Seasonal response of large mobile predators to oceanographic and prey conditions at an offshore abysso-pelagic environment

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Summary

Many large mobile predators occupy offshore pelagic environments, yet these habitats are surveyed less frequently than coastal areas. We present results from one-year (October 2016 – October 2017) of passive and active acoustic observations collected in conjunction with oceanographic measures at a mooring located 150 nmi offshore of Southern California, in abyssopelagic waters. The passive acoustic data indicate seasonal presence of delphinids, and baleen, sperm, and beaked whales throughout the recording period. Seasonal variability is also evident in the acoustic backscatter data from 500 m depth to the sea surface, which is attributed to small pelagic fishes, krill, and diel vertical migrators. Concurrently measured water properties correspond with these changes in animal community composition.

Fin whales (*Balaenoptera physalus*) reacted strongly to backscatter at 100-150 m water depth, most obvious in late summer. Backscatter from diel vertical migrators, present during parts of summer and throughout fall coincided with night-time echolocation clicks of common dolphins (*Delphinus delphis*). Risso's (*Grampus griseus*) and Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) echolocation clicks were coincident with near-surface backscatter but during winter and early spring. This backscatter was likely from small pelagic fishes, as diel vertical migration was virtually absent from the area during that time. Echolocation clicks from Cuvier's beaked whales (*Ziphius cavirostris*) were prominent during winter and spring, associated with water from the California Current, but were absent in early summer when the water warmed and freshened at their foraging depths.

This study of mobile predators, their prey and oceanographic conditions elucidates trophic and environmental interactions and provides new information on ecosystem processes throughout the water column. Further long-term observations are needed to document and understand how warming oceans will alter ecosystems.

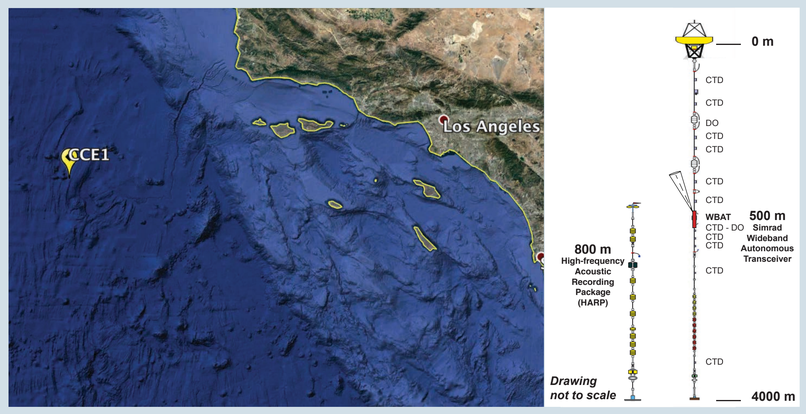

Figure 1. Left: *Location of the California Current Ecosystem mooring 1 (CCE1) offshore Southern California in 4000 m water depth.* ***Right:*** *Mooring drawings with passive and active acoustic recorders and CTDs.*

Marine communities favor very specific water properties. Warming oceans will drastically alter current ecosystems.

Sustained long-term observations are needed to detect and understand ecosystem changes.

Oceanography - Prey & Predator Response

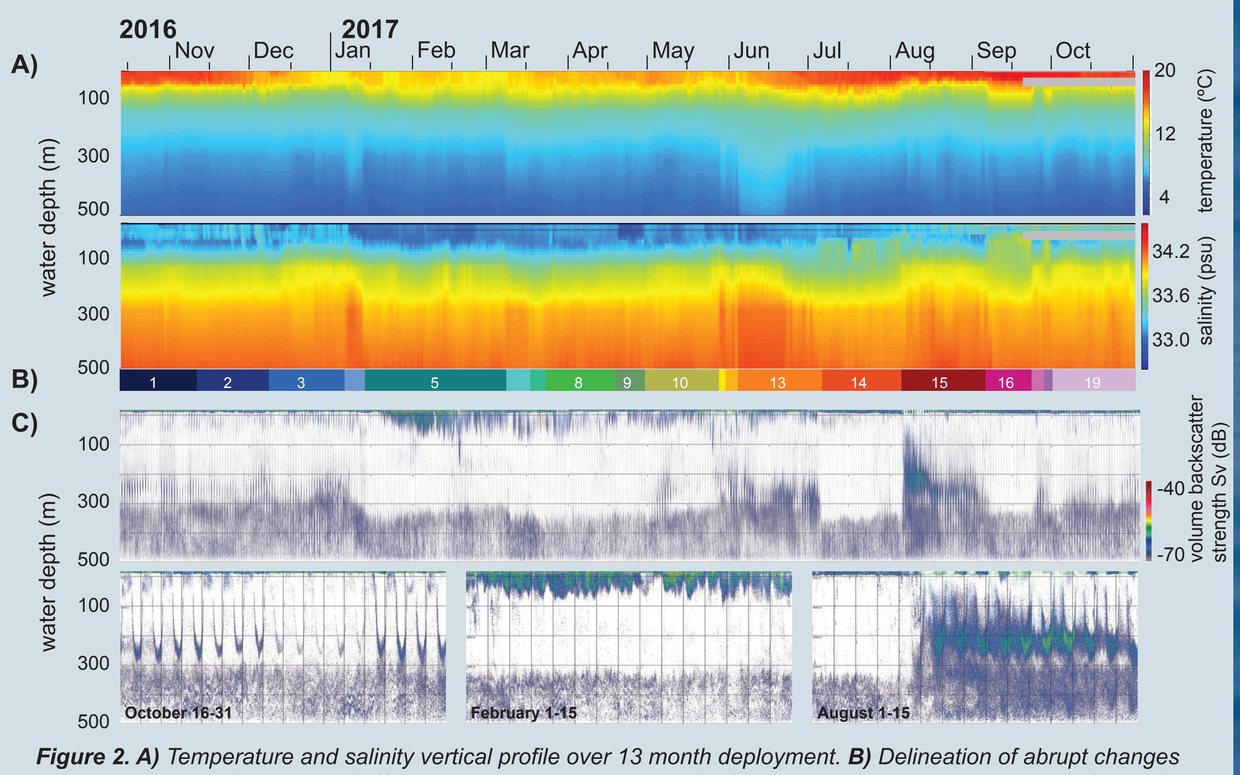

Figure 2. A) *Temperature and salinity vertical profile over 13 month deployment.* ***B)*** *Delineation of abrupt changes in water properties (1-19 colors).* ***C)*** *Volume backscatter strength (top) and representative scatter details (bottom).*

Figure 3. *Acoustic detections of cetacean signals on passive acoustic data.* ***A)*** *Baleen whale calls.* ***B)*** *Beaked whale echolocation clicks.* ***C)*** *Other toothed whale echolocation clicks. Change of water properties (1-19) as background color.*

Prey & Water Features Over Time

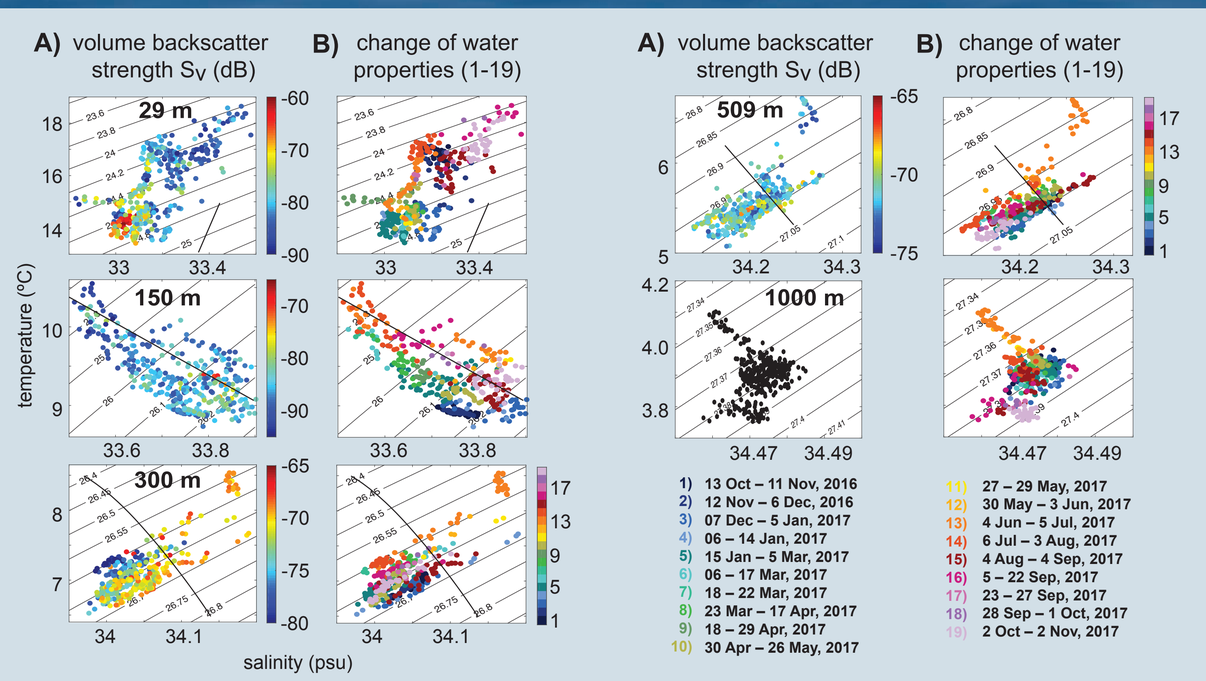

Figure 4. *Daily temperature and salinity at each CTD depth with* ***A)*** *volume backscatter strength in color (not available at 1000 m);* ***B)*** *abrupt changes in water properties (1-19, see Figure 1). Black lines delineate properties of California Current (to left of line) and California Undercurrent (to right of line). Isopycnals in background.*

Generalized Additive Models

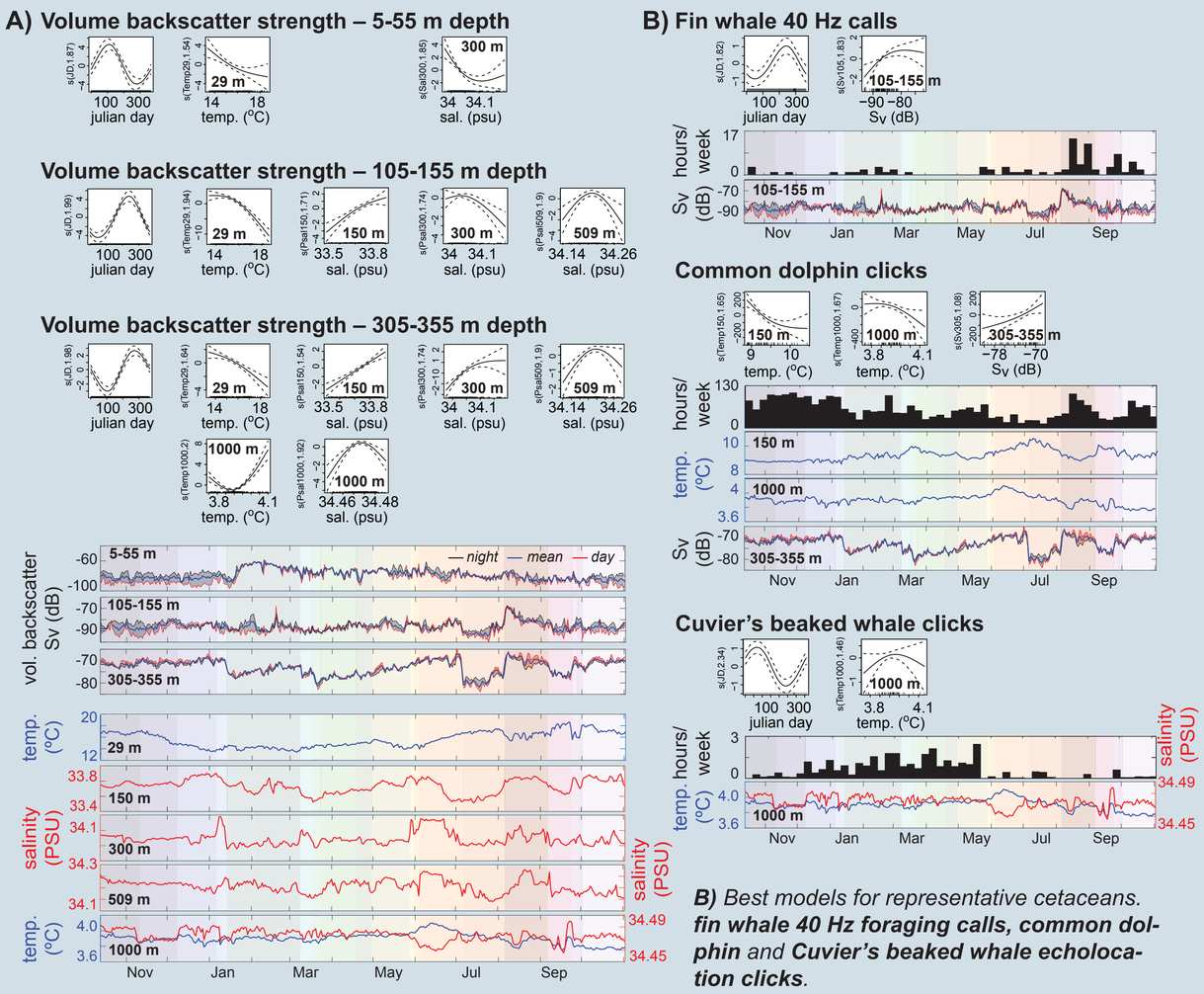

Figure 5. *Predictive variables for patterns of occurrence (generalized additive models).* ***A) Volume backscatter strength*** *at three representative depths and their best models.*

B) *Best models for representative cetaceans.* ***fin whale 40 Hz foraging calls, common dolphin*** *and* ***Cuvier's beaked whale echolocation clicks****.*

Time series are displayed for all selected model variables with change of water properties (1-19) as background color.

Acknowledgements

Funding for this project was provided by the **Office of Naval Research Young Investigator Program**. Data collection for the CCE1 mooring was made possible with funding from the **NOAA Ocean Acidification Program** and the **NOAA Climate Program Office**, as well as funding from the **National Science Foundation** through the CCE-LTER program. The authors thank staff of the Scripps Acoustic Ecology Lab and Scripps Whale Acoustics Lab for fieldwork, gear and analysis assistance.

Illustration: Uko Gorter