



# Acoustic Monitoring in the Sanctuaries: NOAA Ocean Noise Reference Station Results

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# Hello!

- PhD candidate at Oregon State University
- Dr. Nancy Foster Scholar (2017-2021)



# Seasonal trends and primary contributors to the low-frequency soundscape of the Cordell Bank National Marine Sanctuary

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View Affiliations

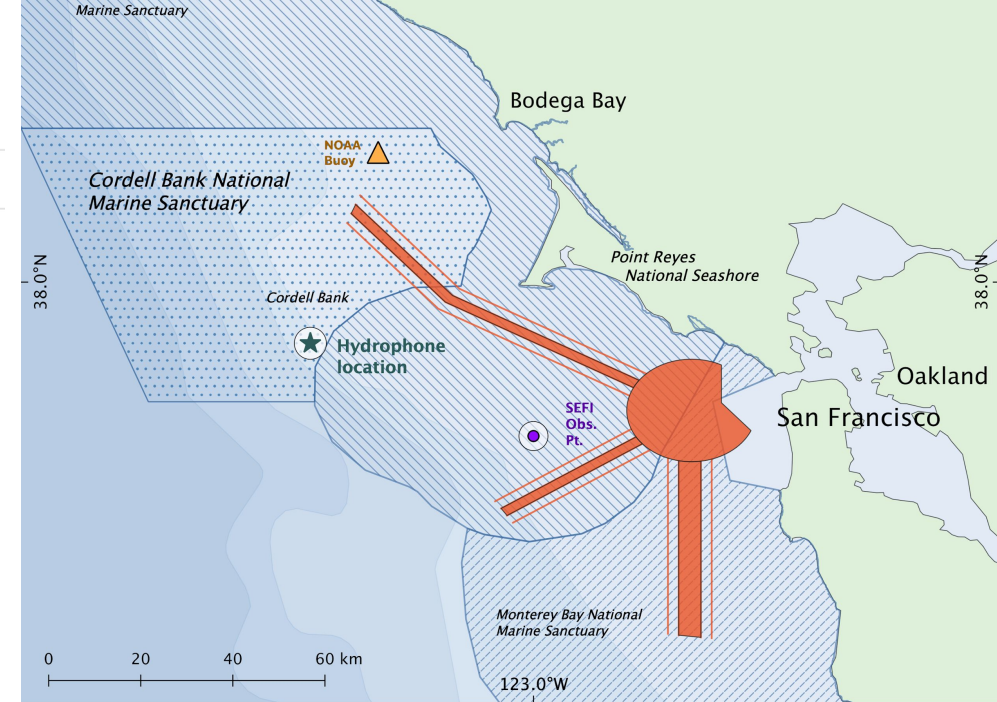
PDF ABSTRACT FULL TEXT FIGURES TOOLS SHARE METRICS

TOPICS

- Acoustic noise
- Acoustic ecology
- Acoustic modeling, simulation and analysis
- Bioacoustics of mammals
- Oceanography
- Signal processing
- Anthropogenic
- Aquatic ecology
- Vocalization
- Animal sounds

## ABSTRACT

Passive acoustic monitoring of ocean soundscapes can provide information on ecosystem status for those tasked with protecting marine resources. In 2015, the National Oceanic and Atmospheric Administration (NOAA) established a long-term, continuous, low-frequency (10 Hz–2 kHz) passive acoustic monitoring site in the Cordell Bank National Marine Sanctuary (CBNMS), located offshore of the central United States of America (U.S.) west coast, near San Francisco, CA. The California Current flows southward along the coast in this area, supporting a diverse community of marine animals, including several baleen whale species. Acoustic data analysis revealed that both large vessels and vocalizing baleen whales contribute to the ambient soundscape of the CBNMS. Sound levels fluctuated by month with the highest levels in the fall and lowest levels in the summer. Throughout the year, very low-frequency (10–100 Hz) sound levels were most variable. Vessels and whales overlap in their contributions to ambient sound levels within this range, although vessel contributions were more omnipresent, while seasonal peaks were associated with vocalizing whales. This characterization of low-frequency ambient sound levels in the CBNMS establishes initial baselines for an important component of this site's underwater soundscape. Standardized monitoring of soundscapes directly supports NOAA's ability to evaluate and report on



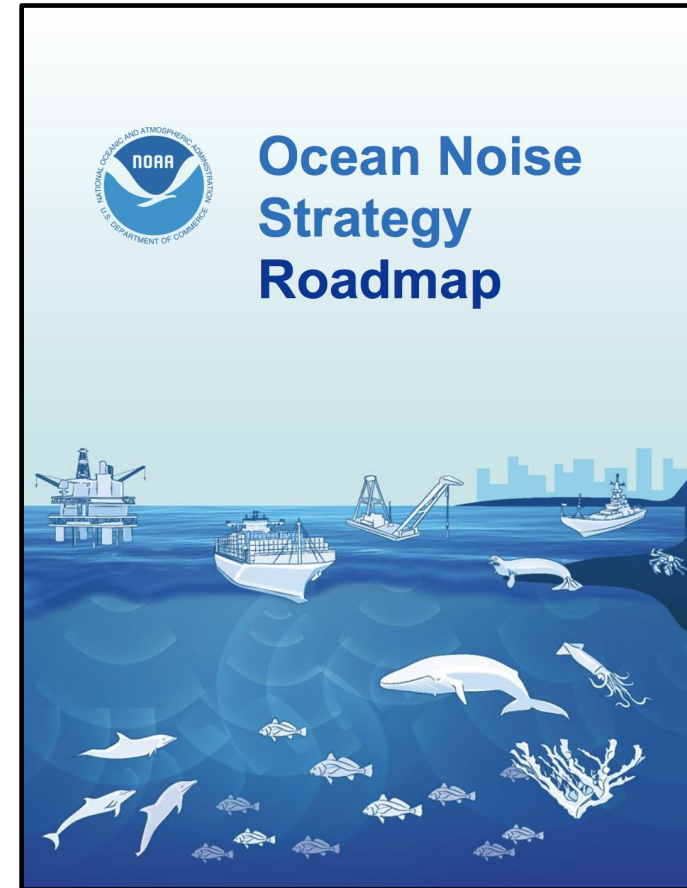
JASA THE JOURNAL OF THE ACOUSTICAL SOCIETY OF AMERICA

**Guest Editors:**  
 Kent L. Gee,  
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Submit Today!



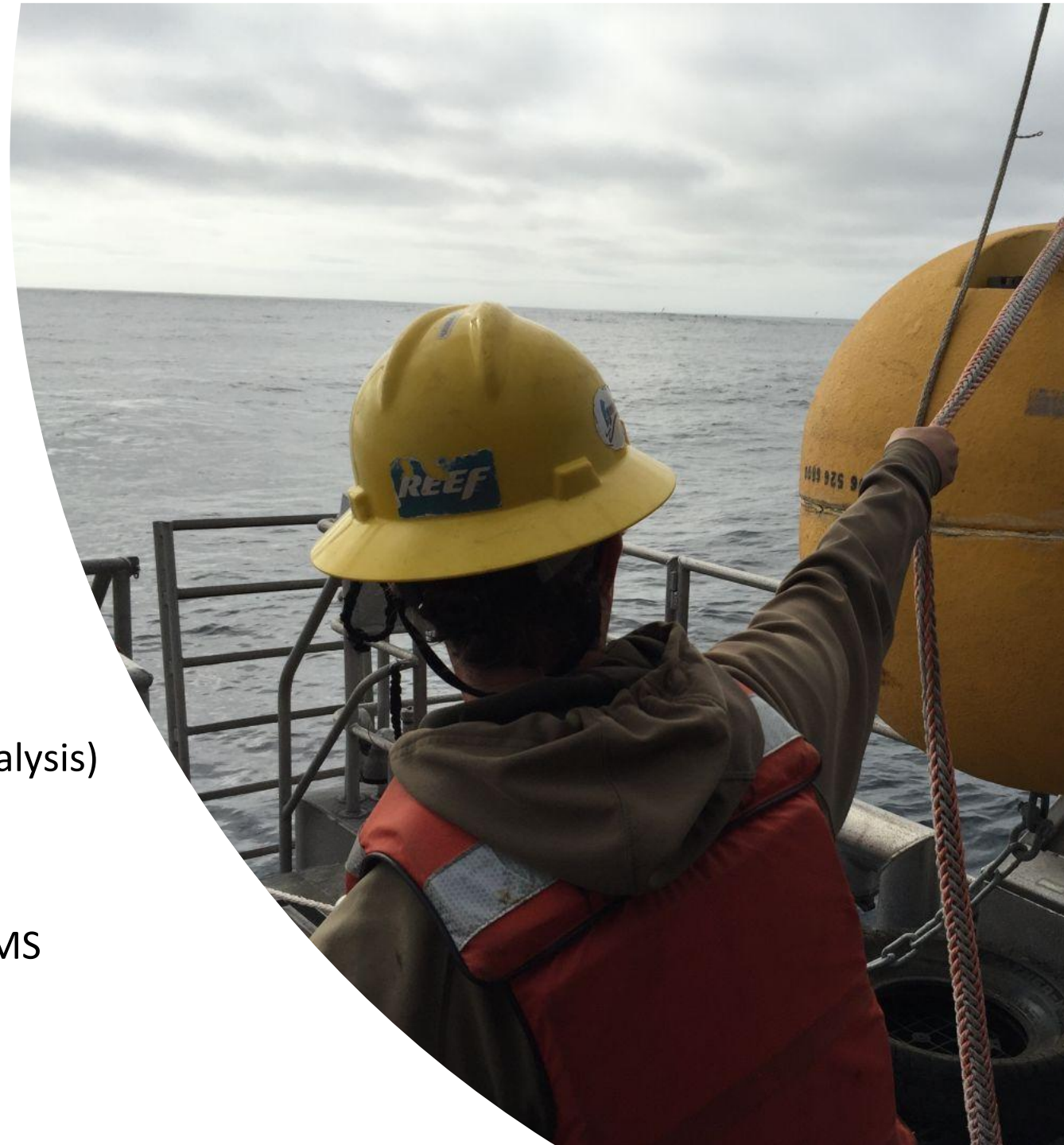
# NOAA Underwater Noise Monitoring



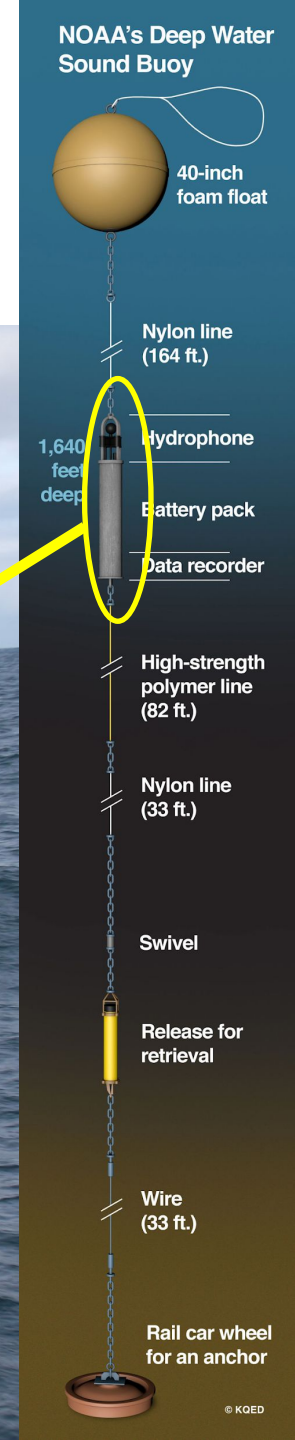
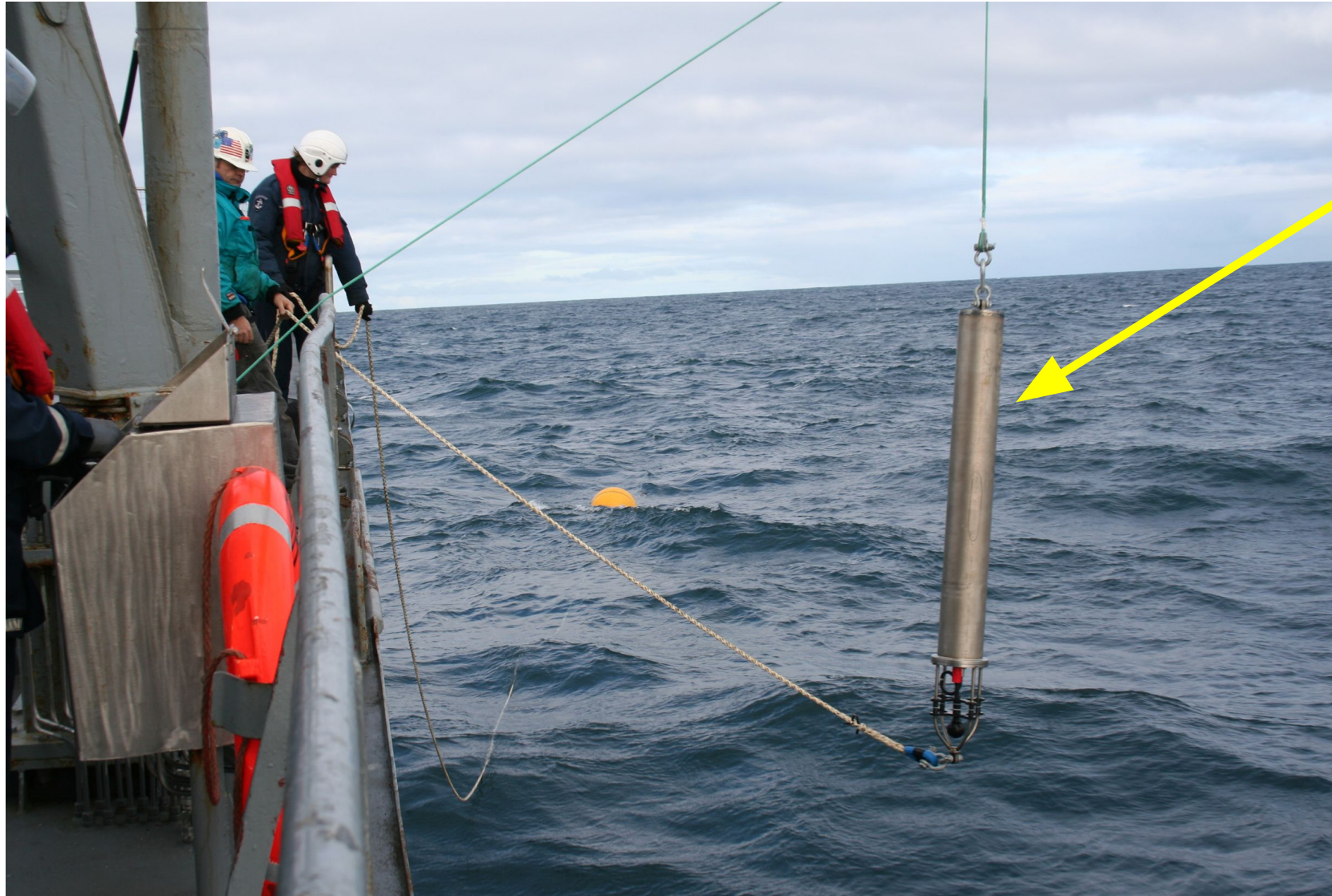
Map: [cetsound.noaa.gov](https://cetsound.noaa.gov)  
Animal images: [cetus.ucsd.edu](https://cetus.ucsd.edu)

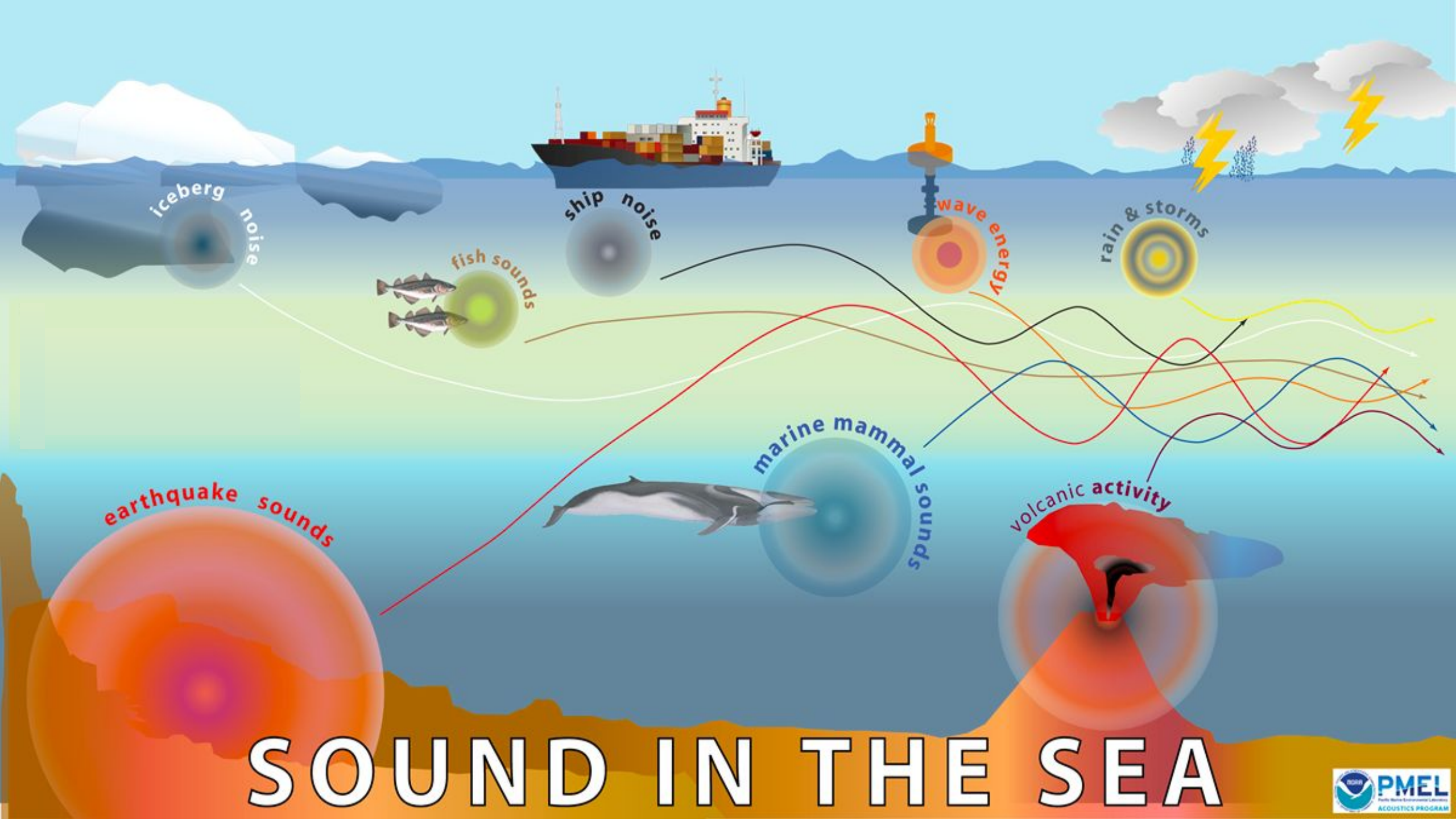
# Why Passive Acoustic Monitoring?

- Year-round effort
- Not limited by weather or daylight
- Minimal disturbance to environment
  - Only during deployment and retrieval
  - No surface expression
- Long-term data collections
  - Initial data download in 2017 (focus of this analysis)
  - Instrument swapped again in October 2019
- Comparisons to calibrated network
  - Including 3 other NMS - OCNMS, CINMS, SBNMS



# NRS Instrumentation





iceberg noise

ship noise

fish sounds

wave energy

rain & storms

earthquake sounds

marine mammal sounds

volcanic activity

# SOUND IN THE SEA

# Soundscape analysis = acoustics + more!

- **Establish baseline sound levels**

- **Quantify** sound levels (at hydrophone) at each frequency in hourly time windows (MATLAB)
- Calculate monthly and 2-year **averages**
- Use **percentiles** to indicate potential influence of chronic vs transient sources

- **Analyze recordings for presence of baleen whale vocalizations**

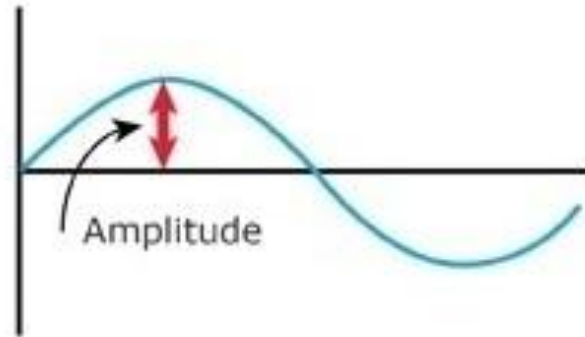
- **Automatic** detector indices – simpler, consistent vocalizations
- **Manual** analysis – for species with large repertoire of call types or possible masking conditions (automatic detector cannot separate from background noise)

- **Comparison to other types of data**

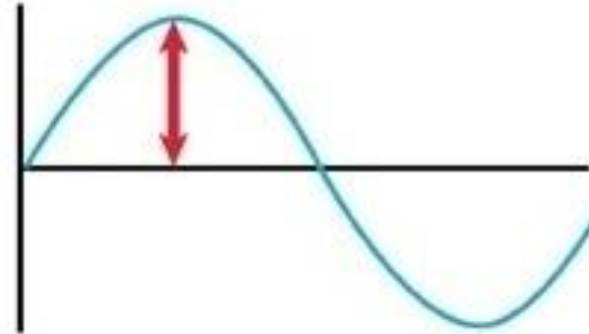
- **Shipping** activity (AIS)
- **Visual whale sighting data** (SEFI/ACCESS)
- **Wind** speed (NOAA weather buoy)
- **Rainfall** measurement (Bodega Marine Lab)
- **Earthquakes** (USGS)



# Measuring Sound



Quieter



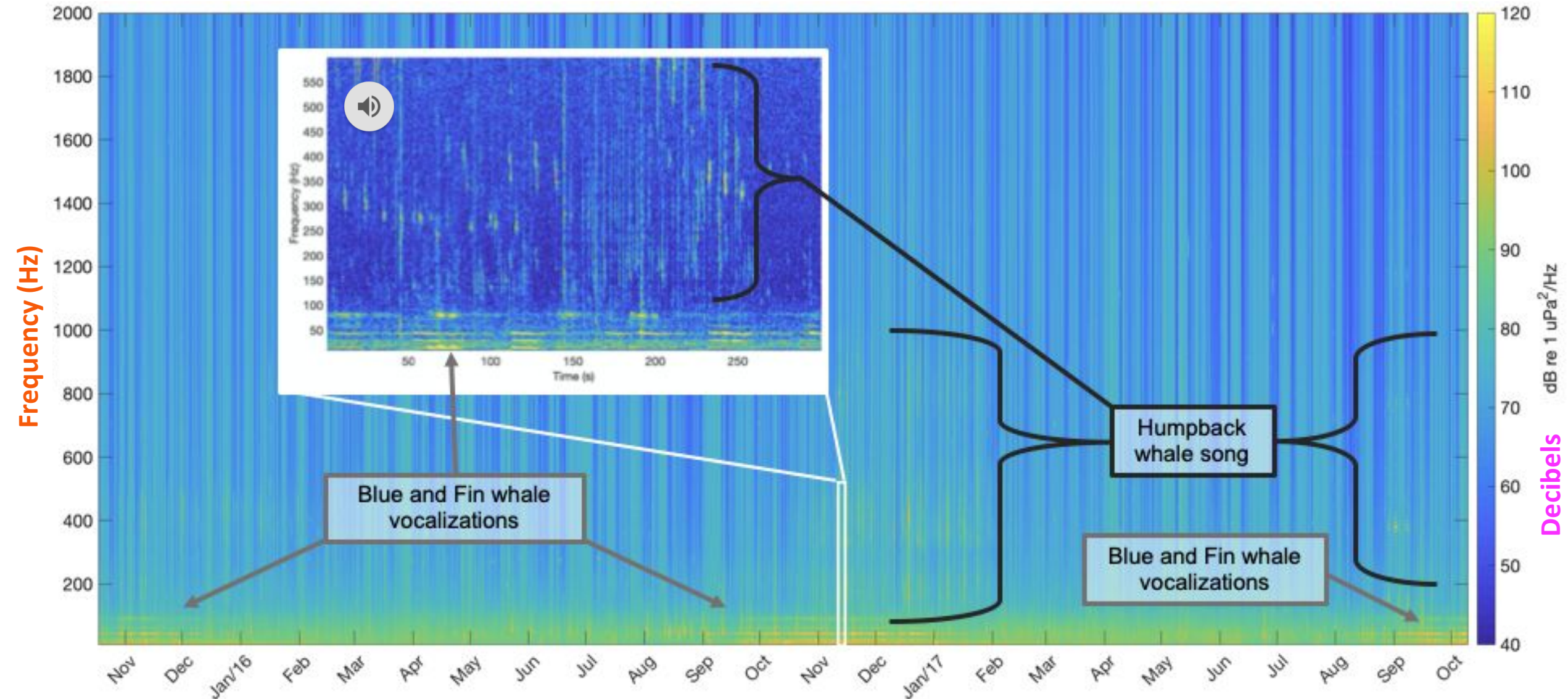
Louder

# What did we hear?

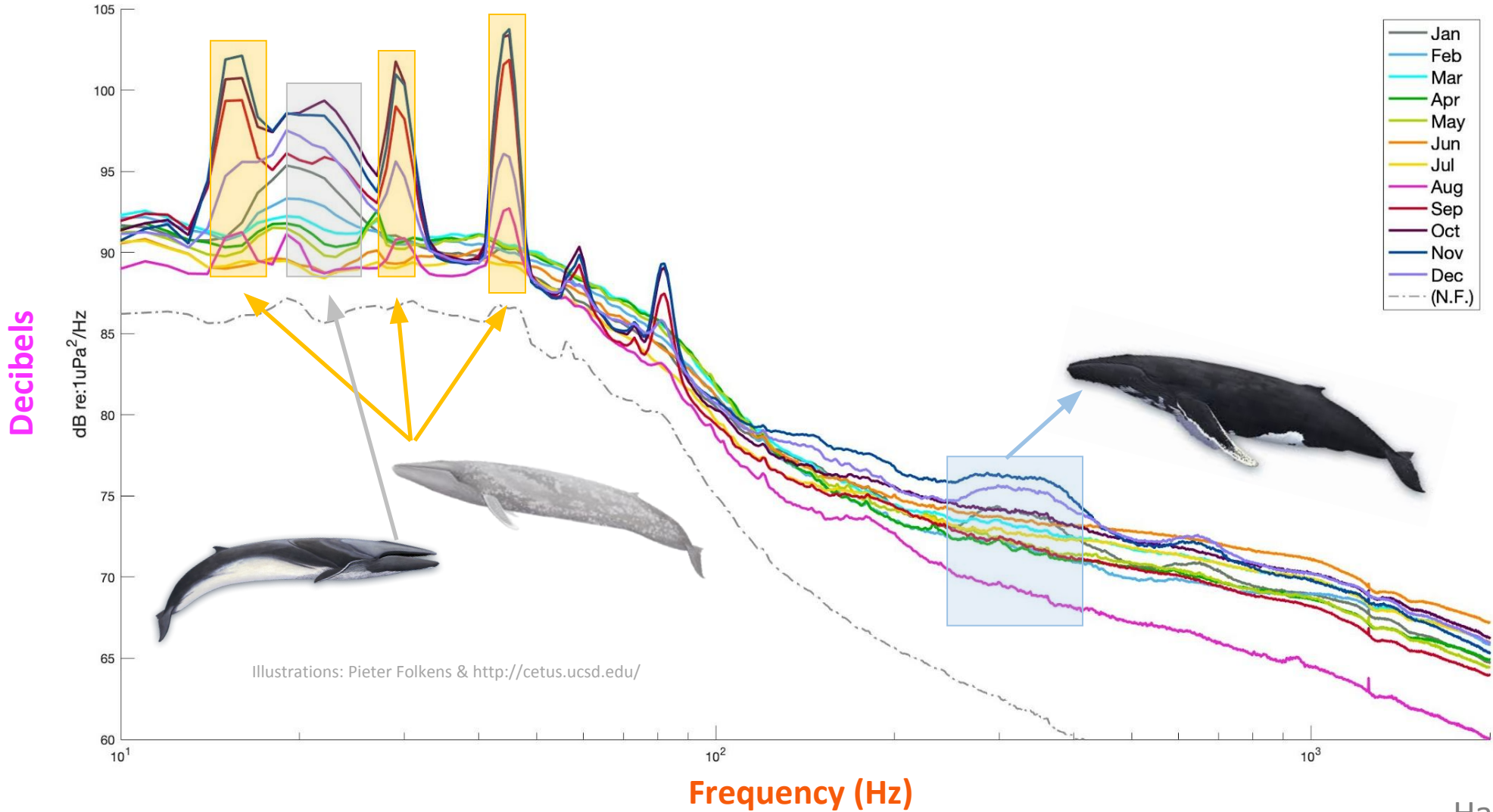
1. Low-frequency soundscape dominated by whales
  - Seasonal patterns of blue and fin whales
  - Humpback whales detected year-round
  - Visual survey and acoustic monitoring detections are not the same
2. Vessel noise is consistent year-round
  - Matches results from AIS
3. Ambient sound levels similar to S. CA
  - Expected because of similar whale habitat and large ports
  - Different sound propagation environments



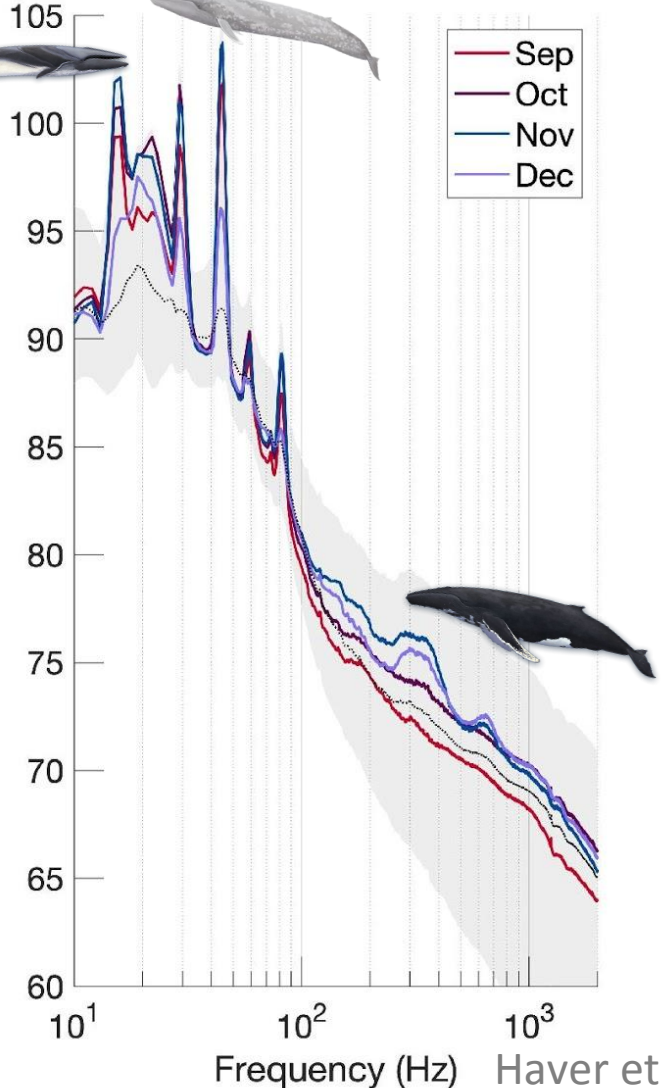
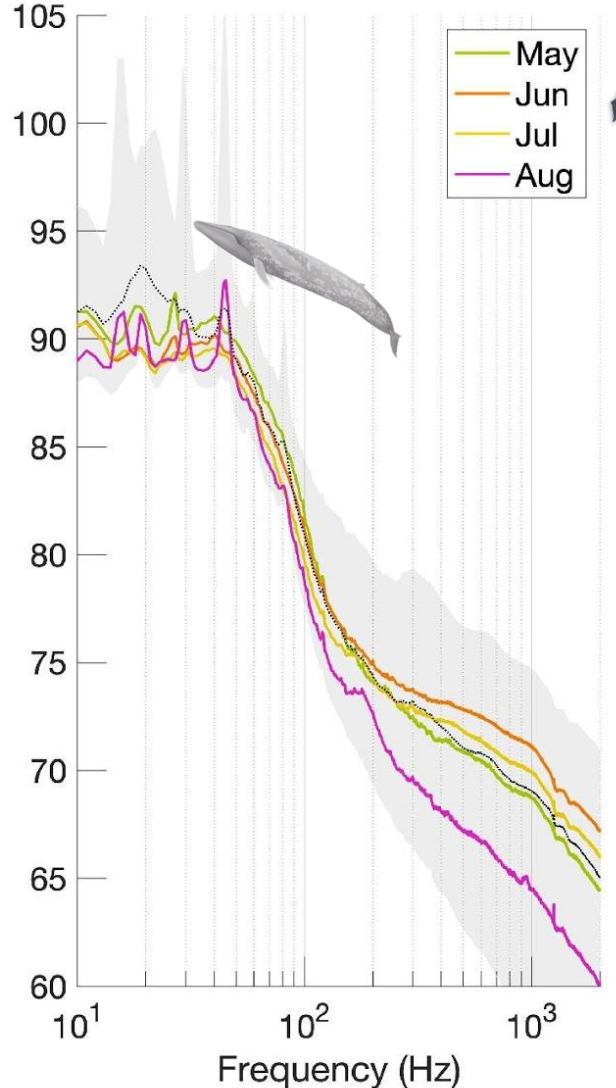
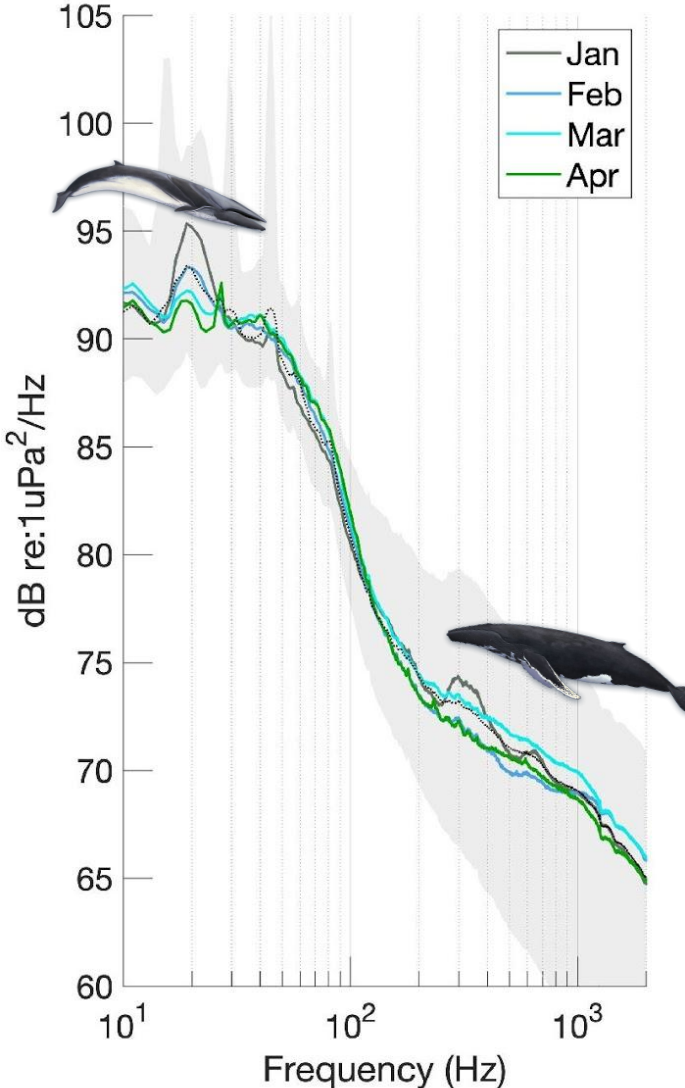
# Biophony (whale vocalizations)



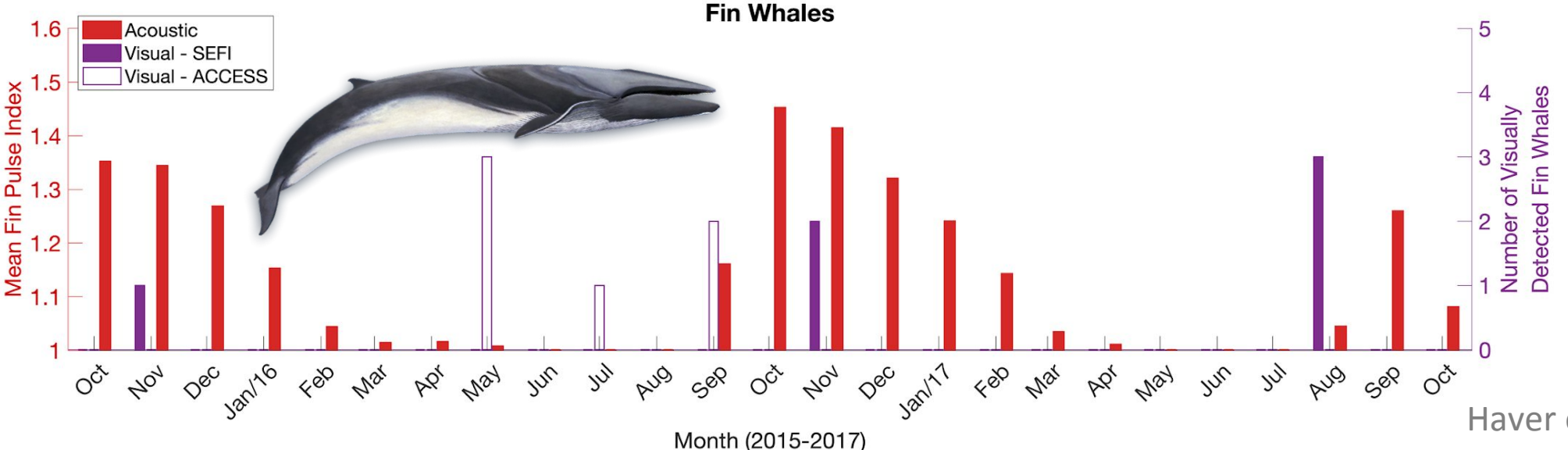
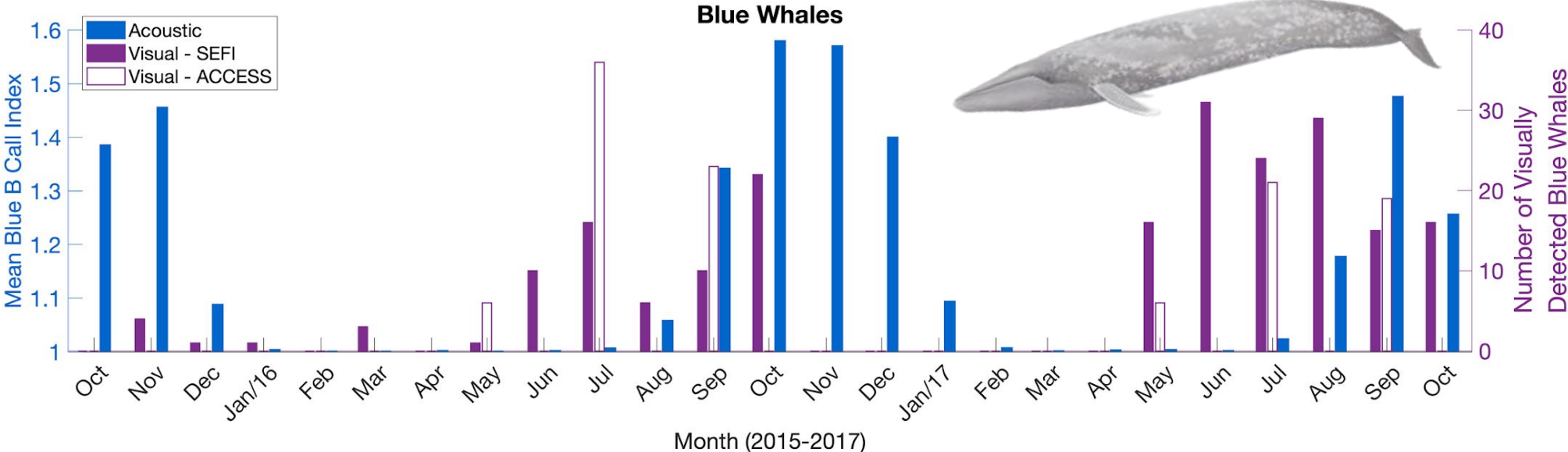
# Whales Affected Monthly Sound Levels



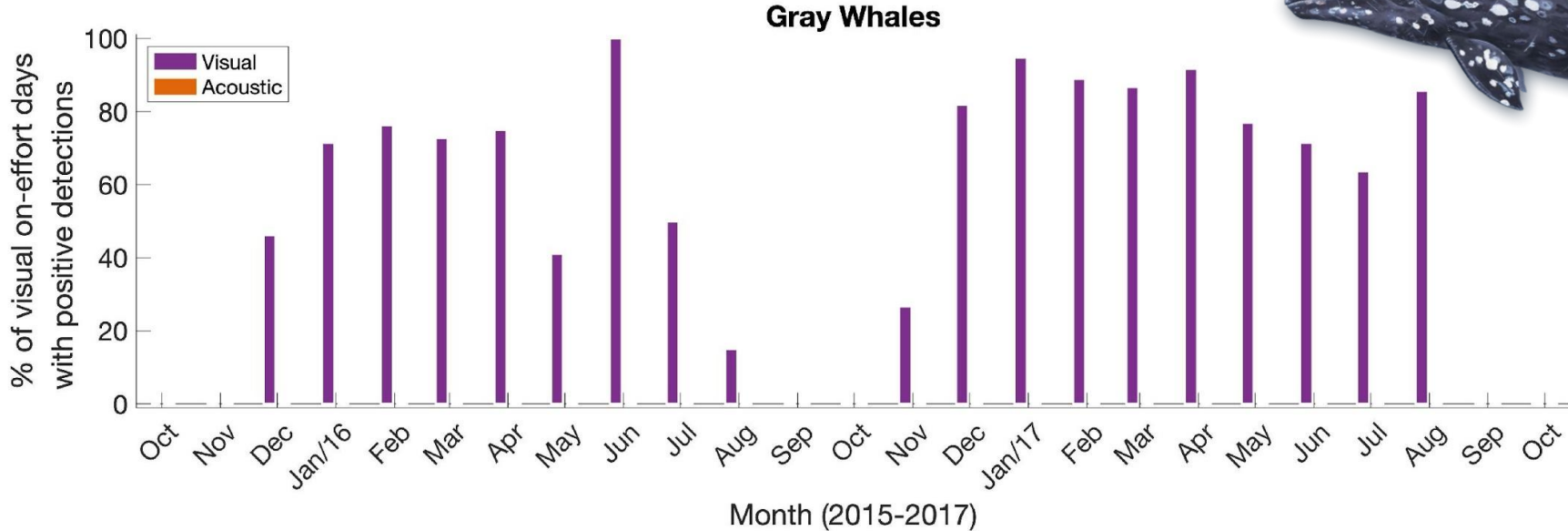
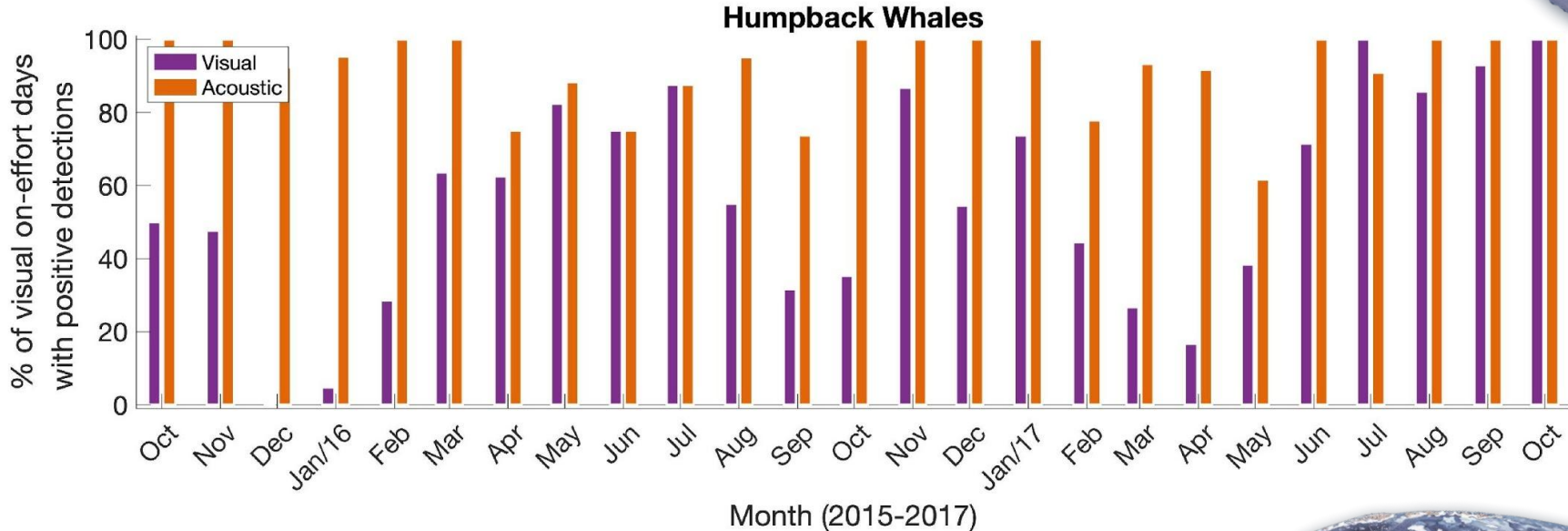
# Seasonality of Ambient Sound Levels



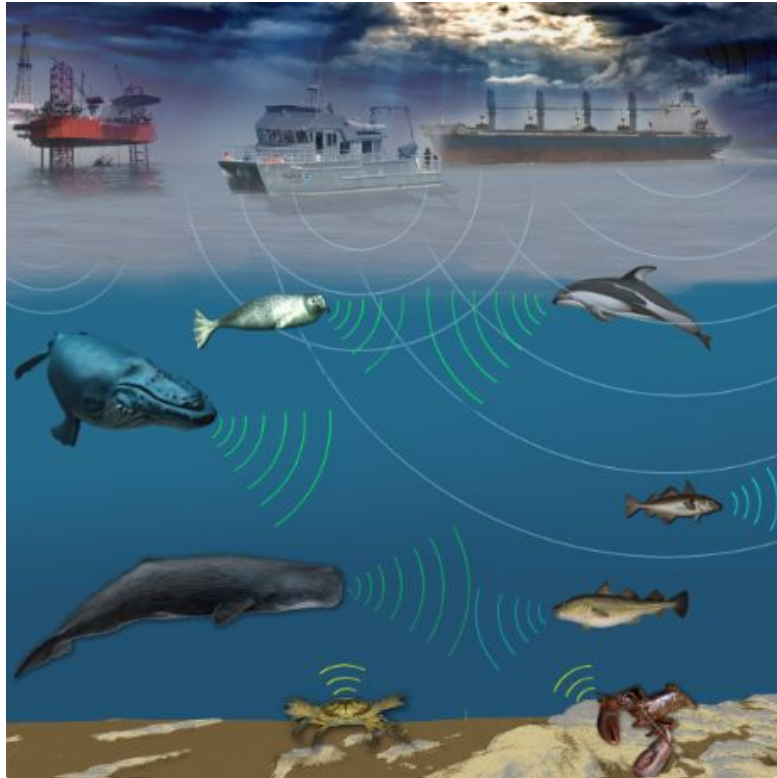
# Visual vs. Acoustic Detections



# Visual vs. Acoustic Detections

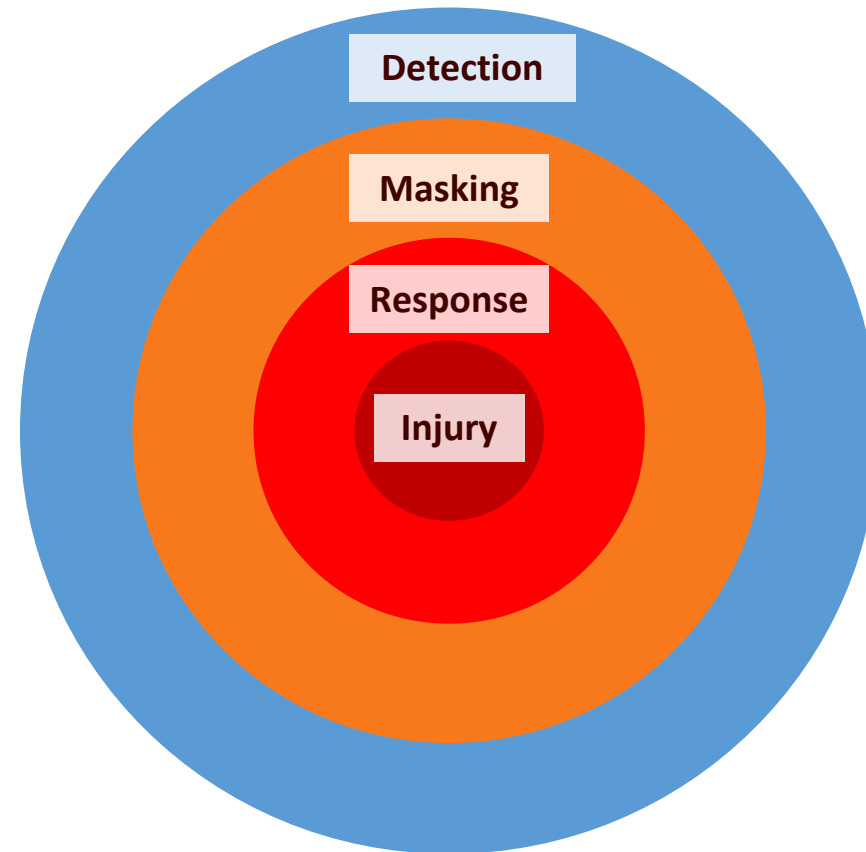


# Whales and Ocean Noise



Van Parijs et al., 2015

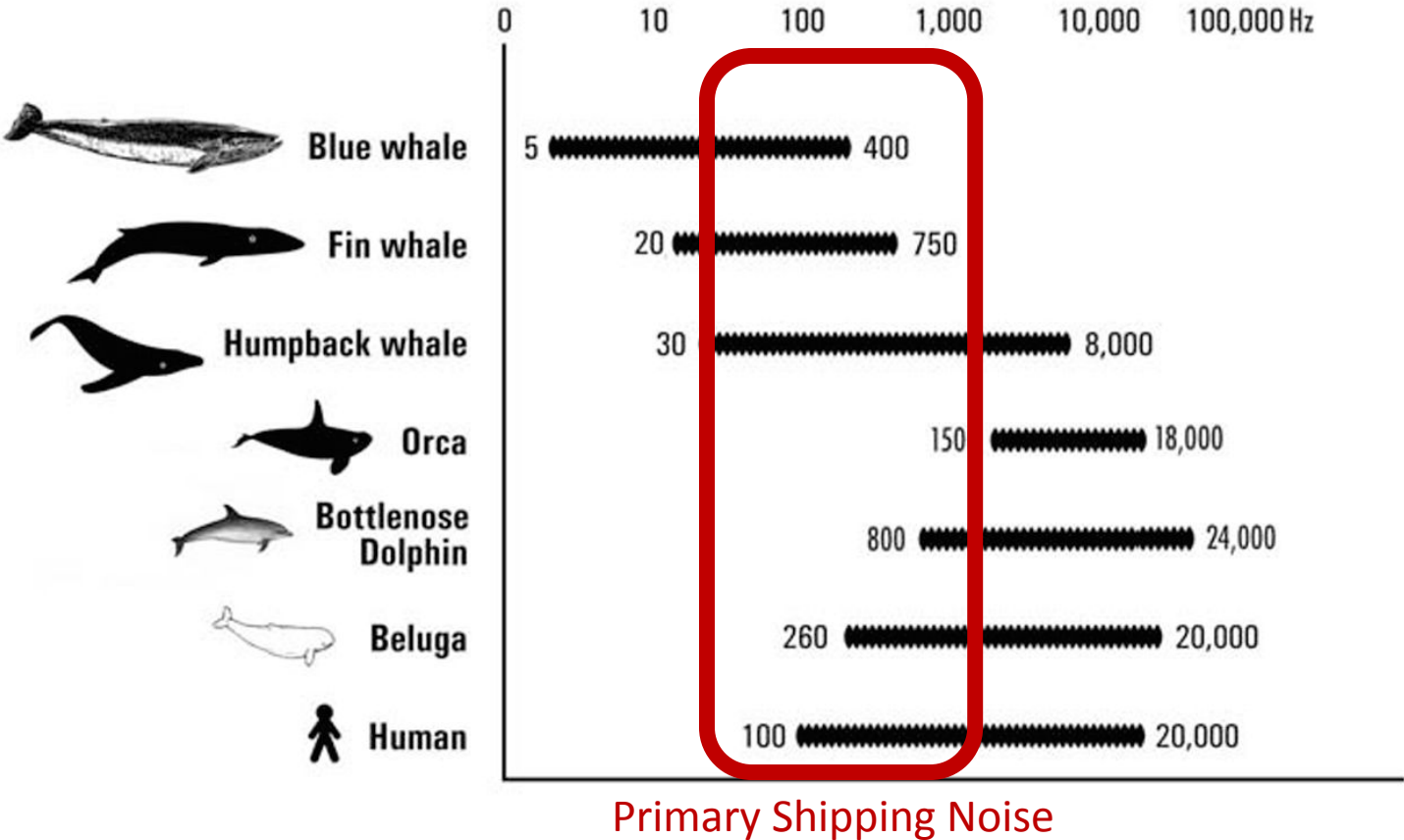
## Theoretical Zones of Influence



Adapted from Richardson et al, 1995



# Whales and Vessel Noise



Graphic: D. Rothenberg, Thousand Mile Song: Whale Music in a Sea of Sound, Perseus Books Group, 2010.

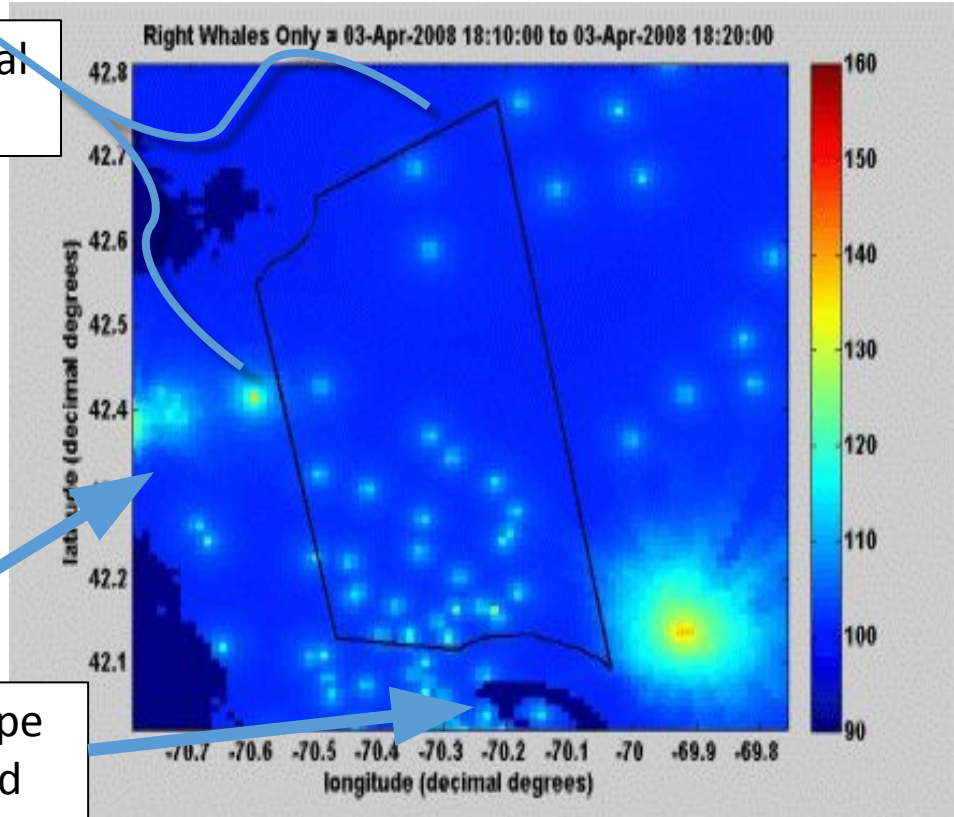


Ghostfishing.org

Stellwagen Bank National  
Marine Sanctuary

Boston  
Harbor

Cape  
Cod

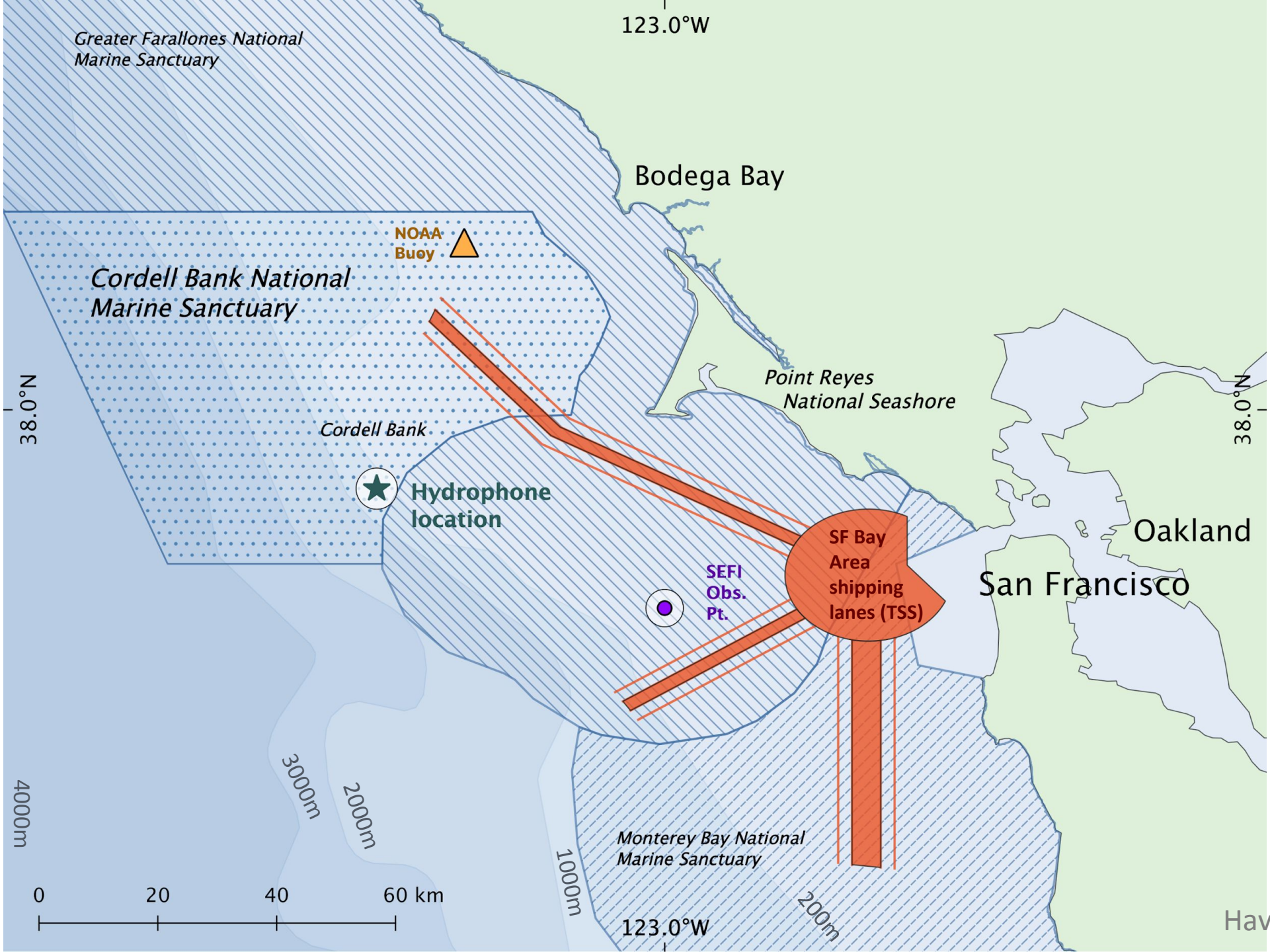


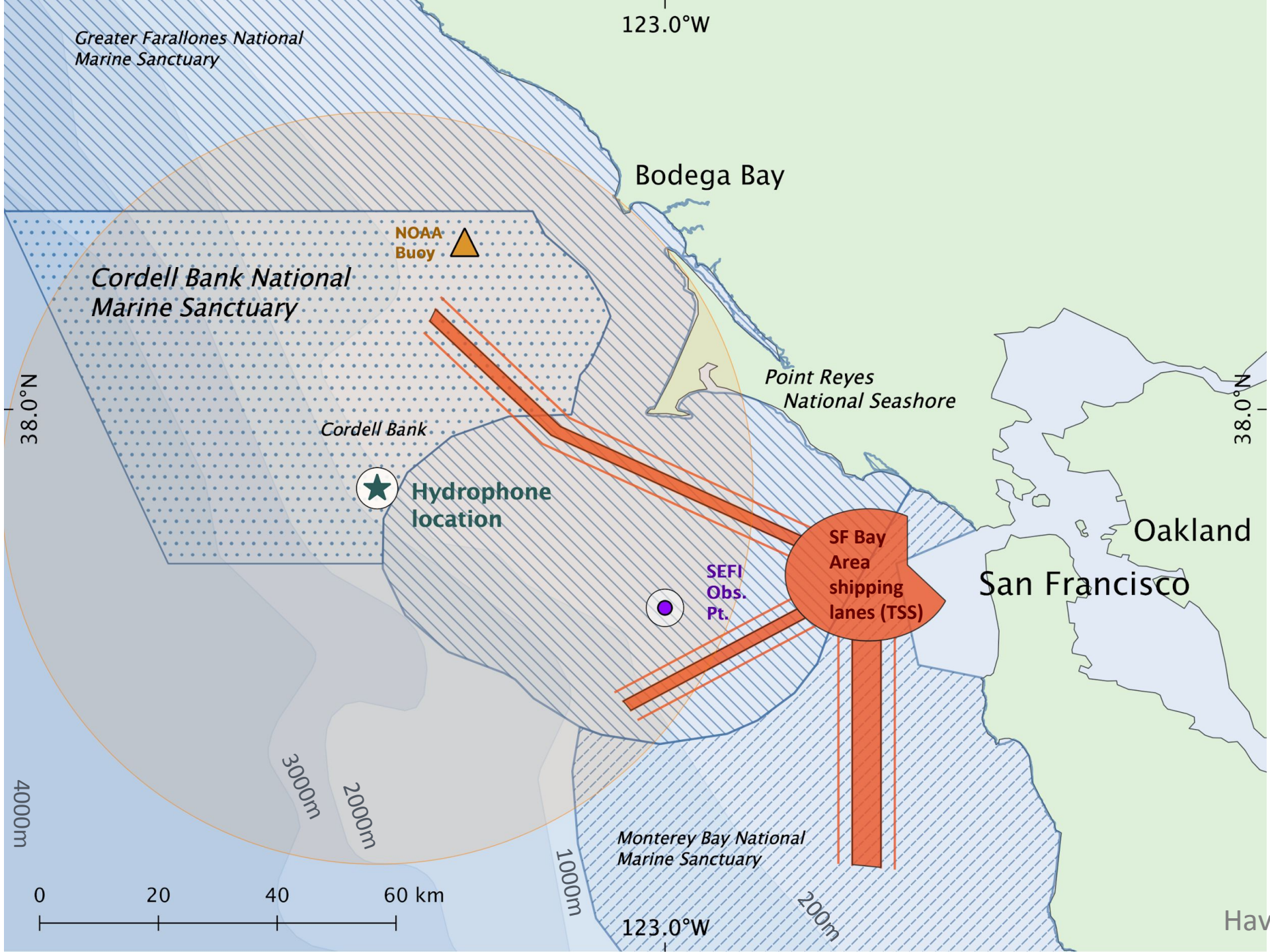
Graphic: Christopher Clark

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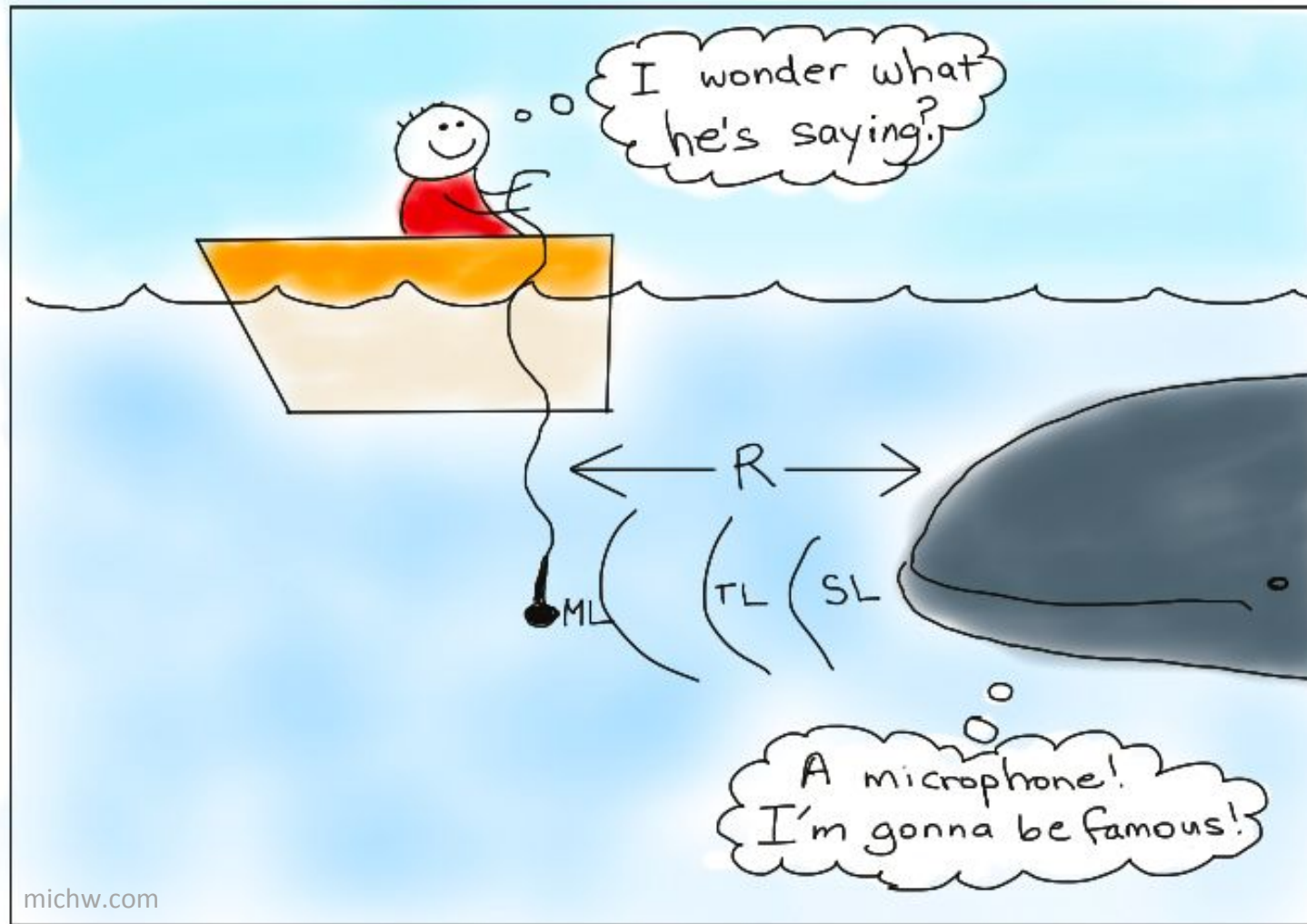




# Implications for Management

- Whale conservation
  - PAM reveals species nearby through the year
- Vessel noise vs. whales
  - Blue and fin whale chorusing detected above ambient, but unknown impact to other species (e.g. grey whales)
- Need more information about where whales are when we are able to hear them





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