



Flexible foragers: changes in the winter diet of California sea lions (*Zalophus californianus*) in Monterey Bay during years with different oceanographic conditions



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Abstract

Temporal variability in oceanographic conditions has been increasing in the California Current system and resulting changes in prey distribution and abundance have been documented; however, predator response is less understood. California sea lions (CSLs; *Zalophus californianus*) are an abundant predator in this system and have a wide breadth of potential prey. We examined the winter diet of CSLs hauled-out at the United States Coast Guard Jetty in Monterey, California from October 2007 to January 2008 during a La Niña event using scatological analysis (n=62). Samples were rinsed through a series of nested sieves and all identifiable prey remains were enumerated to the lowest taxonomic level possible following methods outlined by Weise (2000). Our data were compared with a prior scatology study conducted by Weise (2000) at the same location during an El Niño event from November 1997 to January 1998. Although a similar suite of prey species was consumed during the two winter periods, during the 2007-08 La Niña winter when there was increased upwelling and decreased sea surface temperature significantly greater numbers of Pacific sardine (*Sardinops sagax*), northern anchovy (*Engraulis mordax*) and Pacific jack mackerel (*Trachurus symmetricus*) were consumed while significantly lesser numbers of elasmobranchs and market squid (*Loligo opalescens*) were consumed (G test_(0.05,20,62): 938.7981). Our results support the Weise and Harvey (2008) hypothesis that CSLs foraging in central California are “plastic specialists” whose dynamic diet is a result of feeding on seasonally abundant, aggregating prey.

Methods

• CSLs hauled-out at the site were counted and flushed. Scat samples were collected randomly, placed into individual bags, and frozen for later processing (n=62; Fig.1 and Fig. 2).

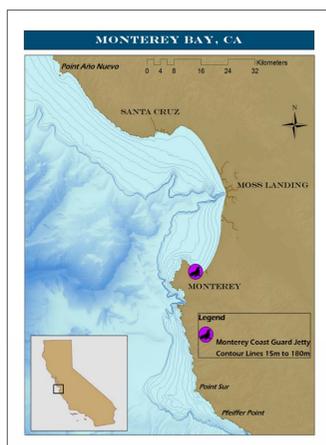


Figure 1. Map of Monterey Bay and surrounding open coast. Haul-out location is close to shelf and pelagic water habitat.

Metrics calculated:

Per sample, and then averaged:

% Number (%N) = number of each species / total number of prey items

% Mass* (%M) = mass of each species / total mass of prey items

*Note: fish mass was calculated using two species-specific regressions: 1) otolith length to fish length, and 2) fish length to fish mass

For all samples:

% Frequency of occurrence (%FO) = proportion of scats containing a species

To minimize biases of these individual metrics we calculated:

Index of Relative Importance (IRI) = (mean %N + mean %M)*(%FO)

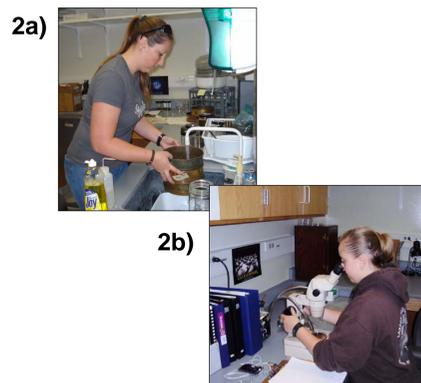


Figure 2. a) Each scat was washed through nested sieves, prey remains were collected, and b) remains were identified and enumerated using a microscope.

Results

- During the present study, 1,892 CSLs were observed using the haul-out site with 90.2% adult females, juveniles, and yearlings of both sexes and 9.8% adult males. Similarly, Weise (2000) observed 14.3% adult males.
- Seven tagged CSLs were observed between October 2007 and January 2008. Two of these tagged individuals were seen on consecutive, random sampling dates spanning four and five weeks.
- Sixteen prey species were consumed in the present study (2007-08) compared with nineteen in 1997-98 (Weise 2000). In both studies five species comprised 97% of the diet by number (Fig. 3, Fig. 4, and Fig. 5).

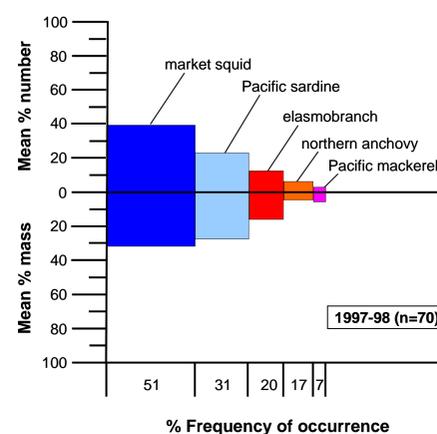


Figure 3. IRI diagram containing mean %N, mean %M, and %FO for the top five prey species during El Niño winter 1997-98 from Weise (2000).

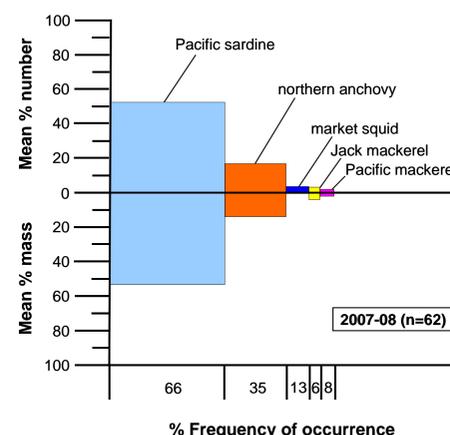


Figure 4. IRI diagram containing mean %N, mean %M, and %FO for the top five prey species during La Niña winter 2007-08.

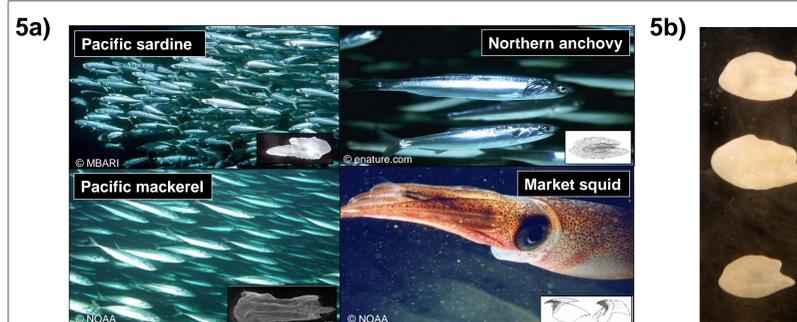


Figure 5. a) Examples of CSL prey species and their undigested, diagnostic structures and b) digested northern anchovy otoliths exhibiting various qualities and erosion levels.

Conclusions

- Re-sightings of marked individuals indicate at least short term site fidelity to the Monterey Coast Guard jetty on the order of weeks.
- The two study periods (1997-98 and 2007-08) had different oceanographic regimes (Pacific Environmental Laboratory (PFEL) upwelling index data, Fig. 6) that likely altered fish distribution and abundance.

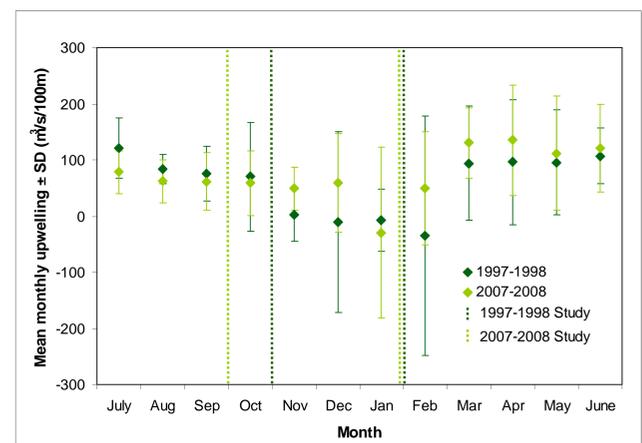


Figure 6. Mean monthly upwelling (m³/s/100m coastline) from 1 July to 30 June (PFEL). Dashed lines indicate the two sampling periods, both of which were during the non-upwelling period of the year. El Niño processes dominated the 1997-98 winter yielding lesser upwelling than the La Niña processes during winter 2007-08.

- This study demonstrates that CSLs feed on a suite of species; however, on a seasonal time scale they specialize on a few main prey items that are influenced by oceanographic conditions.
- During winter 1997-98, coastal water had greater salinity, was nutrient poor, and SST was 2-4°C warmer than normal resulting in a temporary shift of prey northward (Lynn et al. 1998). California Department of Fish and Game (CDFG) commercial fish landings indicated an abundance of squid and sardine with lesser abundance of anchovy and mackerel in Monterey Bay during this time. As “plastic specialists”, CSLs became squid specialists taking some coastal pelagic fishes (notably sardine over anchovy), few elasmobranchs, and incidental mackerel. High squid recruitment in April 1997 likely led to abundant adult squid in Monterey Bay during winter 1997-98 leading to its importance in the diet (CDFG, Squid Fishery Management Plan (FMP) 2005).
- During spring and summer 2007 coastal water off central California was 1°C colder and more saline as a result of anomalously strong upwelling (McClatchie et al. 2008). These La Niña conditions continued into winter 2007-08 when CSLs were Pacific sardine specialists while feeding on some anchovy, small amounts of squid, and incidental mackerel. We believe poor recruitment of squid in the two years before our study led to low abundance of adult squid in Monterey Bay during winter 2007-08 (Squid FMP 2005, CDFG commercial landings). Weise (pers. comm.) found elasmobranchs primarily in scat samples collected in north Monterey Bay; therefore, the lack of elasmobranchs in our study is likely a result of sampling only south Monterey Bay.

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