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Using DTAGs to understand sound use, behavior, and vessel and associated noise effects in Southern Resident killer whales

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Speaker
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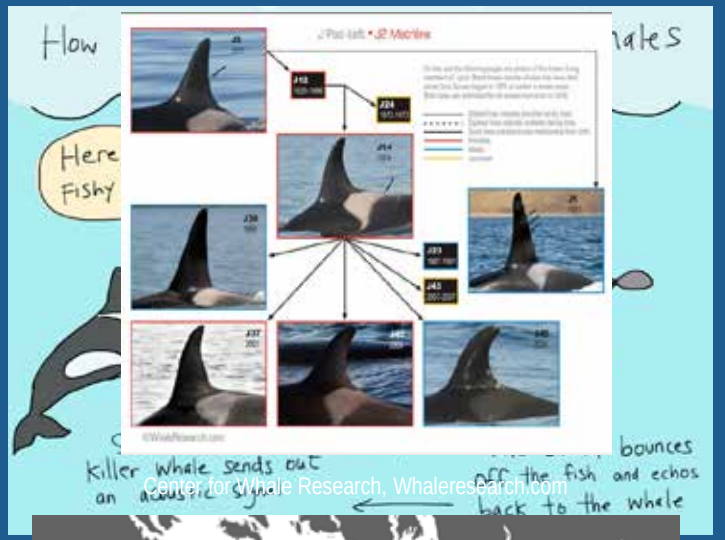
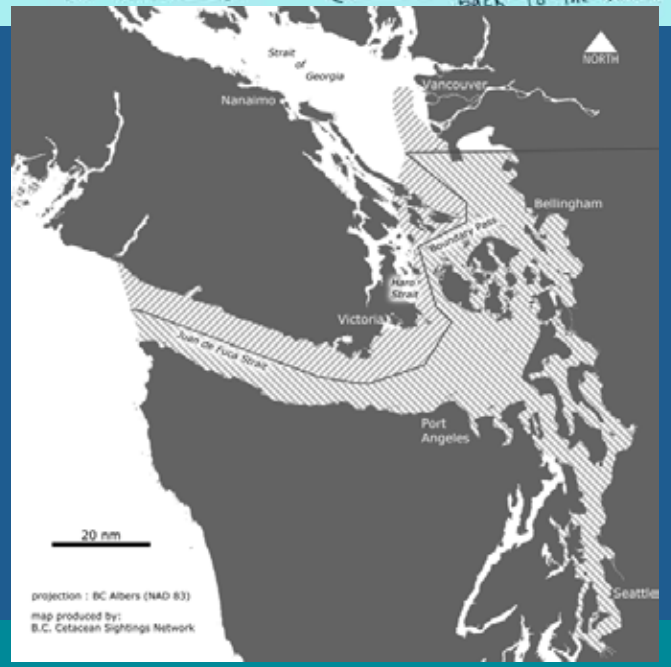
Killer Whale Sound Use and SRKWs

- Killer whales rely on sound
  - Calls, whistles - communication
  - Biosonar clicks - foraging, navigation
  - Passive listening
- Southern Resident killer whales
  - 3 (J, K, L) endangered pods
  - Fish-eaters, Chinook (Hanson et al. 2010)
  - Critical Habitat in Salish Sea
  - Risk Factors:
    - Prey availability
    - Water pollution/contaminants
    - Vessel & noise disturbance
      - Ø Auditory, behavioral, physiological effects

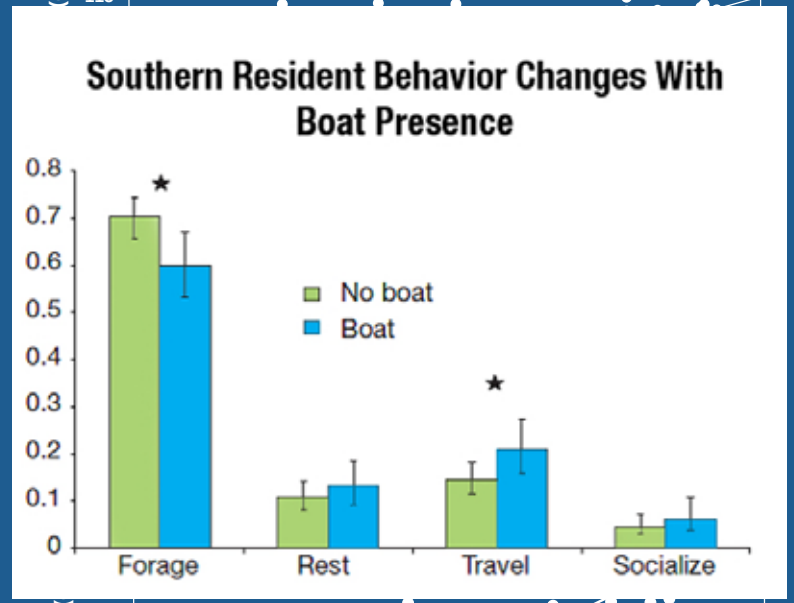




Fisheries and Oceans Canada. 2008. Recovery Strategy for the Northern and Southern Killer Whales (*Orcinus orca*) in Canada.

Previous Work on Vessel Effects

- Noise levels in Critical Habitat increase from nearby vessels (Holt et al. 2009)
- Call (source) levels increase when noise levels increase (Holt et al. 2009, 2011)
  - 1 dB increase in call level for 1 dB increase in noise level
  - Small but measurable cost in dolphins, Holt et al. 2015
- Behavioral responses to vessels include decreased foraging (Lusseau et al. 2009) and increased SABs (Noren et al. 2009)



Lusseau et al. 2009

Holt et al. 2009 JASA Express Letters

Objectives

Utilize multi-sensor tags to address vessel and noise effects

1. Determine relationship between vessels and noise levels received by SRKW, *Houghton et al. 2015 PLOS ONE*

2. Compare received noise levels before/after implementation of U.S. vessel regulations, *Holt et al. 2017 ESR*

3. Utilize acoustic and movement variables, investigate SRKW *subsurface* behavior during different activities, especially foraging

4. Determine effects of vessels and associated noise on behavior, especially foraging

Data Collection Methods

Location

- Trans-boundary waters of San Juan Islands
- Daylight hours- Sep 2010, Jun 2011, Sep 2012, Sep 2014

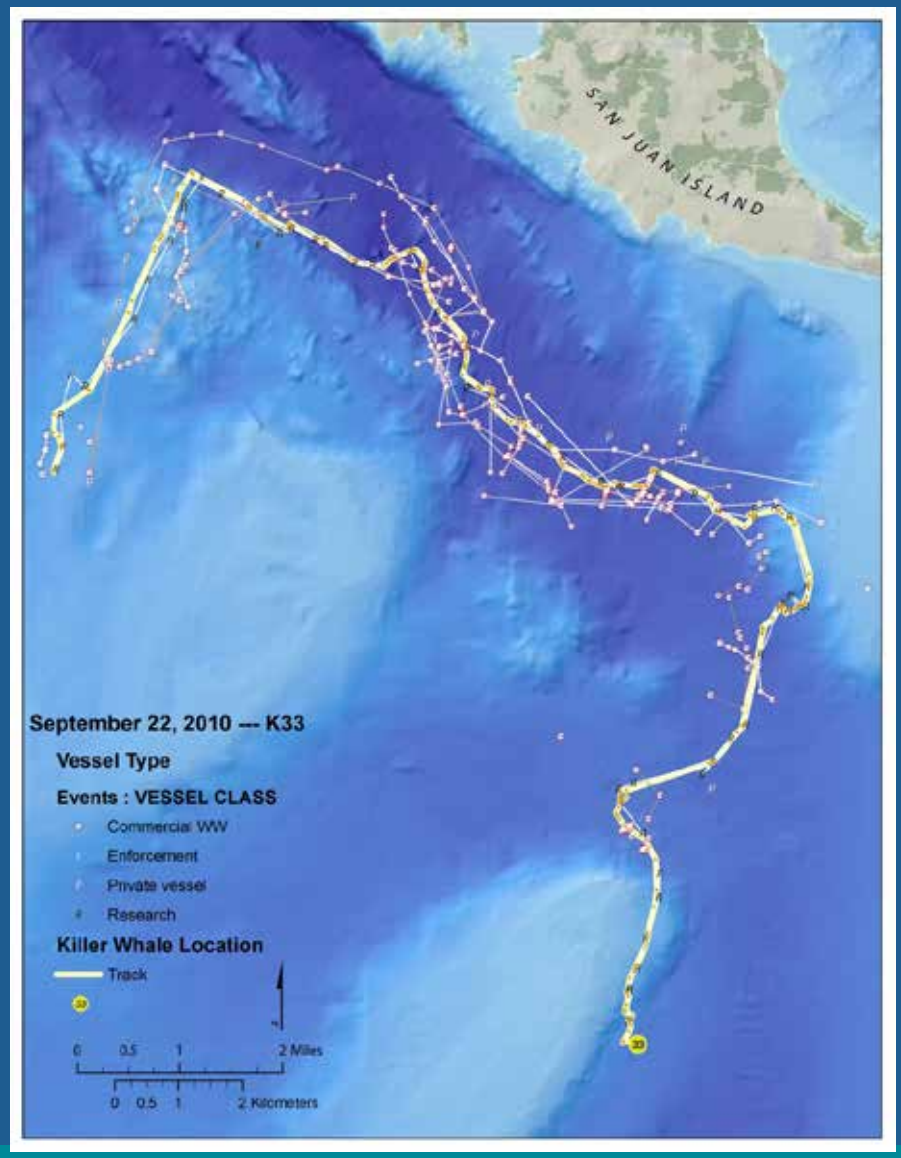
The DTAG (Digital Acoustic Recording Tag)

- Attached via suction cups from pole
- 2 hydrophones, sampled at 192/240 kHz
- 3D accelerometers/magnetometers, pressure, temp
  - à pitch, roll, heading, depth, jerk

Focal follow during tag deployment

- Parallel at 150-250m
- Whale & vessel data, from research vessel
  - à Georeferenced data, equipment designed by D. Giles (Giles 2014)
- Opportunistic observations of predation events (fish in mouth/samples) to validate feeding (Hanson et al. .2010)

Vessel Scene During Focal Follow Example



Acoustic Variables of Subsurface Behavior

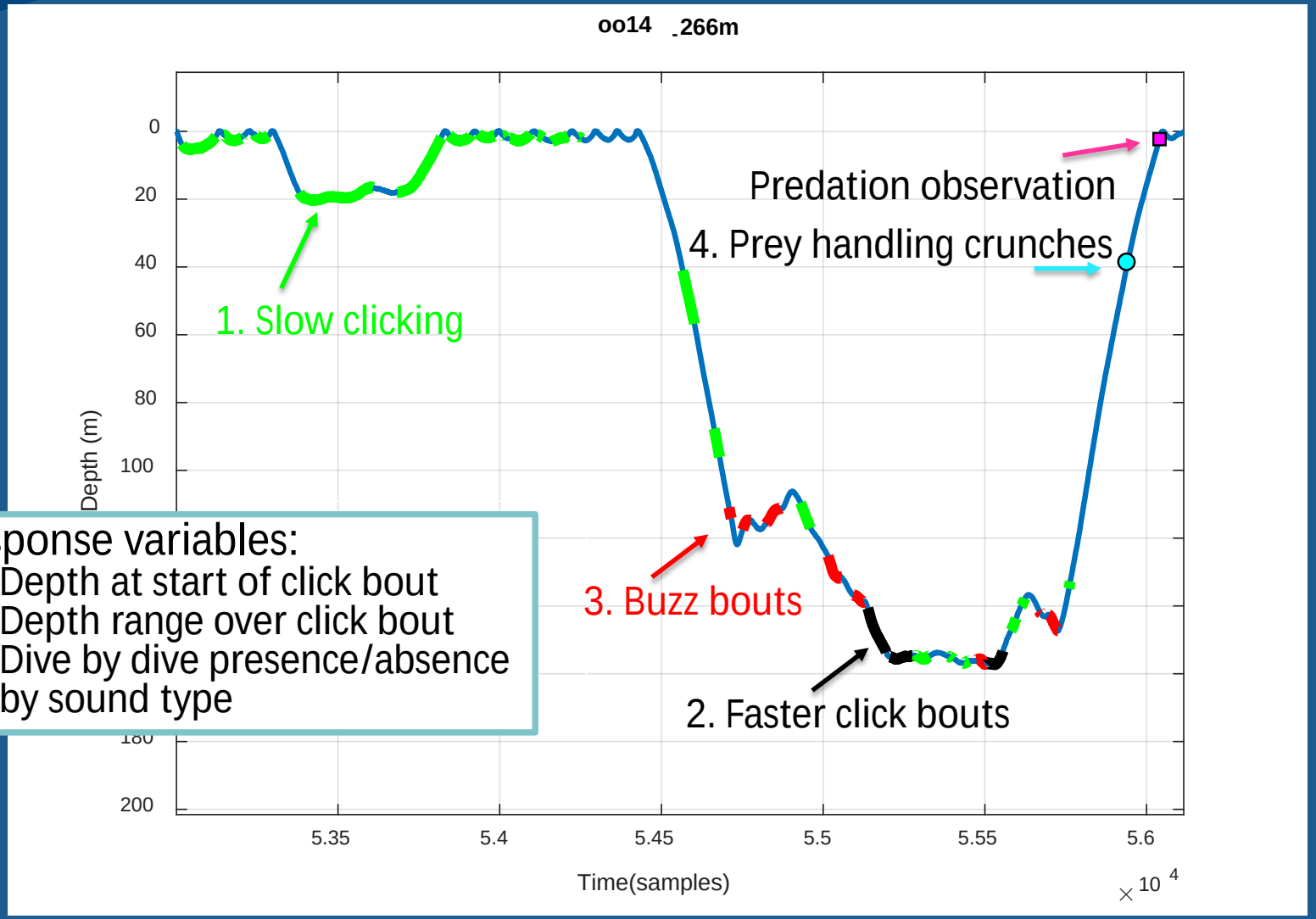
- 17/28 deployments included
- Echolocation clicks of tagged whale

  1. Slow/regular clicking – prey searching
  2. Fast clicking – initial pursuit of prey
  3. Buzzing – final pursuit of prey

- Prey handling sounds – tearing and crunching

1. Slow clicks, bouts limited to ici > 100 ms
2. Fast clicks, bouts containing 100 ms ^{3} ici > 10 ms
3. Buzzes, bouts containing ici £ 10 ms

Acoustic Variables of Subsurface Behavior



Response variables:

- Depth at start of click bout
- Depth range over click bout
- Dive by dive presence/absence by sound type

Results – 17 deployments

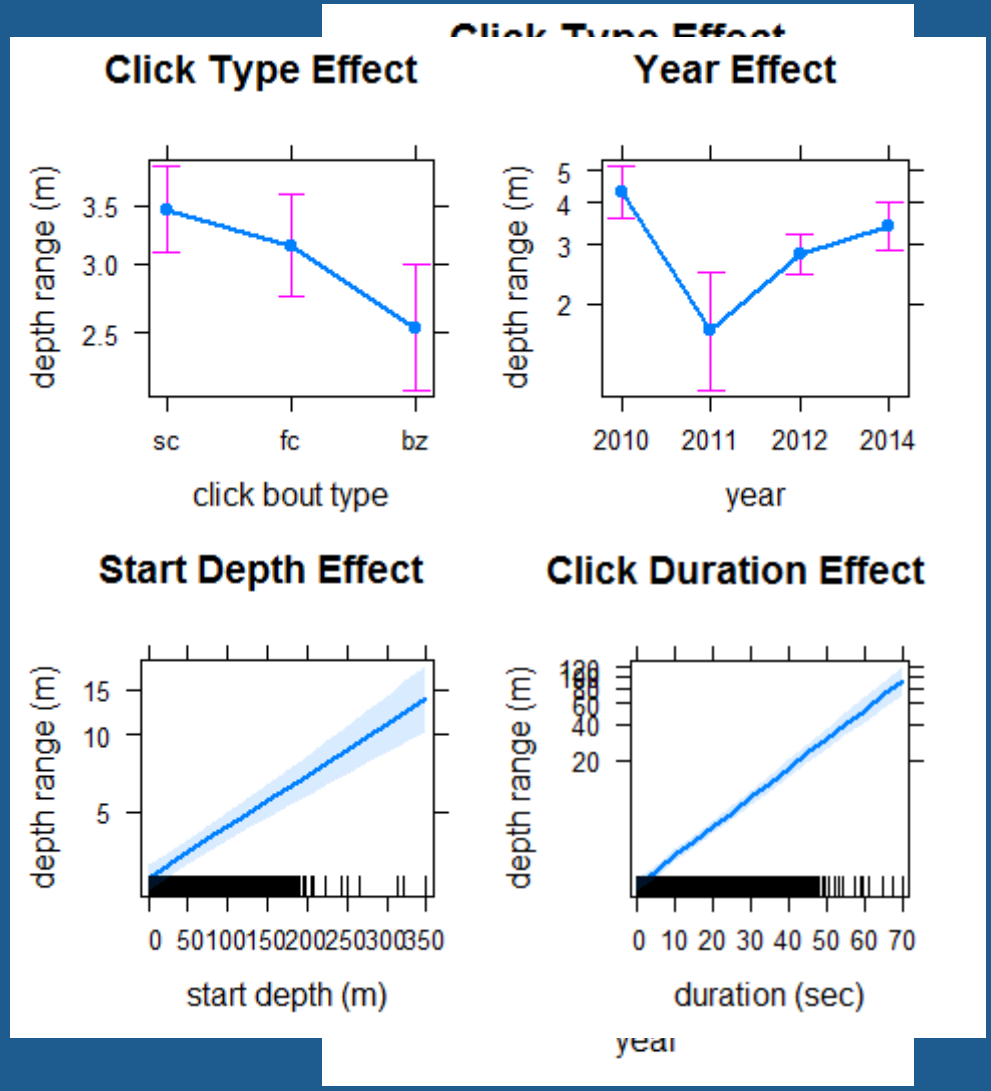
N = 3589 click bouts

GLMM – Animal ID random effect

1. Click bout start depth
   - click bout type, year, sex, age

2. Click bout depth range
   - click bout type, duration, start depth; year, sex, age

Tested explanatory variables not in best model in gray



Results – per dive (N = 4794)

Clicking across all click types

Presence per dive – binomial GEE (AR1)

Slow click bouts - (autocorrelation)

• present in 34% of dives (> 0m) à prey searching

• max dive depth, year, dive duration, sex, age

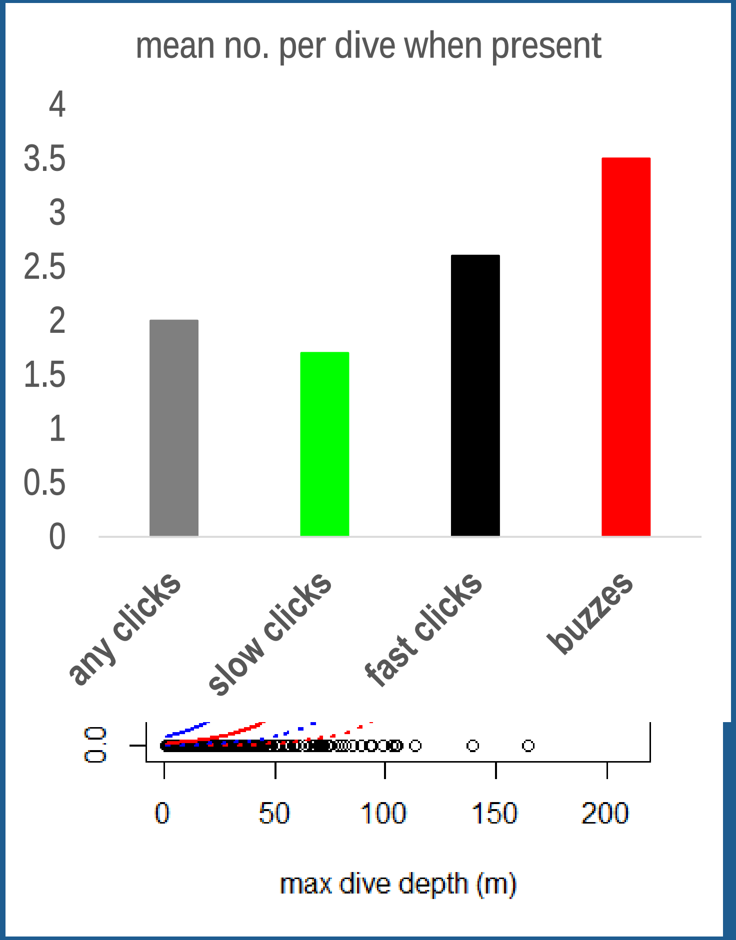
• present, 2 bouts per dive average

Buzz bouts - (binomial GLM)

• max dive depth, sex , fast click presence, year, dive duration, age, sc presence

Prey handling sounds

• year, sex, fast click & buzz presence, max dive depth, dive duration, age, sc presence

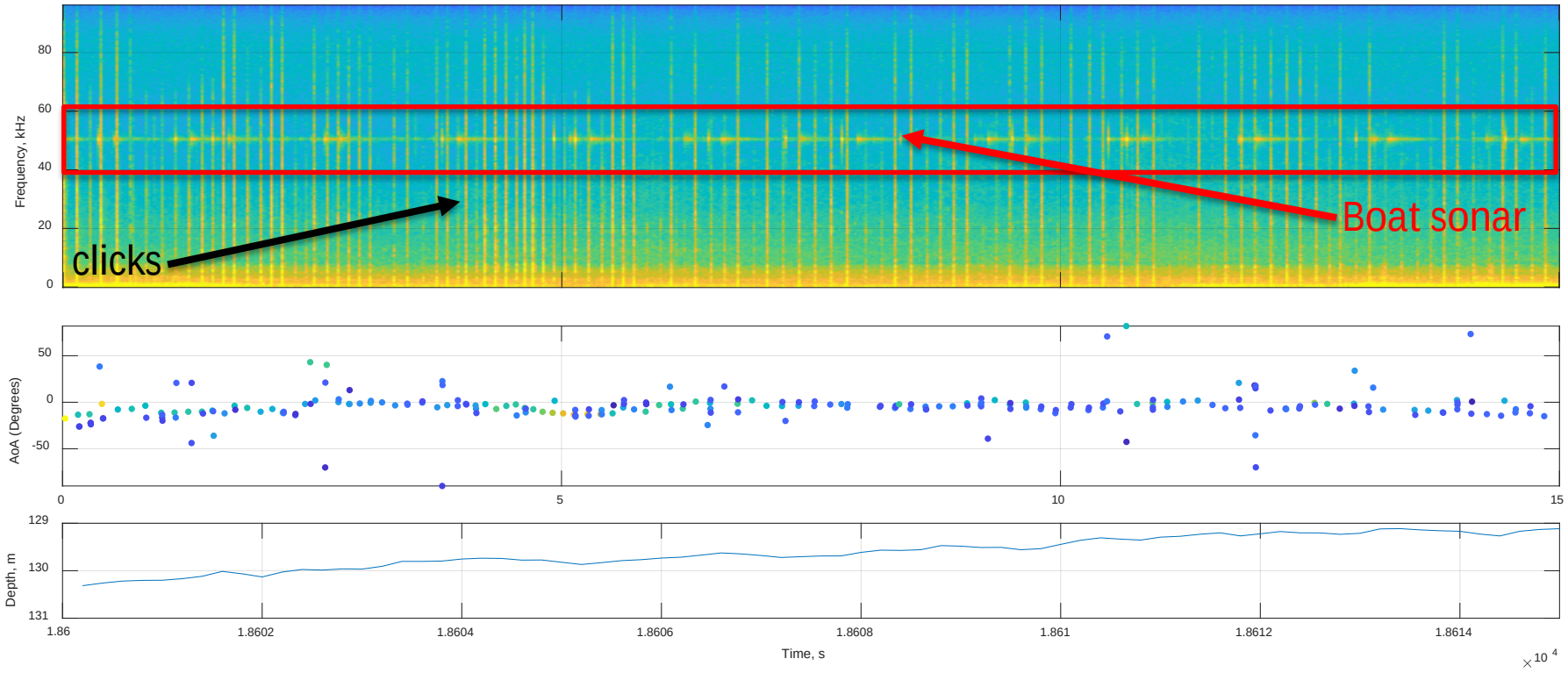


Tested explanatory variables not in best model in gray

Summary and Conclusions

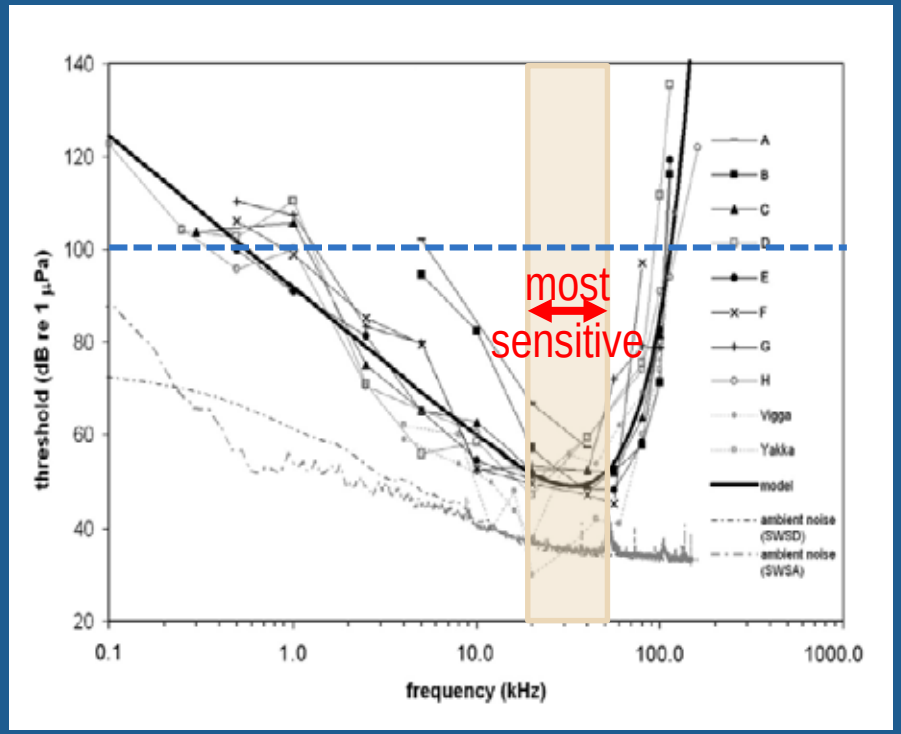
- Most click bouts were slow clicks on repeated shallow dives à prey searching
  - Ø Dive depth and year were important explanatory variables of click presence
- Co-occurrence of buzzes and prey handling sounds indicate prey capture
  - Ø Males had higher presence of buzz and prey handling sounds on per dive basis
- Integration of acoustic data with other tag sensor data à development of foraging detector and categorize behavior (J. Tennessen, next presentation)
- Results used to determine vessel/noise effects on behavior, including different phases of foraging that involve the use of sound
- Data will also be used to compare foraging behavior between Northern and Southern Resident killer whales (DFO/NOAA funded)

Boat Navigational Sonar Example



Received Navigational Sonar

- Received on 25/28 deployments
- Pooled presence of 35% of total tag on time
- Range of 0-81% presence
- Freq - 38, 50, 83 kHz
- 50 kHz most common
  - Most sensitive kw hearing
  - Click center freq (Au et al. 2004)
  - Potential for interference with foraging



Branstetter et al. 2017

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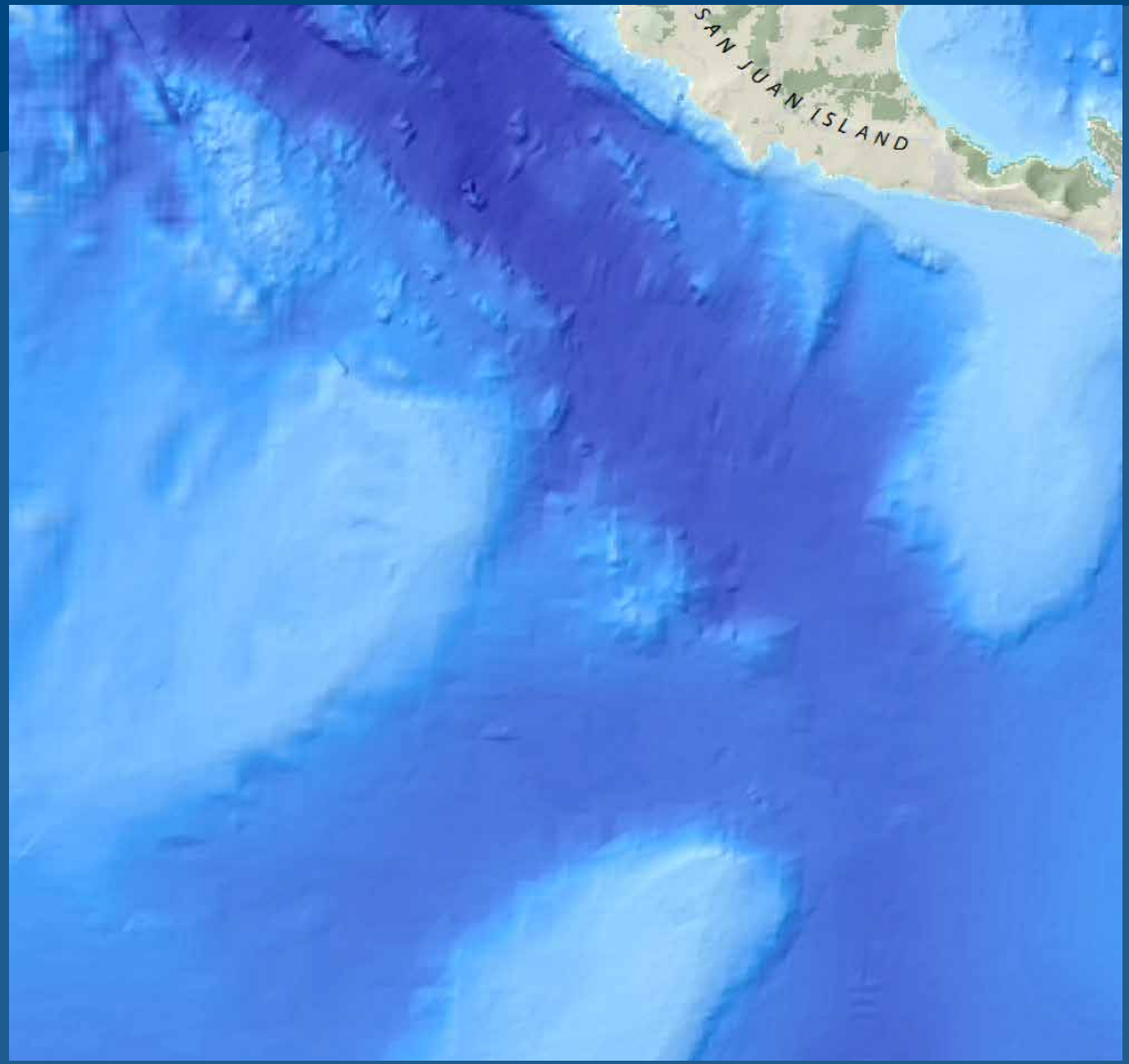
Permits

- Data and photos taken under U.S. NMFS #781-1824, 16163, Canada DFO SARA/MML #2010-01/SARA-106(B)


SAN JUAN ISLAND

Ocean Noise and Effects on Animals

- Ocean noise sources
  - Natural – wind, vociferous animals
  - Anthropogenic – vessels, construction, sonar, airguns

- Effects of noise
  - Auditory – masking, hearing loss
  - Behavioral – context dependent, avoidance, vocal response
  - Physiological - energetic costs, stress response