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REDUCING THE RISK OF VESSEL STRIKES TO ENDANGERED WHALES IN THE SANTA BARBARA CHANNEL:

An Economic Analysis and Risk Assessment of Potential Management Scenarios

A Group Project submitted in partial satisfaction of the requirements for the degree of Master of Environmental Science and Management

by

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EXECUTIVE SUMMARY

Background

Renowned for its biological productivity, ecological diversity, and unique combination of oceanic features, the Santa Barbara Channel represents one of the most dynamic and species rich oceanographic regions in the world. As such, the area serves as an especially important feeding ground for migrating and resident populations of endangered blue, fin, and humpback whales. In addition to its ecological importance, the Channel region is a major shipping thoroughfare by which thousands of ships annually transit to and from the Port of Los Angeles/Long Beach. To safely direct ships entering and exiting the region, the International Maritime Organization (IMO) has designated an official Traffic Separation Scheme (TSS) that routes northbound and southbound vessels between the northernmost Channel Islands and the California mainland. These lanes overlap with whale aggregation sites, potentially placing endangered whales in the direct path of thousands of large vessels.

The co-occurrence of whales and ships, especially in confined areas such as the Santa Barbara Channel, increases the likelihood that a whale and ship will interact, which in the most severe cases leads to lethal injury. This scenario became tragically evident during the fall of 2007 when ship strikes were directly implicated in the deaths of four adult blue whales and one fetus in the Channel region. Prior to fall 2007, the maximum number of documented blue whale fatalities in a given year was three, a number that was inclusive of the entire California coast. The fall 2007 event thus represented an unusually high number of mortalities for a single year, and was especially atypical given that all the deaths were confined to the Santa Barbara Channel region.

In response to this event, NOAA's National Marine Fisheries Service (NMFS) and Channel Islands National Marine Sanctuary (CINMS) are working in collaboration to evaluate possible long-term management scenarios, including mandatory speed reductions and changes to the existing TSS, for their ability to reduce the risk of a lethal strike. Integral to this evaluation is an analysis of the change in risk of a lethal strike resulting from management scenarios, as well as an assessment of the economic impacts to the shipping industry. Political constraints and feasibility will also factor into any evaluation of the effectiveness of management scenarios in reducing the risk of vessel strikes to whales.

Purpose

Recognizing the importance of implementing management scenarios that are both ecologically and economically acceptable, this project provides a framework by which NMFS and CINMS can evaluate both the risk implications and economic impacts of different management scenarios. Specifically we considered four potential management options:

- MANAGEMENT OPTION 1: Year-round mandatory speed reduction to 10 knots in the Channel;
- MANAGEMENT OPTION 2: Seasonal mandatory speed reduction to 10 knots in the Channel from April to September;
- MANAGEMENT OPTION 3: A narrowing of the TSS inside the Channel;
- MANAGEMENT OPTION 4: A shift in the TSS to the south of the Northern Channel Islands.

To evaluate and compare these management options, we developed two models, one that estimates the change in relative risk of a lethal strike based on predicted whale distributions and vessel traffic patterns, and a second that calculates the change in total cost to the shipping industry. By combining the results of these two models, we were able to determine which of the four management options resulted in the greatest reduction in relative risk per dollar cost to the industry.

Risk Analysis

To estimate the risk of lethal vessel strikes to whales in the Santa Barbara Channel, we developed a simple, two-dimensional surface model that combined estimates of whale distribution and vessel traffic patterns. We used vessel traffic data transmitted by ships via the Automatic Identification System to characterize ship traffic in the region for one year. By modeling a change in the speed and/or spatial distribution of vessels, in accordance with the associated management option, we were able to evaluate and compare the change in relative risk of lethal strikes resulting from each management option. Our risk analysis does not attempt to assess the absolute risk of lethal ship strikes to whales, nor does it estimate the number of lethal strikes likely occurring. Rather, we have specifically examined the change in both the relative risk of an encounter and the relative risk of a lethal whale strike resulting from each of the four management options.

We assumed that the relative risk of a lethal strike is a function of both the relative probability of a whale and the relative probability of a ship occupying a given area. Using standardized aerial observation data provided by CINMS, we developed two models to predict the relative distribution of whales in the Channel region. The first model (the Average Distribution Model) applied the average sightings per unit effort value uniformly throughout the study area, while the second (the Linear Predictive Model) predicted whale distribution based on the relationship between observed whale distributions and the static environmental variables of bathymetric depth, slope, and distance to shore. Both models were used separately to calculate the relative probability of a whale in a given area. These relative probabilities were then combined with the relative probability of a ship occupying the same areas under each management scenario to yield the relative probability of an encounter occurring between a whale and a ship in a given area. This value, however, provided no information on whether an encounter would be lethal, which is instead a function of ship speed – increased ship speed increases the probability of a lethal encounter. The relative risk of a lethal encounter was subsequently calculated by combining the relative probability of an encounter with the relative probability that an encounter would be lethal.

Relative risk was calculated, for both models, on a quarterly basis for each management option, and then summed over all four quarters to provide an annual relative risk. We then calculated the percent change in the annual relative risk for each management option compared to the annual relative risk for baseline conditions ("status quo"). The resulting value provided the percent by which each management option changed the relative risk of a lethal whale strike, as compared to the relative risk of the status quo.

Economic Analysis

To determine the economic implications associated with each management option, we designed a model that estimated the annual change in total cost to the shipping industry for each management scenario, using a random subset of transits through the region from July 2008 through June 2009. First, our model estimated the change in voyage costs, including changes in fuel and lubricant costs due to increased distance traveled or changes in speed. As a result of current and forthcoming air quality regulations, our model assumed that ships traveling within the Santa Barbara region will use more expensive, low-sulfur fuel. Where our model predicted that ships would speed up outside the region to make up for lost time due to increased

distance traveled or a mandatory reduction in speed, we assumed they would do so using less expensive, regular fuel. Second, our model estimated the change in operating costs, including changes in crew costs and additional repair and maintenance cost. As with fuel costs, we made certain simplifying assumptions regarding whether crew overtime charges and additional repair costs would be incurred.

Our model also incorporated an additional hourly factor ("*alpha*") to account for certain unpredictable costs that, based on discussions with industry experts, were unlikely to be captured within the voyage or operating cost components of our model. Among other things, this hourly factor may include additional costs of delay or hourly operating costs potentially affected by increased time at sea. *Alpha* was parameterized using data on ship routes before and after air quality regulations were implemented in July 2009. A final component of our model accounts for the Navy's occasional requests that ships transiting the nearby Point Mugu Sea Range slow down or alter course due to ongoing operations within the area. As a result, we included the cost of an unexpected delay resulting from Navy operations for ships transiting on the south side of the Northern Channel Islands. This cost, which applies only to Management Option 4 (a shift of the TSS to the south), was calculated by multiplying the probability of a Navy request that a ship alter course or speed by the expected costs resulting from a missed or delayed port call.

Using these cost components, our economic model estimates the change in cost due to each management scenario by comparing the cost of a transit due to a change in management with the "normal" cost of a transit through the region. The change in costs was calculated annually for Management Options 1, 3 and 4 and from April to September for Management Option 2. To determine the "status quo" against which the change in cost was evaluated, we assumed that the route and speed of each vessel traveling through the region between July 2008 and June 2009 reflected "status quo" behavior and, thus, constituted the preferred operational profile of each ship. The resulting cost of each management scenario provided a basis for comparing the economic implications of potential management options with the estimated reduction in the risk of a lethal vessel strike to a whale.

Results and Conclusions

Of the four management scenarios, only year-round and seasonal mandatory speed reductions reduced the relative risk of a lethal strike. Conversely, both

narrowing the TSS and shifting the TSS to the south may actually increase the relative risk of lethal strike. This is due largely to the fact that modeled shipping lanes would coincide with areas of greater predicted whale densities. On the other hand, mandatory speed reductions may directly reduce the lethality of a strike (as speed reduction has been shown to decrease the probability of a fatal encounter), without altering the spatial distribution of ships.

While mandatory speed reductions resulted in the greatest reduction in relative risk, narrowing the TSS was the only management option that resulted in a cost savings to the shipping industry. Savings are largely attributed to the fact that narrowing the TSS reduces the overall transit by 0.07 nautical miles. Mandatory speed reductions and shifting the TSS to the south, in contrast, resulted in costs to the shipping industry, as these options involve extra time spent at sea, changes in fuel and lubricant consumption, and potentially unexpected delays. In particular, shifting the TSS to the south resulted in the largest annual cost, estimated at nearly ten times the cost incurred by mandatory speed reductions.

Combining the results of the risk and economic models indicates that mandatory speed reductions are, according to these models, the most cost effective management options. While mandatory speed reductions do increase shipping industry costs, these costs are comparatively much lower than the cost of rerouting ships to the south. Furthermore, although narrowing the TSS results in cost savings, it simultaneously *increases* the probability of a lethal strike. It is also important to consider the ease with which each management option can be implemented when evaluating cost-effectiveness. These options would require the collaboration of numerous stakeholders, not to mention time, money, and possibly approval by domestic and international governing bodies.

Ultimately, however, the goal of this project is not to make policy recommendations, but rather to provide a framework for assessing the effects of different management options on the relative risk of a lethal strike and the cost to the shipping industry. In addition to risk and economic factors, a myriad of other considerations may affect the propriety of adopting a particular regulatory scheme to reduce the risk of vessel strikes to whales in the Channel. As a result, future analyses of different management scenarios should also consider other relevant factors, including policy, enforcement, or other issues that may complicate implementation. Moreover, the analyses we have presented here are based on the best available information. As such, new or better information should be integrated accordingly.