# A Proposal for Preventative Measures and Mitigation for the threat of Entanglement in Hawaiian Monk Seals (*Monachus schauinslandi)* in the Northwestern Hawaiian Islands

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**Justification**

The Northwestern Hawaiian Islands (NWHI) is home to several endangered species of animals including marine turtles, seabirds, and Hawaiian monk seals. This island chain extends nearly 1200 miles and supports six main subpopulations of monk seals. The Hawaiian monk seal population is currently down to roughly 1200 individuals, with most of these individuals living in the NWHI.

Monk seals are subject to several threats. Three threats that cause serious harm or mortality and which are crucial to the recovery of monk seal populations include food limitation, shark predation, and entanglement (NMFS 2007). Hawaiian monk seals have had the highest entanglement rates of all pinnipeds (Morishige et al. 2007). Among the Hawaiian monk seal population, pups and immature seals are the most likely to become entangled. Marine debris that could prove hazardous to monk seals are fishing nets, fishing line, buoys, plastics, and other dangerous materials. Observations have shown that pups and juveniles are most likely to become entangled in nets while adults are most commonly entangled in fishing lines.

The issue of pollution was addressed at the International Convention for the Prevention of Pollution from Ships in 1988 with Annex V of MARPOL. This was designed to reduce the amount of pollution from ships, including plastics. Some marine mammals have benefited from the passing of Annex V and have shown decreasing rates of entanglements. However, studies done since the passing of Annex V have shown that Hawaiian monk seals have shown no difference in entanglement rates compared to rates pre-MARPOL (Henderson, 2001).

There were 173 total documented cases of monk seal entanglement during a seventeen year study (Henderson 2001). Some of these cases resulted in serious harm or injury to the monk seal and others resulted in the death of monk seals. However, it should be noted that estimated death rates for Hawaiian monk seals are probably much higher than we are aware because injury and death counts can only be made when seals are rescued or washed ashore. We cannot account for seals that may have drowned or been unable to swim back to shore and were never noticed entangled or found.

Several studies have shown that much of marine debris which ultimately ends up in the NWHI comes from the North Pacific Subtropical Convergence Zone (STCZ), where debris is known to converge and drift for years to decades. This region occurs as a result of strong surface convergence at the edges of the westerlies and trade winds (Roden 1980). The STCZ is found north of the Hawaiian Islands, typically between 23°N and 37°N (Pichel 2007). There are seasonal and annual variations for this frontal zone. The STCZ can be found further north during summer months and further south during winter months. In addition, it has been shown that the STCZ is affected by El Niño Southern Oscillation (ENSO) events, during which the STCZ travels even farther south than during normal seasonal shifts and more debris is typically found (Morishige et al. 2007).

Efforts are ongoing to protect monk seals from hazardous debris that they can become entangled in. There has been much work done to clean up marine debris both on beaches and in the water to prevent as much entanglement and harm to monk seals as possible (Donohue 2003, Donohue et al. 2001). We could better address the issue of entanglement and protect more Hawaiian monk seals form harm if we could obtain more knowledge about which areas are more prevalent for accumulation of marine debris and which areas would be best to target for cleanup.

**Objectives**

- Determine the origin, nature and density of marine debris within the North Pacific Subtropical Convergence Zone
- Study water movements and major currents that are capable of moving debris from the North Pacific Subtropical Convergence Zone to the Northwestern Hawaiian Islands
- Assess debris to determine the probable time of drift before settling or washing ashore based on the amount of surface area that is covered with fouling organisms
- Design a model to determine more precise circulation and water movement patterns
- Obtain a greater understanding of the role of El Niño and La Niña events in the movement of the STCZ
- Learn the role of El Niño events in accumulating more debris than is typical of normal years and La Niña events in accumulating less debris
- Determine which islands are most likely in a position to accumulate debris based on water movements
- Determine which parts of the islands are most prevalent to collecting debris based on current and wind patterns

- Determine which islands or beaches should be heavily targeted for cleanup based on the amount of expected debris and location of major monk seal populations in the Northwestern Hawaiian Islands
- Cross check data from this study to past data and observations of positions of debris and entanglements from various locations in the NWHI

**Methods**

In order to determine the nature and density of marine debris I will continue with past methods of aerial surveys. Surveys will require a consistent effort over a large range of surface ocean. In addition, it will be important to focus more heavily on El Niño and La Niña events by increasing time spent counting marine debris. Surveys should be conducted four times every month with at least three observers in order to cross check debris counts. Debris counts will be made and recorded in one minute intervals. Due to increases in debris with further southern movement during El Niño years, flights and observers should be doubled during these years. Once flights are concluded, an estimate of density should be calculated based on the amount of debris seen for every one minute of flight time.

Direction and speed of water movement will be determined by mass deploying a series of drifters in the North Pacific Subtropical Convergence Zone and tracking their movement in the surface ocean. Tracking and data collection will be obtained through satellites so that progress of movement can be kept track of on short time scales for a detailed and accurate account of movement. This will be especially important in determining the roles of El Niño and La Niña events. Once this data is obtained and analyzed, I will set up a model to predict future water and current movement.

Once actual data and modeling results have been assessed, I will chart the movement of water to determine which of the NWHI lie in the path of water movement from the STCZ. I will also determine the probability of monk seals encountering debris at various locations for each island. At this point, predictions will be made to determine which areas should be more heavily targeted for active ocean and beach cleanup based on likelihood of accumulation of debris and the number of monk seals, or percent of population, that live in that area, especially taking into consideration those areas which are used by females for pupping. With this knowledge, I will calculate the amount of time and manpower that should be spent on debris cleanup during seasons or years that will be most harmful to Hawaiian monk seals as far as incoming debris that will raise the probability of monk seal entanglement.

Lastly, I will cross check my data and model results with historic observations and data. I will look at how far south the STCZ came in past years, the debris density that was seen in this region, and how many seals became entangled during these times. The same will be done for El Niño and La Niña years. In addition, I will look at density of debris and rates of entanglements during seasons or years where the STCZ stayed farther north. Using old data, and understanding patterns of entanglement for various age groups of monk seals, I will calculate how much of the monk seal population was known to be harmed and killed by marine debris each year. I will also determine the percentage of monk seals entangled for each age class so that I can keep track of how population dynamics and age structure are affected by injuries and mortalities associated with debris entanglements.

**Results**

I am expecting that my results will show debris counts and entanglement rates highest in years where the North Pacific Subtropical Convergence Zone traveled further south during winter. Entanglement rates should decrease during months where the North Pacific Subtropical Convergence Zone remained at latitudes further north. With the North Pacific Subtropical Convergence Zone remaining further north of the Northwestern Hawaiian Islands, debris counts during aerial surveys should increase at higher latitudes and decrease closer to the Northwestern Hawaiian Islands. In addition, there should be a peak number of debris seen and seals entangled during El Niño conditions.

My results should show that certain islands have higher entanglement rates based on both current data from this study and past data from aerial surveys and cleanup efforts. Cleanup efforts in these areas should show higher rates of debris seen by divers and on the beach. Marine debris is an independent variable, so if the amounts of marine debris remain the same there should be no increase in known seal entanglements as the population continues to decline.

Based on the information we incur during this study, we should be able to impact the monk seal population by decreasing the numbers of seals which encounter debris and become entangled. With cleanup efforts and removal of marine debris targeted to higher risk zones that we have determined based on aerial surveys and drifter movement and location, rates of entanglement should decline, especially within certain islands and particular areas of islands. If there is no mitigation, rates of monk seals who become entangled should remain stable with current rates under the assumption that seals are still encountering the same rate of debris.

If marine debris is collected prior to reaching the Northwestern Hawaiian Islands, aerial surveys should show a decrease in the amount of debris seen during one minute intervals of flight time, and an overall decrease in density of debris. With removal of marine debris from specifically targeted areas, we should see a decrease in mortality rate of pups and immature seals, and a shift in both population numbers and age structure of the overall subpopulations living within the Northwestern Hawaiian Islands. There should also be a decrease in mortality caused by entanglement in older mature seals, but with a lower direct impact than seen in the pups and immature seals.

**Contributions**

There are management implications for this study. Already, several agencies work together in order to clean up debris by scuba diving to find hazardous materials that have gotten caught on the reefs. In addition, agencies have been working together to clean up debris that has already washed up on the shorelines (Donohue 2003). These cleanups take a lot of manpower and time to achieve safer conditions for Hawaiian Monk Seals. With the ability to predict where marine debris is coming from and where it is most likely to end up, time could be saved in the cleanup process. Manpower could also be put to better use by knowing which areas should be targeted first or more heavily in order to maximize the resources available to address the entanglement threat on Hawaiian monk seals. It is also possible that knowing which direction or location debris is coming from would allow marine debris to be collected before it came close enough to the Northwestern Hawaiian islands so that the probability of monk seals encountering marine debris would be lower. If this could be achieved, it could be expected that entanglement rates would drop.

There is a huge potential to manage one of the largest threats to Hawaiian monk seal populations. Any positive changes that could occur by alleviating a high risk threat that is crucial to monk seal populations would be encouraging to maintaining current population dynamics and hopefully aid in increasing the number of individuals for the endangered Hawaiian monk seals. In addition, it is critical for pups to make it through their first couple of years. After this time they have a higher chance of survival. Since pups and immature seals are at the highest risk for encountering debris and becoming entangled, the management possibilities for this threat could greatly help the monk seal population by increasing survival at such a crucial life stage.

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