Assessing the Extent of Competition Between Steller Sea Lions and Commercial Fisheries

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We conducted a spatial and temporal analysis of fisheries data to assess the extent of overlap between groundfish fisheries and Steller sea lions in the Gulf of Alaska and Bering Sea. Such an analysis has never been undertaken before and has been noticeably absent from recent Biological Opinions addressing the effects of groundfish fisheries on Steller sea lions. Fisheries data (catch, effort and location) were combined with sea lion data (counts and foraging distances) to identify the potential degree of overlap in distributions (the joint probability of fisheries and sea lion probability). This analysis is needed to determine the effectiveness of fishery management measures intended to minimize impacts on Steller sea lions.

We began our analysis by averaging the number of sea lions counted by NMFS and other researchers at each haulout (n=123) or rookery (n=49) in Alaska from 1956 to 2000 to identify areas of high sea lion concentrations. Sea lion (and fisheries) data were split into two seasons: summer (June – August) and winter (October – April). Assuming that swimming sea lions were normally distributed around each rookery or haulout (i.e., sea lions have a higher probability of being near shore than being far out to sea), we calculated the probability of sea lions occurring within a 5km grid overlaid over the entire eastern Bering Sea and Gulf of Alaska. We parameterized this portion of the model using the mean distances traveled (and associated standard deviations) by satellite-tracked individuals reported by Merrick and Loughlin (1997). Figures A and E show the probability of encountering a sea lion in different regions of the Gulf of Alaska and Bering Sea based only on population density and distance from rookeries or haulouts. However, it is unlikely that sea lions swim randomly away from their haulouts. Instead, they are likely drawn to areas of high fish concentrations, which are typically associated with areas of high upwelling and productivity. Such regions are usually associated with sharp changes in bottom topography such as shelf breaks.

We obtained the most comprehensive bathymetry data available for the Gulf of Alaska and Bering Sea from Scientific Fishery Systems Inc. (Dr. E.O. Rogers, personal communication), and combined this with a standardized grid of elevations (ETOPO5) to cover the entire study area. From this, we calculated the average depth and slope (steepness) for each 5km grid cell. We then grouped the slope values into 10 categories, and assigned probabilities ranging from 0 for flat areas, to 1 for the highest slopes. We also created a simple distribution of the preferred diving depths of Steller sea lions using median and maximum dive depths reported by Merrick and Loughlin (1997), and assigned a probability of 1.0 to the median dive depth. Thus we assumed that the sea lions tagged by Merrick and Loughlin (1997) dove to the bottom, and that the occurrence of sea lions increases with increasing slope. Adding these two probabilities together yields a bathymetry-based probability of potentially “good” sea lion foraging areas in the Gulf of Alaska and Bering Sea. Multiplying these feeding probabilities by the swimming probabilities shown for each grid cell in Figures A and E in turn yields a modified probability of encountering Steller sea lions (i.e., the most likely areas used) in summer (Fig. E) and winter (Fig. F).
Fishery observer data (1973-2000) was provided by NMFS and included gear type, duration of haul, location and amount caught, among other parameters. We calculated the logarithm of the total fishing effort (i.e., hours spent trawling, summed across all years) within each 5 km grid cell of the Gulf of Alaska and Bering Sea. We then grouped the total effort into 10 categories and assigned fishing probabilities ranging from 0 for no effort, to 1 for regions with the highest fishing efforts. This effectively modeled the probability of encountering a groundfish vessel fishing within any given region of the Gulf of Alaska and Bering Sea in summer (Fig. C) and winter (Fig. G). Note that these probabilities are likely correlated with the probability of encountering high concentrations of groundfish; and that the data do not distinguish between current fishing areas and historic fishing areas (i.e., prior to fishing closures to protect Steller sea lions).

The final step of our analysis calculated the probability of sea lions (Figs. B and F) and fisheries (Figs. C and G) occurring in the same place (i.e., the same grid cell) in summer (Fig. D) and winter (Fig. H). These figures suggest very low interactions during summer (Fig. D) and significantly higher interactions during winter (Fig. H). However, much of the potential interactions during winter have likely been mitigated by closures or reductions in fishing effort within the regions designated by NMFS as critical habitat.

Figs. D and H show the regions designated as Critical Habitat in 1993 by NMFS (in dark green). Comparing these regions with those we designated as Steller sea lion habitat based on the biology of the animal and the physical properties of the environment (Figs. B and F) show considerable disparity. Some regions designated by NMFS as Critical Habitat appear to be little used by sea lions, while other areas that are likely heavily used by sea lions have no official designation. Our results also suggest that the Gulf of Alaska is more important in terms of sea lion habitat than is the Bering Sea.

The results we have presented here should be considered preliminary and will be refined as we incorporate additional data about foraging locations (from satellite tracking), sea lion by-catch areas (from observer data), fish distributions, and physical oceanography (water currents, temperatures and salinities). The funding we received from PCCRC in 2001 has enabled us to create the first-ever rule-based model to predict sea lion habitat and fishing probabilities. Assumptions about the parameters we have used are well documented, and can be easily changed and examined allowing a relatively transparent means to explore alternative possibilities.

Over the next 3 years we hope to continue developing our Steller sea lion habitat model, and will develop analytical methods to 1) test its validity and 2) fully evaluate the degree of overlap between sea lion habitat and commercial fishing effort. We hope to incorporate bioenergetics and fish distribution data in Year 2, along with biological oceanography and remote sensing data in Year 3. The habitat tools we are developing to accomplish these research objectives are evolving into a software system capable of supporting key decisions regarding the management of commercial fisheries and Steller sea lions.

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A. Sea Lion Habitat (normal distribution)

B. Sea Lion Habitat (modified by bathymetry)

C. Groundfish Fishing Effort

D. Overlap Between Sea Lion Habitat (B) and Fishing (C).
WINTER

E. Sea Lion Habitat (normal distribution)

F. Sea Lion Habitat (modified by bathymetry)

G. Groundfish Fishing Effort

H. Overlap Between Sea Lion Habitat (F) and Fishing (G).

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