

Conservation Value of Having a White Shark on Exhibit
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Randy Hamilton
Monterey Bay Aquarium, 886 Cannery Row, Monterey, CA, 93940
Rhamilton@MBAYAQ.ORG

Abstract:

From 2002 to 2012, the Monterey Bay Aquarium (MBA), Monterey, California has embarked on an initiative to collect biological data on the white shark, *Carcharodon carcharias*. This data will allow better understanding of its life history, to educate the public on the role this top level predator plays in the ecosystem and to place young-of-year sharks on public display. Ultimately, this information should help assist management of the species, which is currently considered vulnerable and protected by the state of California. This presentation will include information on habitat preference, movement patterns and genetics of tagged animals in the wild. In addition, it will allow us to review what we have learned by keeping six white sharks in captivity for a total of 632 days. Finally, the data will show the impact on aquarium visitors, attendance and value in terms of how this effort seeks to portray the white shark as an ambassador for the conservation of other oceanic species, including itself.

Introduction:

Few, if any, marine creatures inspire more intense human emotions than white sharks. They are feared, admired, hated and loved. They have a fearsome reputation, feeding on large marine mammals and occasionally killing or injuring humans. They are mysterious, occurring throughout the world's temperate and tropical oceans yet leading secretive lives not easily conducive to scientific investigation. As extremely large apex predators in coastal and open ocean ecosystems, they are likely to strongly influence the structure and function of these ecosystems. What we do know about their life history (late age at first reproduction, slow growth rate, small litter size) indicates that they are highly susceptible to over-exploitation. Examples of this exploitation can be intentional through targeted fisheries or unintentional as by-catch in other fisheries. White sharks are protected under several conservation and management regimes, including the World Conservation Union (listed as "vulnerable"), the Convention on International Trade in Endangered Species (listed under Appendix II), the California Department of Fish and Game (listed as "protected") and most recently Mexico (Federally protected)

Because white sharks are charismatic, they lend themselves well to the role as a perfect ambassador for ocean conservation. Our decision to launch a multi-year,

multi-faceted conservation initiative interconnecting Research, Husbandry and Education goals was driven by the opportunity to tell a powerful conservation story through this iconic animal.

We had several goals for the project: to better understand the biology and movements of these threatened ocean predators through electronic tagging and DNA sampling (science component); to determine, systematically whether it would be possible to keep and display a young white shark in a mixed community exhibit (husbandry component) and to communicate with visitors and the public in ways that lead to further protection for white sharks (education component).

The focal points connecting our goals are sustainability and conservation. Success is not predicated on having a white shark on exhibit; rather, we focus on protecting white sharks through research, education and policy change. By being a leader in ocean conservation and white shark conservation, we can maintain our vision to have a sustainable white shark population in their natural habitat, the world's oceans.

EXHIBITING A WHITE SHARK:

Exhibiting a young white shark allows us to contribute significantly to public understanding and protection of white sharks. Six times – first in September of 2004 and again in August 2006, August 2007, August 2008, August 2009 and August 2011 – we exhibited young white sharks in our 1.2 million gallon Open Seas exhibit. All but the last shark were successfully returned to the wild.

In the first instance, we introduced a young female into the exhibit for what became the longest- ever exhibit of a white shark – 198 days. In March 2005, we successfully returned her to the wild and then tracked her movements for 30 days. In 50 years of prior attempts, this was the first time any aquarium kept a white shark for more than 16 days in captivity.

We repeated the success in 2006, introducing a year-old male into the exhibit, where he thrived and grew during the 137 days before we returned him to the wild in January 2007. He was fitted with a 90-day tracking tag that documented his travels to the southern tip of Baja California, Mexico – a journey that took him more than 2,000 miles, and to depths as great as 1,000 feet below the surface.

Our third white shark stayed with us for 162 days until we released him in Monterey Bay in February 2008. He was fitted with two tracking tags. One pop-up tag remained with him for 148 days, documenting his migration as well as the water temperatures and depths he favored. A second smart position or temperature transmitting (SPOT) tag communicated his position via satellite when his dorsal fin broke the surface of the water. That tag had a battery life of up to eight months. From the tag, we learned that the shark traveled south to

Mazátlan, Mexico in his first 50 days back in the wild, then north into Mexico's Gulf of California. The public was able to follow his movements almost in real time at the Tagging of Pacific Predators (TOPP) website, www.topp.org, for six months. The same site allows the public to track the movements of several juvenile white sharks tagged in southern California by scientists associated with our white shark project.

Our fourth white shark was a young female shark that was caught by our husbandry collectors in a seine net in Santa Monica Bay. She was the smallest shark to be placed on exhibit at, 4½ feet-long (137 cm), weighing 55½ pounds (25 kilograms). Although she was swimming well on exhibit, she only fed one time during her 11 days on exhibit. The decision to release her back to the wild was governed by our concern for her health and well being. She was tagged with a pop-up archival tag that is programmed to release after 148 days, and released on September 7, 2008. Four days later, she was accidentally recaptured in a fishing net set about 22 miles south from where she was originally released, inspected and returned to swim off.

Our fifth white shark was a young female shark that was caught by our husbandry collectors in a seine net in Santa Monica Bay. She was 5'5" feet-long (165 cm), weighing 80 pounds (36 kilograms). The decision to release her back to the wild was governed by her change in behavior after she received a superficial bite wound, was observed chasing scalloped hammerhead sharks and bit and injured a Galapagos shark. After 69 days on exhibit, she was tagged with a pop-up archival tag and released on November 4, 2009 into Monterey Bay.

Our sixth white shark was a young male that was caught by our husbandry collectors in a seine net in Santa Monica Bay. He was 4'4" feet-long (132cm), weighing 43 pounds (19.6 kilograms). Although the shark was eating well, the decision to release him back to the wild was based on recent changes in how he was navigating the exhibit. After 55 days on exhibit and gaining nearly 9 pounds (26.6 kilograms), he was tagged with a PAT and acoustic tag and released on October 25th, 2011 off Goleta, CA. Although the pop-up tag was recovered, the shark's carcass was not thus a definitive cause of death remains unknown.

ATTENDANCE:

Collectively, the six sharks have been seen by nearly 3 million people during their 632 days on exhibit in Monterey. In addition, hundreds of millions of people around the world have learned about them indirectly through the news media or through visits to our web site www.montereybayaquarium.org. Having a white shark on exhibit had a tremendous impact on our visitors (Peterson, personal communication).

Having a white shark on exhibit also influenced a visit to the aquarium, with 45% being influenced by our first shark, 32% with our second, 18% with our third and 21% with our fifth.

The attendance generated by having a white shark on exhibit also benefited the aquarium financially, with much of the additional – and unbudgeted – revenue reinvested into white shark field research efforts. For the first white shark, attendance was 34% above the previous, same-period attendance, and admission revenue alone was more than \$3.5 million above budget expectations. We also experienced record-setting membership sales as well as strong sales of shark-related merchandise.

Since 2002, we have invested over \$4 million in the white shark project. Of that, about \$3 million was devoted to research that was aimed primarily toward answering husbandry-related questions. This figure includes, tagging white sharks and tracking their movements for up to six months, and the cost of bringing six animals back to Monterey Bay Aquarium for exhibit.

CONSERVATION RESEARCH:

The aquarium has allocated more than \$1 million to white shark field research since 2002, with much of the money supporting the tagging of adult white sharks off the Farallon Islands, Point Reyes, and Año Nuevo Island. When possible, small tissue samples were taken from these tagged animals for DNA analysis. Over the past decade, our team of shark researchers has deployed over 230 electronic tags tracking over 125 individual adult white sharks off California's Central Coast. And more than 70 of these animals have been DNA sequenced. This project has been a collaborative effort involving our research partners at Stanford University; California State University at Long Beach; Southern California Marine Institute, University of California at Davis; Montana State University; Point Reyes Bird observatory; Pelagic Shark Research Foundation; and Tagging of Pacific Predators.

DNA has been collected from tagged adults and juveniles and the mitochondrial DNA (mtDNA) control region has been compared to other Indo-Pacific populations. Our results clearly show white sharks off the coast of California share a recent Late Pleistocene ancestry with those found around Australia (Jorgensen et al. 2010). To date, 189 young of year (YOY) and adult sharks from Mexico and California have been sequenced (Reeb unpublished). At this time, we find no evidence of population structure within the North East Pacific. We are currently analyzing 14 microsatellite loci to study kinship and possible parent-offspring relationships among California adults tagged in the north and YOY sampled in the south. Because adults white sharks are long-lived (~50 years) and populations are considered relatively small (Chappel et al. 2011), we hope that linking adults with high reproductive success in the YOY gene pool to

migration patterns offshore will provide important insights for the management and protection of this species inhabiting California waters.

More research is needed to:

- Inform white shark conservation strategies by improving our understanding of fundamental attributes of the north Eastern Pacific population of white sharks, including: the total number of adults; population trend; genetic diversity; the degree of population structure within the north Eastern Pacific; and their distribution and habitat use.
- Inform time/area management guidelines used by fisheries managers with data from tagging and genetics, to effectively protect adults and young-of-year white sharks.
- Gain improved knowledge of behavior, physiology and environmental preferences of young-of-the-year white sharks, in support of ongoing display of captive white sharks.

CONSERVATION EDUCATION:

Having a white shark on exhibit allowed us to deliver powerful conservation messages about white sharks, and sharks in general to a receptive audience. According to our visitor research surveys, a significant percentage of Aquarium visitors reported that they learned something about the need for protecting white sharks in the wild, and over 90% of visitors reported that they believe our exhibiting a white shark was appropriate.

A staff position was dedicated to interpreting the white shark at the exhibit during all public hours, assisted by other staff and volunteer guides to answer guest questions. Open Seas exhibit feeding presentations highlighted the white shark to large audiences. A 15-minute auditorium presentation about the white shark project, including video clips and a question-and-answer period, filled a 250-seat auditorium to capacity several times a day. The Ocean Explorers activity guide for visiting school groups included observations of the white shark, and virtually all of our self-guided school groups made a point of viewing the shark and interacting with interpreters at the exhibit. With our retail concessionaire, we wrote, designed and published a 16-page book, *Saving White Sharks*.

The experience of viewing a white shark in person proved to be very effective in overcoming traditional misconceptions about these animals associated with sensationalized images common in popular media. Statements and questions from guests indicated a sincere fascination with the shark rather than fear. Interpretation for guests focused on the knowledge we were gaining from studying these animals and avoided terms or references that would reinforce the sensationalized image of white sharks. The presence of the animal coupled with

personal interpretation at the exhibit created a powerful experience for guests of all ages.

Online, we added video clips, weekly updates and links to research partners to our web site. A streaming web cam offered views of the white sharks as they cruise their exhibit. In 2006, average page views to the web cam increased from 1,140 per day to 5,514 per day; furthermore in 2011, visits to our updates page increased from an average of 523 per day to 2,345 per day. Articles in the Aquarium's member publications and on the Aquarium blog site expanded the reach of key white shark messaging beyond the visitor audience.

CONSERVATION POLICY:

Globally, white sharks are threatened by human activities, and the World Wildlife Fund considers them to be among the top 10 "most wanted" species in the international market. Although they have gained protection in a global wildlife treaty approved by the United Nations affiliated Convention on International Trade in Endangered Species (CITES), if their numbers turn out to be falling, they may need further protection. Through its Center for the Future of the Oceans, the Aquarium is working with other institutions and agencies to help develop strategies for white shark conservation policy in California and Mexican waters. Data from white sharks tagged in the field will be shared with wildlife officials who can use the information to inform fisheries management decisions.

A persistent migration corridor exists between hangouts on the west coast of North America (e.g. Farallones) and those on the high seas (e.g. Hawaii and Café) (Jorgensen et al 2010). We still do not know where mating occurs, however, the Southern California bight and northern Mexico waters have emerged as an important nursery area (Lowe et al 2012, Weng et al 2007) and require special attention. Despite protective status in California and Mexico, juvenile white sharks are captured as by-catch in both territories, suggesting that management of fishing mortality should be of increased concern. Yet, not enough is known about the impacts of by-catch on the population to suggest fisheries closures at this time (Lowe et al 2012). Because many shark species are threatened worldwide by destructive fishing practices and are in need of preservation, we are proud that our white sharks have proved to be such incredible ambassadors for white sharks and shark conservation.

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