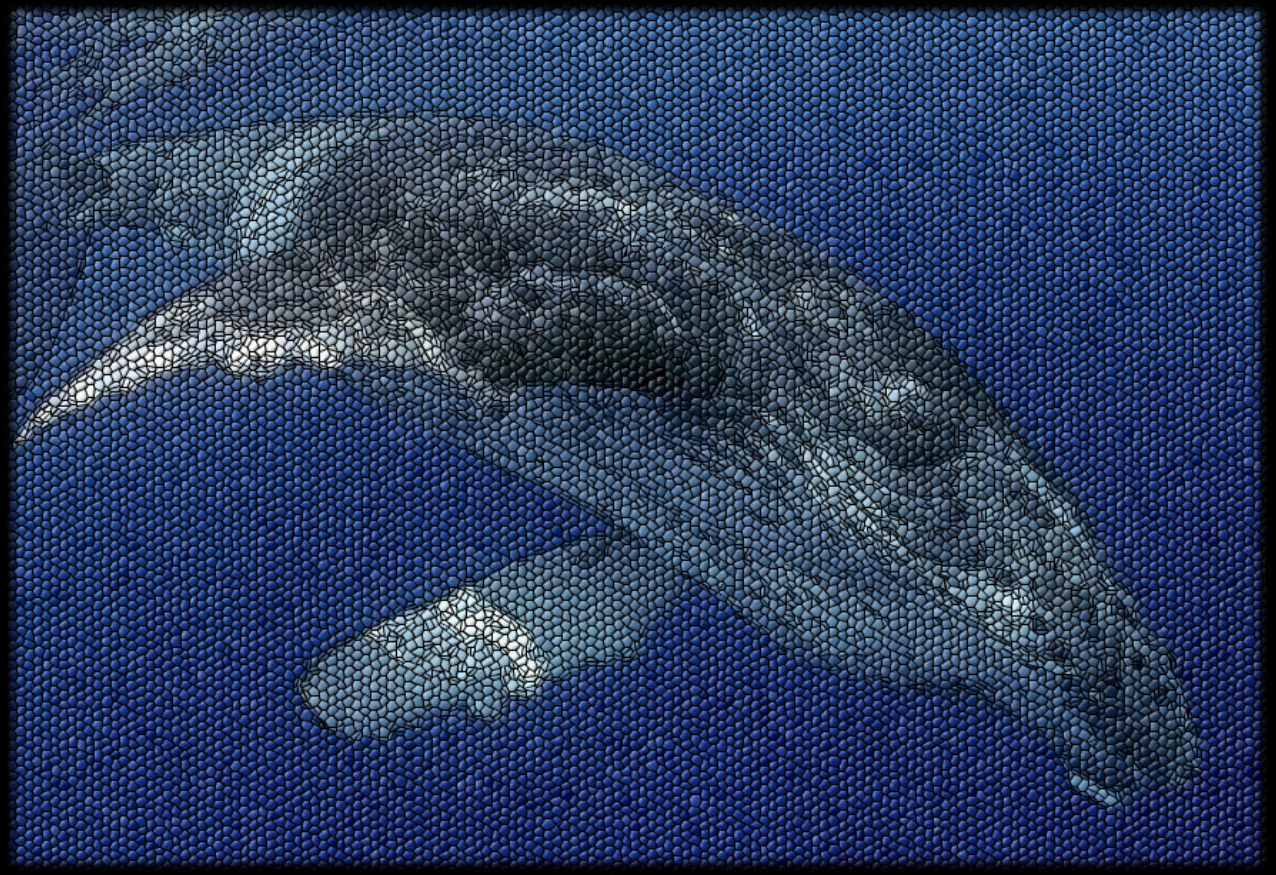
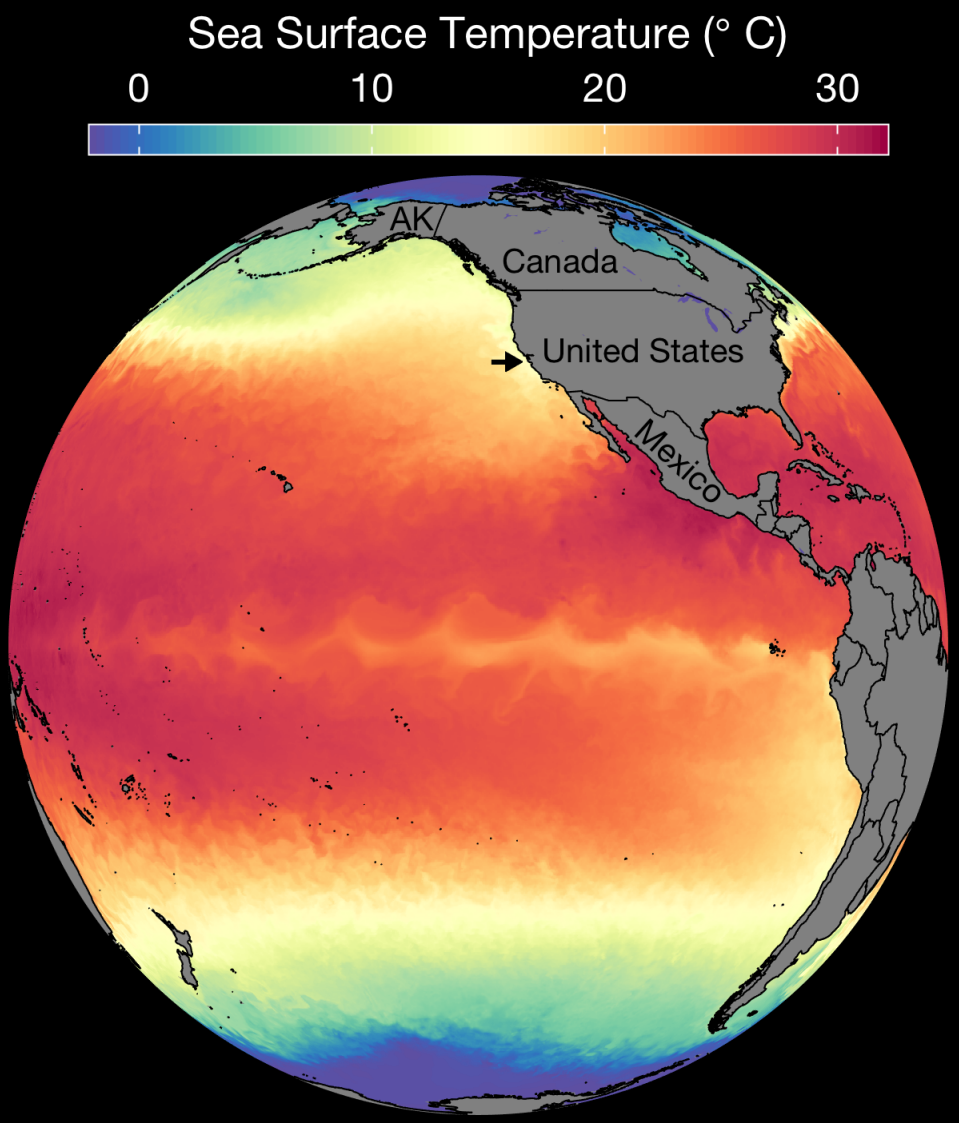
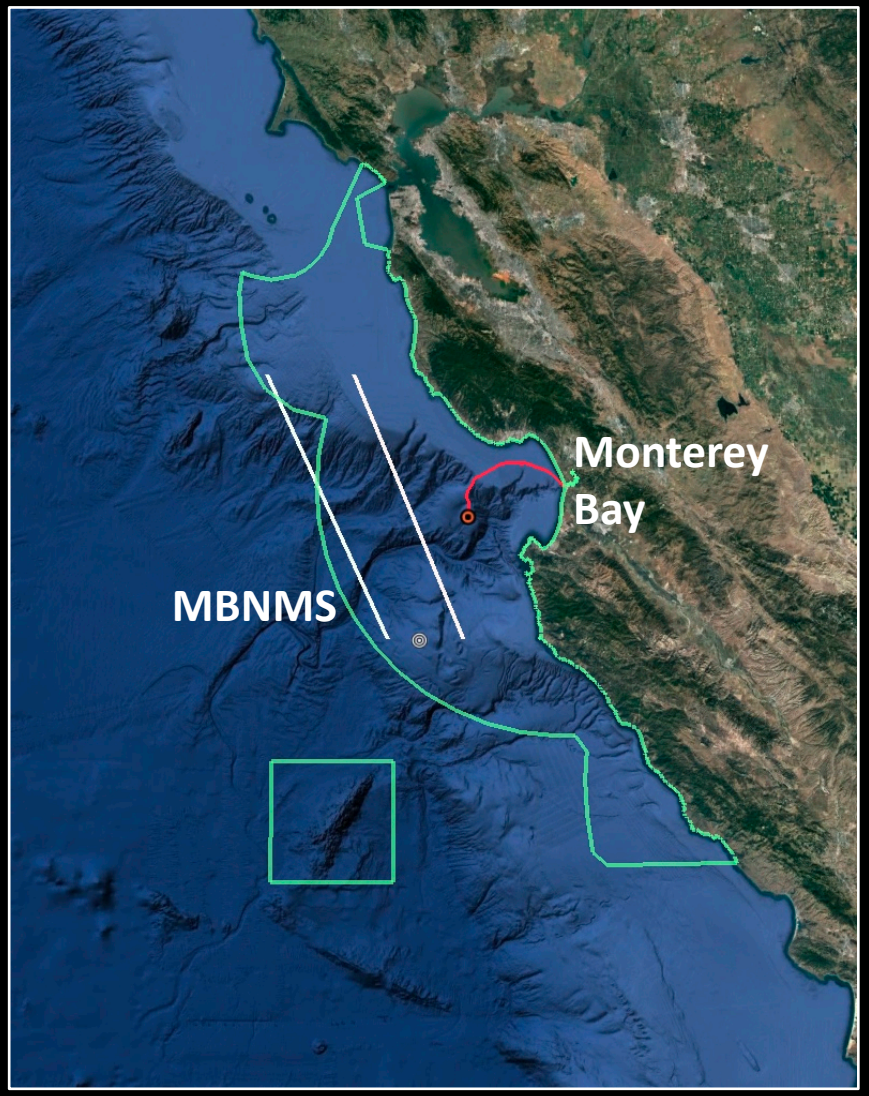
Temporal variations of humpback whale (*Megaptera novaeangliae*) song in *Monterey Bay National Marine Sanctuary*, northeast Pacific



John Ryan, Danelle Cline, Francisco Chavez, Chris Wahl **MBARI**; John Joseph, Tetyana Margolina **NPS**; Alison Stimpert **MLML**; Andrew DeVogelaere, Karin Forney **NOAA**; Nancy Black **MBWW**; Mark Fischer **Aguasonic**

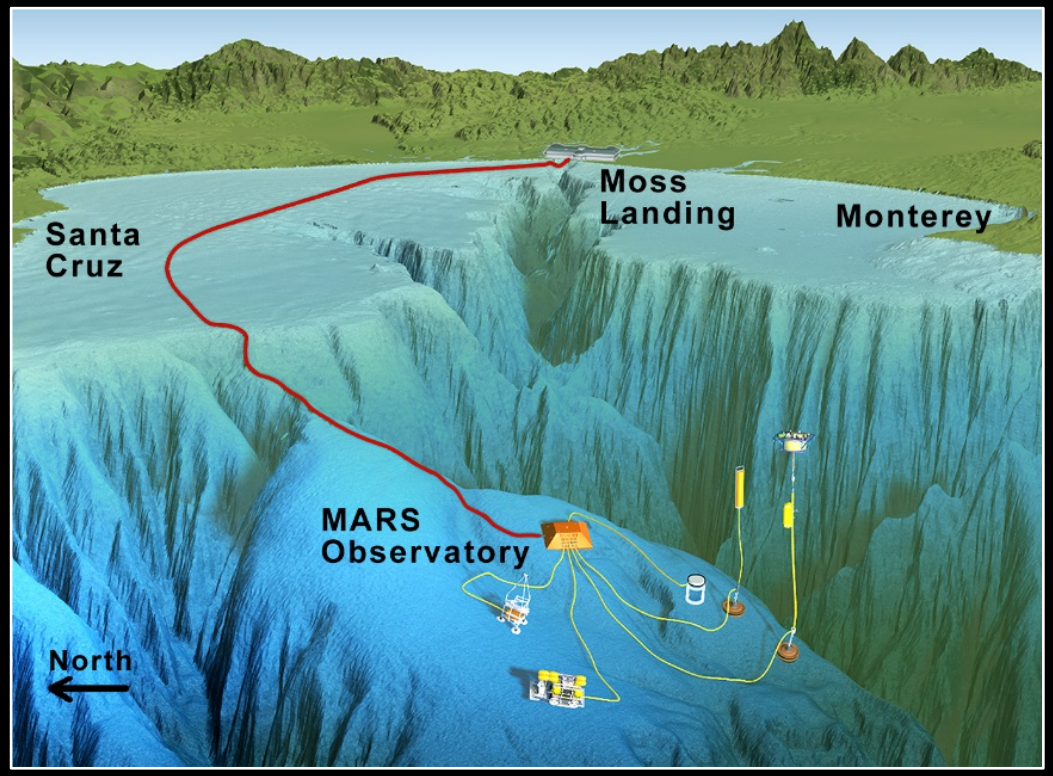
Location



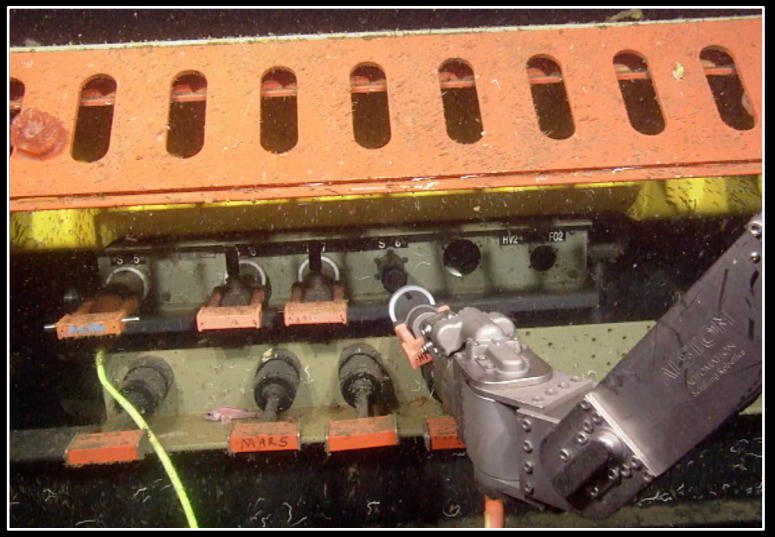


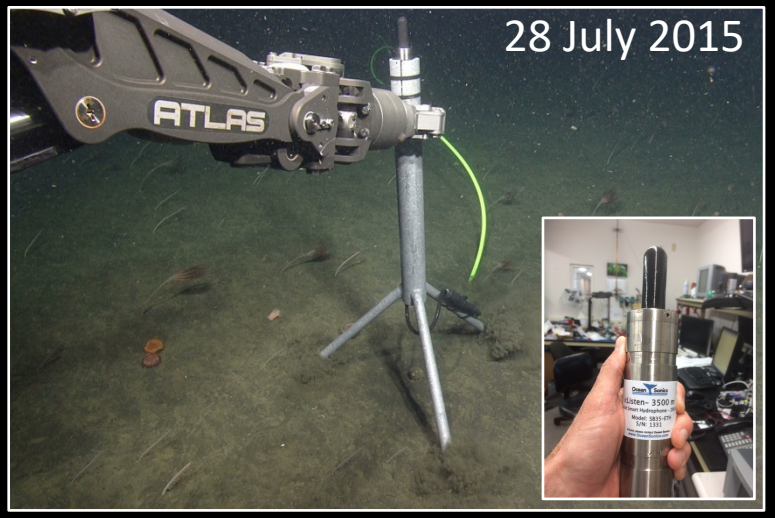
Humpbacks that forage off CA/OR/WA migrate to breeding grounds between Baja and Central America (Steiger et al. 1991, Calambokidis et al. 1996; 2000; Calambokidis and Barlow, 2004; Urban et al. 2016).

MARS cabled observatory



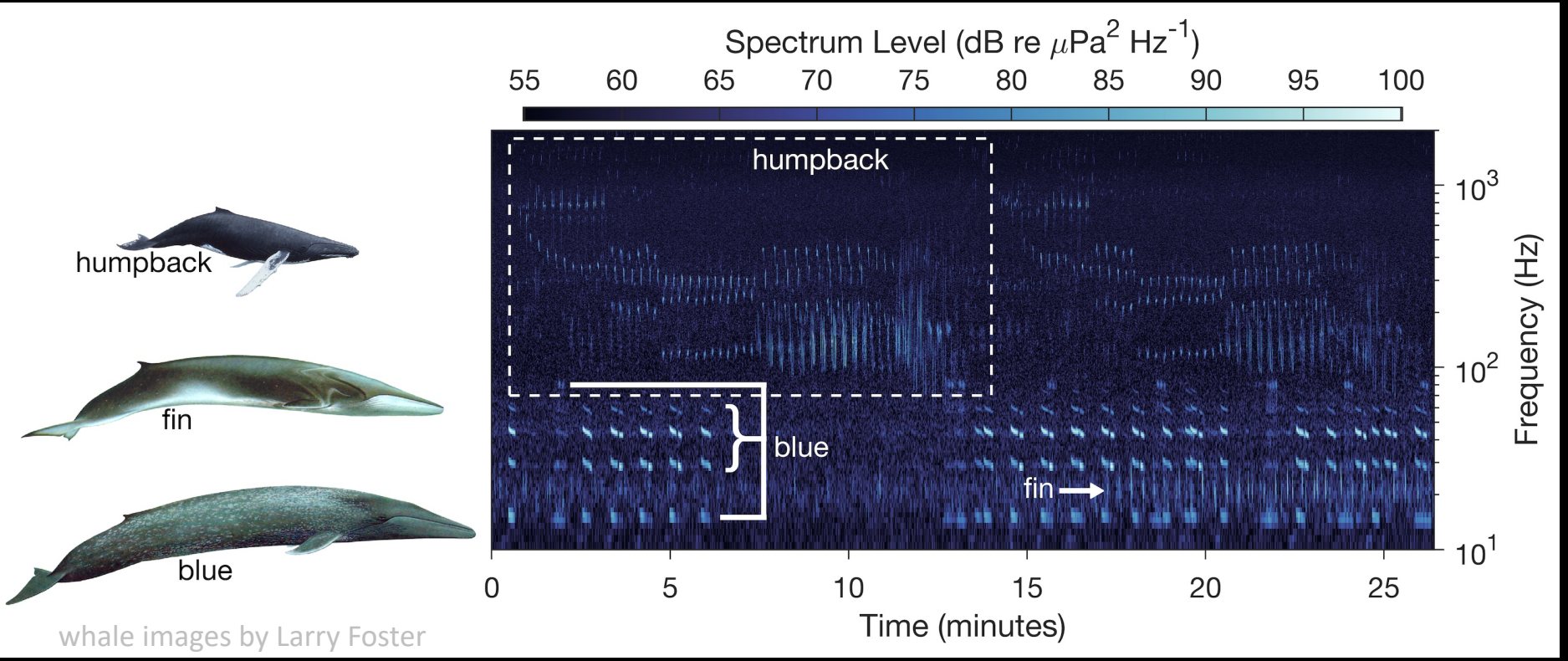
Monterey **A**ccelerated **R**esearch **S**ystem (MARS)





Ocean Sonics icListen HF, sampling at 256 kHz

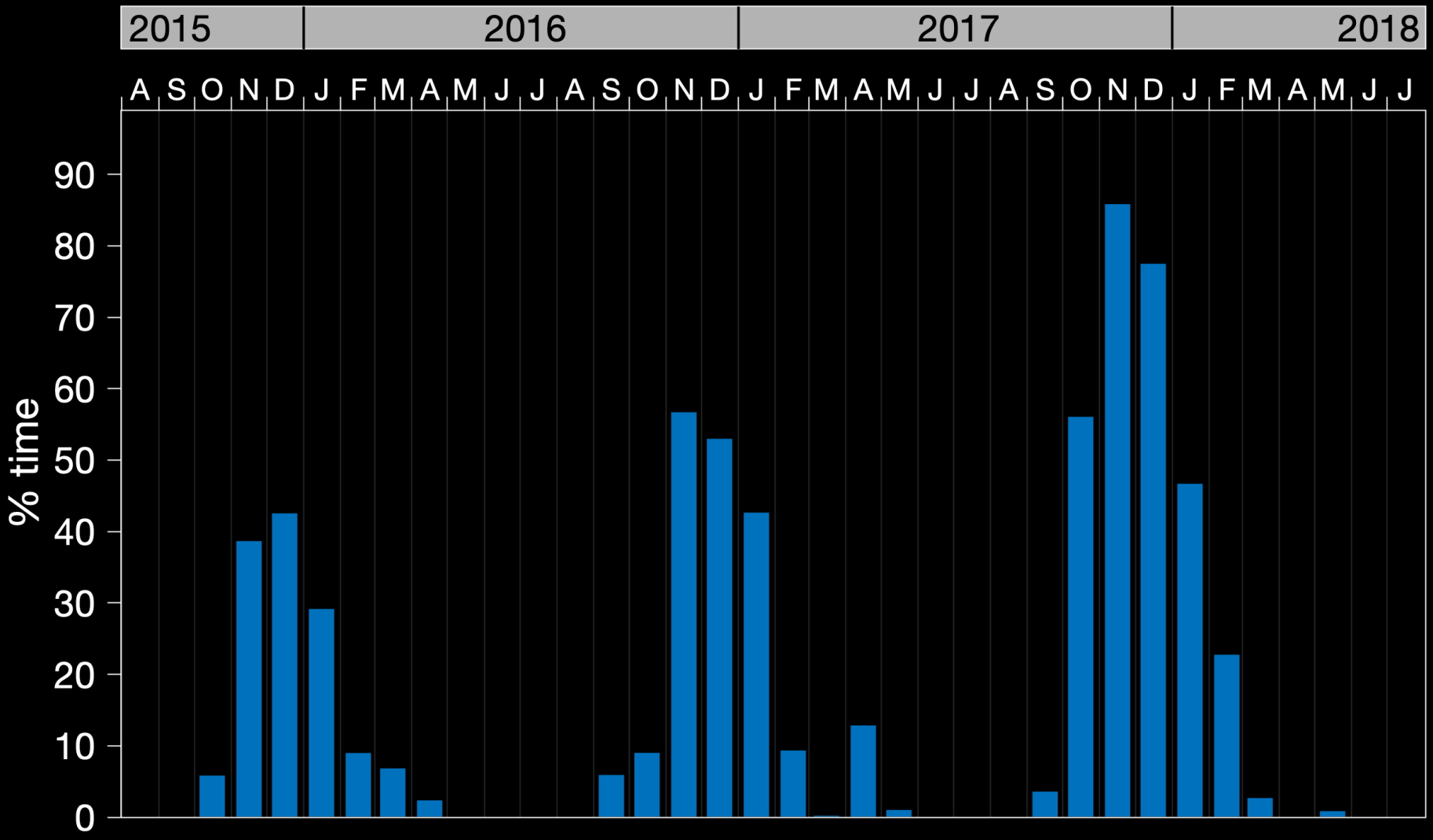
Humpback whale song



Methods:

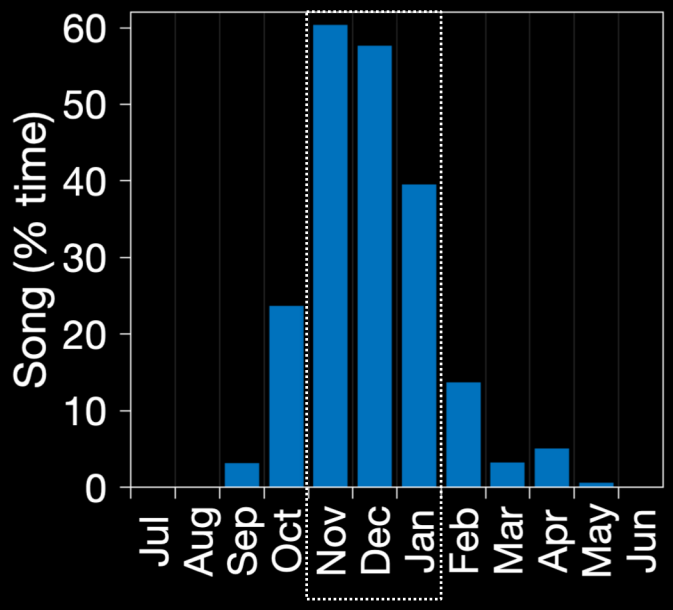
- Pick song session start and end times from 3 years of LTSA plots.
- Examine variation in song occurrence: diel, seasonal, interannual.
- Integrate with environmental and whale sighting data, modeling.

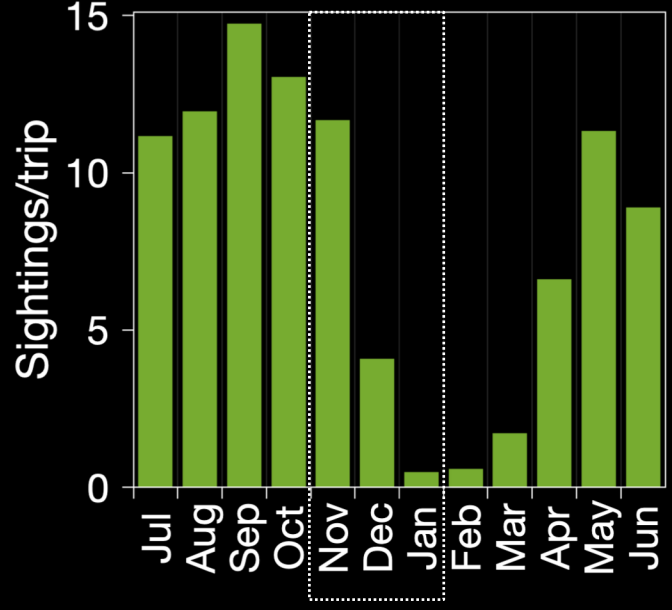
Humpback whale song: the first 3 years

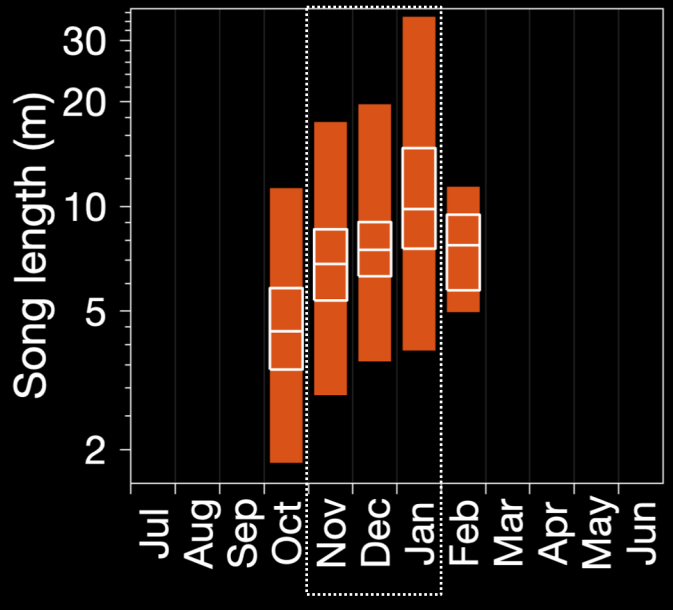


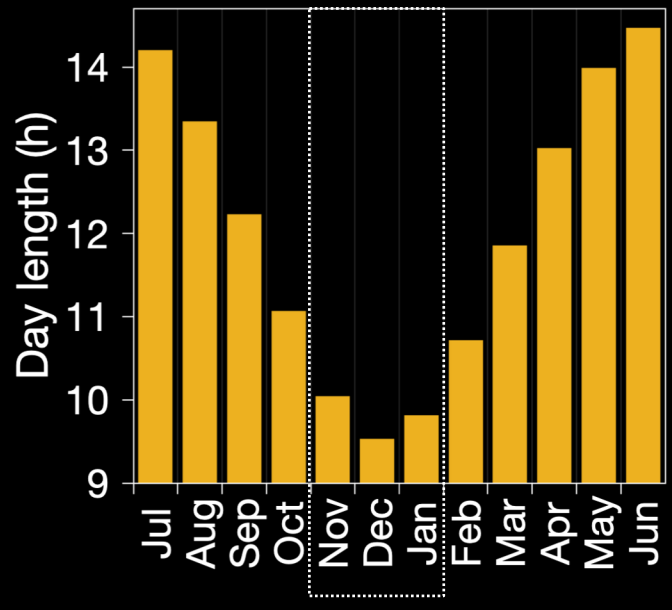
1. seasonal
2. diel
3. interannual

Seasonal

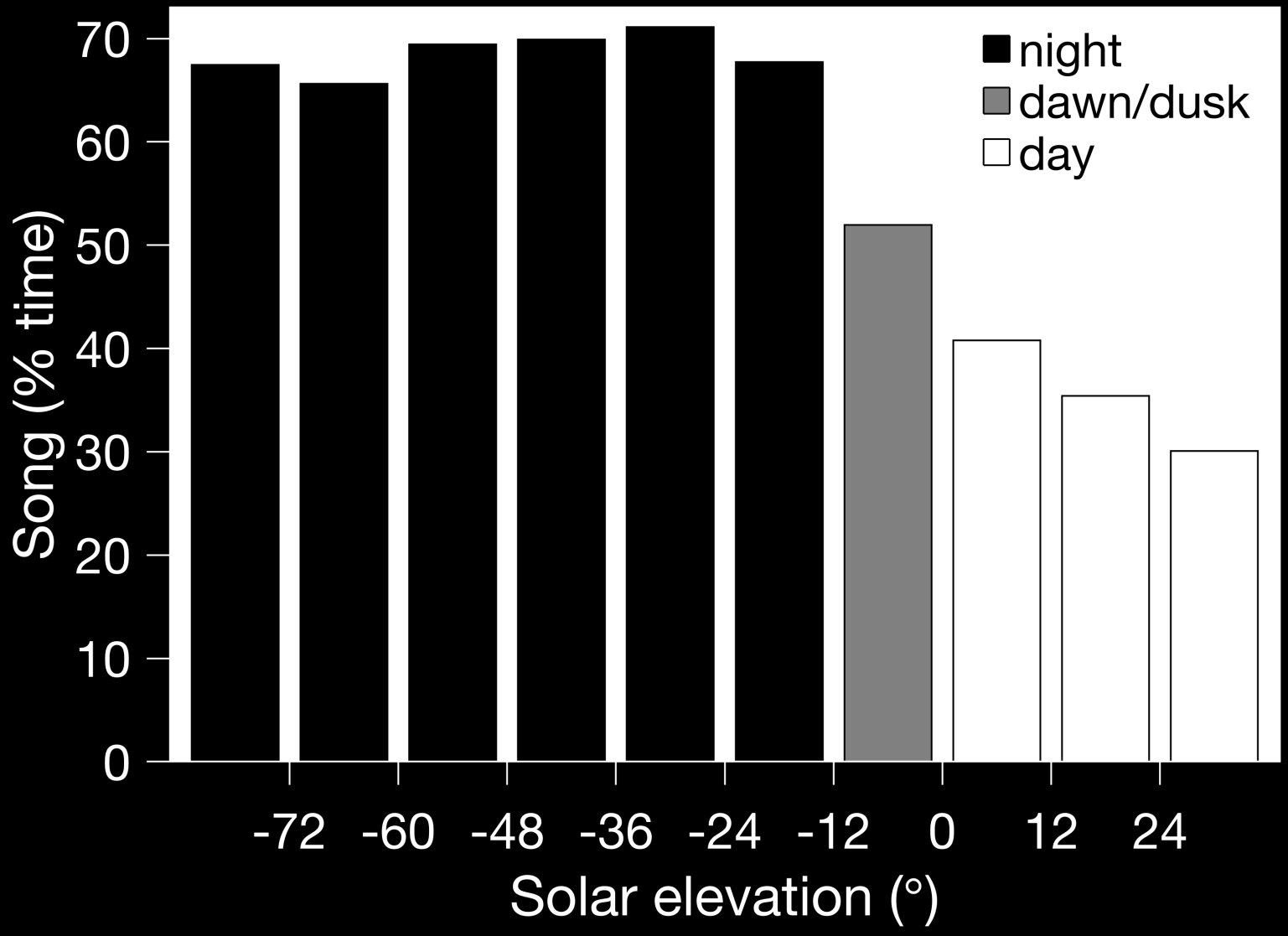

Song (% time)
0
10
20
30
40
50
60
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun


Sightings/trip
0
5
10
15
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun


Song length (m)
2
5
10
20
30
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun

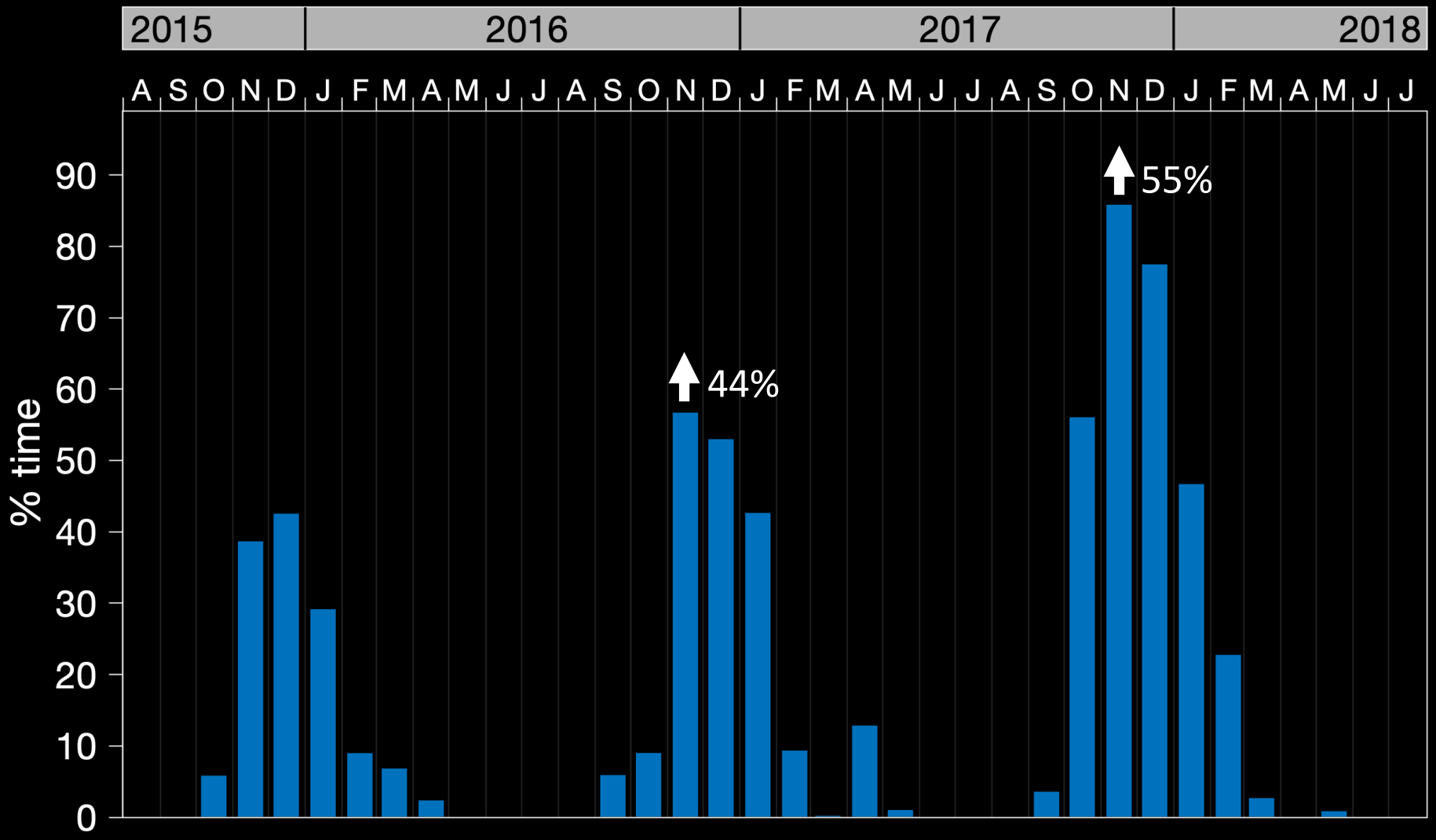

Day length (h)
9
10
11
12
13
14
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun

Diel

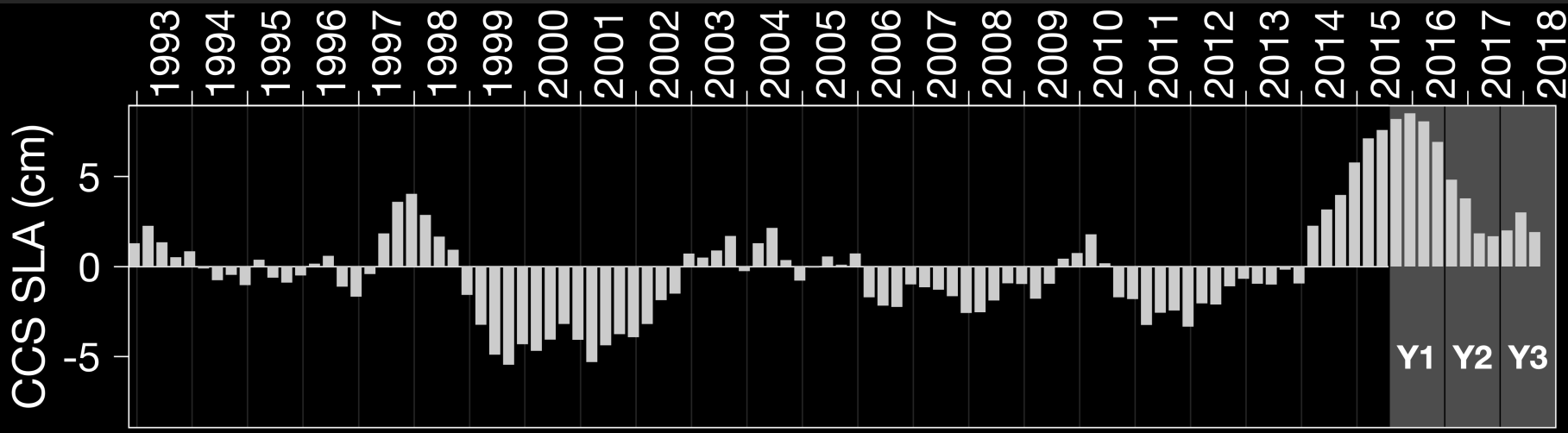


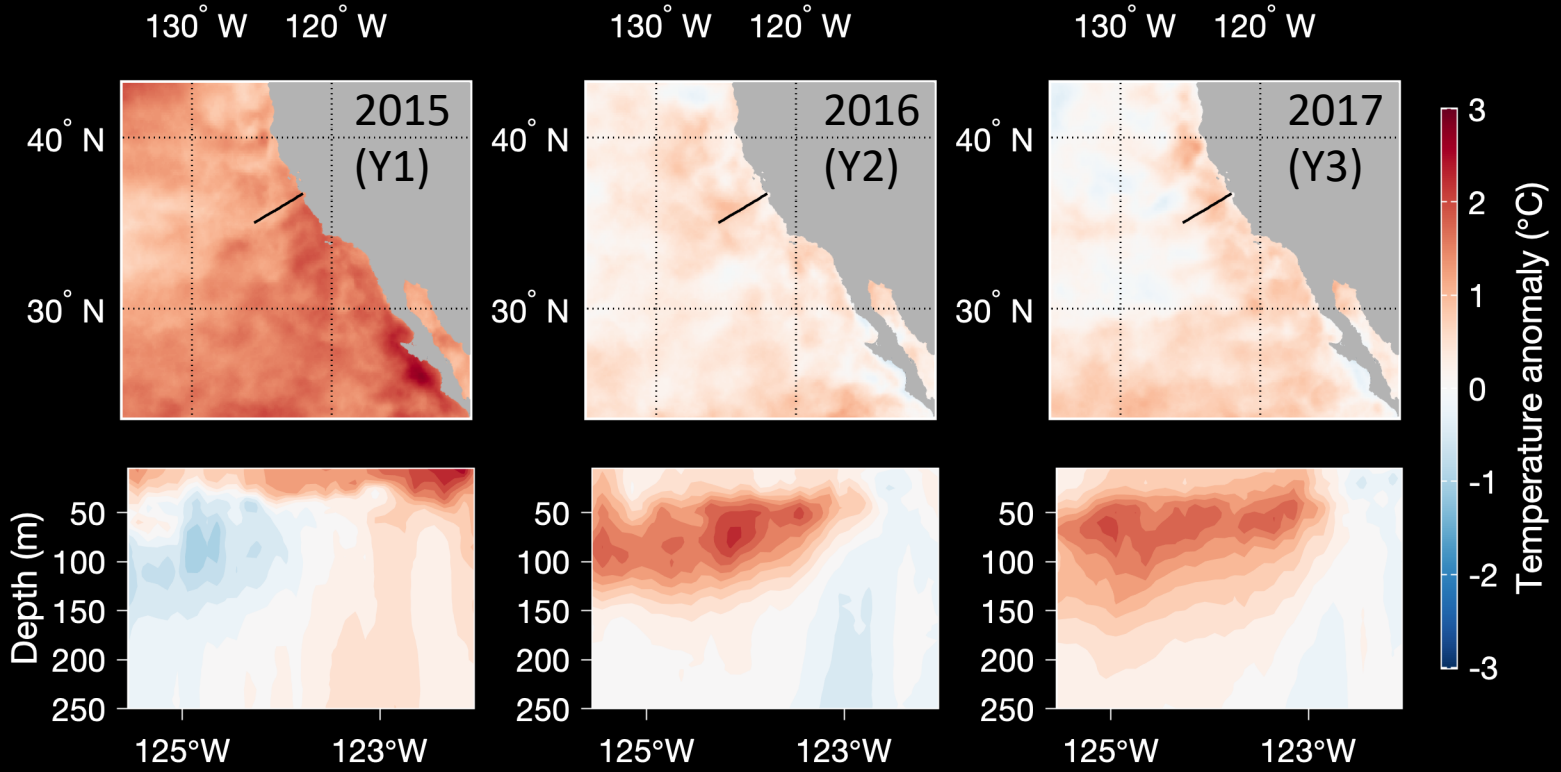
* November through January

Interannual

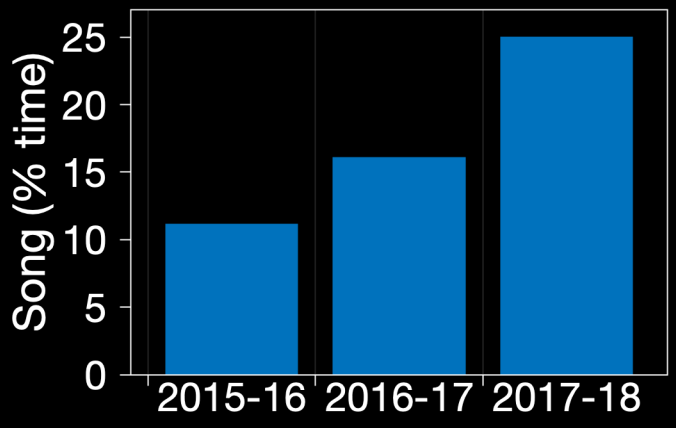


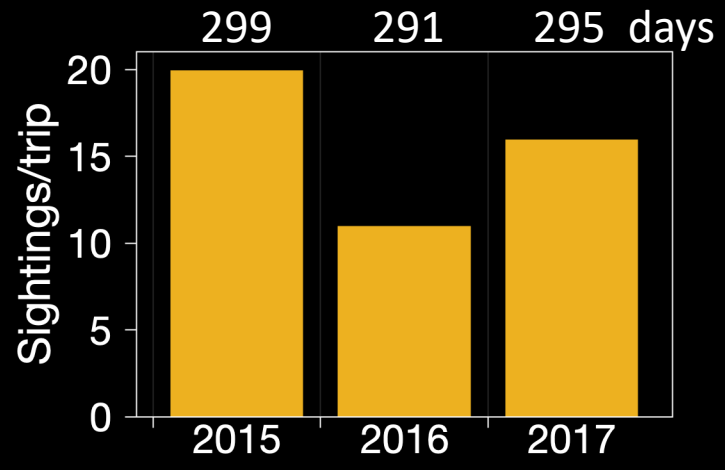
Interannual

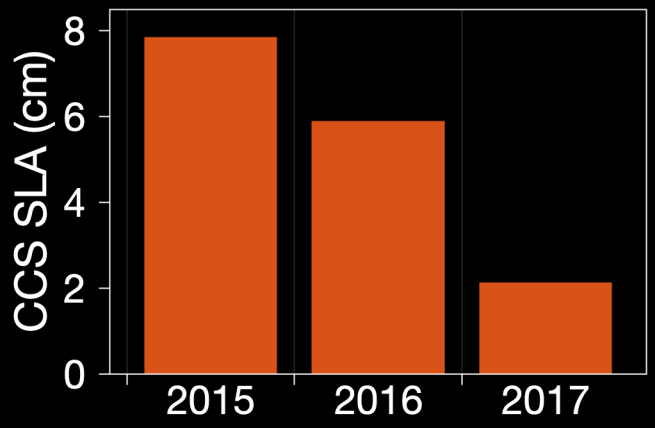


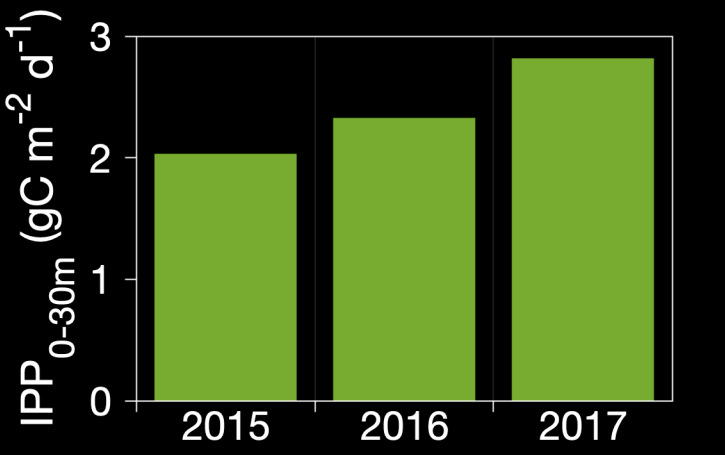


Interannual





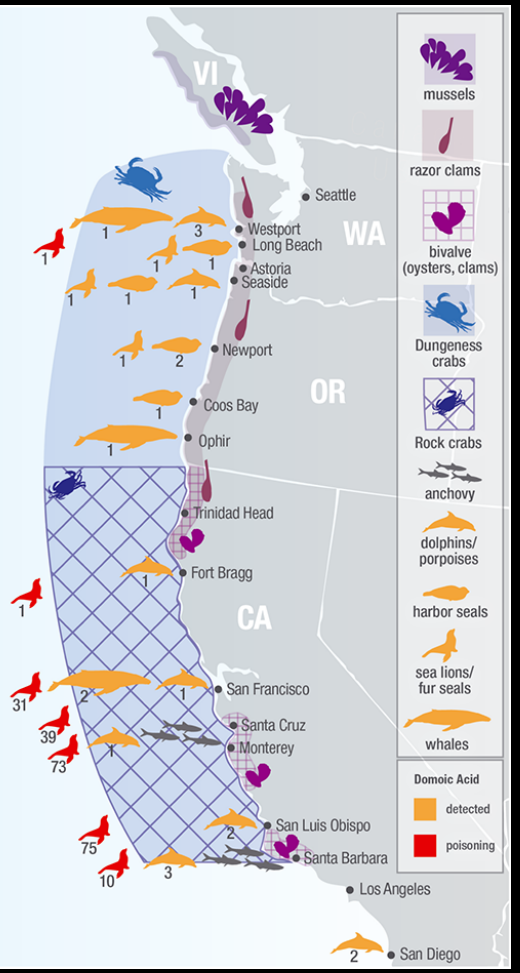




- Forage abundance, species composition, spatial distributions
- Forage not only as food, but also as vector of algal toxin

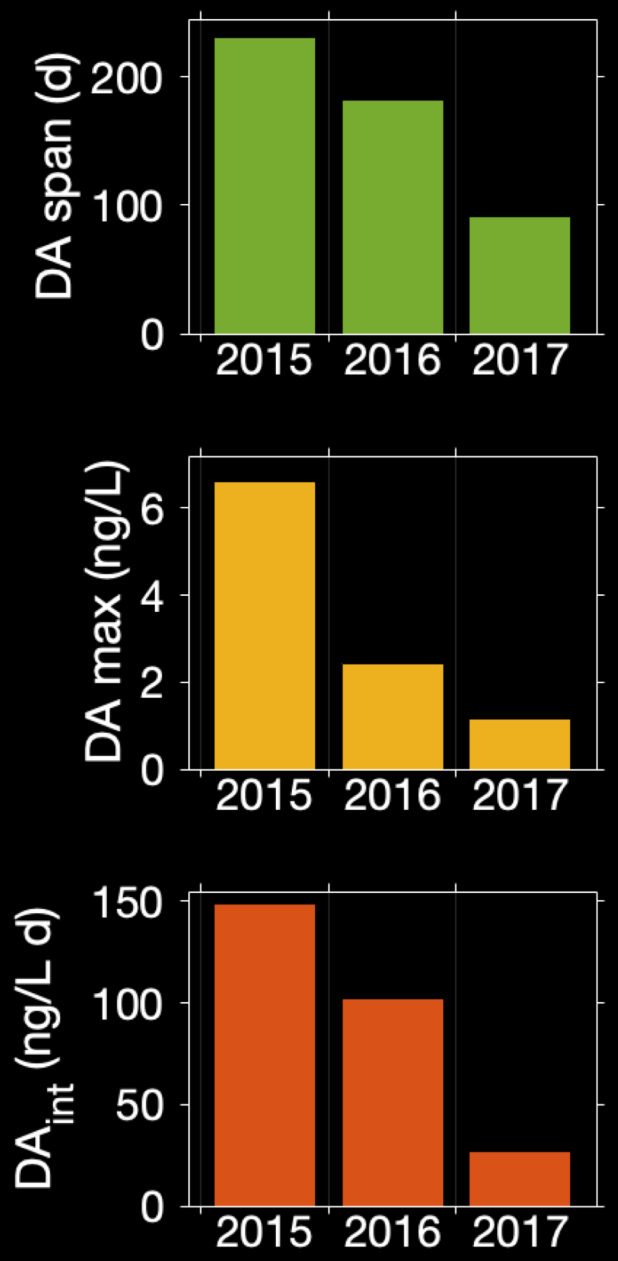
Interannual

2015	Shellfish Harvest and Fishery Closures with Maximum Domoic Acid Values
7-May	Quinault tribe razor clam harvest closure (WA)
8-May	Commercial, tribal & recreational razor clam harvest closure (WA)
9-May	Razor clam harvest closure (northern OR)
14-May	State wide razor clam harvest closure (OR)
15-May	Shellfish harvest closure (BC Canada)
29-May	Anchovy viscera maximum 1671 ppm (CA)
1-Jun	Anchovy, sardine fishery closure (CA)
3-Jun	Dungeness crab maximum 65 ppm (WA)
5-Jun	Dungeness crab fishery closure (WA)
3-Jul	Anchovy, sardine, mussel, & clam closures expanded to southern CA
11-Sep	Dungeness crab maximum 140 ppm (northern CA)
27-Oct	Razor clam maximum 170 ppm (southern OR)
3-Nov	Dungeness crab & rock crab warning for recreational harvest (CA)
6-Nov	Commercial rock crab fishery closed (CA)
8-Nov	Dungeness crab maximum 70 ppm (southern OR)
11-Nov	Dungeness crab & rock crab recreational & commercial fishery closure (CA)
22-Nov	Dungeness crab maximum 270 ppm (northern CA)
23-Nov	Rock crab maximum 1000 ppm (southern CA)
23-Nov	Delayed opening of commercial Dungeness crab fishery (WA, OR, CA)
9-Feb-2016	CA seeks federal disaster declaration for commercial crab fishery

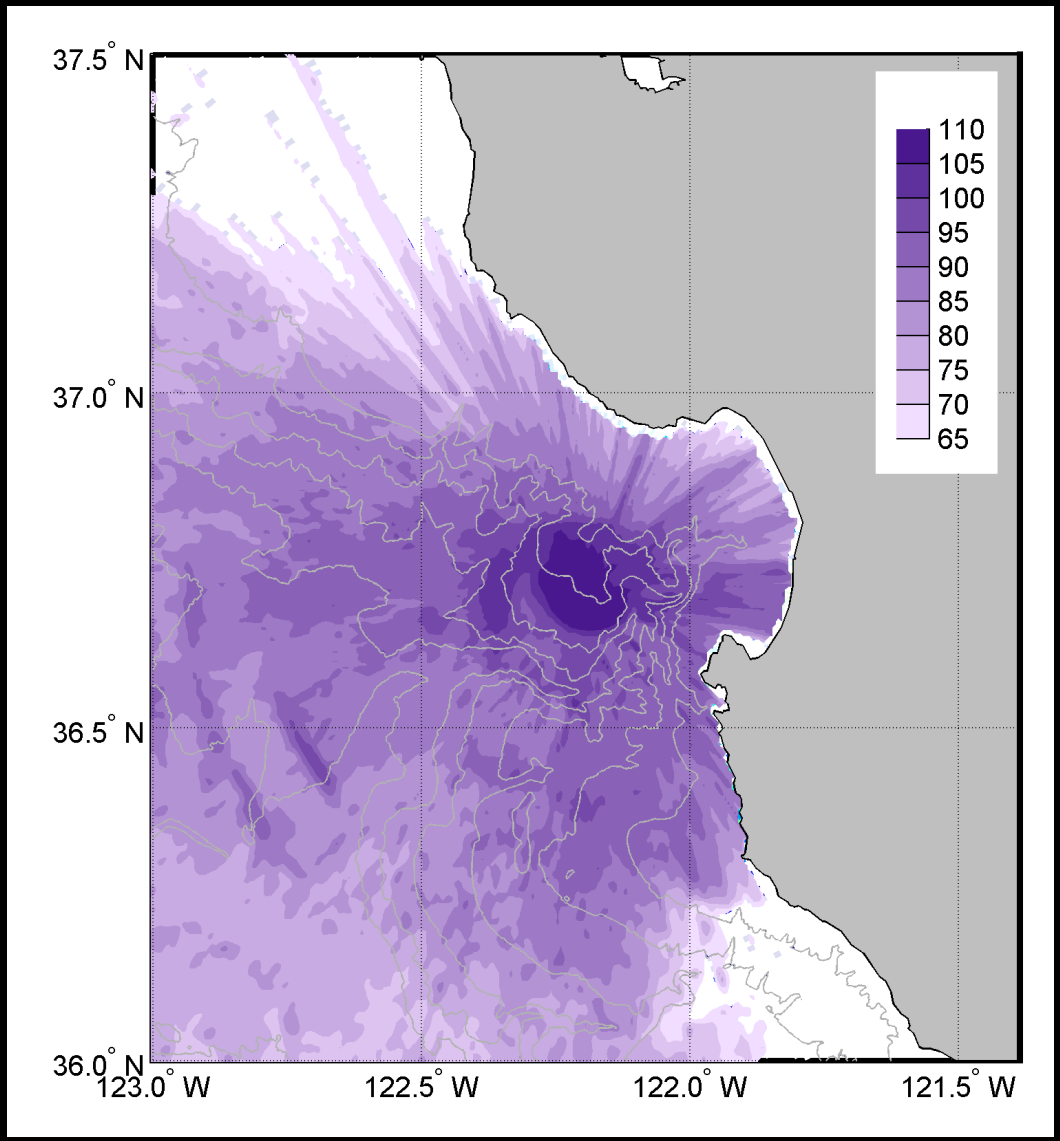


2015: Largest geographic extent of DA detection in marine mammals ever recorded globally (McCabe et al., 2016)

DA data: R. Kudela (UCSC), Santa Cruz Wharf



MARS hydrophone *humpback ear horn*



M. D. Collins, R. B. Evans (1992) A two-way parabolic equation for acoustic backscattering in the ocean, *J. Acoust. Soc. Amer*. 91: 1357-1368.

- 250 m resolution bathymetry
- climatological hydrography for September, US Navy GDEM
- 350 Hz source @ 10 m
- source level 175 dB re 1 µPa

Summary

First description of temporal variations in humpback whale song in MBNMS from long term continuous recordings.

- High levels of song activity in this feeding & migratory habitat, up to 86% coverage in a month
- **Seasonal**: plateau in November – January (76%), coincident with daylength trough & evidence of population movement.
- **Diel**: steady, high level (~70% of time) through night, decreases during dawn/dusk (~50%), further linear decrease during day to minimum (~30%) near solar noon
- **Interannual**: strong + trend over the first 3 years covaries with decreasing sea level, increasing primary productivity, and decreasing algal toxin detection. Examining changes in whale abundance estimates and foraging ecology needs data.
- Single omnidirectional hydrophone provides regional sampling, including important habitat within Monterey Bay.

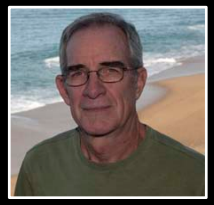
Acknowledgments


Danelle Cline


Craig Dawe


David French


Kevin Gomes


Ken Heller


George Matsumoto


Paul McGill


John Ryan


Yanwu Zhang

the David & Lucile Packard FOUNDATION

NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

NPS Praestantia per Scientiam 1909

Scripps Institution of Oceanography UCSD

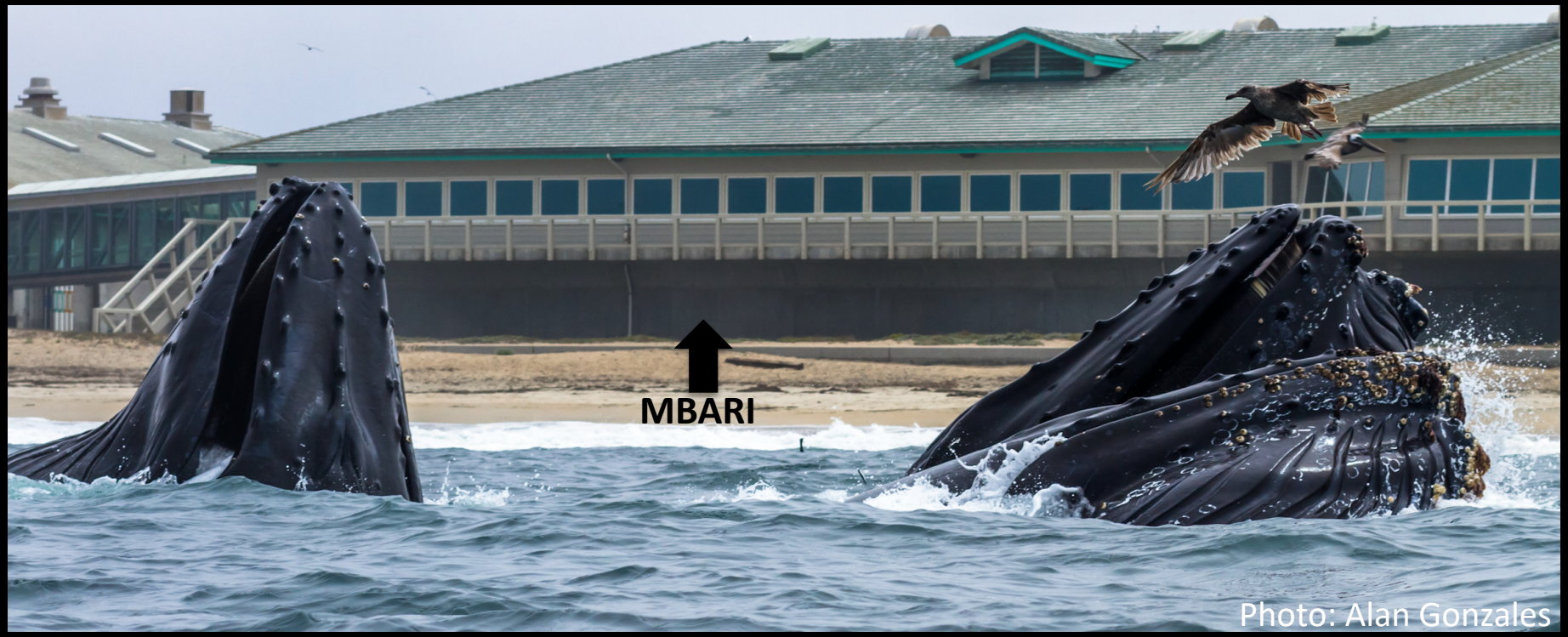
Leland Stanford Junior University 1891

Moss Landing Marine Laboratories

The University of California 1868

UCSC

Thanks! Questions?



Extra stuff