Effects of sea level rise and storm surge on Pacific harbor seal habitat: a comparison of haul-out changes at the Russian and Eel River Estuaries

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Introduction: Indicator species are sentinels of the effects of processes that are, by nature or scale, difficult to observe. The effects of climate change are myriad, and unwieldy to directly observe. Changes in distribution of marine mammals can function effectively as a symptom of larger changes in the ecosystem (1). Pinnipeds are relatively easily observed at terrestrial habitats, called haul-outs, which are essential for resting, pupping, and molting. Harbor seals (Phoca vitulina richardii) are abundant along the California coast (2).

Methods: Citizen science has a critical role to play in responses to impacts of coastal climate change. Collection of the observations necessary to respond at the local and regional level is impossible and impractical without the concerted efforts of interested local stakeholders. At the mouth of the Russian River, Ms. Elinor Twohy has recorded seals at the haul-out for three decades. I used her long-term dataset, coupled with NMFS aerial observations, to support modeling suitable haul-out habitat.

Results: Flood models

Fig. 4. Intermediate SLR value scenarios projected by the United States Army Corps of Engineers (5).

Fig. 5. Griggs et al. 2017 (7), intermediate San Francisco Golden Gate scenario values.

Results: Haul-out Area & Quality Change

Fig. 6. Total change in haul-out area at both sites (total bar size in the figures below). Reduction in shoreline complexity likely explains the loss of habitat under the Eel River 2100 extreme SLR.

Fig. 7. Eel River area, total change in habitat area and quality bin area. Ranks are a summation of landscape factors influencing haul-out behavior, including slope, distance from shore, and protection from wind/wave action.

Fig. 8. Russian River area, total change in habitat area and quality bin area. Ranks are a summation of landscape factors influencing haul-out behavior, including slope, distance from shore, and protection from wind/wave action.

Results: Storms!

Accounting for storms is important. Not only do they add much additional flooding, but the pattern of inundation is different. I used United States Geological Survey (USGS) Coastal Storm Modeling System (CoSMoS) storm models to account for waves and storm surge in the area around the Russian River.

Results: Storms!

Model Validation: Several models were tested to best represent local observed flooding patterns. Differences between the models are generally small, however impactful at the resolution of single estuary sites.

Fig. 11. Habitat available under storm conditions differ in pattern and magnitude from SLR projections alone. The blue line is the same as Fig. 10, while the brown line shows habitat available with and without storms.

Fig. 12. Flood rasters and shorelines derived from CoSMoS storm and SLR projections.

Conclusions: SLRs poses significant changes to coastal areas and habitats. I have chosen relatively moderate scenarios for most of this work – the differences shown at the extreme scenario in less than a century are quite significant. At these extremes, even near-term coastal adaptive management will require swift response. Spatial modeling can be readily adjusted with new understanding of the area or updates in the projections of change. While high-resolution spatial data are expensive and labor-intensive to produce and quality correct, the resulting capabilities are highly plastic. Developing models that can be easily updated as projections change is an essential tactic for responding at the pace changes are occurring, and will continue to occur. Storm surges are critical to consider. They change the extent and pattern of inundation. These events are also highly dependent on the natural buffering and infrastructure capabilities of the shoreline. This would be an interesting and highly relevant avenue for further research.

Further analysis of the Russian River estuary dataset is likely to reveal variables influencing fine-scale haul-out selection. They may serve as an effective indicator for local phenomena, such as factors correlated with prey availability.

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