITES 2007, Vagelli *et al.* 2008). Courtship is initiated by females, after which the pair establishes a spawning territory, which they vigorously defend against intruders. After a few hours or days the female spawns an average of 40 large eggs (a low number for marine fish), which the male quickly scoops into its mouth pouch. The normal loss of unfertilized eggs and embryos that fail to fully develop is augmented by the significant percentage of eggs are lost in this clutch transfer. Males incubate the eggs for about 20 days, and continue to brood the newly hatched juveniles within their mouth for another week to 10 days (Allen and Donaldson 2007, ARKive 2009, Gladstone 2009). Of the 250 species of cardinalfishes the Banggai are the only species that mouthbroods young until settlement (Gladstone 2009, Vagelli *et al.* 2008). During this time the male does not eat, limiting each male to just a few brooding cycles each year. Once the juveniles are released they quickly take shelter within sea anemones or sea urchins and remain in the parent habitat (Vagelli *et al.* 2008). High parental energy investment per offspring is often linked to high survival, but contrary to expectations *P. kauderni* suffers high early mortality (Gladstone 2009, Vagelli 2008). Due to the lack of a pelagic larval phase there is no prospect for recovery of depleted subpopulations through outside recruitment. This unique reproductive trait comes with a cost, increasing species vulnerability to environmental change and overexploitation (Vagelli *et al.* 2008).

The scientific evidence of severely depleted and stressed populations and reproductive vulnerability led United States delegates to propose the inclusion of *P. kauderni* in Appendix II of CITES in 2007. The U.S. invited Indonesia to co-sponsor the proposal, but Indonesia sent a letter stating that they could not support the measure, and that the government was expecting "positive impacts from the current management program being undertaken at the area, such as the establishing of District Marine Protected Areas and a fishermen certification system in collaboration with the Marine Aquarium Council (MAC)." Notably, the U.S. did receive letters of support from the only local NGO that was working on conservation and educational issues in the Banggai Archipelago at the time, as well as from the head of the Banggai Fisheries and Marine Affairs Department.

The U.S. submitted the proposal for consideration at the June 2007 14th meeting of the Conference of the Parties to CITES (CoP14). However, after the proposal was introduced on the floor of the Conference, Indonesia voiced strong opposition, saying the proposal would have severe consequences for local livelihoods and conservation efforts were already underway in the region. The perspectives provided at CoP14 by Indonesia and the UN Food and Agriculture Organization (FAO) on the species' status and productivity resulted in several countries endorsing Indonesia's position on the proposal. The U.S. withdrew the proposal before the vote due to such strong range state opposition.

In his 2008 assessment of the failed CITES proposal, Dr. Vagelli states that during a field survey in March-April 2007 he was able to establish that "there were no areas being established to protect *P. kauderni*, no local aquaculture project being developed, and no village in the Banggai Archipelago [had been] approached by the government to implement any conservation or management plan directed toward *P. kauderni*." In addition, representatives from MAC Indonesia contacted Dr. Vagelli and admitted a lack of knowledge on the species' conservation status and the Banggai region generally, and said they were not planning a certification system for trade of *P. kauderni*. In fact, it was not until August 2007 that the first meeting of regional stakeholders was conducted (Vagelli 2008).

Livelihood Significance and Illegal Trade

The Banggai cardinalfish fishery provides a supplementary source of income for local collectors. Regional surveys have found that as little as 80 and no more than 230 fishers are actively engaged in harvest and local trade of the Banggai (Lunn and Moreau 2004, Vagelli 2008). This is largely due to the lack of economic incentives. When this species was first introduced to the aquarium trade, the retail price per fish was ~US$100. Today the retail price for wild-harvested individuals has dropped to US$ 15-25, but collectors only receive a minute fraction of that sum. Collectors are reported to receive just a few cents per fish (CITES 2007). According to Dr. Vagelli (2008),

> *The real economic importance of the capture and trade of this species within this region is virtually nil. The reality is that…the vast majority of the Banggai people make their living with more profitable and traditional economic activities such as agriculture, seaweed culture, and [food and ornamental] fisheries. About 55% of the region's GDP is due to agricultural and traditional fisheries activities.*

Despite claims by the Indonesia CITES management authority that regulating the capture and international trade of *P. kauderni* would have significant negative economic impacts in the Banggai Archipelago, observations and evidence indicate that the Banggai cardinalfish is not a significant source of income or employment in the region. In addition, there is outside, illegal collection by Balinese fishers; boats come directly from Bali and fish for about a week. People living outside the Banggai district are prohibited from fishing in the area without purchasing government permits. The magnitude of this outside capture is unmonitored and unknown (Vagelli 2008). This illegal activity has gone unaddressed, indicating a lack of official concern about the livelihood impacts of these harvests. The aquaria trade industry itself has recognized the challenge, in the July 2009 issue of Tropical Fish Magazine, Keiron Todd states "Who is affecting this species? We, the aquarium hobbyists, are. Who would be affected by a cessation of its collection? Only a handful of people — to the tune of about a hundred bucks a year each."

CITES Controls?

Despite the abundance of information of the declines brought about in the collection and trade of the Banggai cardinalfish, the absence of a CITES listing for the species means that it remains unregulated in international trade. As a result, retailers and collectors can import as many specimens as they would like without having to meet any requirements as to the sustainability of the trade or collection of the species.

Captive Breeding and Aquaculture

The feasibility of captive breeding and *in-situ* aquaculture of *P. kauderni* was exhibited as long ago as 1997, when the New Jersey Academy for Aquatic Sciences began a captive breeding program (Allen and Donaldson 2007, Vagelli 2008). Facilities can raise market-size fish within 100-130 days and survival rates are good, ranging from 66-95% (CITES 2007). Nonetheless, replacement of wild capture by captive breeding has not been taken up at the community level or within the aquarium trade (Allen and Donaldson 2007, Gladstone 2009). The issue, as with most aquaculture operations in developing countries, is start-up costs and competition with more rapid, lower investment wild capture. Locals willing to invest the time and resources to launch an aquaculture operation would likely be unable to compete with the low price of fish caught using a hand net, held for a short period in a floating cage, and sold to exporters within a few hours or days. In order to incentivize local aquaculture, the trade of wild caught specimens would still need to be restricted and regulated (Vagelli 2008). An additional risk is that a viral disease has been documented in wild-caught individuals maintained in captivity (CITES 2007). This not only threatens the sustainability of the breeding operations, but it also raises the concern that in open water culture operations the disease could be spread to nearby fish populations. In the United States, some traders are proposing that buyers opt for the captive bred specimens as it becomes more widely know about the endangered species status in the wild.

Pet or Medicine? Seahorses: *Hippocampus kuda*

Trade Concerns

There are more than forty recognized species of seahorses (genus *Hippocampus*). It is estimated that at least 25 million seahorses are traded globally each year (Koldewey *et al.* 2010; Pawar *et al.* 2010). It is estimated that one million live seahorses are traded each year (4% of the 25 million traded internationally), primarily destined for the U.S., Europe, Japan and Taiwan (Pawar *et al.* 2010). The majority of seahorses traded are dead animals used for traditional medicine (particularly traditional Chinese medicine or TCM), with high demand in Hong Kong, Taiwan, and the Peoples Republic of China, and a growing market in expatriate Chinese communities in Asia, the United States and Europe (Miththapala 2005, Nijman 2010). In China and Taiwan, tonics and medicines derived from seahorse extracts are used to treat sexual dysfunction, respiratory and circulatory problems, kidney and liver diseases, and other minor ailments (Tacio 2008). Seahorses are also collected for private and public aquariums, and as curios, alongside shells and dried starfish.

The seahorse trade has been on the rise; while just 32 countries were involved in the seahorse trade in 1995, this expanded to at least 80 countries by 2001 (Giles *et al.* 2006, Koldewey *et al.* 2010, Scales 2010). Demand for these unusual fish exceeds available supply. Interviews and surveys of fishers and traders indicate declines in many commercially desirable species (Giles *et al.* 2006, Miththapala 2005, Perry *et al.* 2010, Project Seahorse 2003, Salin *et al.* 2005). The IUCN Red List of Threatened Species lists 37 species of seahorses, seven of which are listed as vulnerable, one as endangered, and the rest as data deficient (Project Seahorse, 2003). In 2002 the entire *Hippocampus* genus was listed under Appendix II of CITES, requiring that all Parties to the Convention ensure any trade of these species does not threaten the sustainability of wild populations.

Identification challenges

The taxonomy of seahorses makes them difficult to identify; they lack many of the distinct characteristics used to identify other bony fish and they are able to alter their external appearance, changing skin color and growing filaments that provide camouflage (Koldewey *et al.* 2010, Scales 2010). This complex seahorse taxonomy has contributed to difficulties in distinguishing species in trade, and gathering accurate data on the magnitude of trade. The CITES listing went into effect in September 2004 and significantly increased trade attention, with a correlated improvement in species identification. For instance, the U.S. Fish and Wildlife Service LEMIS database showed just over 1100 individuals of the vulnerable, yellow/spotted seahorse (*H. kuda*) imported into the U.S. in 2004, but this number increased to more than 11,000 in 2005, and ranged from 36,000-49,000 in subsequent years. Nonetheless, the majority of seahorse imports are still listed generally as "*Hippocampus* spp." in both domestic and international trade data, indicating that trade data for the most popular commercial seahorse species – including *H. kuda* – are likely significant underestimates of the true number imported. In addition, the CITES database is only a record of legal, international (non-domestic) trade, and hence is likely a great underestimate of total global trade.

Life History

There are many inherent characteristics of seahorse reproduction, dispersal, and habitat commensalism that make them particularly vulnerable to overexploitation. Most species of seahorses are monogamous or exhibit high mate fidelity. Seahorses also have a long period of parental care with typically small brood sizes; the males carry the young to term in a brood pouch. The weight of seahorse armor makes them slow swimmers and they often attach to a substrate to prevent currents from carrying them away, leading to a small home range and limited dispersal (Miththapala 2005, Project Seahorse 2003, Scales 2010, Koldewey *et al.* 2010). This means that if a mate is lost a significant energy investment is required to find a new partner, likely leading to reproductive costs (Scales 2010). Seahorses inhabit shallow coastal waters, primarily seagrasses, coral reefs, and mangroves, making them particularly susceptible to habitat degradation and loss, fishery bycatch, and targeting by divers given their proximity to human populations (Project Seahorse 2003, Salin *et al.* 2005).

Trade, purpose and identification

Hippocampus kuda is listed as Vulnerable under the IUCN Red List classification, due to population declines of at least thirty percent, attributed to bycatch, targeted catch, and habitat degradation. “While there is little information on changes in numbers of the species, there is indirect evidence to suggest that declines have taken place and are continuing” (Project Seahorse 2003). *Hippocampus kuda* is one of the most common species traded live for use in aquariums (Scales 2010). It is also one of the most valuable seahorses used in TCM. This species has many desirable qualities for the traditional medicine sector, including large size, smooth texture, and pale complexion when dried, and hence is in high demand. These traits are also attractive for the aquarium and curio trade (Garcia *et al.* 2009, Project Seahorse 2003, Scales 2010). According to U.S. FWS data, seahorses are the second most important taxon in terms of value and volumes of marine curio imports into the U.S. *Hippocampus kuda* is one of at least five species of seahorses that have been imported for the curio market (Grey *et al.* 2005).

Illegal Trade

There are many indications that there is significant illegal and unrecorded trade of seahorses, including *H. kuda*. Under the Philippines national fisheries code seahorses can no longer be legally exported, but Project Seahorse has confirmed that trade continues. It is believed that many seahorses harvested in the Philippines are channeled through illicit trade routes in Malaysia and Thailand (Perry *et al.* 2010, Scales 2010). Officially, exports of marine aquarium fish are prohibited by law in Malaysia, but European trade records still show some shipments. In Thailand *H. kuda* is one of three species of seahorses for which exports of live species have also been prohibited, but illegal exports are still being recorded (Perry *et al.* 2010).

In a study in India in 2001 that used catch data to derive the volume of dry seahorse trade it was found that catch tonnage greatly exceeded official statistics, indicating that a significant amount of trade occurred through non-conventional routes. Concerns about seahorse conservation led the government of India to outlaw the capture of wild seahorses that same year, but while capture and export of seahorses has been substantially reduced, trade from India is still taking place (Salin *et al.* 2005). There is extensive illegal trade of natural resources along the border between China and Vietnam, and seahorses are believed to be a part of this trade (Giles *et al.* 2006). High demand and attractive prices mean that seahorse landings continue in all of these countries despite certain national prohibitions.

Exporting countries and harvest methods

Hippocampus kuda is native to the Indo-Pacific and is found in the coastal waters of India, throughout Southeast Asia, northern Australia, Japan, and some of the Pacific Islands, including Hawaii (Project Seahorse 2003). The primary exporting countries are India, Malaysia, Thailand, Vietnam, the Philippines and Indonesia (Giles *et al.* 2006, Miththapala 2005, Perry *et al.* 2010, Salin *et al.* 2005). Many of these countries also sell this species domestically for traditional medicine. (domestic trade is generally not monitored systematically). CITES trade records indicate that Thailand is the largest global exporter of dried seahorses (Perry *et al.* 2010). U.S. FWS LEMIS data indicates that, since 2006, the vast majority of imports of *H. kuda* into the U.S. have originated in Vietnam, while from

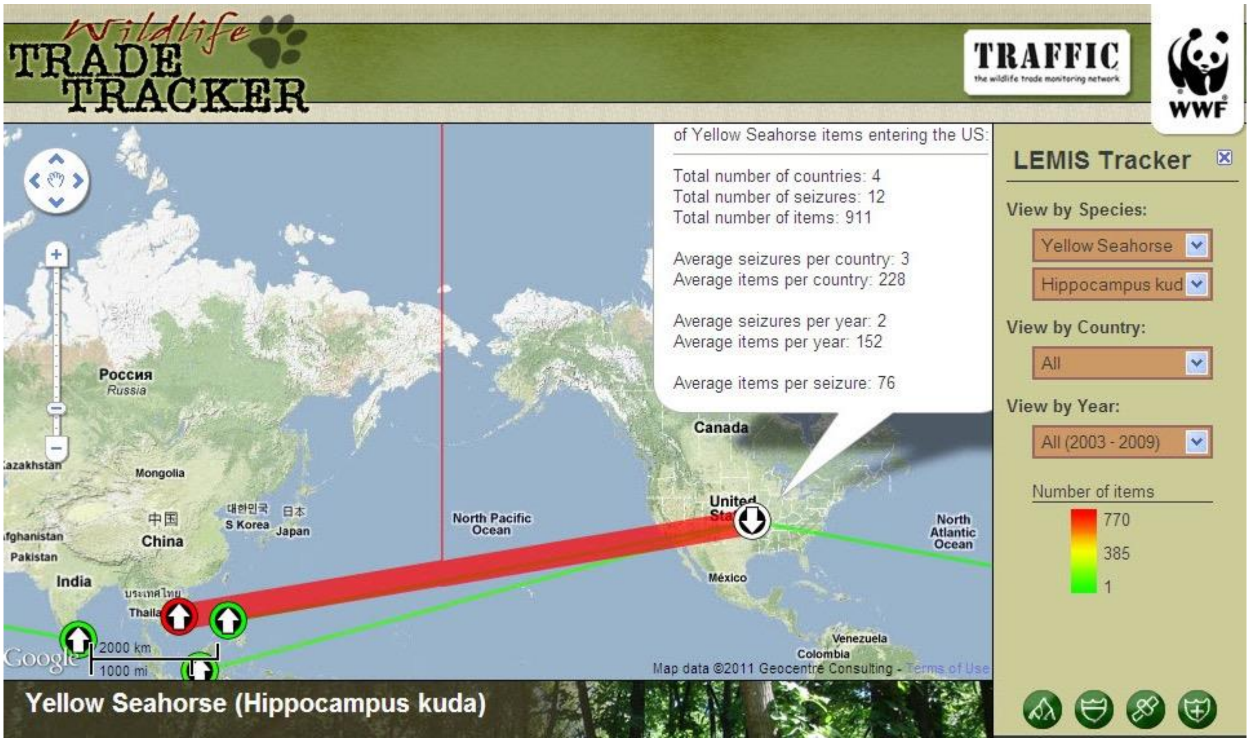
2004-2005 the majority came from Indonesia, and from 2000-2003 the majority came from the Philippines. A 2006 study on the catch and trade of seahorses in Vietnam (Giles *et al.*) indicated that exporting seahorses is a relatively new phenomenon in Vietnam, likely linked to decreased supply in other countries in the region. Markets in China and US have increased sourcing from Vietnam due to normalization of trade relations in the1990s. Additionally, fishing fleets have expanded and gear has improved, and with trawling effort increasing, mostly inshore, this has lead to increased seahorse bycatch.

Trade studies in South India, Malaysia, Thailand, and Vietnam have all revealed *H. kuda* as one of the main species harvested. A recent study on culture of *H. kuda* in sea cages (Garcia *et al.* 2009) also stated that it is one of the most heavily traded species in the Philippines, despite the fact that the trade of seahorses has been outlawed. The vast majority of seahorses landed in Southeast Asia, including *H. kuda*, are caught as bycatch by trawlers targeting shrimp and other inshore fish. Trawling not only poses a direct threat to seahorse populations, but also leads to widespread habitat degradation that further threatens the resilience and survival of seagrasses, coral reefs, and associated species. A much smaller number of seahorses are hand caught by swimmers and divers. Although targeted seahorse fisheries are relatively small in scale, they still serve as a critical source of livelihoods for tens of thousands of fishers in the region (Salin *et al.* 2005, Sanders *et al.* 2008).

Addressing overexploitation

While it is recognized that countries in the Indo-Pacific are the most important contributors to the seahorse trade, not enough is known about these seahorse fisheries and their degree of exploitation. Few species of seahorses have been comprehensively assessed, and prior to 2004 few countries recorded any aspects of seahorse trade, to the point that some officials did not even know their countries were involved. Seahorses are used in traditional medicine within India, Indonesia and the Philippines, and domestic consumption may be particularly large in both Malaysia and Thailand (Perry *et al.* 2010). Domestic use needs to be better tracked and recorded in order to determine sustainable export levels. CITES depends on self-reporting at the national level and is not established in a way that is cannot address illegal trade, domestic trade, or bycatch issues. From a conservation perspective, non-selective trawling poses the greatest threat to seahorse populations. But if there is a lack of scientific data on populations, reproduction of species, harvest levels and mortality then it is very difficult for CITES scientific authorities to determine if the trade is to the detriment of the species or not. It is vital that more information is provided to ensure that effective CITES Non-Detriment Findings can be performed and the authorities make those findings. The challenge is often a widespread lack of resources to undertake the field research and analyze the data. However, in many cases countries will still issue export documents for species where they have little understanding of the impact on the species populations in the wild. Other methods are required to deal with this and some countries like those in the European Union have a process to prohibit imports if they believe that the species are being harvested unsustainably, even if CITES permits are issued at import. Other countries should also apply such a mechanism for species of concern where it can be proven that the assessments are not being undertaken or the species are being impacted seriously due to harvest. Additionally, there needs to be improved identification and tighter restrictions at trade gateways in order to incentivize shifts in fisheries practices and improve fisheries management in exporting countries.

The image below is a screen capture from the TRAFFIC online "*Wildlife Trade Tracker"* a Google maps based system that spatially plots data from U.S. FWS LEMIS database on trade to and from the U.S. This screen capture shows trade flows of seized or abandoned shipments of *Hippocampus kuda*, highlighting the country of origin, relative volumes and details of total amount of specimens seized between 2003-2009. Vietnam was the most prevalent source country for illegal shipments to the U.S. of with two thirds of the total illegal trade in this seahorse species, all were shipments of live animals.



U.S. Seizures of *Hippocampus kuda* (source: TRAFFIC Wildlife Trade Tracker Mapping Tool, 2011)
Note: Up arrows = export / Down arrows = import. Red arrows = major export by number of items. Green arrows = lower level of export by number of items

Potential for Captive-breeding

There are at least thirteen species of seahorses being cultured or under research for their culture potential, of which *H. kuda* is one. The majority of seahorse culture is occurring in developed countries at a small scale and bolstering the aquarium trade. Economic viability is a challenge for culture operations due to price competition with wild caught species. In developing countries that are experimenting with seahorse culture, technical challenges have proven difficult to overcome in terms of success of reproduction and juvenile survival (Garcia *et al.* 2009, Koldewey *et al.* 2010). Large-scale aquaculture to supply the traditional medicine market and reduce exploitation of wild populations for the TCM trade has not yet proven to be viable. Apart from questions on the desirability of wild specimens over captive bred ones, the costs and energy investment of seahorse culture also has not made it an attractive livelihood alternative for local fishers.

Culturing will only have a conservation benefit if it can reduce overexploitation in major exporting countries, without leading to other environmental costs commonly associated with aquaculture operations, including water pollution, eutrophication, spreading of disease, and release of exotic species. Since developing countries are the primary exporters of wild seahorses, culture of seahorses on a sustainable, economically beneficial, local-scale needs to be based in the countries with the greatest potential to reduce pressure on wild populations (Koldewey *et al.* 2010).

Tridacna gigas – The heavyweight champion of mollusks

Trade Concerns

The giant clam species *Tridacna gigas* is the most heavily exploited of all Tridacnids (Okuzawa *et al.* 2008). They are among the top ten most traded invertebrates worldwide, popular in the aquarium trade, commonly harvested for food, and their shells are sold as ornaments (Okuzawa *et al.* 2008, Othman *et al.* 2010). The extraction and collection of giant clams is quite simple, as these are sessile organisms typically occurring at less than 20 m in depth (ARKive 2008, Lindsay *et al.* 2004).

Tridacnids have long been, and still are, an important component of the diets of people throughout Southeast and East Asia. In most coastal communities throughout this region *Tridacnids* are still gathered on a daily basis and can be found at local markets (Lindsay *et al.* 2004, Okuzawa *et al.* 2008). This subsistence food purpose has contributed to illegal poaching, despite regulations that have been put in place in many countries to protect this unique species (Gomez and Mingo-Licuanan 2006).

The illegal trade in the species to the U.S. only based upon known seizures of shipments from 2003-2009 involved 42 illegal exports from 13 countries, totaling 129 clam specimens, often shells. The average number of illegal shipment seizures in the U.S. per source country is 3, with an average of 10 items per seizure and an average of 6 U.S. seizures per year. The image below is a screen capture from "*Wildlife Trade Tracker"* This screen capture shows trade flows of seized or abandoned shipments of *Tridacna gigas*, highlighting the country of origin, relative volumes and details of total amount of specimens seized between 2003-2009. Tonga, followed by the Philippines were the most prevalent source countries for illegal shipments to the U.S. of this clam species.

Life History

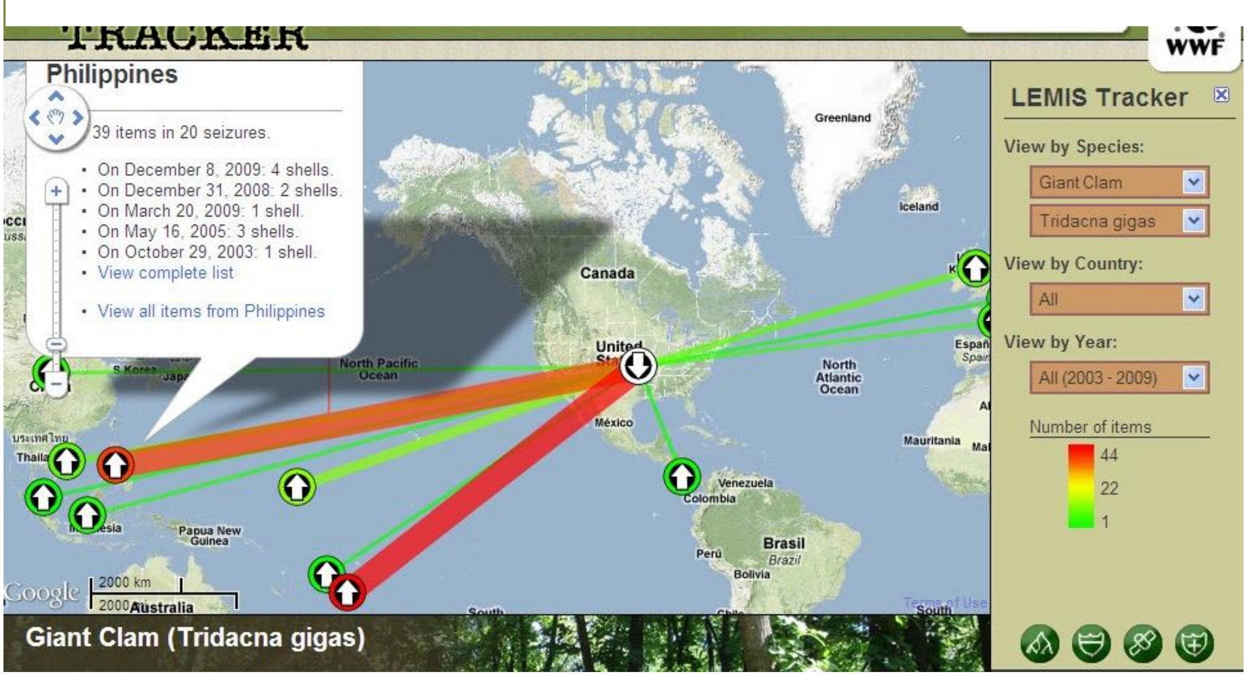
These enormous shellfish often reach a meter or more in length, and can weigh up to 300 kg (~660 lbs), making this the largest species of bivalve mollusk in the fossil record, and the heaviest species of living mollusks. Their lifespan in the wild can exceed 100 years (ARKive 2008).

Status

Despite being listed in Appendix II of CITES in 1985, *T. gigas* remains listed as Vulnerable in the IUCN Red List of Threatened Species (Wells 1996). Between 1983 and 1996 the status of *T. gigas* was assessed six times and confirmed as vulnerable each time. Unfortunately, since 1996 there has been no follow-up assessment of the population status of this giant clam species, despite continued evidence of overexploitation for the aquarium and food trade, and despite new risks associated with climate change. Of the seven species of giant clam included in the IUCN Red List four are listed as vulnerable, the other three as conservation dependent, and all are listed as in need of updating, given that none of these species have been assessed for over fifteen years. A 2010 comprehensive analysis of available information on the status of giant clam populations revealed that the majority of the most recent surveys date from the late 1980s (Othman *et al.* 2010).

T. *gigas* is considered extinct or virtually extinct in Myanmar, Thailand, Malaysia, the Philippines and Taiwan, as well as several small island nations, although restocking of *T. gigas* in protected areas in the Philippines may have led to small pockets of local populations (Mingoa-Licuanan and Gomez 2002, Okuzawa *et al.* 2008, Othman *et al.* 2010, Wells 1996). In addition to overexploitation, *Tridacna* species are threatened by land-based pollutant runoff, harmful fishing practices used to collect other coral-associated species, and stress-induced bleaching due to warming sea surface temperatures attributed to climate change (Othman *et al.* 2010).

U.S. Seizures of *Tridacna gigas* (source: TRAFFIC Wildlife Trade Tracker Mapping Tool, 2011)



Distribution

Prior to the rapid escalation of the aquarium trade *T. gigas* could be found throughout the shallow tropical waters of the Indian and Pacific oceans, typically associated with coral reefs. The species' range extended from East Africa to Micronesia, and Australia to Japan, but in the past three decades over harvesting has severely reduced the number and extent of this species (ARKive 2008, Othman *et al.* 2010). The greatest diversity of giant clams is found in the central Indo-Pacific (Othman *et al.* 2010).

Reproduction, Symbiosis and Commensalism

Giant clams, including *T. gigas*, are prime builders for coral reefs, providing shelter for small marine life. All *Tridacna* species have a mutually beneficial relationship with photosynthetic algae known as zooanthellae. These algae inhabit their mantles, gaining protection from predation by being associated with these large organisms, and in turn provide the majority of the clam's nutrients as the clam obtains the carbon by-products of photosynthesis (ARKive 2008, Othman *et al.* 2010). In addition, giant clams also provide protection for a small species of pea crab – a single pair will often be founding sheltering in the cavity of the clam. Since giant clams are unable to move they reproduce by spouting sperm and eggs into the sea, where fertilization occurs (ARKive 2008). The larvae that survive the open ocean phase eventually settle on the reef. There are also high rates of mortality among juveniles as it takes several years for them to grow large enough to be immune to predators (Okuzawa *et al.* 2008).

Exporting Countries and Trends

The U.S. has consistently been one of the primary import markets for *Tridacna* species. In 2002, 70 percent of the giant clams exported for the aquarium trade went to the U.S. (Mingoa-Licuanan and Gomez 2002). Vietnam has been a rapidly rising competitor in the marine ornamental trade in the 21st century, and between 2003 and 2009 consistently exported the largest numbers of *Tridacnids*. U.S. imports of *Tridacnids* climbed from 60,000 individuals in 2002 to 120,000 in 2007, but have dipped the past few years, again nearing 2002 levels (see Table A). There is known to be some successful culture in the Marshall and Solomon Islands (Mingoa-Licuanan and Gomez 2002), which likely accounts for the small percentage of imports of captive bred individuals, but still by far the majority are wild caught (see Table B).

For *Tridacna gigas* specifically, imports have declined from nearly 4,000 individuals in 2005 to less than 1,000 in 2009 (see Table C). It is unlikely that this is due to a decline in demand, given their consistent popularity in the aquarium trade for several decades, but more likely can be attributed to a lack of available supply. Since *T. gigas* has already been fished to extinction or alarmingly low numbers in many of the larger countries involved in the marine aquarium trade, supplies are now being sourced from just a few small island nations, primarily Tonga (LEMIS 2010). As with most tropical marine species sought after in the ornamental trade, the Philippines have historically been a major supplier of *Tridacna* species, including *T. gigas.* Local extinctions in the late-1980s led to early restrictions of harvest and trade of *Tridacna*, and of course there are no contemporary trade statistics as the Philippines has outlawed trade of CITES listed species. Nonetheless, there was evidence in 2002 that illegal shell trade continued to occur in the Philippines, and more recent CITES trade statistics reveal wide disparities in yearly giant clam trade figures, suggesting inconsistencies in several countries in their control of the clam trade (Mingoa-Licuanan and Gomez 2002, Othman *et al.* 2010). Fiji and Vietnam have imposed zero CITES export quotas for the species since 2009.

Culture & Restocking

Local extinction of *T. gigas* in the Philippines led to one of the earliest restocking initiatives in the region; the University of Philippines Marine Science Institute began a culture and restocking effort in the late 1980s. *T. gigas* have been one of the most attractive targets for culture and stock replenishment because they spawn prolifically, have a short larval life, require minimum maintenance during grow-out, and their sustenance travels with them in the form of their symbiotic algae (Lebata-Ramos *et al.* 2010, Lindsay *et al.* 2004, Othman *et al.* 2010). While the culturing process has proven successful, the real challenges come with transport, choosing appropriate restocking locations, followed by protection of reintroduced individuals until they are large enough to avoid predation (some three years) and then mature enough to reproduce (another six years). Due to this significant time and financial investment culture and restocking efforts have necessarily focused on rebuilding severely depleted and/or locally extinct populations rather than commercial grow out operations (Gomez and Mingo-Licuanan 2006, Okuzawa *et al.* 2008).

Many restocking efforts have had high rates of mortality due to poaching and illegal fishing, leading to increased emphasis on partnering with local communities and creating incentives for protection. While tens of thousands of giant clams have been restocked in the Philippines (primarily *T. gigas* and *T. squamosa*) follow-up on a large project in the early 2000s revealed that grow-out of the clams to larger sizes was largely unsuccessful, and the few that did survive were ultimately donated to a protected area in a neighboring province. A Pew Charitable Trusts grant for a Fellowship project distributed from 2002-2004 allowed additional restocking of *T. gigas* (~1,000 sub-adult and ~10,000 juveniles). A follow-up one year later again linked insufficient levels of onsite staff to high juvenile mortality. However, more than 90 percent of sub-adults did survive (Gomez and Mingo-Licuanan 2006).

Given the length of husbandry required, and the difficulties encountered with monitoring and enforcement, restocking of hatchery produced giant clams has waned in recent years in the Philippines. As Okuzawa *et al.* state (2008):

> *The ultimate criteria of restocking success is whether the released animals contribute to the genetic pool of the local population and whether their offspring are able to survive and reproduce, which may take decades…As the seeded animals need protection before they can reproduce, the best strategy is to couple stock enhancement programs with established MPAs that have strong community support.*

Recognizing the critical role protected areas can play in minimizing poaching-related mortalities, there is a new giant clam stock enhancement program underway in the Philippines' Sagay Marine Reserve, chosen because of the presence of Bantay Dagay (deputized fish wardens) that protect the area (Lebata-Ramos *et al.* 2010). Past restocking efforts have led to several important lessons that will be taken into account in this new program: site selection with approval from the local community is critical, linked with a resolute commitment by local teams to guard the stocks; in order to sustain the interest of local stewards restocking and establishment of local ocean nurseries has to be complemented with technology transfer and training; lastly poaching and inadequate enforcement of local and national law related to endangered species remains a persistent problem that still needs to be addressed (Gomez and Mingo-Licuanan 2006, Lebata-Ramos *et al.* 2010). Ultimately, because it takes such a substantial infusion of capital to rear giant clam species such as *T. gigas* to aquarium size, culture has not significantly reduced demand for wild species for ornamental purposes; commercial trade in wild collected *Tridacnids* is ongoing throughout the region. In order for culture to out-compete the wild trade the time and cost benefit has to improve and cultured clams have to be more competitive in size and color with wild harvest specimens. Until then, vulnerable coral-dwelling *Tridacnids* will continue to be harvested for the international ornamental trade.

Table A – Quantity of Imports by Country of Origin (all *Tridacna* species)
(**Top 5 only:** VU=Vanuatu, SB=Solomon Islands, TO=Tonga, MH=Marshall Islands, VN-Vietnam**)**

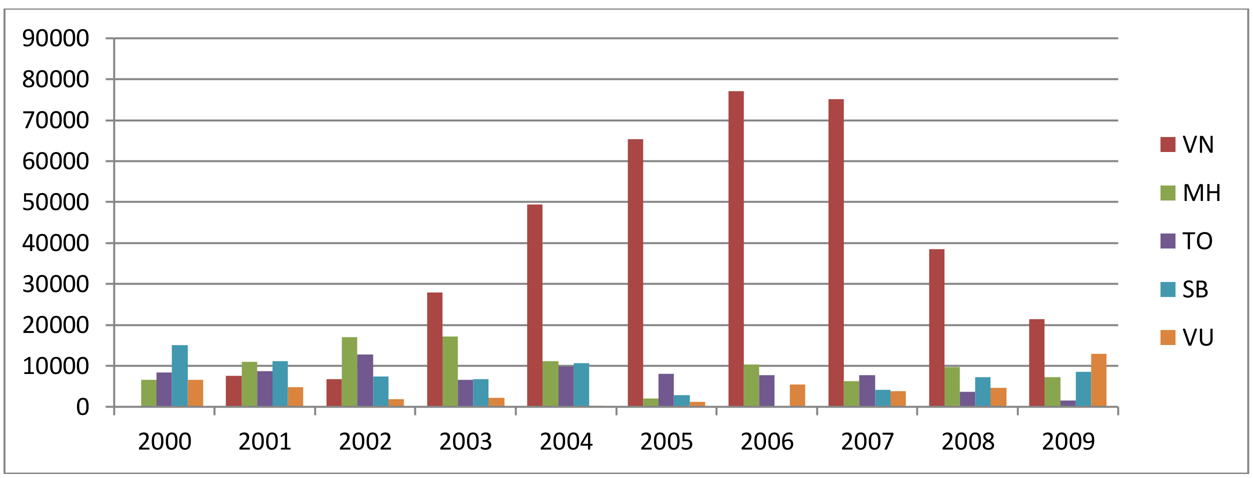


Table B – Quantity of Imports by Source (all *Tridacna* species)
(**W=**Wild caught**, C+F+D=**captive bred+captive born+bred in captivity for commercial purposes)

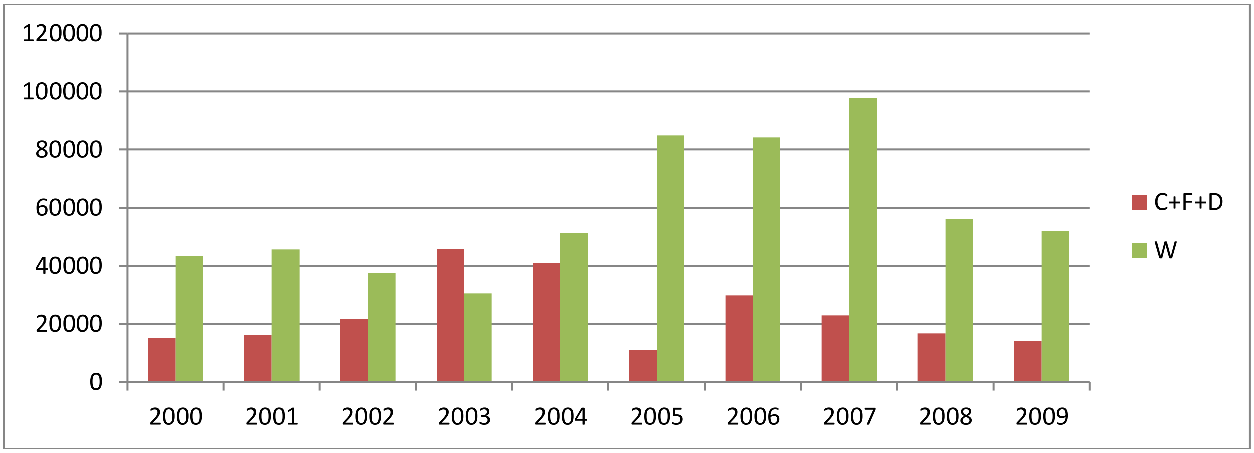
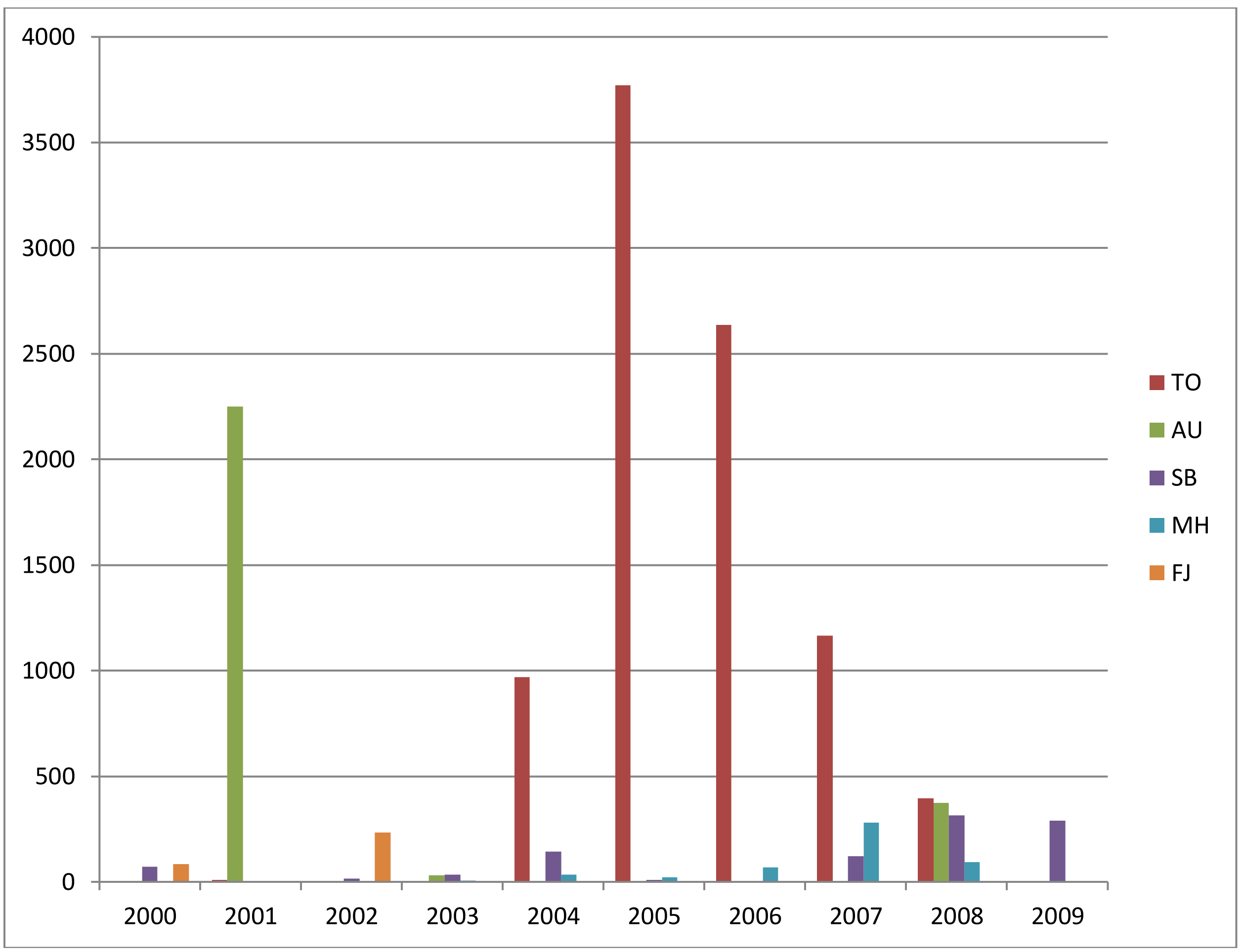


Table C – *Tridacna gigas* – Quantity of Imports by Country of Origin (Top 5 only)
(TO=Tonga, AU=Australia, SB=Solomon Islands, MH=Marshall Islands, FJ=Fiji,)



Underwater Finery – Precious Black and Gold Corals

The phrase "precious corals" refers to species of corals used to produce jewelry and curios for home décor. The most well-known and valuable precious corals are the red and pink corals of the *Corallium* species. Some seven species of *Corallium* are traded internationally, with the most sought after being *Corallium rubrum* (Tsounis *et al.* 2010). *Corallium* is harvested primarily from East and Southeast Asia and the Mediterranean. In 2007, there was an effort to include red and pink corals under Appendix II of CITES. However, there was political resistance to scientific findings of significant population declines, despite scientific consensus, and the listing was not successful (Bruckner 2009).

Traded in smaller amounts are the black (primarily *Antipathes* spp.) and gold (*Gerardia* spp.) corals. The two most commonly traded types of black coral are *Antipathes grandis* and *A. griggi*. Specific species of *Gerardia* are extremely difficult to identify with any accuracy and are not listed in trade documents (Tsounis *et al.* 2010). Black corals are listed in Appendix II of CITES. Unfortunately, the IUCN Red List does not include assessments of any of these species. The U.S. is the largest documented consumer of precious corals, with tens of millions of pieces imported since 2000 (Debenham 2008, Tsounis *et al.* 2010). According to LEMIS trade data, legal imports of black coral (*Antipathes* spp.) have averaged roughly 50,000 pieces per year from 2000 through 2009.

Black corals are more valuable and heavily harvested than gold corals. Black corals are distributed throughout the sub-tropical and tropical Pacific, and live at depths anywhere from 20-8,000 m, with the greatest abundance usually found between 30-80 m (Bruckner *et al.* 2008). Typically, the largest quantities of black coral have been harvested in the Philippines, exported primarily to Taiwan for processing and manufacturing (Bruckner 2005, Tsounis *et al.* 2010). Black coral has also been harvested in significant quantities in Hawaii. Until very recently it was believed that black and gold corals had relatively short life spans and sufficiently rapid reproductive cycles for sustainable harvest and trade. However, recent improvements in radiocarbon dating have proven this is not the case. In 2009, Roark *et al.* published a study dating deep-sea gold and black (*Leiopathes* spp.) corals from the Hawaiian precious coral fishery. Their results showed that *Gerardia* species live anywhere in the range of 300-2700 years, and some *Leiopathes* species may live more than 4,000 years (Roark *et al.* 2009). Additionally, black corals are characterized by delayed first reproduction and low survivorship and recruitment of larvae.

Several studies on black corals in Hawaii have revealed a decline in younger age classes, with indications that there were considerable reductions in recruitment. NOAA reported a decrease in the biomass of black coral in the commercially targeted Au'au Channel of at least 25% between 1976 and 2001 (Bruckner *et al.* 2008). In addition to extreme longevity, and declines in abundance of harvestable colonies, the depth of these coral ecosystems does not provide immunity against natural and anthropogenic changes in surface ocean conditions, such as warming temperatures and increased ocean acidification due to climate change (Roark *et al.* 2009).

Threats

Deep-sea corals face multiple threats at once: increasing consumer demand and commercial harvest for the jewelry trade, damage caused by deep-water fishing methods and human-induced shifts in the ocean system. Meanwhile, these deep-sea corals can provide invaluable insights into past climate and environmental change within the interior of the ocean, a huge area of the earth for which we have virtually no other high-resolution paleoclimate records (Roarke *et al.* 2006). In 2008, a quota was put on Hawaiian black coral harvests in the Au'au Channel, and a 5-year moratorium was put on the harvest of gold corals (Federal Register 2008). However, this quota may not be sufficient to ensure sustainable domestic harvest and trade of black coral, and five years is fleeting for gold corals that live hundreds to thousands of years. Roark *et al.* (2009) argued that given the longevity and slow growth rates of deep-sea corals maximum sustainable yield limits are grossly overestimated and “any future harvesting [should] be considered in the context of a nonrenewable resource framework”.

Unfortunately, while there is increasing control and monitoring of domestic harvests of black and gold corals, by far the majority is harvested in Asia, with limited policy prescriptions, and even less enforcement of the policies that are in place. In Taiwan, it has been shown that illegal, unreported or unregulated (IUU) coral trade far exceeds legal, permitted trade (Ming-Ho and Ching-Hsiewn 2010). The trade of a specific genus or species is very difficult to track. Currently, there is no Customs Harmonized System Code (HS Code) for any species of precious coral in the Southeast and East Asia region. The most specific commodity codes differentiate between raw (unworked) or powder coral, and worked or finished coral products. Hong Kong, mainland China, Japan and Taiwan all have different sets of commodity codes, making direct comparisons of trade in this region virtually impossible (Wu and Takahashi 2009).

Ecosystem Function

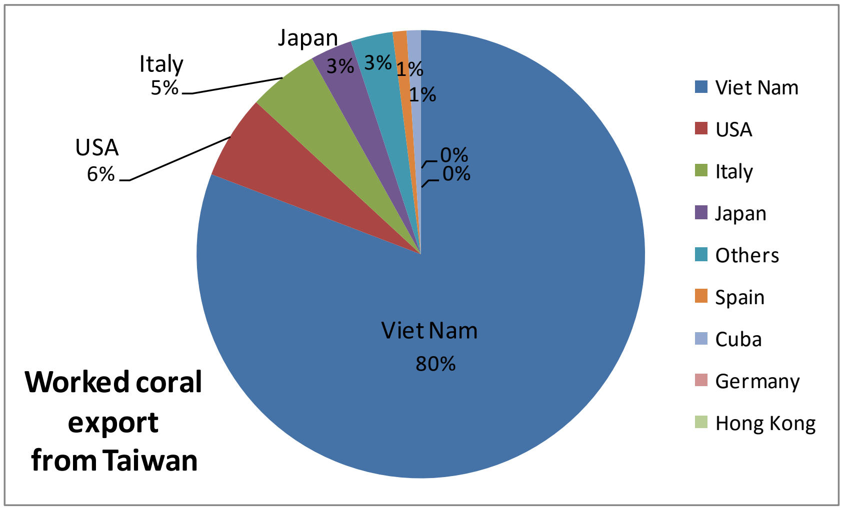
Black and gold corals are alternately described as “structure-forming”, “foundation species”, and “ecosystem engineers” (Cerrano *et al.* 2010, Roark *et al.* 2009). These corals increase the complexity of seafloor habitat and create critical habitat for fish and invertebrates, serving a similar ecological function as their shallow water reef-building counterparts. Black coral colonies in particular have been found to host commensal species that depend on these coral structures for their survival (Bruckner *et al.* 2008). Their erect, branching structure provides a substrate for attachment by a range of species, shelter from predators for small fishes, and sleeping perches for larger vertebrates.

In the deep-sea coral beds in Hawaiian waters, *Gerardia* and *Leiopathes* are two of the largest megafauna invertebrates and support diverse communities of invertebrates and fish that, in turn, attract endemic and highly endangered monk seals who forage for food among the coral branches. Roark *et al.* (2009) observed “an increase in fish and invertebrate biomass and diversity within and adjacent to colonies of *Gerardia* and *Leiopathes*”. Boland and Parish (2005) examined the ecological role of black coral and found that the absence of black coral may impact fish assemblages. Several species of invertebrates have been found only among antipatharians, some that populate dead skeletons, and others live branches (Bruckner *et al.* 2008).

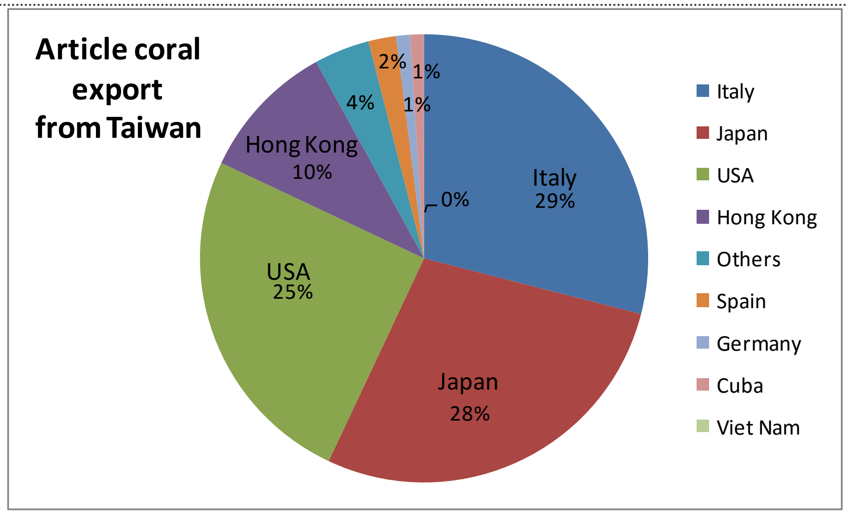
A study of an endemic species of gold coral (*Gerardia savaglia*) living in the “twilight zone” of the Mediterranean (the disphotic zone, where only faint, filtered sunlight is received during the daytime) found that the presence of these colonies “was associated with a significantly increased deposition of bioavailable substrates and enhanced biodiversity, when compared with soft bottoms at the same depth but without gold corals”. These corals serve as ecosystem engineers in that they can reduce current flow velocity, increase fine particle sedimentation and reduce re-suspension, thus stabilizing soft substrates. The authors (Cerrano *et al.* 2010) found that “organisms living in habitats characterized by the presence of these ‘engineers’ can experience a sort of ‘buffer zone’ where environmental modifications occur slower and within narrower ranges with respect to the surrounding ambient”. Unfortunately, most work has focused on Hawaii and little is known about the state of black and gold corals in the Indo-Pacific region, where the majority of commercial harvests occur. It is known that most black coral colonies have been depleted at depths accessible by divers, and with increasing access to deep sea coral ecosystems there is concern that these colonies will also come under increasing pressure (Bruckner *et al.* 2008).

Trends in Exports and Imports

Taiwan and the Philippines began to export large quantities of black coral in the 1980s. Taiwan is the world’s largest supplier of worked black coral, accounting for more than 90% of exports. In the past Taiwan imported most of the raw coral from the Philippines (Bruckner *et al.* 2008, Tsounis *et al.* 2010). The Philippines ultimately made it illegal to “gather, possess, send, or export ordinary, precious or semi-precious corals” except for research use, but illegal smuggling of corals from Philippines reefs is still considered common (Debenham 2008). It is unclear from available trade data where Taiwan now sources its imports of unworked and raw coral (potentially because the sourcing may at times involve illegal collection and trade). China is another important coral processing and manufacturing center. According to Taiwan customs data Italy, Japan, the United States, and Vietnam are the primary export destinations for worked and articles of coral (see Table D below), while imports to Taiwan of worked and articles of coral come from Vietnam, Hong Kong, Japan, Myanmar, and mainland China (Wu and Takahashi 2009).



Taiwan worked and article coral customs data (2001-2008) – Source: Wu and Takahashi (2009)



Taiwan worked and articles of coral customs data (2001-2008) – Source: Wu and Takahashi (2009)

Table D. Taiwan coral exports – worked coral and articles of coral (Kg)

	2002	2003	2004	2005	2006	2007	2008	%
Cuba	276	196	85	266	0	0	0	1%
Germany	109	227	192	155	74	116	85	1%
Spain	494	377	370	246	179	212	15	2%
Hong Kong	2,286	503	913	557	3,097	1,173	622	8%
Italy	3,640	8,326	3,995	2,348	3,599	3,428	1,199	24%
Japan	5,886	3,329	2,848	4,313	4,084	3,642	1,443	23%
USA	2,599	5,361	4,147	3,560	3,261	2,194	1,804	21%
Viet Nam	4,410	3,896	2,272	3,209	317	2,221	3,575	18%
Others	807	430	459	472	1,397	240	167	4%
TOTAL	**20,507**	**22,645**	**15,281**	**15,126**	**16,008**	**13,226**	**8,910**	

Source: Wu and Takahashi 2009

Italy is the primary manufacturing hub for pink and red *Corallium* corals. According to industry insiders the Italian black market for coral is quite significant, potentially accounting for half of all trade (Tsounis *et al.* 2010). Research and trade information suggests that Vietnam is an important partner for Taiwan's coral processing industry. This suggests that Italy and Vietnam's roles in manufacturing and processing are significant, while Japan and the U.S. are the primary end markets for precious coral products (Bruckner *et al.* 2008, Wu and Takahashi 2009).

Judging from *Corallium spp*. import data, the trade of precious corals into the U.S. has been increasing in recent years**.** In the years preceding the quota on black coral domestic harvests in Hawaii also increased considerably. Black coral landings between 1999 and 2005 made up 58% of the total Hawaiian catch since 1985. Additionally, spikes in demand were recorded in the early 2000s, with a 50% increase in sales volume recorded in Hawaii (Tsounis *et al.* 2010). Retail prices for manufactured black coral jewelry can range from around $35-300 for earrings, $50-750 for small pendants, to thousands and tens of thousands of dollars for fine jewelry set in gold and paired with diamonds and other precious stones.

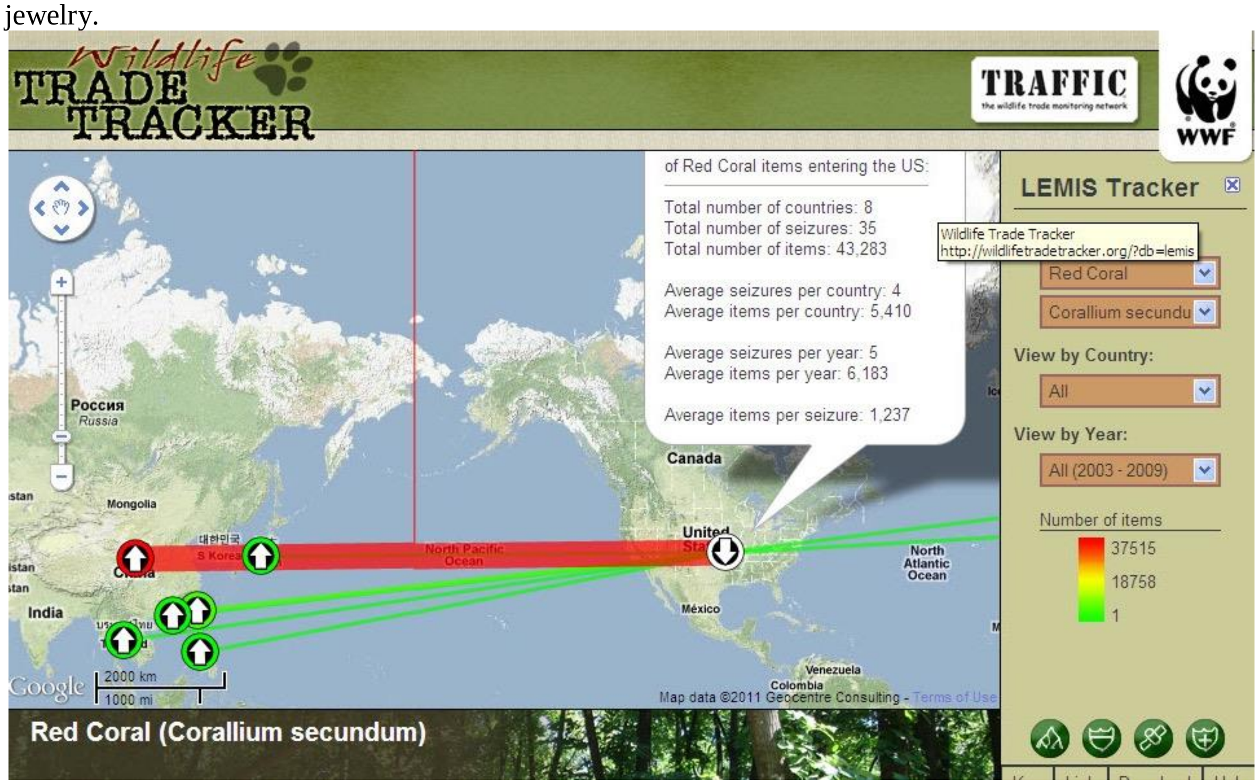
Illegal Trade

Illegal harvest and trade of precious corals remains a significant problem. The scale of black-market trade is of course very difficult to quantify. Since only 1-2% of international shipments are inspected it is likely that significant amounts of illegally traded precious corals make their way across borders.

In 2010, a Taiwanese couple was convicted of conspiracy to smuggle protected black coral into the United States from Asia. The couple pleaded guilty to selling nearly US$200,000 of coral to a jewelry design and manufacturing company in the U.S. Virgin Islands. They admitted to falsely labeling shipments over two years to conceal the coral from the U.S. Customs and Border Protection authorities (Department of Justice 2010). In July of 2011, the U.S. Virgin Islands company, called GEM, was also sentenced as part of the case in knowingly trading in the falsely-labeled black coral that had been shipped into the U.S. in violation of the Endangered Species Act and the Lacey Act (Department of Justice 2011). None of the shipments had the required CITES certificates, and each shipment was labeled "plastic of craft work". The company, GEM, was sentenced to pay a criminal fine of $1.8 million and an additional $500,000 in community service payments for projects to study and protect black coral. They were also ordered to forfeit black coral goods worth $2.17 million. The aggregate financial penalty of $4.47 million makes this the largest fine for the illegal trade in coral, the largest non-seafood wildlife trafficking financial penalty and the fourth largest for any United States case involving the illegal trade of wildlife. GEM was also sentenced to three and a half years of probation and a 10-point compliance plan that includes an auditing, tracking and inventory control program (DOJ 2011).

Illegal harvesting of corals in Taiwanese waters, primarily *Corallium* spp., has been well documented. In 2007, an investigation by the Department of Fisheries Administration found that there were 30 times as many illegal vessels in operation as legally operating vessels (three vessels with legitimate licenses versus 96 illegal vessels operating without licenses). This is particularly problematic as the illegal vessels employ unselective, environmentally destructive fishing methods, such as trawl or seine nets anchored by large rocks. In 2009, the government drafted a more stringent Management Regulation for the coral fishing industry. The challenge is adequate government investment in monitoring and enforcement to implement the new measures, given traditionally low-density fishery management. The Taiwan Coast Guard only caught 17 vessels illegally harvesting coral between 2000 and 2007 (Ming-Ho and Ching-Hsiewn 2010). It seems there are similar problems in the Philippines, as there are numerous indications that this country is still significantly involved in precious coral harvest and trade.

The image below is a screen capture from "*Wildlife Trade Tracker"* This screen capture shows trade flows of seized or abandoned shipments of *Corallium secundum*, highlighting the country of origin, relative volumes and details of total amount of specimens seized between 2003-2009. China was the most prevalent source country for illegal shipments to the U.S. of this red coral species, mainly used for jewelry.



U.S. Seizures of *Corallium secundum* (source: TRAFFIC Wildlife Trade Tracker Mapping Tool, 2011)

In addition to illegal, large-scale commercial shipments of precious corals, there is also an illegal trade in frequent, small volumes by individuals that annually amounts to significant total volumes of precious corals. An example of this is the extensive trade in black coral jewelry sold to tourists in the Caribbean that is then exported when the travelers and tourists bring their coral home. While this may be classed by some countries as exempt under CITES as personal effects, other countries will seize these products if they do not have CITES documentation for CITES listed species like black coral. In other cases, the precious corals may have been harvested and exported illegally under domestic laws of the country of origin, or the products smuggled into the country of sale (as was the situation with the black coral smuggling case detailed above in the U.S. Virgin Islands).

Conclusion

The global nature of the trade in coral reef species means that there is a strong correlation with market drivers and the 'push and pull' effect of shifting economies, prices, and elasticity of demand. The increased demand for sustainable products creates additional opportunities for alternative products or captive-bred animals to meet the need, but currently, the overwhelming majority of coral reef species collected for trade are taken from the wild. Whatever shifting realities may emerge, the analysis conducted in this report has found that:

- At least 95% of all U.S. imports of coral reef associated species are wild sourced and the trade to the U.S. continues to be driving wild harvest, despite some dip in demand during the economic crisis years of 2008 and 2009.
- Imports of over 12 million live fish per year in 2008 and 2009 are indicators of that high demand, even if they are approximately one third lower in volume than the peak of 18 million live fish that were imported in 2006. (But that dip in recent years may be temporary as demand rebounds and economic growth resumes.)
- The massive growth in imports of coral species during the recession period may result from better trade data transparency or it could be linked to a major fashion trend for coral jewelry that evolved from around 2007 onwards.

From the trade analysis in this report it is clear that in the case of coral species, there is a significant increase in trade to the U.S. in recent years, as fashion demand for precious coral jewelry has gone through a boom period and the aquaria industry has seen a growing popularity for saltwater aquaria. The combination of increasing demand, with declining wild populations, damaging extractive measures, and high mortality rates in the supply chain is a hazardous mix for the health of coral reef ecosystems, particularly when the impacts of climate change and ocean acidification are becoming more pronounced in many areas. Burgeoning human populations in developing countries, particularly in coastal areas with reefs, also means that the demand to make a living from the reef will not dissipate.

Local people in exporter countries sometimes have few options other than using their natural resources that surround them, which increases the mounting pressures on coral reefs. In theory, if harvest, management and trade in reef associated species is undertaken in a sustainable and equitable way there are long term opportunities and benefits to both conserve reefs and meet people's needs. Consumer nations then, have a responsibility to ensure that reef associated species being imported are sourced sustainably, legally and equitably and that they limit the opportunities for illegal and unsustainable supply reaching their market. The need to establish successful quotas, effective monitoring, and the continued implementation of industry standards to protect this shared and essential resource is an increasingly important requirement, not only for the industries that utilize coral reef species, but for the lives that are dependent on it. Consumer education and implementation of practices that reduce negative ecosystem impacts can also lessen demand for fish or invertebrates caught unsustainably. For example, a more environmentally-sensitive aquarium trade could provide the opportunity to educate the public about environmental issues and increase understanding of what is often perceived as a hidden ecosystem (Wabnitz *et al.* 2003).

All of this suggests that now is the time to harness the demand for coral reef wildlife to direct it towards sustainable and alternative products before it expands again. With a role as the largest importer and consumer of coral reef associated species, the U.S. has a responsibility to take appropriate action to ensure that its negative impacts on coral reefs globally are minimized. It seems obvious that if the U.S. imposes measures to ensure sustainable sourcing of supply, then harvesters, exporters, and traders have to respond accordingly or abandon exports to the U.S. With such a large market share, changes in demand dynamics by the U.S. cannot be ignored. The markets in Europe and Asia are significant but may not be large enough to consume the resulting excess supply of unsustainably-harvested species.

Coral reefs are undeniably important to ecosystems, providing shoreline protection, recreation and tourism, sources of food, jobs, pets, ornaments and pharmaceuticals to millions of people. Their value is estimated at approximately $375 billion each year (USCRTF). However, according to the World Resources Institute's 2011 *Reefs at Risk Revisited* report, more than 60% of all reefs are threatened due to local sources of human activities, and when combined with thermal stresses, like rising ocean temperatures, almost 75% of coral reefs are rated as threatened (Burke *et al.* 2011). Harvesting corals, reef rock and coral reef fishes for the trade is also currently unsustainable and contributes to the continued and significant deterioration of coral reef ecosystems (Bruckner 2008). A study of 300 reefs found that species targeted for commercial interest were absent or only present in low numbers at a majority of the reefs, signaling deleterious effects due to overharvesting (USCRTF). Given the growing evidence for the decline of coral reefs, it would appear prudent for the U.S. to start developing standards to ensure trade is sustainable without delay. The potential for the U.S. to play a globally catalytic role in securing a future for coral reef species subject to trade is very real. Stepping up and taking responsibility now is vital before it is too late. The following section provides recommendations to guide behaviors and actions that are needed for the U.S. and other stakeholders to take that responsibility seriously.

Recommendations

The trade in coral reef wildlife for aquarium use, jewelry, and home decor is growing, in volume and scope. There are approximately 45 countries participating in the trade, but new collection areas and species are continually being discovered and exploited. Indonesia and the Philippines continue to be the largest exporters of these animals, whereas the U.S. remains the world's largest importer, putting it in a unique position to reform the market. The following are recommendations to the U.S. government that should be pursued in concert with other countries, industry, and civil society on key issues that require intervention to address the management loopholes that currently plague the trade and jeopardize coral reef wildlife. Many of these recommendation support suggestions previously outlined by the U.S. Coral Reef Task Force. Those recommendations are provided in their entirety in Appendix II.

Recommendations to the U.S. Government:

- **Legislation and Regulations** – New U.S. legislation should be enacted in Congress to establish federal import and export standards that would require that collection, handling, and transport activities only occur for ornamental purposes, if, when, where, and as appropriate, as judged against clear sustainability criteria. Legislation should include a rulemaking process that would provide stakeholders, including the public, a voice in further defining allowable collection and transportation activities as well as reporting requirements and should address other key issues, consistent with standards provided in legislative language. The U.S. is the world's largest consumer of coral reef wildlife used for ornamental purposes, purchasing 60% or more of the world's supply. Requiring that all coral reef wildlife imported into or exported from the U.S. meet high standards for sustainable collection, holding, and transport will create real incentives for improvements in source countries and throughout the supply chain, thereby driving global reform of current practices

- **International Cooperation** – To reform international trade of coral reef wildlife comprehensively and to increase the effectiveness of policies adopted domestically, the U.S. should work with major import markets as well as export/harvest nations. Specifically, to prevent the diversion of unsustainable and illegal products, the U.S. should encourage and partner with other import nations, such as the E.U., to develop joint mechanisms to close major markets to illegal trade and unsustainably harvested wildlife and to harmonize standards for evaluating such products.

  Additionally, the U.S. should support the creation or improvement of in-country, coral reef fisheries management plans that address ecological, social, and economic considerations. At a more local level, the U.S. should work with partners to strengthen agency and community capacity for effective and consistent enforcement of regulations or behaviors that reduce impacts of fishing on coral reef ecosystems. U.S. demand for ornamental products has incentivized illegal and destructive practices that hurt local reefs and economies. Voluntary efforts have been laudable, but largely insufficient in a system with no accountability and significant profit potential. Increased capacity and regulatory oversight in key harvest nations will substantially improve the current situation and provide the necessary counterpart to increased import controls.

- **Convention on the International Trade of Endangered Species (CITES)** – As progress continues toward new legislative authority and in addition to that authority, the U.S. government should continue to support CITES and its initiatives to train CITES scientific authorities in source countries to implement CITES and identify coral reef species that may require CITES listing. The U.S. should also provide support for CITES non-detriment findings and capacity building, to establish research, monitoring, and management measures and protocols for, CITES listed, coral reef species.

However, there is recognition of the limitations of CITES, often because of political factors. Because of their potential power and utility, CITES-based strategies should be incorporated in a broader set of approaches to reform the ornamental trade. In terms of specific problems to date and potential solutions, there is a recognition that despite the efforts of CITES to list some marine ornamental fish species on Appendix II, only a handful of such species are listed under CITES. Additionally, there are challenges for many CITES parties to implement non- detriment findings where population data are lacking and resources and expertise are low, particularly for stony corals that are listed on CITES Appendix II. It is vital that *in situ* management approaches look at the ecosystem as a whole and do not deal in isolation with a few specific target species. Where CITES is applicable, the effective use of CITES non-detriment findings, combined with holistic management is necessary.

- **Government Data** – Although the trade in coral reef wildlife is tracked through federal import and export records (LEMIS), this information, in its current form, lacks the level of detail necessary for it to be used effectively, particularly for marine invertebrates and fish. The data's level of resolution is not refined enough to allow managers to quantify and assess the trade in most coral reef species that are imported into the U.S. Resolving this will require reporting taxonomic groupings involved in the trade at greater levels of specificity. This change would allow the U.S. to improve its recordkeeping and data availability to empower the National Oceanic Atmospheric Administration and Fish and Wildlife Service to assess trends in trade volume, sources, species, and violations. Additionally, a new, system of harmonized tariff codes for customs should be established internationally, including through U.S. support, to improve the level of detail and increase transparency in the trade statistics related to species type and uses.

Recommendations to Marine Ornamental Industry:

- **Supply Chain** – Businesses should identify sustainable suppliers and establish Corporate Social Responsibility policies in order to make the most responsible purchasing decisions, particularly in the absence of regulatory import standards and potentially to go beyond those standards if established. Professionals throughout the supply chain should be trained in suitable practices to reduce mortality at every stage of the supply chain, thereby reducing collection pressure on coral reefs. Some coral reef wildlife businesses already rely on shorter supply chains that both reduce the time animals spend in transit and increase the accountability of source country suppliers.

- **Certification** – Although voluntary certification efforts could produce a set of industry best-practices for sustainable sourcing, establishment of federal standards would significantly help to reform harvest activities in exporting countries by creating a meaningful point of accountability in the trade and by creating consistent standards for all U.S. import and export. However, businesses play a key role in generating the necessary groundswell of interest and support for setting standards to improve the industry and species and ecosystem sustainability. If willing businesses were to demand sustainably harvested coral reef products in the near term and over time, the health of coral reef ecosystems would improve as well as the variety of services and economies that they support.

- **Engaging Consumers and Promoting Sustainable Products** – Businesses should promote sustainable products and alternatives that can be used in place of species and products that are damaging to coral reef ecosystems. For example, businesses can promote the benefits of captive-bred and sustainably-sourced supply as premium products as a means to help the reef ecosystem and to provide consumer confidence. The use of social media, industry forums, and media to raise awareness among the industry and their consumers about the real world impacts of this trade – including encouraging naming and shaming of countries, regions, suppliers, and traders involved in damaging harvest and sourcing practices –could go a long way toward securing legally binding and voluntary reforms. When the trade is improved, American retailers and consumers can feel confident that their purchases are sustainable and, in the case of pets, healthy.

- **Philanthropy** – Businesses could set up an industry-based donation initiative, in which the donations would flow into a relevant conservation fund such as the U.S. Coral Reef Conservation Fund. This fund could be linked to donations made by consumers through retail outlets at point of sale.

Recommendations to Civil Society:

- **Conservation Community and Public Awareness** – Broaden a coalition group of concerned conservation and industry groups in the U.S. to link to civil society groups in source countries to share information, provide mutual support, and develop global campaigns to protect reefs from unsustainable harvest and trade. This could also include naming and shaming the worst offending companies that are trading in species and products that are having the greatest negative impact on coral reefs.

- **Advocacy** – Increase awareness and political will to encourage multi-sector initiatives and resource allocation in support of the types of recommendations provided in this report including: pressure governments in source countries and the U.S. to impose laws and regulations to prevent illegal and unsustainable harvest and trade and damaging harvest practices, support governments in developing appropriate new CITES Appendices listing proposals or amendments to existing listings for selected taxa groups to improve trade transparency, and help initiate management programs linked to CITES.

- **Alternatives** – Identify alternative income streams, positive economic incentives and community-based programs to promote effective conservation measures linked to livelihoods schemes.

APPENDIX I – Methods, Data Recording and Reporting

This appendix explains in more detail the methods employed in producing this report and the caveats involving data sources and analysis.

The report primarily covers trade in coral reef species used for ornamental purposes. For the purposes of this report, "ornamental" use includes living specimens used in aquaria and dead species used for home decor, curio and jewelry. The report includes "live rock": live rock is largely calcareous rock with micro and macroscopic marine life attached to or living inside of it and, also traded for use in marine aquaria. It can be challenging to identify the species attached to the rock, but it may be comprised of encrusting organisms, such as coralline algae and sponges, macroalgae, clams, mussels, crabs and shrimps. Most trade in live rock to the U.S. is documented in trade statistics by number of pieces of rock and not by weight.

Due to the nature of the data available and the way in which the data are grouped (i.e. there is not a great degree of resolution for the purpose of imports), it is almost impossible to know of all potential uses - commercial, scientific, personal, etc. - of the traded coral reef species. The vast majority of the data by both volume and frequency of imports, however, do relate to species traded for ornamental purposes.

It is important to note however, that the trade in coral reef species extends beyond the trade for ornamental purposes, such as live reef fish trade for food markets. Coral reef ecosystems and the genetic diversity within are also being used to develop medicines and other potentially beneficial chemical compounds. Many species found in coral ecosystems are important sources of new pharmaceuticals being developed to induce and ease labor, treat cancer, arthritis, asthma, ulcers, human bacterial infections, heart disease viruses, and other diseases; as well as sources of nutritional supplements, enzymes, and cosmetics (Burke 2002).

This report does not attempt to update global figures for international trade; rather it summarizes available information to date on international trade of coral reef associated species from existing literature. Import data for the United States was gathered from the U.S. Fish and Wildlife Service's Law Enforcement Management Information System (LEMIS) database.

Quantifying this trade, and monitoring and evaluating the extent, scale and frequency of the trade in marine ornamental species is necessary to evaluate the sustainability of the harvest of those species, and to detail the scope of U.S. involvement as the primary driver of that trade. However, any analysis of the volume of the trade and the composition of the marine ornamental species in the trade is highly challenging due to the limited details and poor resolution of the trade data being collected internationally. This report attempts to tackle that challenge, to show trends and indicators in the trade, and to flag significant concerns. In some cases identifying species specific challenges was not possible because the existing official data does not always contain species specific detail.

Data Recording, Reporting, and CITES

The Global Marine Aquarium Database (GMAD) was created in 2000 by the United Nations Environment Program's World Conservation Monitoring Center (UNEP-WCMC), the Marine Aquarium Council (MAC), and members of several aquarium trade associations in order to provide better and more accurate trade data (Wabnitz *et al.* 2003). The GMAD and MAC have both now ceased operation.

GMAD contained voluntarily contributed data from wholesale exporters and importers that had been combined and standardized into quantitative, species-specific information and made available to the public through a website. Records were by species name, quantity, date, and origin/destination. However, the data came from only "58 companies, approximately one-fifth the wholesalers in business, and four government management authorities" (Wabnitz *et al.* 2003). Furthermore, because some importers trade with exporters, the data could not be combined to produce trade totals because it would contain duplications. Therefore, GMAD data "cannot be used to calculate net volumes of trade in any one species, or between any pair of countries" (Wabnitz *et al.* 2003). It is best used as an "indicator of trends" and allows for estimates based on quantitative rather than qualitative data for the first time with respect to fish and invertebrates (Wabnitz *et al.* 2003).

The Convention on the International Trade of Endangered Species (CITES) is an international agreement that aims to protect wildlife by ensuring that international trade is not detrimental to the survival of species in the wild. Established in 1973, by 2011 CITES had 177 member countries called Parties. Animal and plant species threatened by trade are listed under one of three appendices within CITES. Appendix I includes species threatened with extinction which are or may be affected by trade: international trade for primarily commercial purposes in listed species is not permitted. CITES Appendix II includes species which may become threatened with extinction if trade controls are not in put place: international trade is allowed by only when the scientific authority of the exporting party has determined that the export will not cause a detriment to wild populations (known as the non-detriment findings), and when the management authority has determined that the specimens were legally acquired and, in the case of live animals, that they will be prepared and shipped so as to minimize injury, damage to health, or cruel treatment. Appendix III includes species that are unilaterally listed by parties on that Appendix because the parties seek international cooperation to control the trade in that species: international trade is permitted without the exporting country making a non-detriment finding.

Regarding the CITES non-detriment finding, there is often a significant lack of data on the population status for most marine species in trade and many countries do not have the scientific capacity to undertake the process of a "non-detriment finding". Despite this, many countries issue CITES export permits. Stony and black corals are the few types of coral reef wildlife that are listed on CITES. Because of the difficulty of identifying coral to the species level, CITES has allowed export permits to be at the genus level. However, the problem is that the abundance and distribution of coral species varies immensely, and therefore, the threat of over collection (and that of other impacts) on individual coral species varies just as immensely. Hence, issuing CITES permits at the genus levels may drive certain species to extinction through over collection and the identification of a species nearing extinction might not even be known (Wabnitz *et al*., 2003)

Each CITES party is required to report trade in CITES listed species to the CITES Secretariat on an annual basis. However, there are a number of problems in the way these data are reported. Coral trade can be recorded as weight or number for instance. For corals, many countries will not report trade statistics on the number of specimens exported (Wood, E. 2001). Collectors in Vanuatu, Tonga and Solomon Islands are required by the CITES authorities to submit export records, documenting the number of each species exported to maintain government compliance and keep their license (Green E. 2002). Australia is unique in that collectors are required to register catch data, as opposed to export data. Government records, which may cover non-CITES species as well as different datasets, have faults as well. There are concerns about the accuracy of reporting, but in particular trade categories are infrequently reported fully, and specimens were frequently combined (especially prior to the creation of U.S. tariff codes), making it difficult to differentiate freshwater specimens from marine specimens, fish from invertebrates, etc. With greater clarity required under changes to the US tariff codes there was a distinction between freshwater and marine fish for aquaria trade for example.

Trade statistics available by weight, also include the weight of the water and packaging, potentially leading to an overestimation of the number of animals involved; Furthermore, trade data obtained through customs should be treated with caution, particularly in regard to exports, as some operators have been known to understate quantities so as to reduce the amount of tax payable and keep annual shipments within the individual allowable quota.

APPENDIX II – U.S. Coral Reef Task Force (USCRTF) 2010-15 International Goals and Objectives

Goal 1: Work with regional initiatives to build MPA networks and strengthen local management capacity to improve and maintain resilience of coral reef ecosystems and the human communities that depend on them.

- Objective 1.1: Work with regionally-based social networks of MPA practitioners to undertake capacity assessments that will form the basis of future Coral Reef Conservation Program (CRCP) support.

- Objective 1.2: Develop and implement comprehensive long-term capacity building programs for existing MPAs, based on capacity assessments to provide training, technical assistance, and follow-up support specifically for:

    - Management planning and effectiveness evaluations;
    - Community engagement program development;
    - Integrated biophysical and socioeconomic monitoring linked to site management goals, including data analysis and interpretation;
    - Use of climate change tools and crisis response planning; and
    - Other topics as needed

- Objective 1.3: Increase local enforcement capacity to improve compliance with MPA regulations and conservation-oriented customary practices.

- Objective 1.4: Support the development and sustainable finance tools and site implementation of sustainable finance plans to ensure long-term support for conservation efforts.

- Objective 1.5: Use regionally appropriate biophysical and socioeconomic monitoring and evaluation protocols to:

    - Establish baselines and detect changes over time in an adaptive management framework; and
    - Identify priority sites for conservation and assess community support for designation of new MPAs and MPA networks.

Goal 2: Develop and implement tools and practices to more effectively observe, predict, communicate, and manage climate change impacts in priority international locations.

- Objective 2.1: Collaborate with global partners to broaden the international delivery of coral bleaching prediction and warning tools and improve the science and technology for predicting climate impacts on global coral reef ecosystems.

- Objective 2.2: Expand observing networks to identify and monitor priority coral reef areas that are especially resilient or vulnerable to climate change.

- Objective 2.3: Develop international case studies on impacts of climate change and ocean acidification in order to encourage global greenhouse gas reductions and to encourage greater incorporation of climate change impacts on coral reefs into future global assessments.

- Objective 2.4: Build local capacity to test, implement and evaluate management strategies to respond to climate change impacts.

Goal 3: Strengthen local and national capacity and policy frameworks to reduce impacts of fishing on coral reef ecosystems.

- Objective 3.1: Provide support and technical assistance to strengthen fisheries policy, governance and regulatory measures at national and regional levels to foster an ecosystem-based approach to fisheries management.

- Objective 3.2: Facilitate local cooperative enforcement partnerships and socioeconomic monitoring to address community concerns and to assess and improve compliance with sustainable fishing regulations and customary practices.

- Objective 3.3: Assess the U.S. role in the international trade of coral reef-based ornamental, food and curio species, evaluate U.S. and international legal mechanisms to assess trade impacts and work with exporting countries to adopt sustainable and responsible harvesting measures.

Goal 4: Strengthen policy frameworks and institutional capacities to reduce impacts to coral reef ecosystems from pollution due to land-based activities.

- Objective 4.1: Support national-level and regional initiatives to identify priority coral reef areas threatened by pollutants and assess pollutant sources to those areas.

- Objective 4.2: Collaborate with U.S., regional and local partners to develop and implement coastal and watershed management plans to reduce land-based pollution.

- Objective 4.3: Support national-level and regional initiatives to determine gaps in policy and legislation preventing the effective management of land-based pollutants.

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