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## Independent Review of the Status of the White Sharks Tagged Under the Domeier Permit

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In response to public concern, Gulf of the Farallones National Marine Sanctuary initiated an Independent Review to assess the status of two white sharks tagged in October and November 2009 under a permit issued to Dr. Michael Domeier of the Marine Conservation Science Institute (GFNMS-2009-004).

Materials reviewed included:

- 1) Excerpts from video of male white shark tagging at Farallon Islands, Oct 29, 2009.
- 2) Photos and timeline of tagging event, Oct. 29, 2009.
- 3) Draft Environmental Assessment for the application to amend permit GFNMS-2009-004).
- 4) Separate plots showing the tracks of Farallon tagged sharks and Guadalupe tagged sharks.
- 5) Plots showing the tracks of longitude by date for Farallon tagged sharks and PSAT and SPOT tagged sharks from Guadalupe Island.
- 6) Information on fight time, sizes and departure dates of sharks tagged at the Farallones and Guadalupe Island.
- 7) Previously published information on the movement of white sharks tagged at the Farallon Islands – Jorgensen et al. 2009, Weng et al. 2007.
- 8) Information on the presence and departure of white sharks from the Farallones as observed by the Vessel Monitoring Project<sup>1</sup>, PRBO Shark Watch<sup>2</sup> and/or GFNMS permittee log reports.

This review addresses four specific sets of questions regarding the status of the tagged sharks and recommendations to improve capture, handling and tagging methods.

### ***Are the sharks alive?***

As of the end of August, 2010, we believe both sharks tagged at the Farallones in 2009 are alive. The tag from the first shark tagged is transmitting good quality locations on a regular basis and the movements of

<sup>1</sup> The Vessel Monitoring Project, lead by Gulf of Farallones National Marine Sanctuary in collaboration with PRBO Conservation Science and U.S. Fish and Wildlife Service, assesses whether vessel operators are complying with sanctuary regulations and provides baseline information on vessel use patterns near southeast Farallon Island. This study is conducted in conjunction with PRBO Conservation Science Shark Watch.

<sup>2</sup> For the past 22 years, biologists have been conducting standardized surveys from the lighthouse on southeast Farallon Island. White shark predation events are recorded between 1-September and 30-November, during daylight hours; however, the total number of shark survey hours per day depends on the number of biologists on the island. Surveys are cancelled if weather limits the visibility of the observer to less than 1 km of water around the island. Shark surveys as well as the Vessel Monitoring Project resume as weather permits.



the tag are consistent with what is known of movements of white sharks in the northeast Pacific. Transmissions in early August were from the coast north of the Farallon Islands. For the second tag, only poor quality transmissions (type Z hits) that do not provide location information were received between January 31, 2010 and July 26, 2010. Starting on July 26, 2010 the tag has reported a few locations from the coast north of the Farallon Islands. The persistence of transmissions and the transmitted temperature data are consistent with the survival of both sharks. Similarly, all white sharks tagged using these tags and methods at Guadalupe Island also survived, based on either resightings or tag transmissions, although some of the earlier tags did not report.

Table 1. Dates concerning the two sharks tagged under the Domeier permit.

	Tagging date	Departure date	Return date
Shark #1	October 29, 2009	~ December 13, 2009	~ July 26, 2010
Shark #2	November 2, 2009	~ November 8, 2009	~ August 4, 2010

*Has the behavior of the shark(s) been significantly altered since tagging? How is the behavior of the shark(s) similar or different to other sharks tagged near the Farallon Islands? Did the shark(s) leave at the same time as other sharks, compared across years?*

Both sharks left the GFNMS earlier than usual post tagging, based on the Jorgensen et al. 2009 and Weng et al. 2007 studies. Departure time does appear to be quite variable. In the Jorgensen study, most tagged shark departures began after December 1 and by March 15, with the majority of departures occurring in January through mid February. In the Weng study, departures occurred between November 19 and March 24 with an average departure date of January 2. In the GFNMS, shark sightings have been recorded in GFNMS permittee logs, by the PRBO Shark Watch and through a Vessel Monitoring Project until November 30 or December 15 nearly every year. Exceptions were in 1997 and 2009 when Orcas were present near the Farallon Islands. The sharks Dr. Domeier tagged in 2009 departed around November 8 and December 13. Dr. Domeier suggested early departures may have been due to the presence of Orcas which were first sighted in the GFNMS on November 2; the available sightings data have no records of sharks past November 8, 2009. While these departure dates, especially the November 8 departure, may be earlier than most based on the other tagging studies, it is impossible to assign a cause to the early departures.

A longer-term component of behavior is the seasonal migration. For the Farallon tagged sharks, both animals have returned to the Central California coast near the Farallones suggesting that a migration pattern typical of other tagged male white sharks has resumed.

*Given your knowledge of sharks and shark behavior, based on the shark's known injuries, what long-term injuries, if any, may persist? Repercussions of these injuries?*

In reviewing the materials provided and the methods employed, there is definitely the potential for physical injury from hooking and handling the sharks. The first shark was hooked in the esophagus and the researchers attempted to remove the hook by reaching into the bucal cavity through the gill slits. In addition to a wound where the hook was lodged, there was likely some damage to the gills as efforts were made to free the hook through the gill slit. In the end, the hook was cut near the eye of the hook with most

of the hook left in. Our experience is that sharks appear to be quite robust and capable of recovering from superficial hook wounds, as we have caught sharks with healed wounds. The hook was tin-coated steel and because the eye was cut, the tin was compromised and the hook should have started to rust immediately. But the hook was also very large and how long it may have remained lodged in the esophagus, and to what degree it may have interfered with feeding is unknown. Additionally, there could be injury to internal organs due to the pressure of lying unsupported on the deck. Unfortunately, this type of injury is difficult to assess, confirm or predict the impacts of.

The sharks are intentionally tired out prior to pulling them on the deck. While white sharks may be pre-adapted to tolerate low oxygen conditions, voluntary excursions into oxygen poor waters are likely very different physiologically from an hour-long fight at the end of a line. The survival of these sharks demonstrates that they were able to recover from any potential anaerobic debt. But there is a growing body of literature on stress associated with capture in large pelagic fish, and there may be a threshold stress level beyond which recovery is less likely (e.g. Moyes et al. 2006). It may be worthwhile to measure levels of stress-associated metabolites and blood parameters in order to help evaluate impacts of the capture and handling methods and make recommendations for future safe handling techniques.

The fact that both tags have been transmitting for over 10 months suggests that short-term lethal injury did not occur. However, stress or sub-lethal injuries associated with the capture may still affect the shark's well-being. The long term effects of the methods employed are difficult to assess.

***Are there any changes (in addition to those already made by the permittee) to the hooking/tagging techniques that you would recommend the Sanctuary consider?***

Many of the other tagging studies on sharks have been done in the water or in a cradle or sling and thus are not directly comparable to this one. The large size of these sharks and the hard flat platform may create excessive pressure on tissues and organs that usually do not bear weight. All efforts should be made to minimize the handling time once the shark is on the platform. It would be valuable to work with the permittee to determine if there are other options to reduce the time on the deck and to provide additional support to the animal. Insufficient information was available in the materials provided to assess the timeline of individual components involved in the handling process in order to suggest specific improvements to handling time.

We recommend trying a smaller hook, and the hook should be barbless. Discussions with other researchers and fishermen who have caught large white sharks on hooks suggest that a hook 2/3 or half the size of the one Dr. Domeier uses may be adequate. A smaller barbless hook, no matter where it is lodged, is likely to leave a smaller hole, tear less tissue when removed and corrode more quickly if left in. It is unclear how their revised methods for hooking (using bait near the surface in cloudy waters) help reduce the potential for swallowed hooks. An observer should be on board to record details of the capture and handling. If the revised methods prove inadequate and another white shark is foul hooked, i.e. swallows the hook, then we suggest the GFNMS consider terminating the project.

We recommend using floats that don't have hard ridges and are large enough so that they don't fit in the shark's mouth. The video and photos provided showed that the shark had taken a buoy into its mouth. It took 10 minutes to free the buoy from the shark's mouth.

It may be worth considering limiting the sharks to be tagged to adult females no larger than the maximum size successfully tagged at Guadalupe Island (roughly 18 feet). The effects of being elevated out of the water may be greater as shark size increases and we have no information to indicate that survival rates will be as high for larger sharks. Furthermore, the applicant states that enough information is known about the migrations of adult males. While any potential injury or mortality of a reproductive female would clearly have a greater negative impact on the population reproductive potential than the loss of an adult male, because males are already well studied, there is no need to subject them to the tagging protocols. Given the murky conditions at the Farallones, allowances should be made for accidentally taking males or larger females, both of which should have the hook removed and be released as quickly as possible.

#### **Literature cited**

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