

Chambered Nautilus Experts Workshop Report Summary

June 4-5, 2014

Silver Spring, MD

Published April 2015



Photo Credit: Gregory Jeff Barord

EXECUTIVE SUMMARY

Chambered nautilus* are easily found for sale and in trade as whole specimens and shells, and as inlay or ornamentation in jewelry, furniture, and buttons. In 2008 (and in 2012), due to concerns about the shell trade, the public requested that all *Nautilus* and *Allonautilus* species be proposed by the United States for listing under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) at the 15th and 16th meetings of the Conference of the Parties, held in Qatar (2010) and Thailand (2013), respectively. The U.S. Government decided there was insufficient biological and trade information to propose a listing at that time. Since then, the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (FWS) have since been gathering biological and trade data to better understand the conservation status and impact of trade on these species.

To that end, NMFS and FWS held a workshop in June 2014 that brought together experts in the study of chambered nautilus to discuss recent and historical biological and trade data. The workshop was meant to inform the U.S. Government about the status and biology of chambered nautilus populations, their demand in international trade, and what impact such trade may have on wild populations.

Experts presented on their areas of nautilid expertise and covered a range of topics, including population estimates, laboratory studies, demographics, life history characteristics, breeding, and trade. Discussions around species characteristics, status and trends of chambered nautilus, and their utilization and trade also occurred. Experts proposed locating a repository for historical records (logbooks, film, and other information) and publishing historical catch and effort data to assist in the assessment of historic population abundance and distribution.

Since the workshop, the U.S. Fish and Wildlife Service opened a public comment period (June-Aug. 26, 2014) requesting recommendations for possible U.S. submissions for species proposals to amend the CITES Appendices at the next CITES Conference (CoP17 – tentatively planned for fall 2016). Several recommendations were again received to protect all *Nautilus* and *Allonautilus* under CITES. FWS and NMFS are in the process of evaluating these comments. Once the United States identifies what proposals we are considering advancing, which proposals we remain undecided about, and which we will not be taking forward, we will issue a Federal Register notice. In this notice, we will again solicit input from the public and as well as other range States.

*Clarification of terms: Unless otherwise noted, the common names “chambered nautilus” and “nautilus” and the term “nautilid” are used interchangeably in this report to refer to any species in the genera *Nautilus* and *Allonautilus*.

PRESENTATIONS

Participants were asked to deliver presentations based on their expertise. They provided an overview of CITES, and summarized chambered nautilus life history, evolution, physiology, behavior, and status. Presentation summaries are provided below. Click on a title to go to the full presentation.

Overview of CITES

Patricia De Angelis, U.S. Fish and Wildlife Service, explained the requirements and processes of CITES and its use as a conservation tool in regulating international trade and its benefits and limitations in addressing aspects of wildlife conservation. The presentation also discussed the species' listing criteria used in CITES.

Combining field and laboratory study of Nautilus enhances our understanding of their behavioral ecology

Jennifer Basil, CUNY-Graduate Center and Brooklyn College, discussed aspects of the behavioral and sensory biology of nautilus which she has learned from combining field and laboratory studies, including: how they track distant food sources and discriminate the sexes via olfaction (females seem to repel each other), their scavenging behavior and ability to detect food (which would increase their susceptibility to being captured in baited traps), and their complex learning and memory abilities (including the capacity to learn and remember 3-dimensional spatial features of the environment).

Nautilus pompilius fishing and population decline in the Philippines; a comparison with an unexploited Australian Nautilus population

Andy Dunstan, Queensland Department of Environment and Heritage Protection, discussed data collected with baited remote underwater video systems (BRUVS) on *Nautilus pompilius* populations of an isolated Coral Sea seamount (Osprey Reef) and the Great Barrier Reef. Maturity, sex ratio, growth rates and longevity were deduced from the data. Ultrasonic telemetry techniques were also employed to track individuals and determine home range size. He also discussed the first comprehensive review on the impacts of Nautilus fishing for the shell trade, which focused on the Philippines.

The studies of *Nautilus pompilius* at Osprey Reef revealed that this unexploited population is stable in regards to catch per unit effort (CPUE) over 10 years. In contrast, data from a detailed interview questionnaire of *Nautilus pompilius* fishers and traders in Palawan, Philippines, where nautilus are exploited, highlight a fishery that is unsustainable. The results from the Philippines show up to 80% declines in reported CPUE from 1980 to the present, fewer than two generations, which can be attributed to fishing pressure.

Population assessment of *Nautilus* in the Philippines, Australia, Fiji, and American Samoa

Greg Barord, CUNY-Graduate Center and Brooklyn College, collected and compared data for an exploited nautilus population in the Philippines (Panglao, Bohol Sea) to three non-fished populations in Australia, Fiji, and American Samoa. Anecdotal information from fishermen in the Philippines suggests declines in several areas where chambered nautilus have been targeted in fisheries. Where traps once yielded more than two per trap, according to fishermen, it now takes more time to catch the same number. Historical fishery trapping methods and BRUVS were used to assess the current state of each population. The results of this study showed that the unexploited populations in American Samoa, Australia, and Fiji were small like the unexploited population in Osprey Reef – indicating that population sizes are naturally small. The CPUE calculated in the Philippines was substantially lower than any of the three non-fished populations, and lower compared to historical trapping records. In one location in the Philippines with a history of fishing, only one nautilus was caught in 120 traps in 2012. The BRUVS provided information to calculate population abundance at each site; the Philippines population abundance was found to be significantly lower than the three non-fished populations. Together, these methods and findings support earlier claims and reports of declines in CPUE and in population abundance in areas that have supported fisheries in the past. Further, they suggest that fisheries are the primary reason for the discrepancy in CPUE values and population abundances between the sampled sites. This research also helped to characterize the nature of the fishery in the study area of the Philippines.

Comparative catch records of nautilus and life history traits from fished and unfished nautilus populations

Peter Ward, University of Washington and University of Adelaide, explained how the distribution of extant nautilid species is tied to its life history, and how limited temperature and depth tolerance reduce dispersal potential, compared to aquatic species that have planktonic larvae or adults capable of long distance swimming in mid water (e.g., squids). New oxygen isotope records also indicate that until recently, nautilid species lived in warm and shallow habitat, and only post Miocene Epoch species have adopted to a deeper, colder habitat. Yet modern chambered nautilus do not survive in water above temperatures 25° C (77° F). This talk discussed new ultrasonic tracking records, oxygen isotope records of both extant and extinct species of *Nautilus* spp., and the first records of extant *Allonautilus* spp., to provide information regarding the biological and physical barriers that hamper these species' potential for re-colonization of Philippine or Indonesian habitats should local extinction occur.

New reflections on old data: living populations of *Nautilus* and *Allonautilus*

Bruce Saunders, Bryn Mawr College, discussed data he collected primarily during the late 1970s and 1980s from previously undisturbed populations of *Nautilus* spp. and *Allonautilus* spp., and how these data can provide a basis for characterizing natural nautilid population profiles, in

terms of relative maturity and sex ratios. A table was presented outlining the location, year, total catch, male:female ratios, and immature:mature ratios for sites in Indonesia, American Samoa, Western Australia, Papua New Guinea, New Caledonia, and Palau. Occurrences of geographically and genetically isolated, commercially unfished population samples of nautilids from Papua New Guinea, Palau, New Caledonia, the Great Barrier Reef, Western Australia, American Samoa, Indonesia, and Fiji allow characterization of undisturbed population profiles. These were compared to a population in the Philippines that has been subjected to increasingly intense fishing since approximately 1900. Such data may provide a basis for estimating whether local populations are in sustainable equilibrium, or need greater protection and conservation.

Nautilus Retrospective: 1976-2014

Bruce Carlson, Georgia Aquarium, provided a brief summary of field research in Palau and Fiji from 1976 to 1984, followed by a discussion of husbandry and breeding research conducted in the Waikiki Aquarium, with the first hatchling in 1990. Specimens in aquaria have a survival rate of one to five years, living a maximum of about five years. He concluded with data and remarks on nautilids currently held in public aquariums, including breeding efforts at the Toba Aquarium in Japan. This facility produced its first hatchling in 1988 and reportedly hatched as many as 220 in 2009; however, only 11 survived for less than three years. Because these invertebrates do not survive very long in captivity, and none of the hatchlings have reached sexual maturity in captivity, the evidence presented suggest that it is currently both impractical and nearly impossible for captive breeding to be used as a tool to satisfy trade or for restoring wild populations.

U.S. Trade Overview (2005-2010)

Patricia De Angelis, U.S. Fish and Wildlife Service, discussed anecdotal and quantitative trade data for nautilids. There is anecdotal evidence that all six recognized species of chambered nautilus have or are being sold into international trade. This trade originates from countries to which chambered nautilus is native and also from non-range countries. The only quantitative international trade data available for chambered nautilus is from the U.S. Fish and Wildlife Service Law Enforcement Management Information System (LEMIS). This data, which is compiled from U.S. wildlife declaration forms that are required for import or export of any fish and wildlife, indicates that between January 2005 to August 2010, more than 789,000 chambered nautilus products were recorded in U.S. trade. Nearly all of this trade was U.S. imports, but about 57 transactions were re-exports (material that was imported to the U.S. and subsequently re-exported). The LEMIS data includes material ranging from whole shells, to worked material, to live specimens, and one shipment of meat, and was reported under the broad categories of "Mollusk," "*Nautilus* species," or "*Allonautilus* species," with some data reported to the species level (including *Allonautilus perforatus*, *N. balauensis*, *N. macromphalus*, and primarily *N. pompilius*). Ninety nine percent of the quantitative U.S. trade

data came from range countries and 99% of products were from wild sources. Approximately 4,500 products were reportedly bred in captivity, including 24 live specimens imported from Japan. Given that repeated attempts at captive breeding have not yield viable offspring, the veracity of this information merits independent confirmation.

An investigation into the trade of Chambered nautilus

Ben Freitas, TRAFFIC, discussed a nautilid trade study conducted by World Wildlife Fund (WWF) TRAFFIC in North America, Europe, East Asia, and Southeast Asia. The study focused on the source countries of the Philippines and Indonesia, Taiwan as both a producer and consumer country, and the United States and European community as consumer countries to investigate how chambered nautilus are fished (looking at gear, techniques, and harvest seasons), the extent of their sales in shops and online, the sources of products, trade routes, and domestic laws to protect the species. Fishermen and traders note a decline in the past ten years. Where catch today is between zero and three individuals per trap in the Philippines, 10 years ago, as many as seven individuals could be trapped. In parts of Indonesia, current average catch rates are between one and three animals per night, which is in contrast to estimated catch rates of 10-15 individuals per night that were found approximately five years ago. Where applicable, illegal trade and enforcement of domestic laws were also discussed. TRAFFIC analyzed LEMIS trade data from January 2010 to December 2013, and found that more than 115,000 products were imported to the United States during that four-year period. Most of the products consisted of jewelry and shell products, and there were more than 7,000 whole (live or dead) specimens. TRAFFIC also explored prospects for developing conversion metrics, looking at the number of individual nautilus represented by various products, to better understand the number of individuals being impacted by trade.

DISCUSSION AND OUTCOMES

The experts discussed nautilids in three separate sessions focused on species characteristics, status and trends, and utilization and trade. Each of these topics elicited information from the experts that begins to show a more complete picture of nautilids in the wild, including traits which make them susceptible to decline and fishery characteristics with the potential to drastically alter their populations on a local level.

Species Characteristics

In this section, experts were asked to discuss the current knowledge about the vulnerability of nautilus to exploitation with regard to their species characteristics.

Nautilids are highly vulnerable due to a variety of factors, including low fecundity, slow growth, relatively late maturity, and high price and demand that drive fisheries pressure.

Nautilus generally live as geographically distinct populations and adults do not disperse widely. Nautilus are poor colonists because they do not have a larval phase and do not swim in open water. Rather, they travel along coral reef slopes. They are also limited by depth depending on environmental and individual variability. Nautilus will implode at high pressures beyond certain depths, and they do not tolerate water above a certain temperature. Thus, they cannot repopulate across deep water and are poor recolonizers.

Nautilus are easily targeted by predators because of the habitat they live in. In coral reefs, teleost fish predate on chambered nautilus. Other coral reef denizens are also predators of nautilus, including octopus, as evidenced by drill holes observed on chambered nautilus shells. Nautilus also show evidence of shell breaks indicative of larger predators, such as sharks or large teleost fish.

Nautilus can be more susceptible to mortality during research experiments, which highlights their vulnerability. *Allonautilus* spp. do not tolerate being pulled out of the water, dying quickly upon removal. During catch-and-release experiments, chambered nautilus are particularly susceptible to predation when released at shallow depths; their movement is inhibited if the air bubbles formed in their chambers during ascent are not released slowly during descent.

Little is known about chambered nautilus reproduction in the wild; nearly all information has been obtained in captivity. Nautilus have a low replacement rate, reaching maturity at a decade or later. Females produce low numbers of eggs, and unlike other cephalopods, chambered nautilus lay only one egg at a time. Eggs are relatively large and require up to a year to develop. There is evidence that eggs are predated upon in aquaria tanks. Unlike most other mollusks, chambered nautilus do not have a larval stage and juveniles have low

dispersal rates, as evidenced by the species' inability to readily colonize new habitat. Despite years of research on nautilus, most of the experts at this workshop have never actually seen chambered nautilus hatchlings in the wild. Unlike most of their mollusk relatives, chambered nautilus exhibit classic traits of a k-selected species with relatively stable populations, low numbers of offspring, and long gestation periods.

There is uncertainty as to the true natural sex ratios of nautilus populations. Research and fisheries data have shown a male-biased catch ratio (60:40 and 80:20 for males to females, respectively). However, some baited-trap and trawl research have yielded 50:50 ratios. Species experts are not convinced that natural sex ratios are male-dominated. It is possible that the low rate of capture of females is due to repellency that females exhibit to other females, as suggested by the lab studies of Basil. A better understanding of sex ratios in the wild is important, as sex ratios assist in understanding the reproductive structure of the population. Differential catch rates of males to females could potentially impact the sustainability of populations and vulnerability of the species.

Nautilus possess a strong olfactory sense which can draw them in from a large area to feed. In isolated geographic areas, traps can become feeding stations with the ability to catch nearly all of the individuals in an area. This information indicates that nautilus can be relatively easy and inexpensive to catch, requiring little equipment. It is unknown how the repellency effect females may have on each other affects the feeding behavior of nautilus and whether it is the reason that few females are caught in baited traps compared to males.

Status and Trends

In this section, experts were asked to discuss the vulnerability of nautilus to exploitation with regard to status and trends seen in nautilus populations.

Threats

Due to the isolated nature of populations and low replacement potential, nautilus are vulnerable to overexploitation. According to most of the experts at the workshop, sustainable fishing is not possible with nautilus in light of their life history characteristics. Nautilus cannot be compared to other species of cephalopods or fish in terms of their life history traits or responses on a population level to fishing. Fishing for nautilus is extractive; unlike most other species, it may be possible to catch every single individual of a nautilus population in an area.

Differences between species should also be taken into account in the research context. *Allonautilus* appears to be easily caught and, as noted above, has high mortality when brought out of the water.

Each localized population of nautilids is different in terms of the anthropogenic stresses placed upon it and the surrounding environment. Ocean acidification and increased sedimentation may be threats to nautilus populations.

Status

In terms of the overall status of nautilus, there is only spotty abundance information for nautilids from a small number of locations. The researchers agreed that historical CPUE data could be used to obtain abundance estimates for particular locations, but that this abundance estimate could not be extrapolated across the species' range without taking suitable habitat into consideration. Although some experts expect that nautilus exist in some locations where they are not currently known to occur, research data has shown negative results as many traps set out do not capture nautilus.

It was determined that CPUE data exists for the Philippines, Japan, Fiji, and likely New Caledonia. For purposes of comparison, at Osprey Reef, an isolated, undisturbed, unfished nautilus population in Australia, there is no evidence of decline based on available data. In contrast, qualitative estimates of decline exist according to fishermen in Palau, Philippines, and New Caledonia, as noted by several experts. There was some discussion over whether certain locales have been fished before, such as in New Caledonia and Palau. There was also discussion that age class distribution (and the ratio of mature to immature individuals) could be used as an indicator of population decline. Unpublished data on age class distribution from New Caledonia suggests overfishing is affecting populations there.

Utilization and Trade

In this section, experts were asked to discuss their experiences, inferences, and observations related to trade and utilization of Nautilus species.

The experts agreed that captive breeding could not supply the market with enough shells to meet demand, nor is it a feasible option. In captivity, nautilus have low survival rates. Those that survive do not live long, and therefore have smaller shells. The shells are not as attractive as those found in the wild, so it is unlikely that captive bred specimens would be a viable market alternative to wild caught specimens. In addition, breeding nautilids in captivity for commercial purposes or to re-populate them in the wild would take years, is extremely expensive, and would require tremendous effort to accomplish.

Likewise, drift shells are not currently a large part of the market, and they would not be able to satisfy international demand. The U.S. market, for instance, could not be supplied by drift shells. In addition, it does not take long for shells to become etched, or to break, when drifting. When this happens, they are not as valuable in the marketplace.

Nautilid meat has been seen for sale in a Chinese market, but is not desirable as a food source in the Philippines. It is eaten when the shells are caught for trade, and sometimes also used as bait.

There is not a lot of local demand for shells; mostly they are being exported for international sale. The shell market drives prices and fishing pressure. Some species of *Nautilus* and *Allonautilus* are rarer than others, and therefore are potentially more valuable, which can further drive fishing pressure.

Fishermen in Palawan and Bohol have stated that chambered nautilus fishing is not a traditional subsistence fishery, and fishing techniques were learned from demand-driven shell traders. According to experts at the workshop, chambered nautilus may not be the main target of fishing effort, but when shell prices are high, fishing effort for nautilus shifts from incidental catch to a targeted fishery. Some doubt was expressed whether nautilus fishing is not targeted, because little else can be caught at the depths where nautilus fishing occurs. The United Nations Food and Agriculture Organization (FAO) does not consider this an opportunistic fishery. There is evidence that chambered nautilus fishery efforts are expanding as regions are being depleted, and traders are training fishermen to exploit new areas for targeted chambered nautilus fishing. Targeted chambered nautilus fisheries have occurred and are occurring in the Philippines, Thailand, Indonesia, Vanuatu, and New Caledonia.

In those areas where fishing gear may be prohibitively expensive, several experts at the workshop asserted that people external to the community may be funding the fishery in order to collect and sell the shells elsewhere, based on their discussions with fishermen. In Savu, Indonesia, and Bohol, Philippines, traders teach locals how to fish for nautilids, and organize fishers' transport to fishing sites. Fishermen sometimes get orders from the traders for a certain number of shells to bring in, further evidence that nautilus fishing is targeted and demand-driven.

The experts asserted that research-based fishing effort that harvests only a small number of specimens for a brief period should not be a big impact on local populations would not be considered a threat to, or exploitation of, the species based on the relatively low mortality of species used for scientific research. However, earlier discussions noted that some "research" efforts have involved large numbers of specimens that are retained and that chambered nautilus that are returned to the water during research studies often suffer higher predation or death from air bubble formation.

Experts agreed that it is possible to use the morphology of whole shells to distinguish between species of nautilus. They also asserted that it is relatively easy for experts to differentiate males from females. Chambered nautilus shells have an external matte white layer and an inner

nacreous, or pearly, layer. The mother-of-pearl (nacre) of chambered nautilus shells is not different from other nacre. A characteristic of chambered nautilus shells is that it is distinctively large, flat, and thin, which lends itself to being used as inlay. According to several workshop participants, when used as inlay, an expert could probably determine whether it is chambered nautilus shell from the thickness of the shell. However, the average person may not be able to, and even experts would not be able to tell what species it is. Growth lines can be seen in chambered nautilus shells, even if they are polished, and even on buttons; no other mollusk has these lines and so this could make a good diagnostic tool. As to whether there are substitutes for chambered nautilus shell, there would be no substitute for the whole shell and it would also be difficult to find a substitute for the larger pieces.

Synthesis and Outstanding Issues

There was agreement that the life history traits of nautilids and fishing impacts on nautilids given those traits should be synthesized and published. These characteristics include: slow growth, vulnerability to fishing, susceptibility to extirpation, and lack of active recolonization within and between populations. Because of its unique life history traits, the experts asserted that chambered nautilus differ from other cephalopods and cannot be managed like other fisheries.

Further, catch per unit effort data, going back to the early 1900s, should be compiled to show the potential decline of chambered nautilus populations over time. Although this may be difficult to show on a global scale, the susceptibility of populations that have been fished versus those that have not been fished can be shown locally.

There was a recognized lack of comprehensive trade data on chambered nautilus shells, parts, and meat and a discussion of the difficulty monitoring these products in trade in the absence of more specific harmonized tariff codes. Based on the work presented by TRAFFIC and the experience of the experts through their field studies, there was agreement that the demand for chambered nautilus has increased the harvest of these species by local fishermen for international markets.

Nautilus Experts Workshop
Final Agenda
June 4-5, 2014
Silver Spring, MD

Meeting Venue: Silver Spring Civic Building at Veterans Plaza
1 Veterans Place, Silver Spring, MD 20910
GPS device address: 8525 Fenton Street, Silver Spring, MD 20910
Approximately 15 minute walk from the Silver Spring Metro on the red line

Goal of the Meeting: To bring together experts in the study of chambered nautilus to discuss the recent and historical biological data and trade data to help inform decision-making by the U.S. Government (USG) about whether chambered nautilus could meet the criteria for listing under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Facilitator: Luis Leandro, Communications Program Lead, NOAA Fisheries Office of International Affairs

Agenda

Day 1, June 4 – Colesville Room on the 2nd Floor

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| 8:30am | Meeting Starts <ul style="list-style-type: none">• Quick Introductions Around the Room• Overview of the Schedule and Meeting Goals |
| 9:00 | Welcome and Brief Introductory Remarks (Angela Somma, NMFS, and Rosemarie Gnam, USFWS) |
| 9:15 | Overview of CITES (Patricia De Angelis, USFWS) |
| 9:45 | Break |
| 10:15 | Introduction to Presentations |
| 10:30 | Research Presentations |
| | Session 1 – Three presentations, each 30 minutes in length with 15 minutes for the presentation and 15 minutes for Q&As |

- 10:30 Jennifer Basil - How combining field and laboratory study of Nautiluses can enhance our understanding of their behavioral ecology
- 11:00 Andy Dunstan - Chambered nautilus Population Estimation, Demographics and Fishery Impacts
- 11:30 Greg Barord - Population assessment of Nautilus in the Philippines, Australia, Fiji, and American Samoa
- 12:00pm Lunch
- 1:15 Research Presentations (Continued)
- Session 2 – Three presentations, each 30 minutes in length with 15 minutes for the presentation and 15 minutes for Q&As
- 1:15 Peter Ward - Comparative catch records of nautilus and life history traits from fished and unfished nautilus populations
- 1:45 Bruce Saunders - New Thoughts on Old Nautilid Data: Comparisons of fished vs. unfished nautilid populations
- 2:15 Bruce Carlson - Nautilus Retrospective: Collecting, Tracking, Breeding - 1976 to Present Day
- 2:45 Break
- 3:15 Trade Presentations
- 3:15-3:45 Patricia De Angelis, USFWS – U.S. Trade Overview
- 3:45-4:30 Ben Freitas, WWF-TRAFFIC – An investigation into the trade of Nautilus
- 4:30 Day 1 Wrap Up and prep for Day 2
- 5:00 Day 1 ends

Day 2, June 5 – Fenton Room on the 2nd Floor

- 9:00am Re-cap of Day 1 presentations and discussion
- 9:15 Discussion of Species Characteristics

- Based on what we know, what can we say about the vulnerability of nautiluses to exploitation?
 - What research shows us this?
- 10:15 Discussion of Status and Trends
- Based on what we know, what can we say about the vulnerability of nautiluses' exploitation?
 - What research shows us this?
- 11:00 Break
- 11:15 Discussion of Utilization and Trade
- What are your experiences, inferences, and observations related to trade and utilization of Nautilus species?
- 12:00pm Lunch
- 1:30 Synthesis Discussion and Determining Outstanding Issues
- 3:00 Break
- 3:15 Next Steps
- Timeline for CITES work
 - Upcoming scientific meetings
 - Projected Research Publications
- 3:45 Wrap up
- 4:15 Close of meeting

Meeting Participants

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Expert Biographies

Gregory Jeff Barord attended Texas A&M University at Galveston where he obtained a B.S. in Marine Biology and Minor in Chemistry. While in Galveston, Greg worked at the National Resource Center for Cephalopods (5 years) and in the Quarantine Facility at the Aquarium at Moody Gardens (2 years). After 2 years working as a fisheries observer for the National Marine Fisheries Service in the Bering Sea, Greg began his graduate studies towards his PhD at City University of New York - Brooklyn College. Greg has published on several aspects related to cephalopods, including husbandry, veterinary care, behavior, and physiology (he also reported on the first occurrence of the invasive jellyfish, *Phyllorhiza punctata*, in Texas). He is currently working on several aspects of nautilus biology and behavior by combining laboratory and field work to inform conservation practice.

Dr. Jennifer Basil received her PhD in Zoology from the University of Massachusetts, performing a comparative study of the cognitive and neural correlates of spatial memory in food-storing birds. She then moved to the Marine Biological Laboratory in Woods Hole MA for a post-doc studying the sensory and navigation behavior in a variety of crustaceans. After a Grass Fellowship, Basil became a senior Research Associate at the MBL examining the sensory biology and cognition of the Chambered Nautilus. She is currently a Professor of Biology at the City University of NY at Brooklyn, and in the Ecology, Evolution and Behavior PhD program at CUNY. Her laboratory's area of focus is the evolution of complex brains and behavior using the comparative approach, and she uses cephalopod mollusks as her model system.

Dr. Bruce Carlson received his Bachelor of Science degree from the University of Michigan in April 1971, then traveled to Guyana to assist in a study of cichlid fishes. From 1972 - 1975, he participated in a survey of the marine fauna and flora of the Fiji archipelago as a joint project of the Peace Corps and Smithsonian. In 1975, he moved to Honolulu where he earned his PhD in Ichthyology at the University of Hawaii and started work at the Waikiki Aquarium where he pioneered new exhibits featuring nautilus, cuttlefish, giant clams and living corals. In 1990, he was appointed Director of the Waikiki Aquarium. He left Hawaii in April 2002 to join the design team to create the world's largest aquarium in Atlanta, Georgia. He retired from the Georgia Aquarium in April 2011 and returned to Hawaii. Bruce has published numerous scientific articles ranging from descriptions of new species of reef fishes, to telemetry work on chambered nautilus, to culture methods for corals.

Patricia De Angelis, Ph.D., at the U.S. Fish and Wildlife Service-Division of Scientific Authority, works on a variety of native and non-native plant and animal species that are impacted by international trade. She focuses particularly on collaborating with stakeholders and species experts to ensure the sustainable use and conservation of native animals and plants. In this capacity her portfolio has included black corals of Hawai'i and seahorses of Florida. Patricia's

background is in Ethnobotany, with a doctorate from the University of Maryland at College Park for her collaboration with Miskito Indians of Nicaragua to document their everyday plant usage. She obtained an undergraduate degree in Botany from the George Washington University.

Andrew (Andy) Dunstan currently works as the Project Manager at the Raine Island Turtle Recovery Project, Threatened Species Branch, Queensland Department of Environment and Heritage Protection in Queensland, Australia and as a consulting biologist with Aurora Expeditions, working in Antarctica and Papua New Guinea. Andy received his PhD from the University of Queensland in 2011. His work focused on Chambered nautilus research and deep sea biology with the Deep Ocean Australia group, School of Biomedical Sciences and Queensland Brain Institute. His Masters Qualifying is in Biochemistry from the University of Queensland, and his Bachelor of Science from James Cook University is in Biochemistry and Marine Biology. Andy is also a Master Mariner USL Class 4, and can captain vessels up to 35 meters and is a Scuba instructor (NAUI) and Divemaster (PADI). As the Founder and Director of Reef Check Australia from 1998-2010, Andy conducted long term volunteer coral reef monitoring programs and training. He has also served as a consultant to WWF and worked in the marine ecotourism industry as a manager and research director.

Ben Freitas is a program officer with the World Wildlife Fund's Smart Fishing Initiative (SFI) and TRAFFIC, the wildlife trade monitoring network that is a joint program of WWF and the IUCN. Ben has been with WWF and TRAFFIC since 2011 working on fisheries governance and marine trade issues. Prior to that he was a Science Fellow at Oceana conducting research and analyzing data for their responsible fishing and global trade campaigns. Ben is a graduate of the University of Virginia and Brown University and still calls the San Francisco Bay Area home.

Dr. Clyde Roper has worked as a marine biologist in the Department of Invertebrate Zoology at the Smithsonian's National Museum of Natural History since 1966. Clyde's research specialty is the biology, behavior, diversity and distribution of Cephalopda (squids, octopuses, cuttlefishes, and Chambered nautilus). Clyde's most recent research passion has been the quest to find and film a living giant squid in its natural habitat, thousands of feet down in the deep sea. In addition to publishing over 150 scientific papers, books, general magazine articles and a children's book, Clyde is a frequent lecturer and consultant on marine biology in educational programs, public museums and aquaria, schools, universities, exhibitions, websites and on Smithsonian Journeys and National Geographic Study Tours and cruise ships. Clyde's research on giant squid has resulted in three television documentaries: National Geographic Television, Discovery Channel and First Person, which won the 2001 Earthwatch Film Award. Clyde has held Adjunct Professor positions at the George Washington University, the University of Miami School of Marine Sciences, and Mote Marine Laboratory (Sarasota, FL).

Bruce Saunders, a Paleontologist, saw his first live Chambered nautilus in Palau in 1977. In the succeeding 20 years, Chambered nautilus expeditions were undertaken to Micronesia, Melanesia, Indonesia, Australia, etc. Discovery of new populations of Chambered nautilus (and, in one case, *Allonautilus*) in these areas was matched by fruitless efforts at other sites, providing new data on the distribution of living nautiloids. Additionally, a large body of data was assembled, from several thousand live-caught animals, the majority of which were tagged and released. In 2010, Bruce retired to a 1790 farmhouse in N. PA, from whence he “campaigns” (i.e., spends inordinate money on) a 1962 sports car at racetracks such as Watkins Glen, NY.

Dr. Peter Ward is a Professor of Geobiology at the University of Adelaide and Professor of Biology, and Earth and Space Sciences at the University of Washington. He has been working on modern nautiloids since 1975 and fossil species since 1971. He received his PhD in Geology from McMaster University, Hamilton, Ontario, in 1976 under the advisement of Gerd E. G. Westermann.