Thesis outline  
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## Objective: Characterize the soundscape/acoustic habitat of beaked and sperm whales in the California Current Ecosystem using soundscape metrics and vessel tracking.

#### Explore the relationship (spatial/temporal variation?) between soundscape metrics and environmental variables, and beaked whale (BW) and sperm whale (SW) detections. (Alternative: Describe the acoustic environment where deep-diving species are present/absent. Describe sound levels during vessel passage, describe acoustic and physical environment during loud sound events)

Goals:

1. Evaluate spatial and temporal variability of sound within various frequency bands and oceanographic variables when beaked and sperm whales are present and absent.
2. Determine strong environmental and acoustic predictors of beaked and sperm whale presence.
3. Evaluate sound levels at points before, during, and after vessel-buoy co-occurrence.
4. Evaluate the effect of spatial proximity of vessels during loud sound events with the use of AIS tracking.

How?

* Exploratory plots: Create histograms, scatterplots, time series, facet graphs of:
  + A soundscape metric/BW/SW presence + absence/env variable
    - Comparing TOL intensities between drift 8 and 10 (**only two drifts for now**)
    - Broadband levels, Third-octave levels at 63, 125, 2000, 5000, 20000 Hz
    - Created time series for avg daily environmental variable
    - Which frequencies had the most loudness? What does the soundscape look like when there are high BW detections? What sound levels are BW/SW most getting exposed to?
    - At the species level – can I identify a species that is more tolerant of loud noises?
  + Oceanographic characteristics
    - Bottom depth (**done for drift 8**)
    - Bottom slope (**done for drift 8**)
    - Distance from shore **(done for drift 8)**
    - Distance from continental shelf (**done for drift 8**)
    - Sea surface temperature **(done for drift 8**)
    - Sea surface height anomalies **(done for drift 8)**
    - Sea surface height slope (in progress)
    - Chlorophyll-a **(done for drift 8**)
    - Curl of wind stress (in progress)
    - Mixed layer depth (MLD) **(done for drift 8**)
    - Mixed layer depth Temperature **(done for drift 8**)
    - Thermocline temperature (TTemp) **(done for drift 8**)
    - Thermocline depth **(done for drift 8**)
    - Temperature at 400 m **(done for drift 8**)
    - Salinity at 400 m **(done for drift 8**)
  + Vessel Presence
    - Find and compare instances of BW detection with no vessel with BW detection with vessel at 10km away and 5 km away**. Assess sound levels** for each
      * Number of ship passages, types of ships (**IN PROGRESS**)
        + Create 10-km buffer around drift tracks (“listening space”)
        + Intersect vessels that lie within buffer
        + Identify 1) distance to closest vessel within 10 km, and 2) number of unique vessels within 10 km
        + Drift 8: 5 instances of co-occurrence
      * **Assess sound levels**: difference in decibels, change in sound levels just before and just after a vessel passes - do we see sound levels increase and decrease as vessel passes? Can we attribute noise to a vessels passing by in any frequency band?
      * Closest ship passage (When a ship has a close encounter with a drift, how close is it on average? How is soundscape affected? Does vessel presence create a louder soundscape? What factors affect how a vessel passage affects the soundscape – is it proximity, duration in listening zone, approach?)
      * Does it change over the season?
      * Does looking for large vessels over 100m give enough information of sound source, or will I need all vessels?
  + Other potential variables: seasonality, hour of the day
  + Questions: Does soundscape change when conditions change? Is sound seasonal?
* Fit a model (GAM, possibly zero-inflated, GLM, random forest, ~~Akaike Info Criterion~~)

## This research will…

* Improve current species distribution models of beaked and sperm whales that utilize visual survey methods only
* Improve understanding of effect of large vessel presence on local sound levels