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Population Trends of Steller Sea Lions *(Eumetopias jubatus)* with Respect to Measures of Chlorophyll-*a* in Critical Habitat

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Abstract

Although a myriad of factors likely contributed to the decline of the western distinct population segment (wDPS) of Steller sea lion *(Eumetopias jubatus)* in Alaska, changes in life history over the past three decades have been consistent with nutritional stress attributed to bottom-up forces. As a result, the Recovery Plan for this species suggests that designated critical habitat should be enhanced to incorporate the spatial and temporal variation of essential oceanographic features that potentially influence the distribution and abundance of prey and ultimate survival of Steller sea lions. The Recovery Plan also states that in addition to stationary habitat features (i.e. bathymetry and the continental shelf), dynamic features should be considered (NMFS 2008). It is first necessary, therefore, to determine which dynamic features constitute essential habitat. For this study, chlorophyll-*a* (chl-*a*) data (2000-2009), which serve as a proxy for primary productivity, were collected by the SeaWIFS sensor and obtained from the Ocean Color Discipline Processing System. Steller sea lion pup productivity for sub-regions of the wDPS during this time period were examined with respect to corresponding average, maximum, and variance of chl-*a* concentrations in Steller sea lion critical habitat. There were no apparent relationships between pup productivity and measures of chl-*a* within regions, whereas data pooled across regions displayed a significant, positive relationship with respect to annual values of maximum chl-*a*. Additionally, rate of population change from 2000 to 2008 was significantly related to the average of annual values of maximum chl-*a*. Overall, it appeared large pulses of chl-*a*, which primarily occurred during spring and summer months, were beneficial for pup productivity and population growth. Management of dynamic oceanographic features that are important to sea lions will inevitably entail having a clear understanding of their underlying processes. Furthermore, the exploration of how other dynamic oceanographic features affect Steller sea lions will be useful for evaluating the efficacy of conservation measures, including the revision of designated critical habitat.

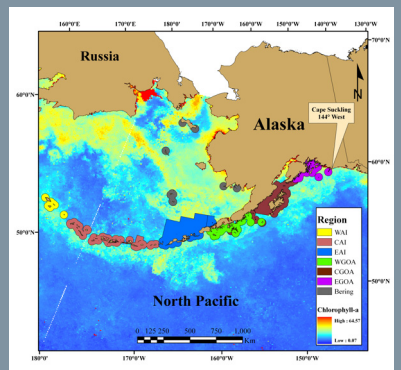

Fig. 1. Steller sea lion critical habitat (50 CFR 226.202, including all protection zones). Colors denote the geographical sub-regions of the wDPS as outlined in Fritz et al. (2008).

Methods

- Seasonal chl-*a* data (9 km resolution) collected by the SeaWIFS sensor (2000 to 2009) were obtained from the Ocean Color Discipline Processing System (oceancolor.gsfc.nasa.gov).
- All remote sensing data were converted to raster grids, projected to an Albers equal-area conic projection (ArcInfo; ESRI, Redlands, CA), and clipped to Steller sea lion critical habitat (Fig. 1).
- Annual composites (June to June) of chl-*a* were formed to coincide with Steller sea lion surveys, which were conducted during June (mid breeding season).
- Annual measures of sea lion productivity (ratio of pups/non-pups) for six regions of the wDPS including the western, central, and eastern Aleutian Islands and the western, central, and eastern Gulf of Alaska (Fig. 1), were calculated with counts obtained from aerial surveys.[1] Measures of sea lion productivity for each region were examined with respect to corresponding average, maximum, and variance of chl-*a* for the previous year. For example, data resulting from counts conducted during 2000 were examined with respect to measures of chl-*a* from June 1999 to June 2000. Additionally, rate of Steller sea lion population change (non-pups) from 2000 to 2008 was examined with respect to measures of chl-*a*.

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Results

- There were no apparent relationships between pup productivity and remaining measures of chl-*a*.
- Relationships within regions and time lags were not investigated because of insufficient data.

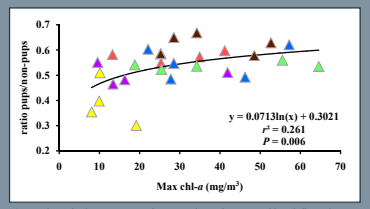


Fig. 2. Relationship between pup productivity and annual maximum chlorophyll-*a*. Colors denote the geographical sub-regions indicated in Fig. 1. Data points (n = 27) were from 2000, 2002, 2004, 2005, and 2009.

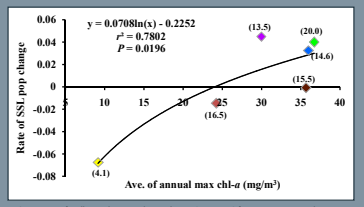
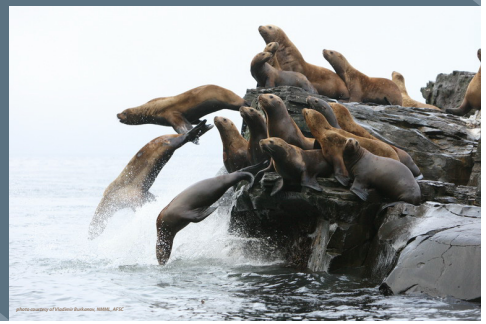


Fig. 3. Rate of Steller sea lion population change (non-pups) from 2000 to 2008 relative to the average of annual maximum values of chlorophyll-*a* over that time period. Numbers in parentheses denote the standard deviation for chlorophyll-*a*.

Discussion & Conclusions

- It appeared that large pulses of primary productivity were beneficial for pup productivity and population growth.
- Management of dynamic oceanographic features that are important to sea lions will ultimately entail having a clear understanding of their underlying processes and the investigation of substantial time series of data at proper spatial & temporal scales.
- Future work will entail examining the persistence and predictability of chl-*a* hot spots.



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Footnote
1. Data were compiled from Sease and Gudmundson 2002, Holmes et al. 2007, Fritz et al. 2008, and NMML unpublished data.

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