How are Passive Acoustic Data Used to Inform the Decision-Making Process?

Elizabeth Henderson

NIWC Pacific

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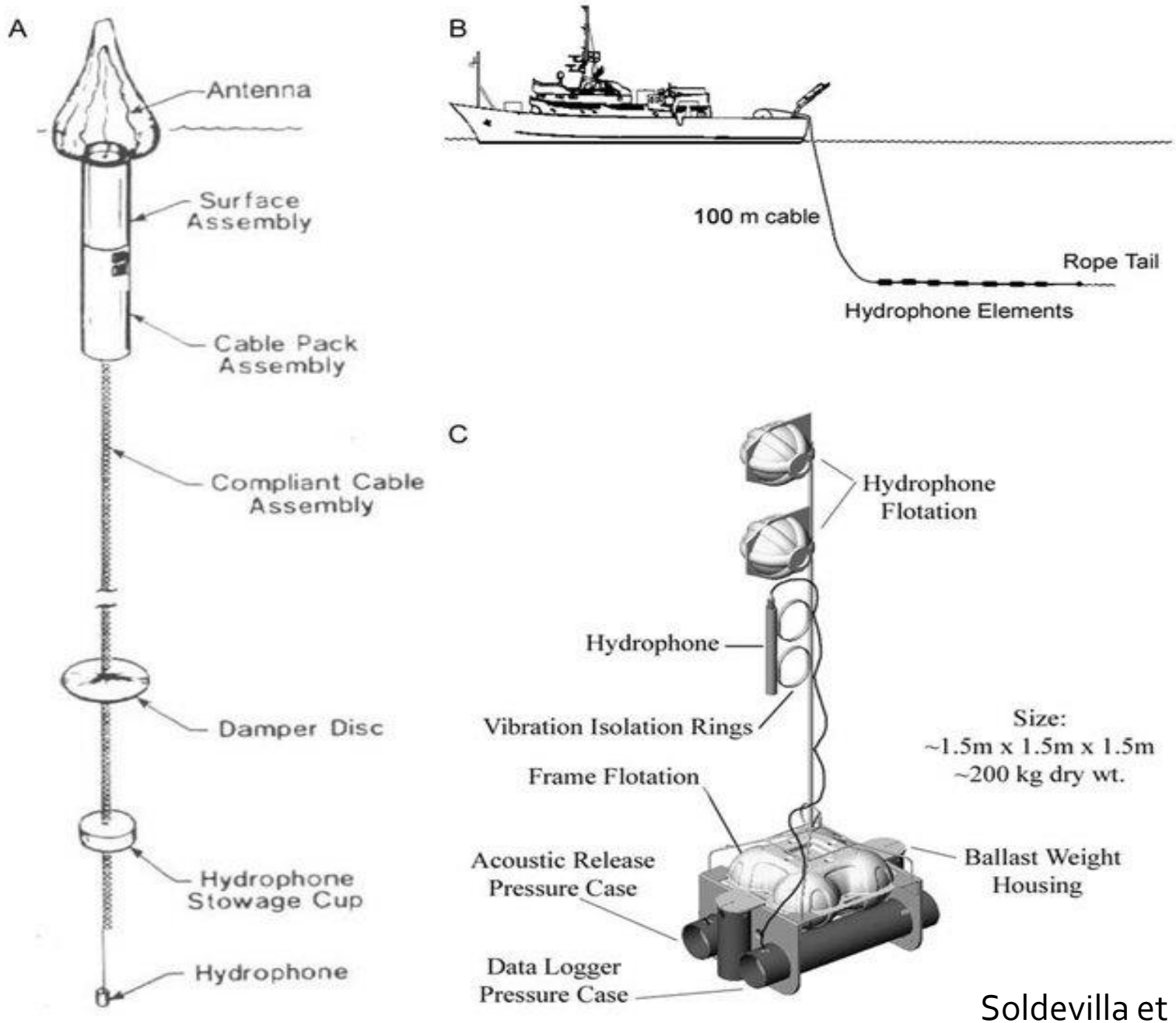
What is Passive Acoustic Monitoring?

- Use of a hydrophone and recorder to listen to underwater sounds
- Passive vs Active?
  - Listening/recording rather than emitting sound
- Sound/Signal vs Noise?
  - Sound of interest often referred to as "sound"
    - Marine mammal vocalizations
    - Seismic air guns
  - Other incidental sounds often referred to as "noise"
    - Ambient/background sounds
    - Anthropogenic sounds
- Types of recording instruments vary
  - Towed arrays
  - Instruments to be recovered
  - Non-recovered recorders
  - Bottom-mounted hydrophones

What is Passive Acoustic Monitoring?



Soldevilla et al. 2006

How Does Passive Acoustic Data Help Decision Making?

- Typically less expensive/longer duration than other methods
- Can address a variety of data topics
  - Marine mammal occurrence, behavior, habitat use, behavioral response
  - Presence of anthropogenic activity
  - Noise levels (Background, specific sounds)
    - Source level vs received level
- Depends on question, type of recording system, and type of data
- DOSITS page
  - How sound is used to help marine mammals

Passive Acoustic Data Types

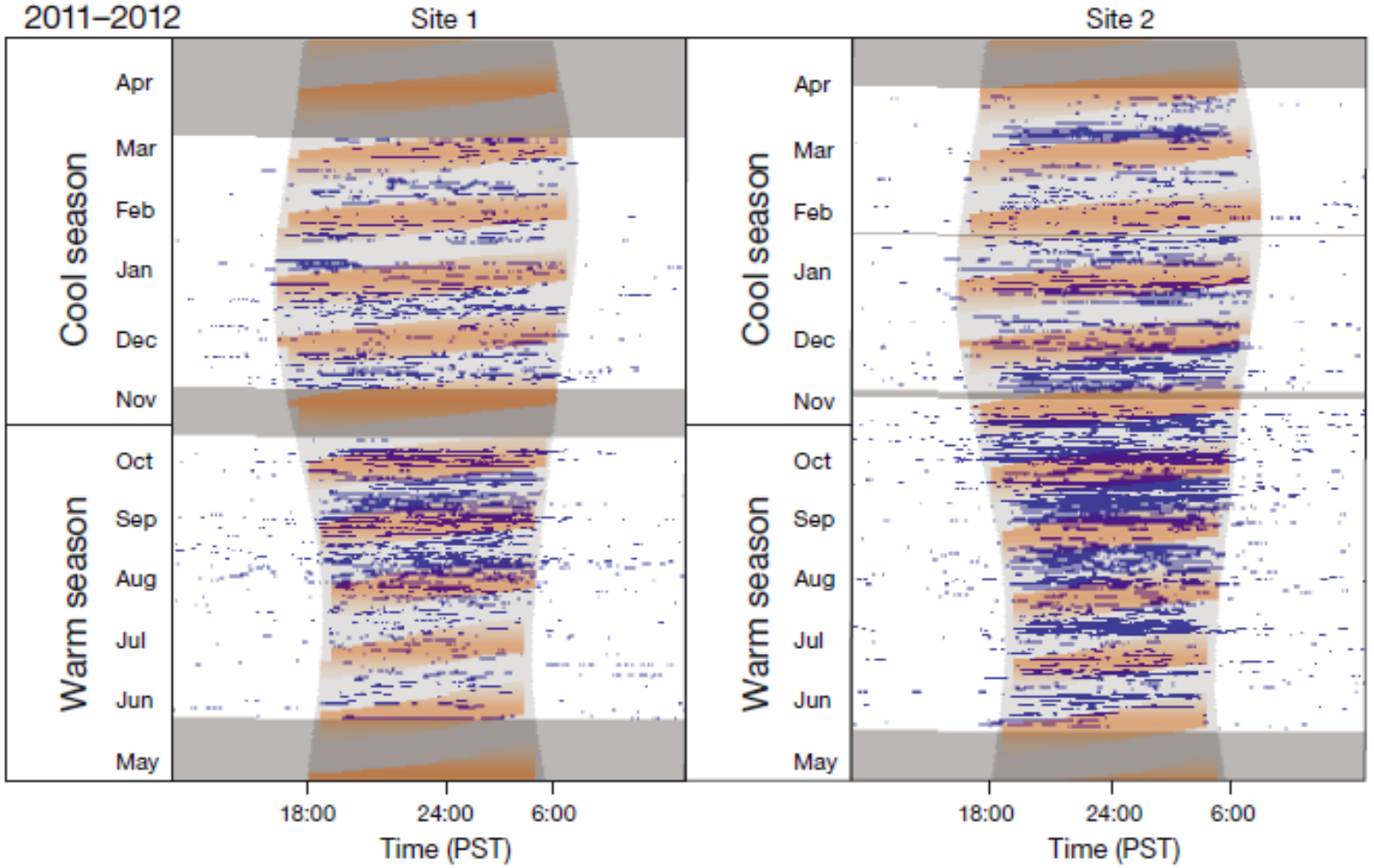
- How much data recorded?
  - Continuous
  - Periodic
  - Duty-cycled data (e.g. record 5 min, off for 15 min = 25% duty cycled)
- How many receivers?
  - Single sensor recorders
  - Multi-sensor recorders/arrays
- Where are receivers located?
  - Water column vs seafloor
  - Recorders that are deployed and recovered
  - Permanently mounted/cabled hydrophones
  - Acoustic tags attached to animals (e.g. DTAG)
- What data are recorded?
  - Raw acoustic files
  - Detection reports (e.g. C-PODS)

Passive Acoustic Data Capabilities and Questions

- Different questions can be answered by different data types
  - Presence/Absence of a species
  - Types of detections relative to behavior
  - Localization of animals
  - Track animals
  - Abundance/Density

- Any type of recorder, duty cycle, or data format
- What species are present in a given area?
- Are there patterns to that species' presence?
  - Diel, seasonal, interannual
  - E.g. Simonis et al. 2017 – Seasonal and diel patterns of common dolphins
- How much temporal/spatial overlap between species' of interest and planned activity?
  - Johnson et al. 2016 – Acoustic (and other) detections of sperm whales, overlap with proposed marine protected area

Presence/ Absence

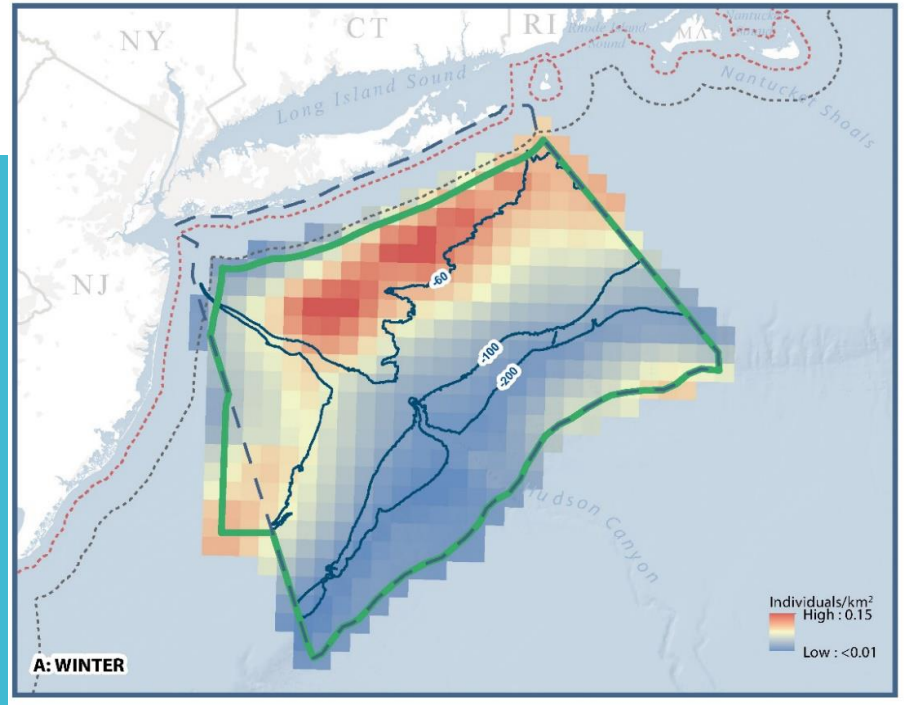


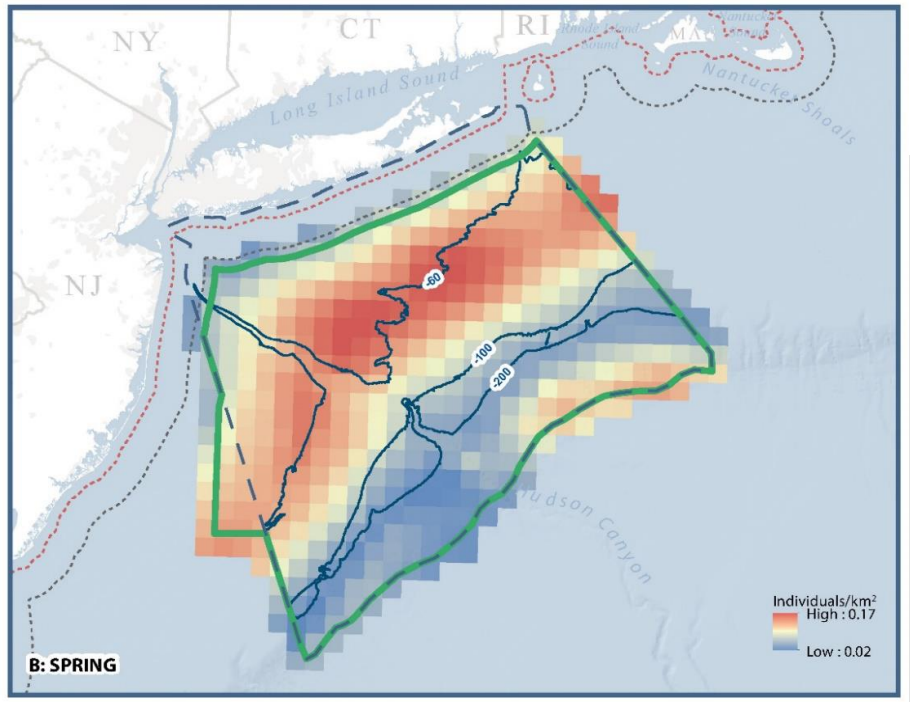
Simonis et al. 2017

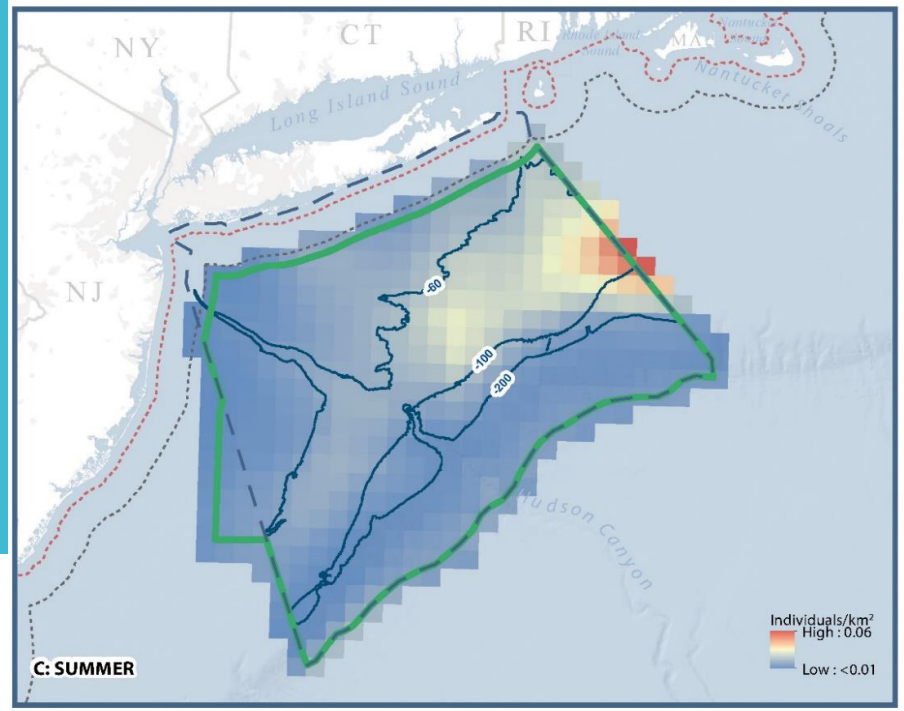
Presence/ Absence

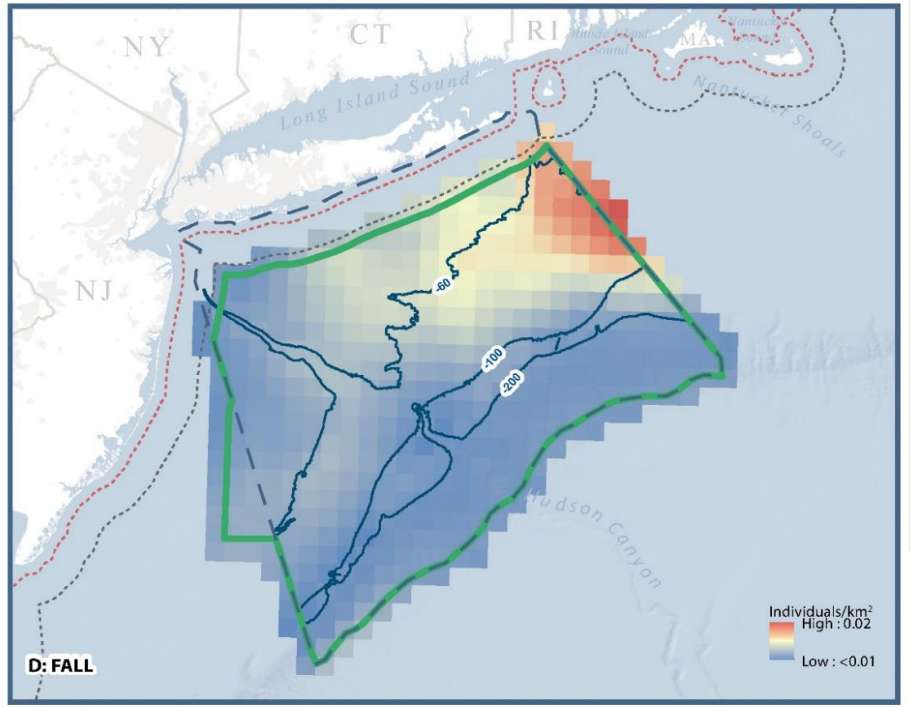
- Important for project planning, shipping traffic
- Historical passive acoustic data
- Seismic surveys, wind farm development, coastal construction
  - Can plan seasonally when high risk species are not present
  - New York State Offshore Wind Master Plan Marine Mammals and Sea Turtles Study
- Real time acoustic data
- Whale Alert - http://www.whalealert.org/
  - West Coast - blue, fin, and humpback whales
    - Reduced ship strikes in shipping lanes
  - East Coast – North Atlantic right whales
    - Dynamic and Seasonal Area closures
    - Acoustic system in Stellwagen Bank to report detections

Presence/ Absence

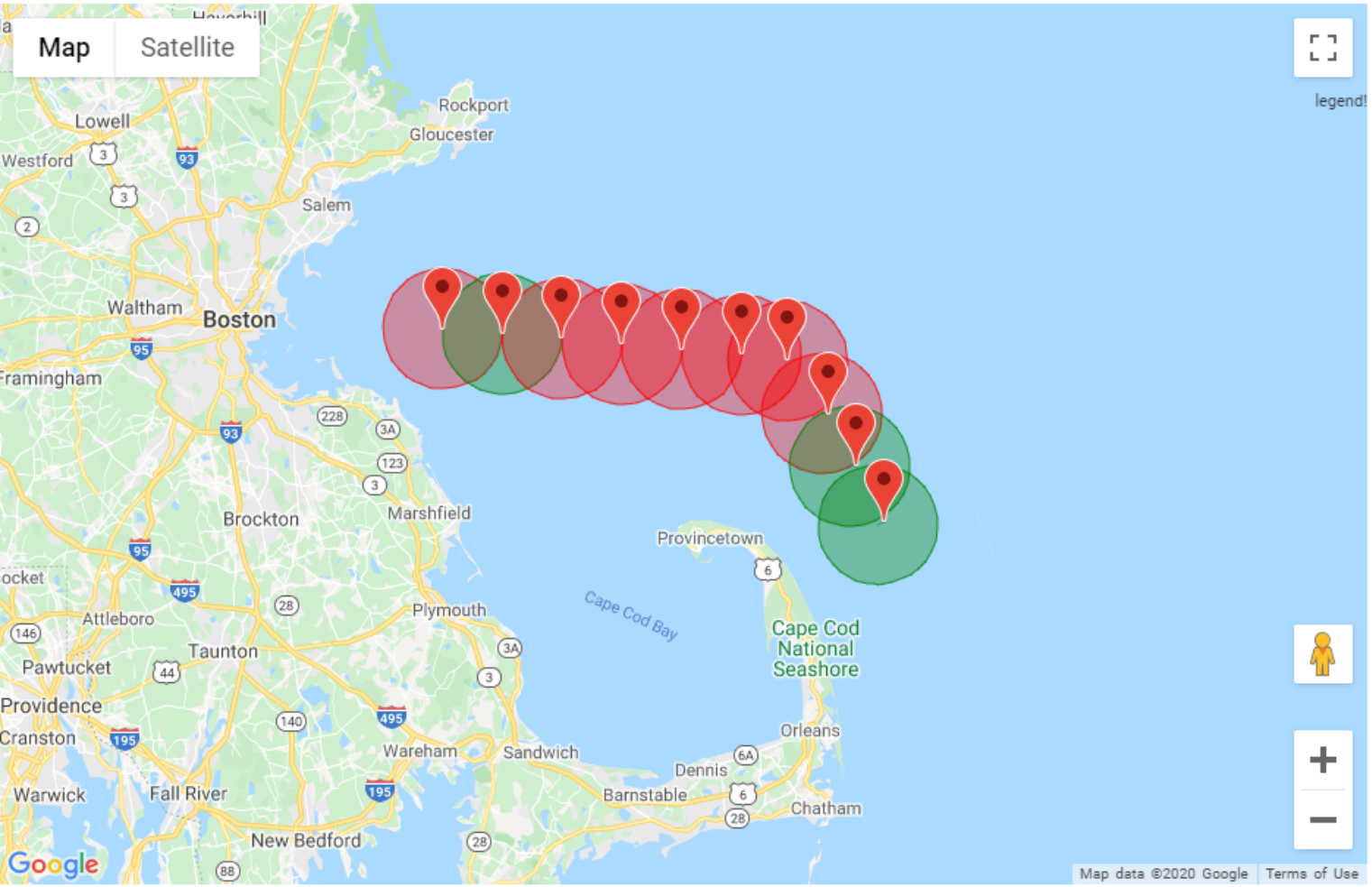








TSS Neptune Construction Southeast Test Zone Cape Cod Chukchi Sea Gunshot



Last Alert Expires: Mon Oct 19 2020 22:53:23 GMT-0700 (Pacific Daylight Time) (about 13 hours from now)

recent detections

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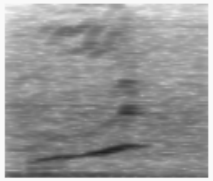
@ TSS-AB05
about 6 hours ago



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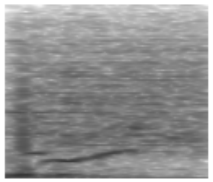

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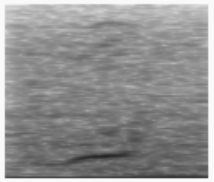

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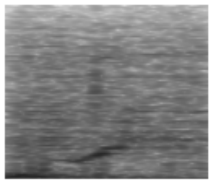

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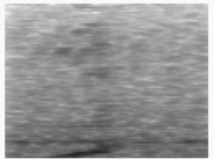
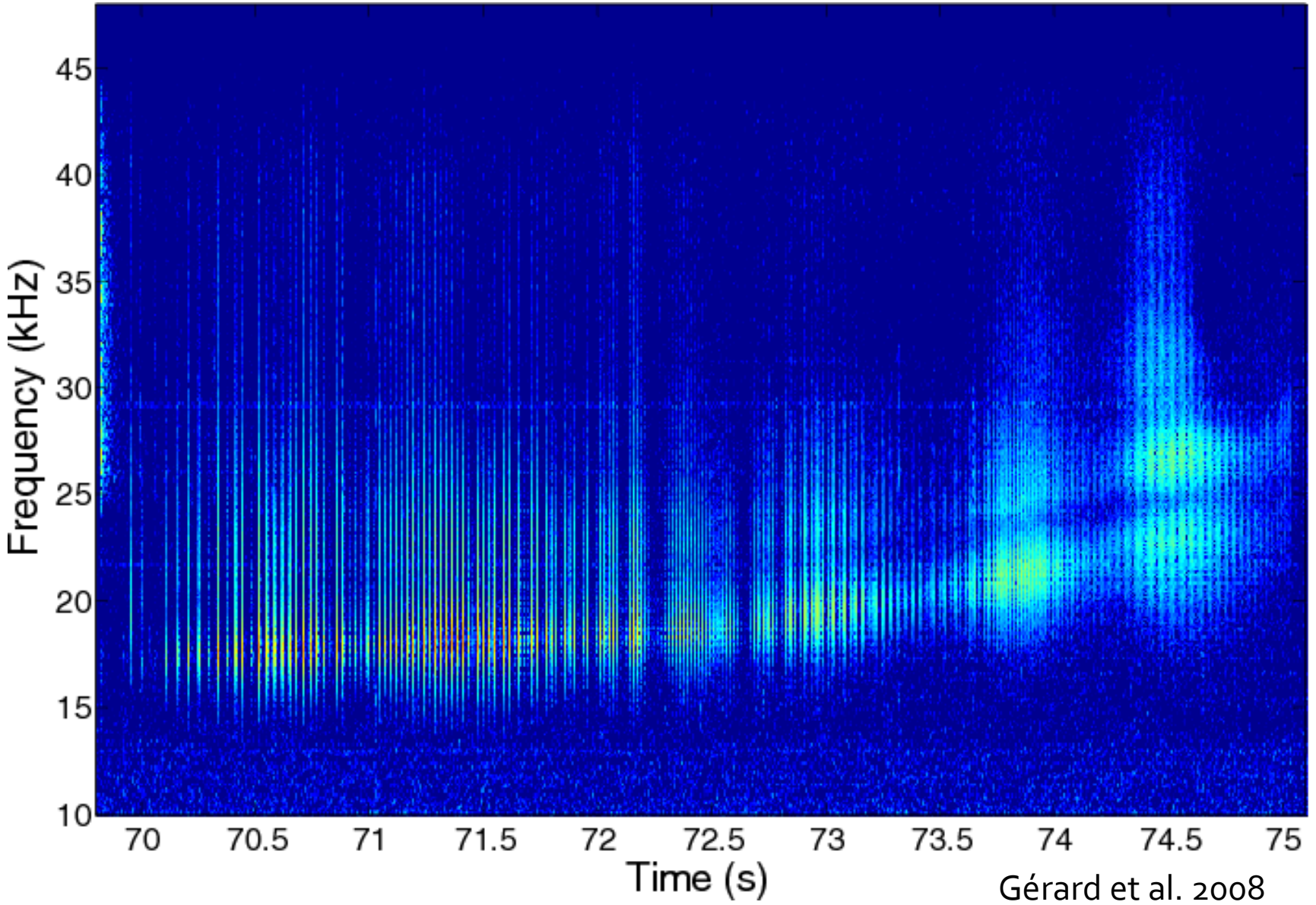


Behavior

- Behavioral States
  - Foraging/Socializing/Traveling/Resting
  - Specific foraging vocalizations
    - Echolocation clicks and buzzes (e.g. Blainville's beaked whales, Gérard et al. 2008)
    - Acoustic cues (e.g. humpback whale bubble net feeding, D'Vincent et al. 1985)
  - Often more vocalizing (whistling) when socializing
  - Fewer vocalizations in some states
    - Resting
    - Mammal-eating killer whales reduce vocalizations when hunting

    (e.g. Deeke et al. 2005)
- Time/activity budgets of behavior
  - e.g. Henderson et al. 2011
- Humpback song/other baleen whale song

Behavior

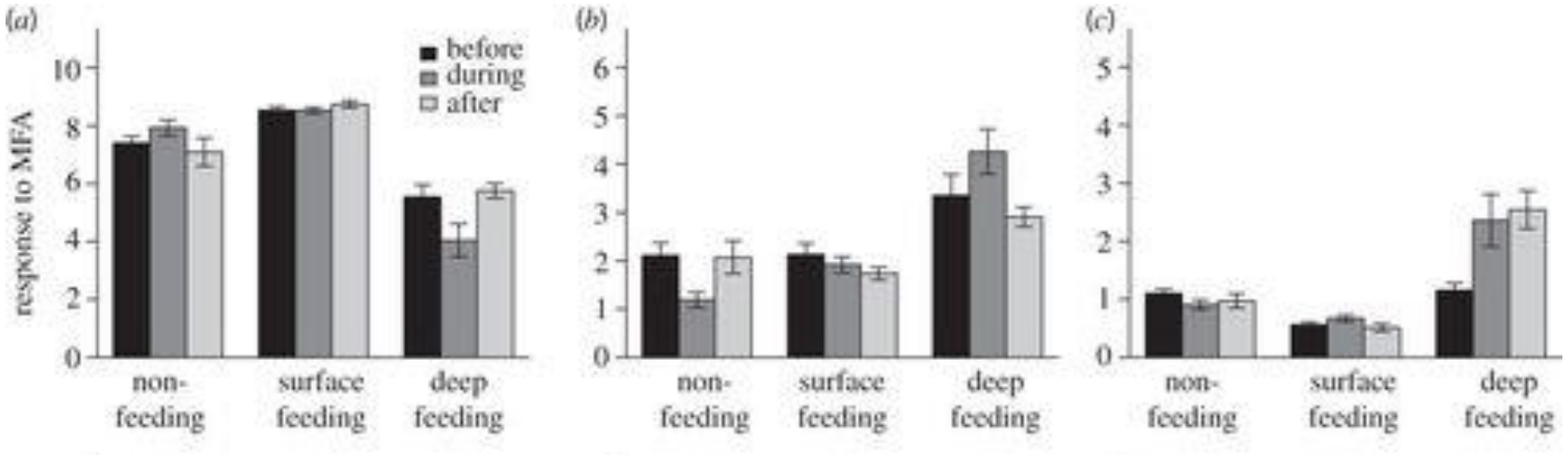


Gérard et al. 2008

Behavior

- Some species more responsive/sensitive to sounds when in specific behavioral state
  - Blue whales
    - Goldbogen et al. 2013 – blue whales responded more to mid-frequency sonar when deep feeding, less when shallow feeding
  - Humpback whales
    - Sivle et al. 2016 – humpback whales stopped foraging when sonar began
    - BUT Wensveen et al. 2017 – found a lack of avoidance behavior in humpback whales when exposed to sonar (same study)
- Risk of entanglement
  - Santora et al 2020 – Increase in humpback whale entanglements during Pacific Heat Wave
    - reduced foraging habitat plus shift in peak crab fishing
- Can develop mitigation strategies based on location/time of year for important behaviors

Behavior

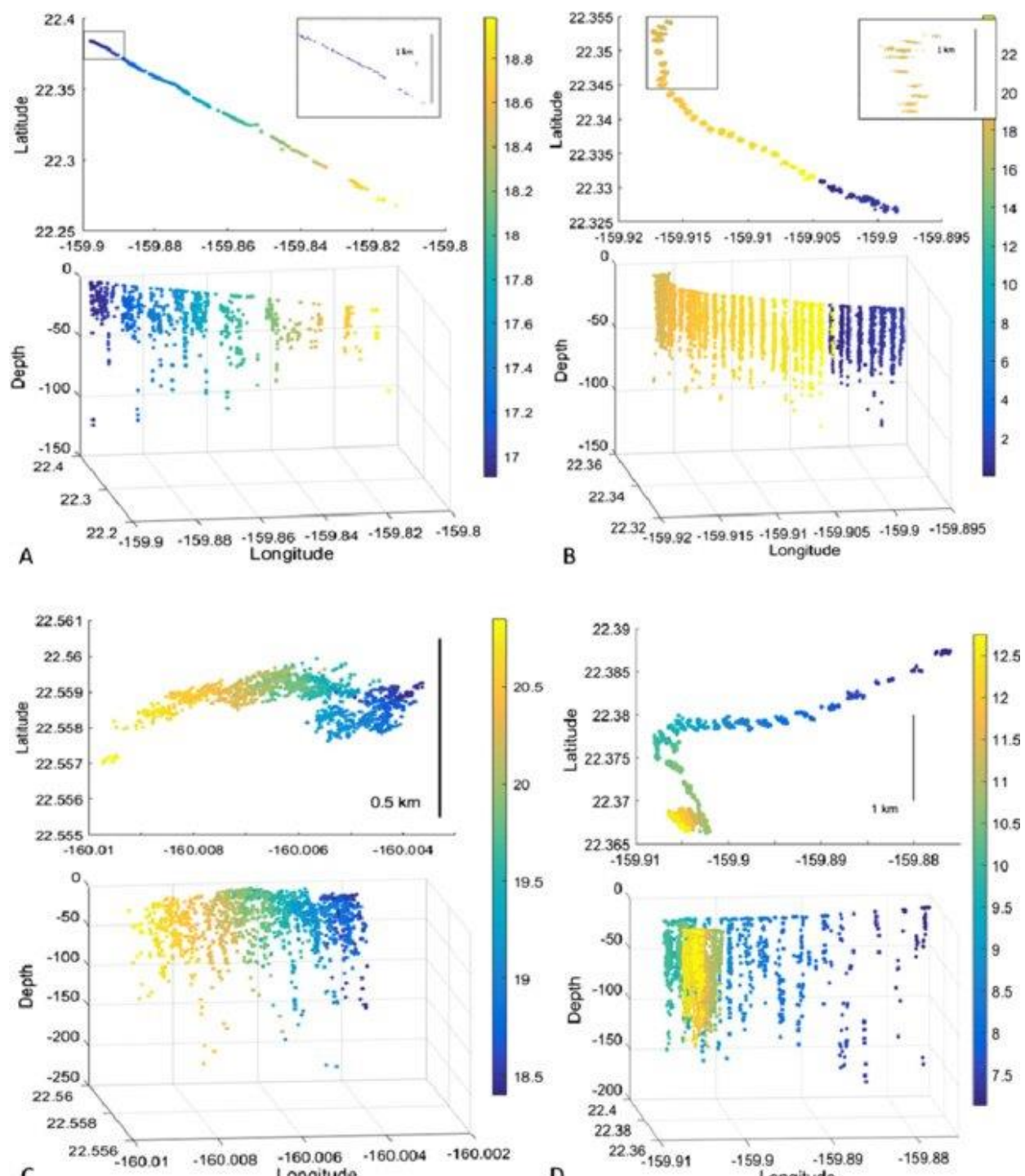


Goldbogen et al. 2013

Localized/ Tracked Animals

- Localize groups of vocalizing animals
  - Sperm whales, beaked whales
- With multiple sensors can also acoustically track animals
  - Gassmann et al. 2013 – used four recorders on seafloor to localize and track killer whale group
- Navy ranges have hundreds of bottom-mounted hydrophones
  - Can detect, localize, and track frequently calling animals in 3D
  - Henderson et al. 2018 – tracked singing humpback whales in Hawaii, identified different movement behaviors
  - Helble et al. 2020 and Guazzo et al. 2020 – tracked humpback and minke whales in Hawaii, estimated source levels of vocalizations

Localized/ Tracked Animals

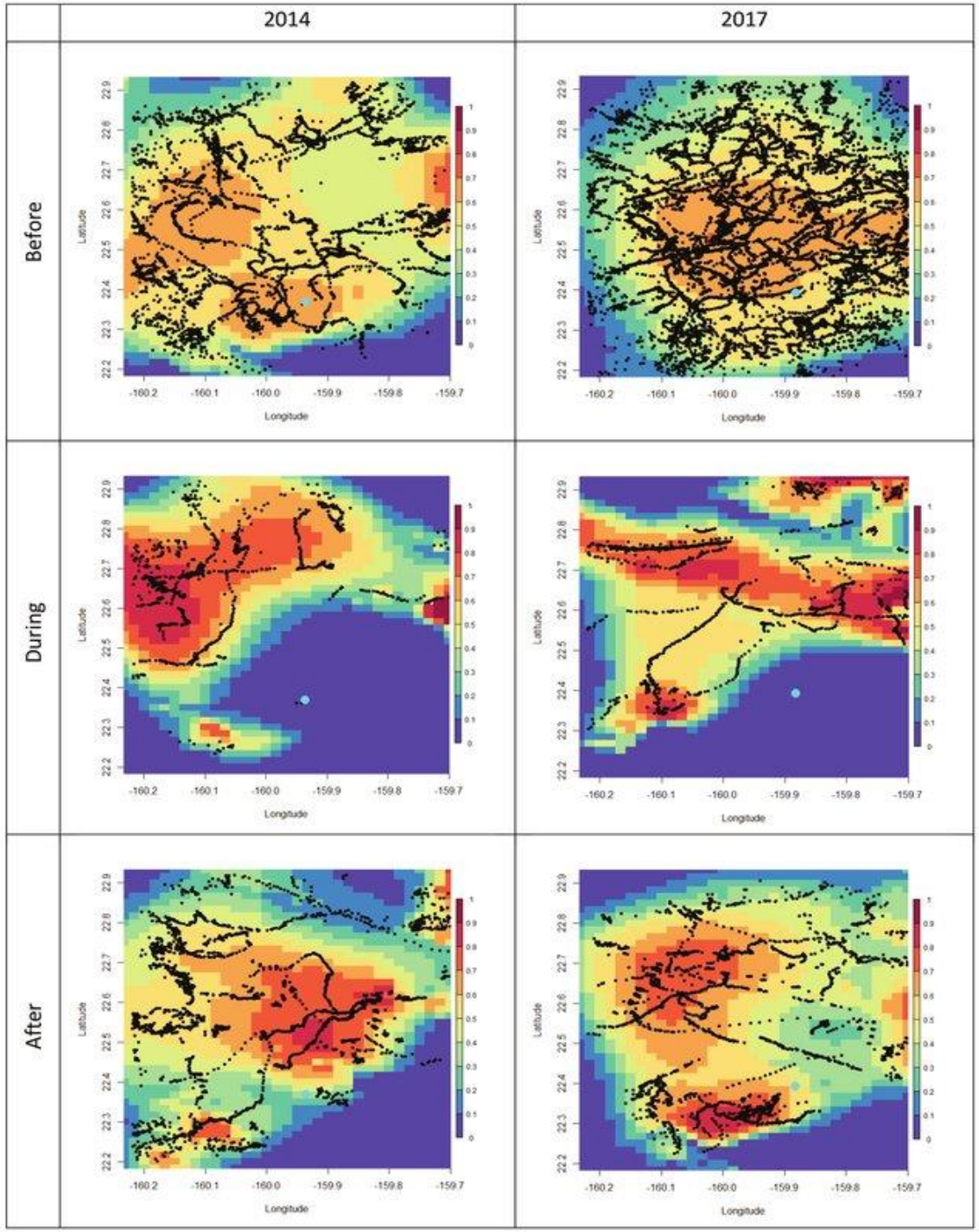


Henderson et al. 2018

Localized/ Tracked Animals

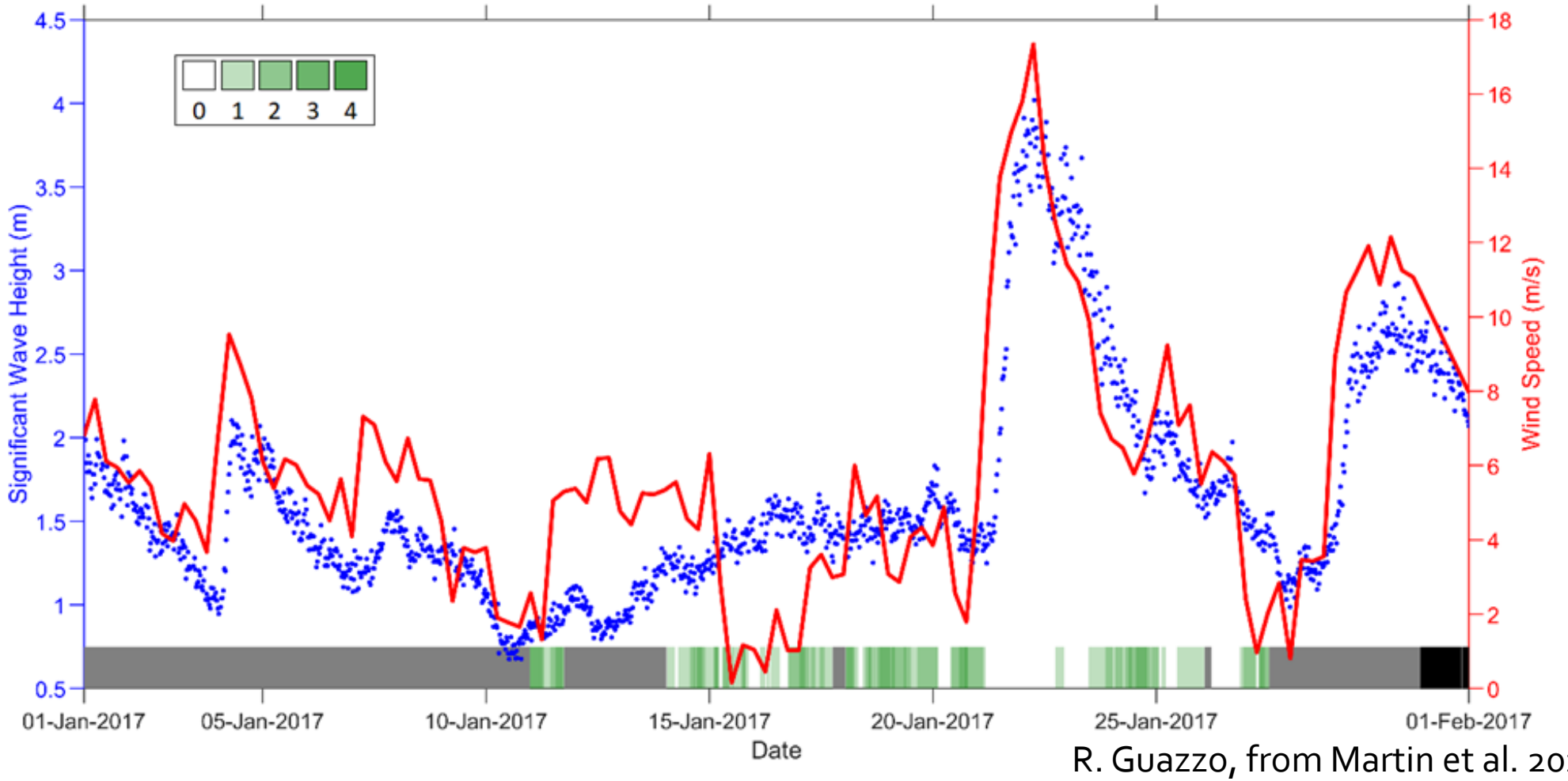
- Assess response in the vocal and movement behavior of acoustically tracked animals
  - Harris et al. 2019 – Examined acoustically tracked minke whales before, during, and after Navy training events and observed changes in spatial distribution of whales
  - Durbach et al. in prep – changes in movement behavior of minke whales during periods of MFAS
  - Martin et al. 2020 (figure by R. Guazzo) – minke whales stop calling during high ambient noise periods

Localized/ Tracked Animals



Harris et al. 2019

Localized/ Tracked Animals

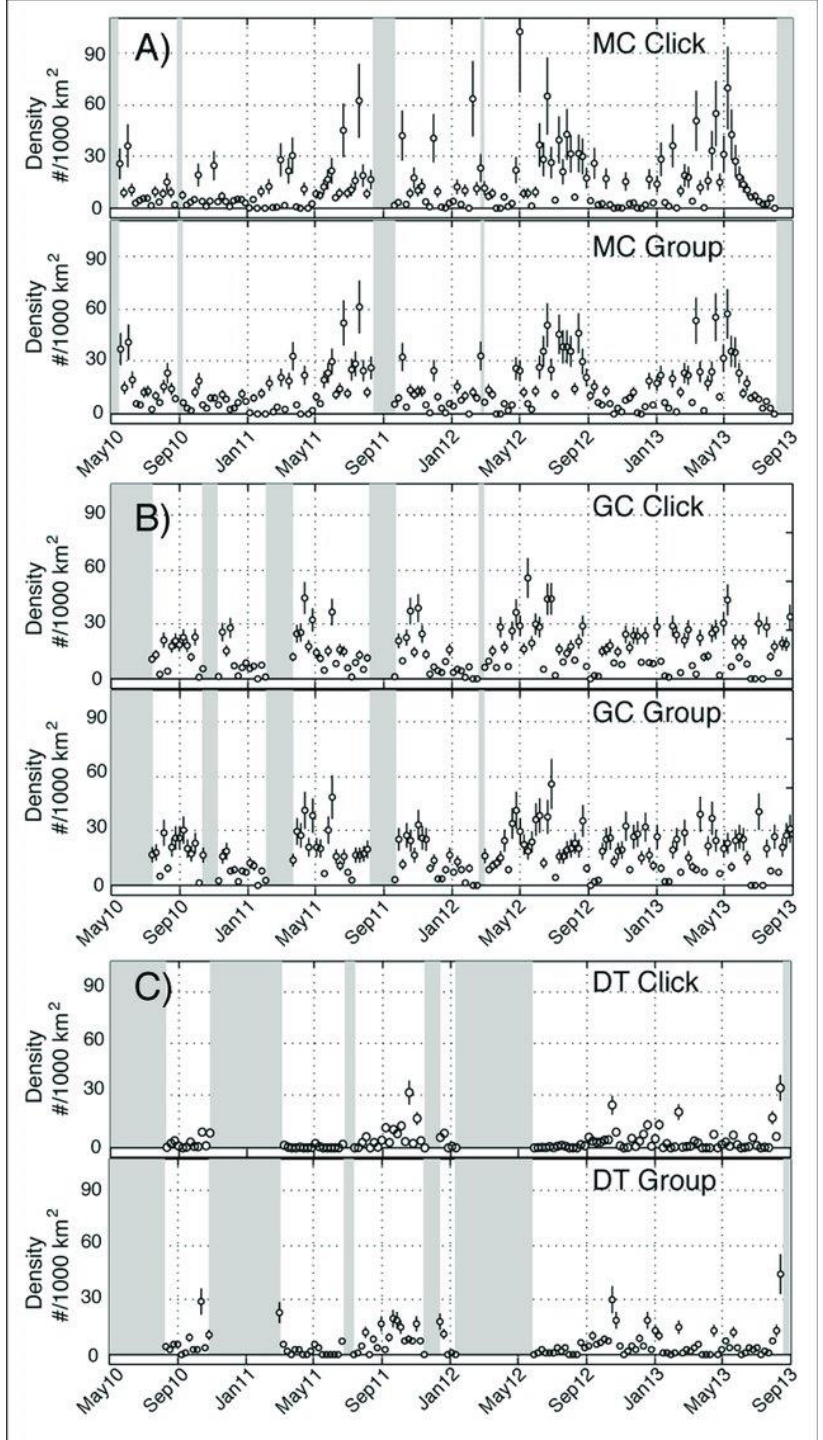


R. Guazzo, from Martin et al. 2020

Abundance and Density

- Can use acoustic data to obtain density estimates
- Cue Counting method
  - First need to know the cue/call rate and how stable it is
    - Guazzo et al. 2020 – Acoustic call rates of fin whales in Hawaii over a decade
    - Marques et al. 2009 – Used echolocation clicks from Blainville's beaked whales to estimate density from Navy range
      - Est. 22.5 - 25.3 animals/ 1000 km^2
- Group/Dive Counting Method
  - Need information on group size and dive rates
    - Moretti et al. 2010 – Blainville's beaked whale dive rates known from Navy range monitoring; group size known from visual surveys
      - Est. 16.99 – 24.75 animals/ 1000 km^2, comparable to click-counting method
    - Hildebrand et al. 2019 – used click- and group-counting methods for dwarf and pygmy sperm whales in the GoM; found densities much higher than found in visual surveys – better coverage & detectability acoustically

Abundance and Density

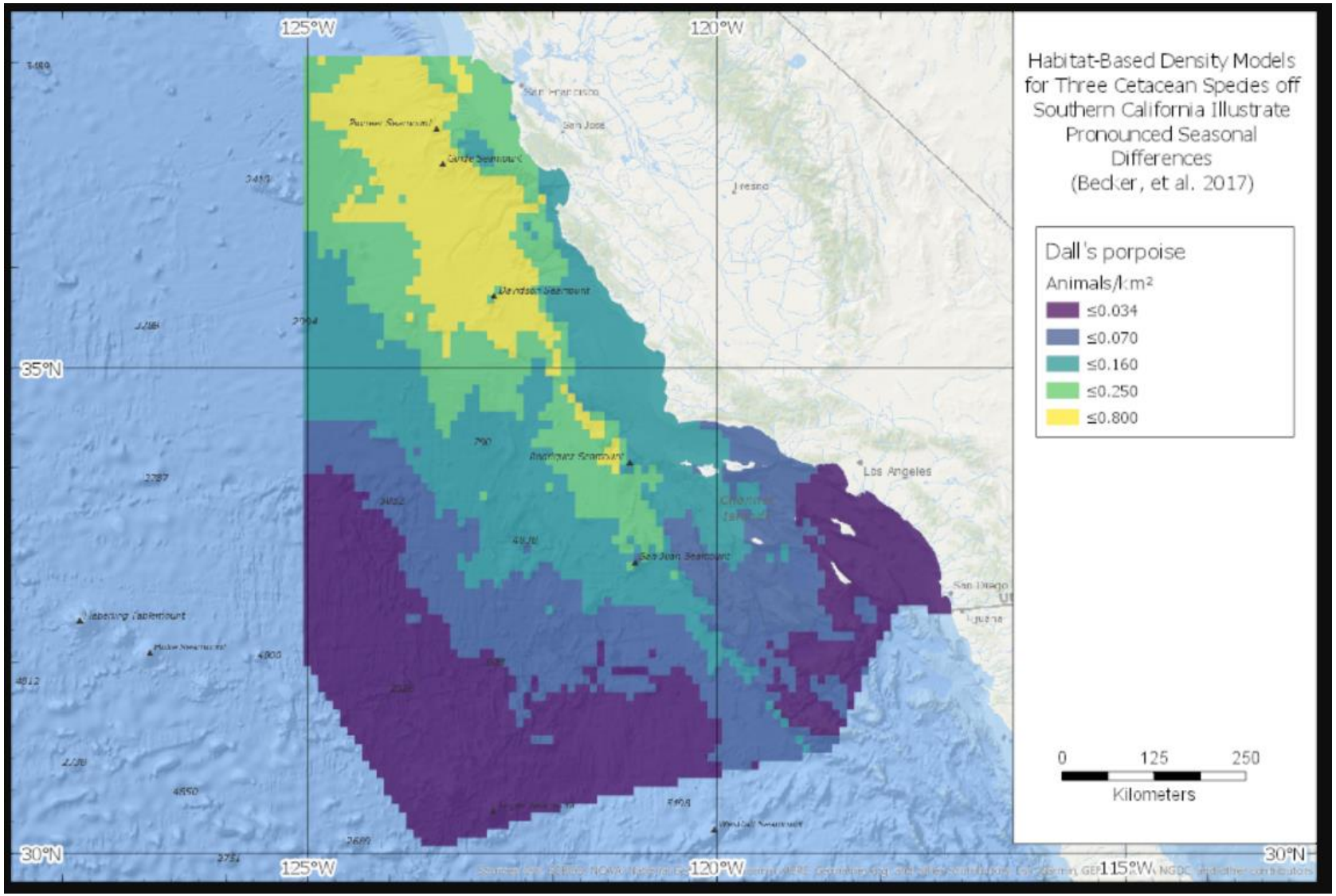


Hidebrand et al. 2019

Abundance and Density

- Maps of marine mammal density
  - https://cetsound.noaa.gov/cda-index
  - http://seamap.env.duke.edu/ - OBIS SEAMAP
- Density maps used by regulators for decision making
  - Navy uses density surfaces to estimate impacts of training activity
- Long term assessment of density can show if populations are increasing/decreasing
  - Vaquita in Gulf of California – repeated visual and acoustic surveys were able to track the population decline from 567 in 1997 to 245 in 2008 to ~50 in 2015 (Barlow et al. 2007; Gerrodette et al 2010; Jaramillo-Legorreta et al. 2017)
    - Collaborative effort between US and Mexican scientists and government agencies
  - This rapid decline led to emergency 2-year ban on gillnets in GoC by Mexican government
  - Population now less than 30 animals

Abundance and Density

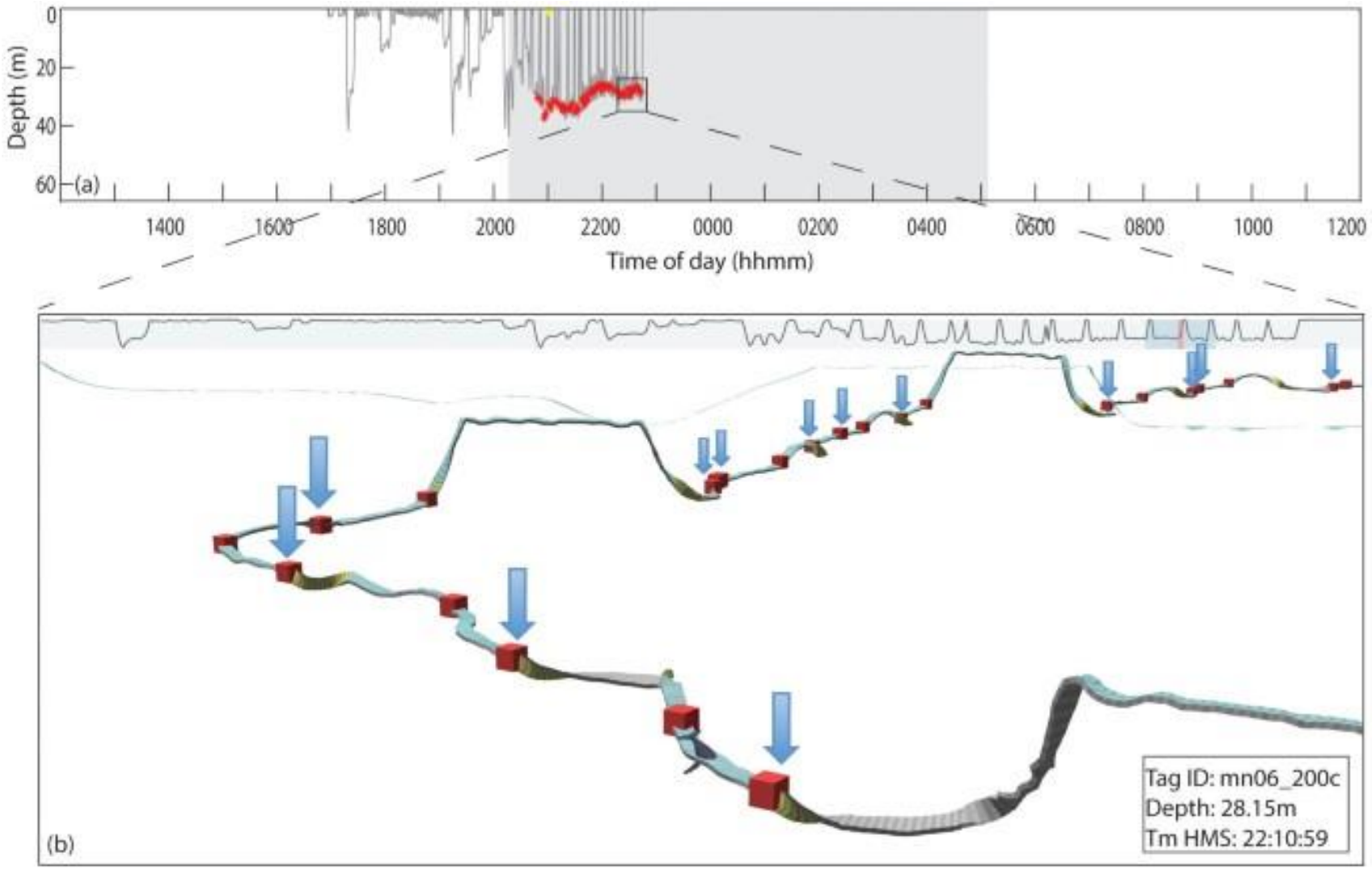


OBIS-SEAMAP (from Becker et al. 2017)

Acoustic Tags

- Acoustic tags – record sound plus fine movement, can link acoustics and behavior
  - Tyack et al. 2006 – early work tagging Blainville's and Cuvier's beaked whales; discovered echolocation click behavior only occurred in certain period of dives
  - Lewis et al. 2018 – linked blue whale vocalizations with dive behavior to determine when blue whales are calling (e.g. more at surface, less during deep foraging dives)
  - Parks et al. 2014 – "paired burst" calls during humpback whale bottom feeding behavior

Acoustic Tags

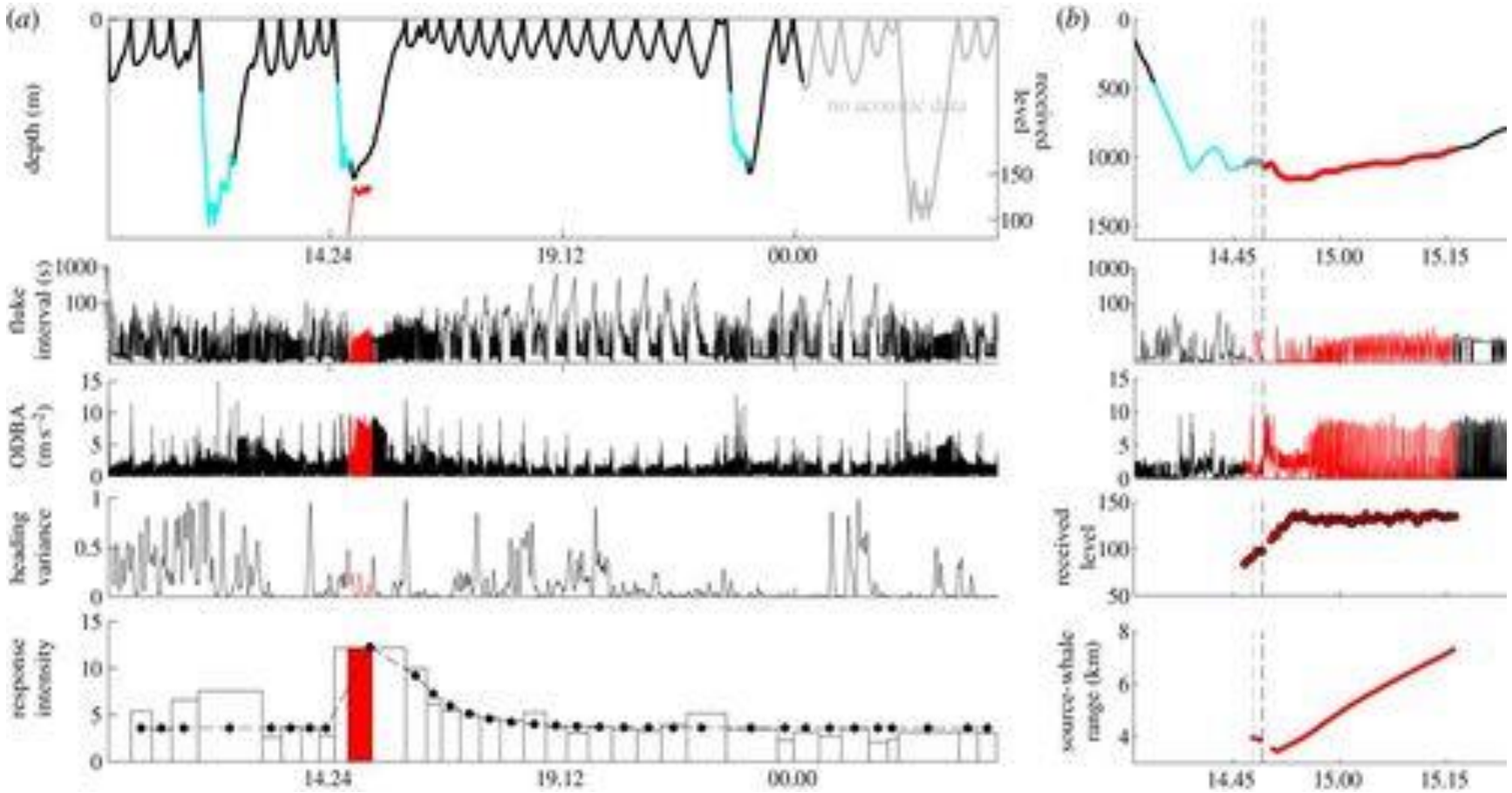


Parks et al. 2014

Acoustic Tags

- Acoustic and other tags used in behavioral response studies
  - DeRuiter et al. 2013 - Looked at course and fine scale movements of individual Cuvier's beaked whales to determine if a response occurred
  - Falcone et al. 2017 - Aggregate data from many Cuvier's beaked whales to look at overall changes in behavior
- Examine the relationship between received level and response
  - Miller et al. 2013 - Measured received sound level on tagged killer whales, developed dose-response function
  - Schick et al. 2019 – Modeled sound propagation field to estimate sound level at satellite tagged beaked whales and pilot whales

Acoustic Tags

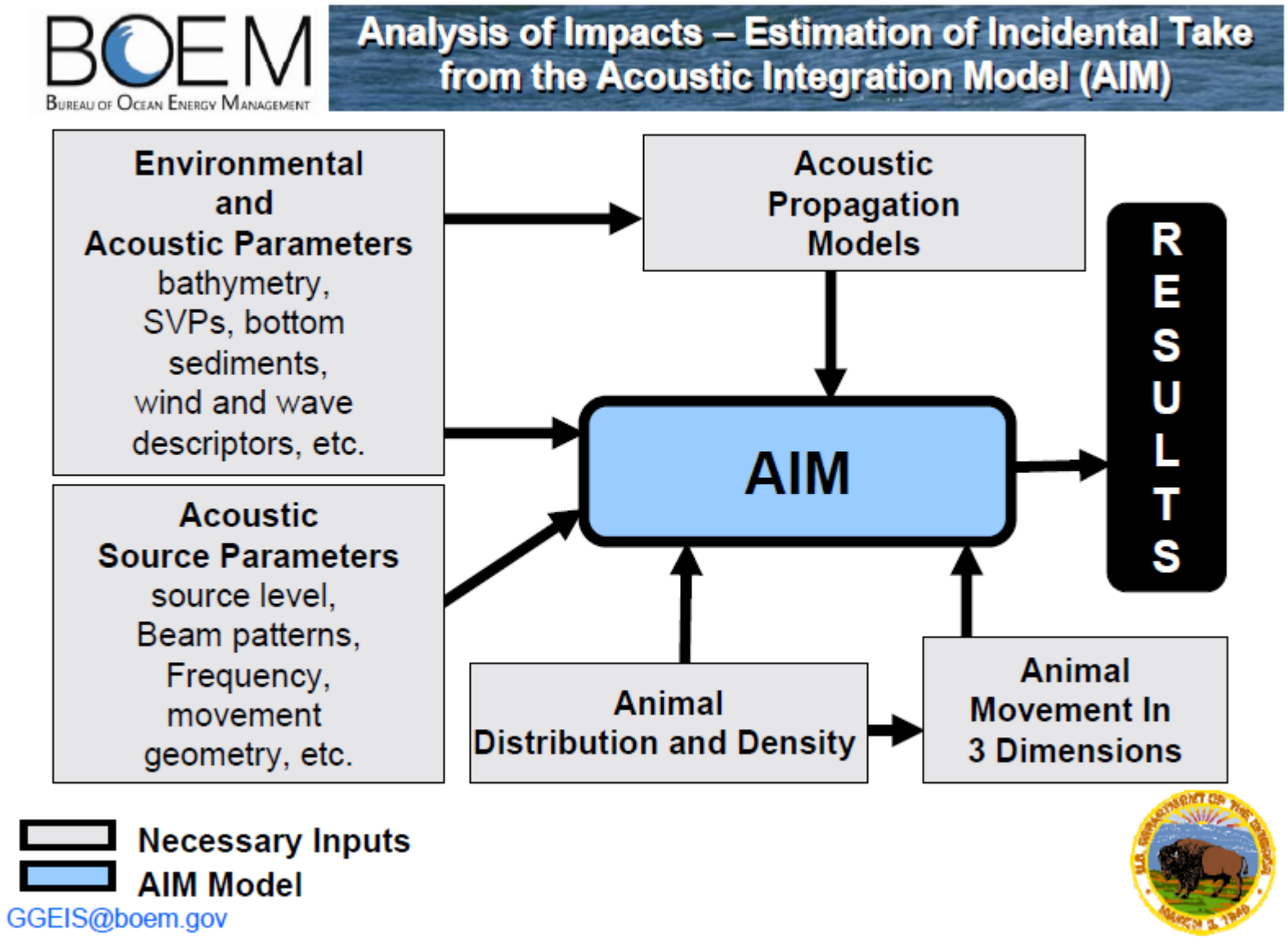


DeRuiter et al. 2013

Decision Making Tools

- NMFS and Navy both developed criteria to estimate hearing threshold impacts for various sound sources
  - NMFS Acoustic Technical Guidance
  - US Navy Criteria and Thresholds
  - Similar thresholds and methods for TTS/PTS from sonar, developed in consultation together
- Behavioral Risk Functions for Navy
  - primarily relied on Behavioral Response Studies using acoustic tags, plus some captive research
  - Updating risk functions, considering incorporation of other sources of behavioral response
    - Acoustically tracked whales on ranges
    - Satellite tags with propagation modeled received levels
- BOEM assess takes using the Acoustic Impact Model (AIM)

Decision Making Tools



QUESTIONS?