Salish Sea Ecosystem Conference

2022 Salish Sea Ecosystem Conference (Online)

Apr 27th, 11:30 AM - 1:00 PM

Interactive threats reduce foraging and prey capture effort by endangered killer whales
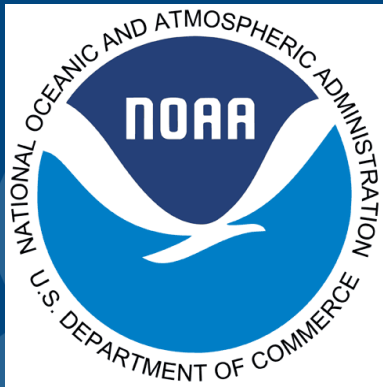
Dr. Marla Holt

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Interactive threats reduce foraging and prey capture by endangered killer whales

Marla Holt[1], Jennifer Tennessen[2], Brad Hanson[1], Candice Emmons[1], Deborah Giles[3], Jeff Hogan[4], Eric Ward[1], Mike Ford[1], Sheila J. Thornton[5]

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Southern Resident killer whales

- 3 endangered (J, K, L) pods
- Large maternally-related groups
- Risk factors include
  - Prey availability
  - Contaminants
  - Vessel & noise disturbance
    - Several aspects to consider
    - Challenges of studying cetacean behavior
    - Field-based research to guide management
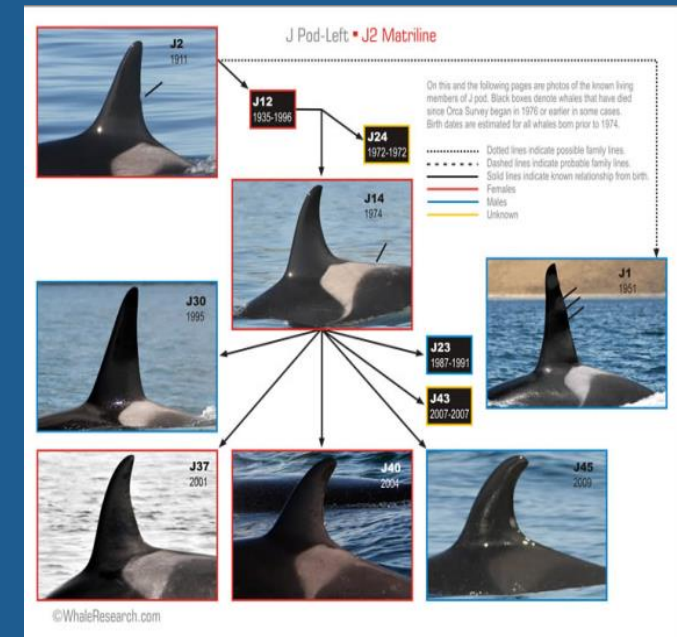

Center for Whale Research, Whaleresearch.com

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Study Justifications

Utilizing multi-sensor tags to

- Obtain acoustic & movement cues during subsurface behavior, esp. foraging (Tennessen et al. 2019a & 2019b, Holt et al. 2019)

- Investigate effects of vessels and associated sounds on behavior (Holt et al. 2021a & 2021b)

- Understand diel patterns of behavior, noise exposure

- Compare results with other resident killer whales

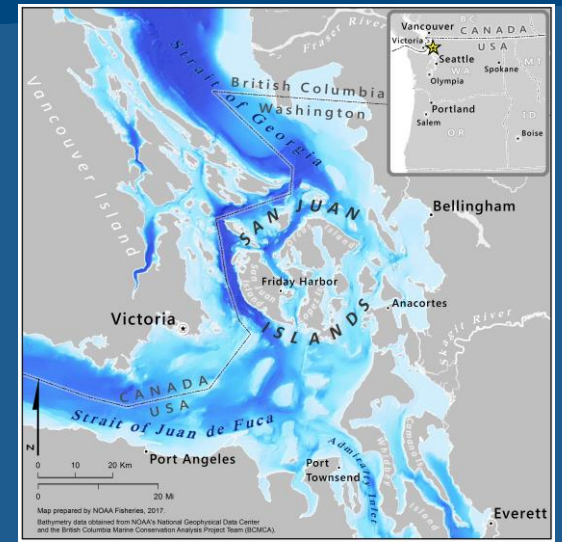- Inform decisions within an adaptive management framework, e.g. vessel regulations
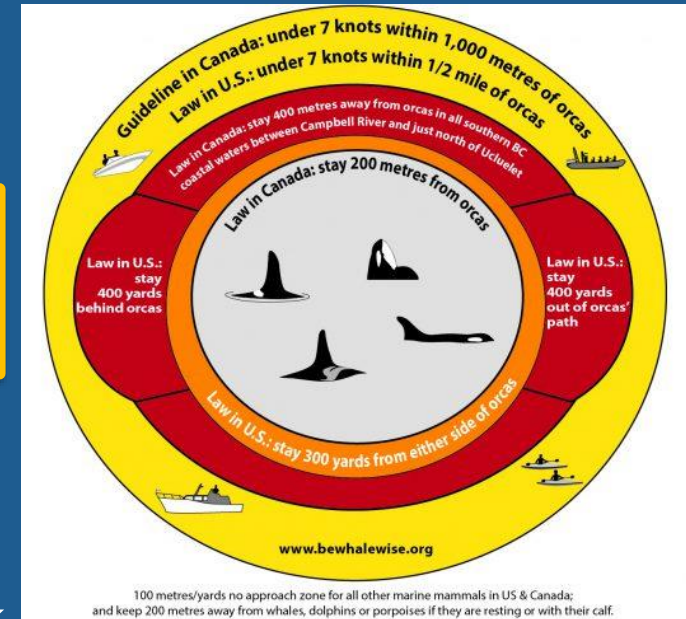
www.bewhalewise.org

Data Collection

The Dtag (Digital acoustic recording tag)

- Suction-cup attached
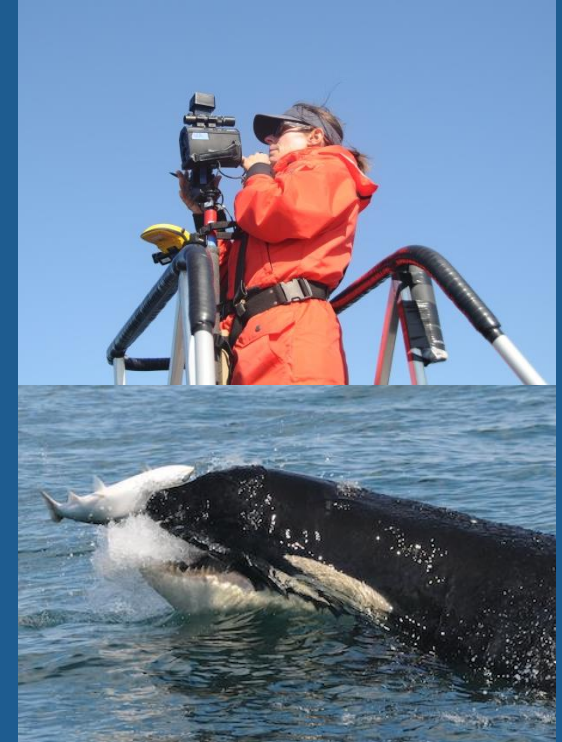- Multi-sensor sound and movement tags

Study Location

- Trans-boundary core summer habitat
- Vessel effect - 2010-2012, 2014 (Holt et al. 2021a & 2021b)
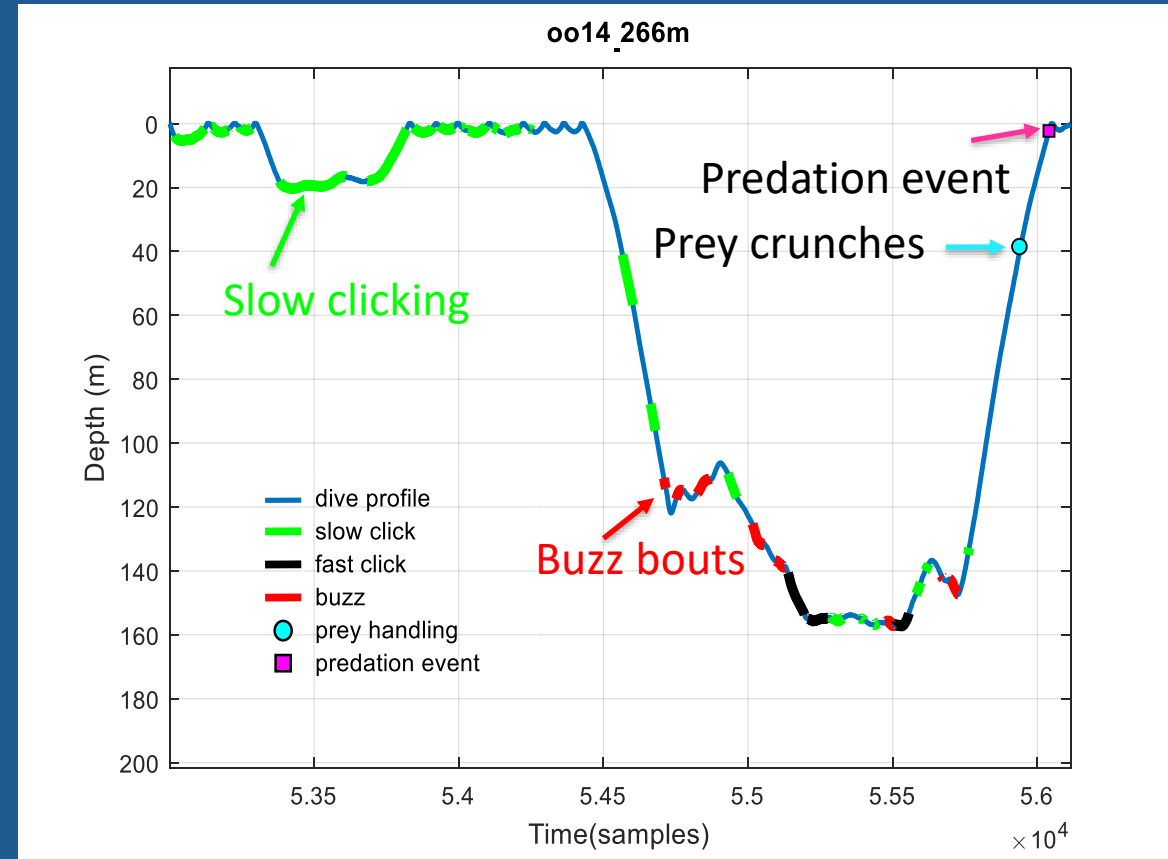- Diel patterns – 2018-2021

Focal follows

- Georeferenced whale & vessel (within 1.5 km) data
- Observations of predation (fish in mouth/tissue samples)

SRKW Sound & Movement of Foraging

- ## Echolocation sounds during foraging
  (Holt et al. 2019)
  - ➤ On shallower dive, slower clicking
  - ➤ On deeper dives, buzzes

- ## Signature movements before fish kills
  (Tennessen et al. 2019a)
  - ➤ On deep dives
    1. Jerk peak (change in acceleration)
    2. Roll
    3. Heading variance
    4. Used to detect prey capture dives
       - – True positive rate of 79%
   - – False positive rate of 0.2%

oo14_266m

Behavioral Analysis

Effects of Vessel Distance and Sex on the Behavior of Endangered Killer Whales

Marla M. Holt[1]*, Jennifer B. Tennessen[1,2], Eric J. Ward[1], M. Bradley Hanson[1], Candice K. Emmons[1], Deborah A. Giles[3†] and Jeffrey T. Hogan[4]

- 13 deployments, 3609 dives

- 6 tag variables populated per dive
(Holt et al. 2019, Tennessen et al. 2019a & 2019b)

  - Acoustic – 1.) slow click 2.) buzz presence

  - Movement – 3.) depth 4.) jerk 5.) roll 6.) heading

- Explored effects on behavioral state transitions

  - Vessel variables – counts, distance, speed

  - Echosounder presence (depth/fish finders)

  - Demographic, environmental – sex, year

Hidden Markov Model (HMM) Conceptualization

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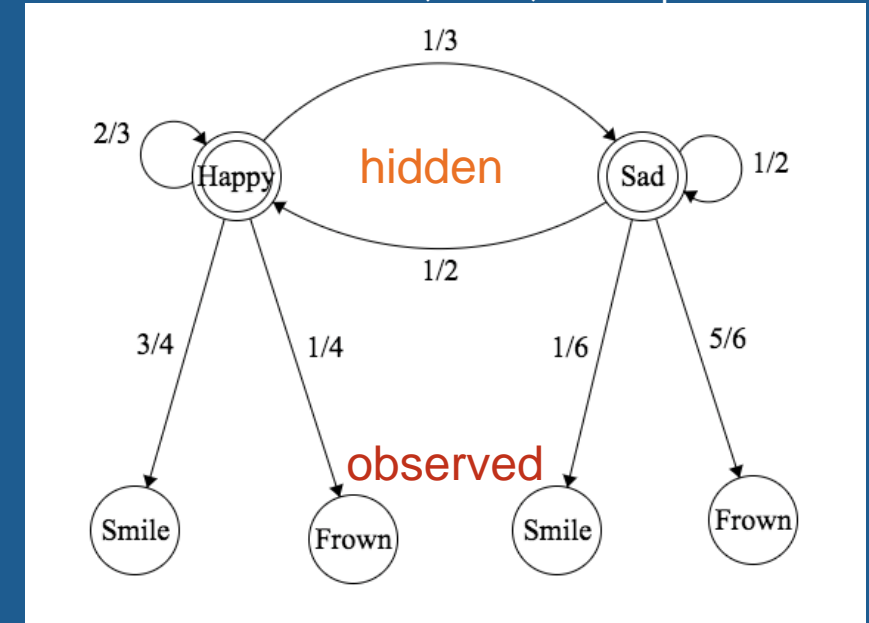
4 Behavioral State Results (Holt et al. 2021a)

State 1 - lowest values of whale variables

- Shallow silent, travel/respiratory

State 2 - highest values

- Deep foraging incl. prey capture
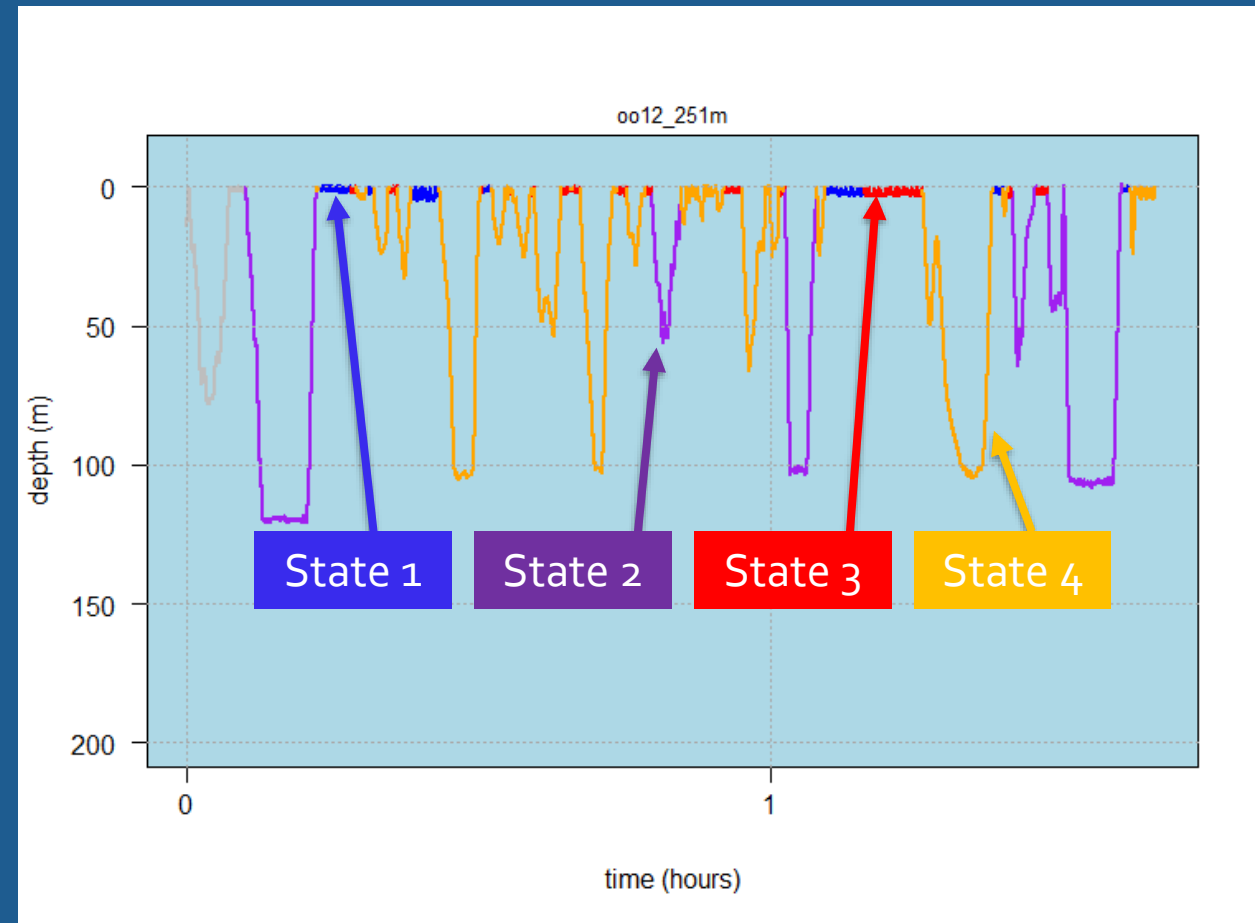
State 3 - clicking at shallow depth

- Acoustic searching

State 4 - in between values

- Intermed. search, pursuit , no prey capture

State transition depends on:

- Sex – male and female difference

- Vessel distance (close < 400 yd, far ≥ 400 yd)

Phases of foraging

oo12_251m

State 1   State 2   State 3   State 4
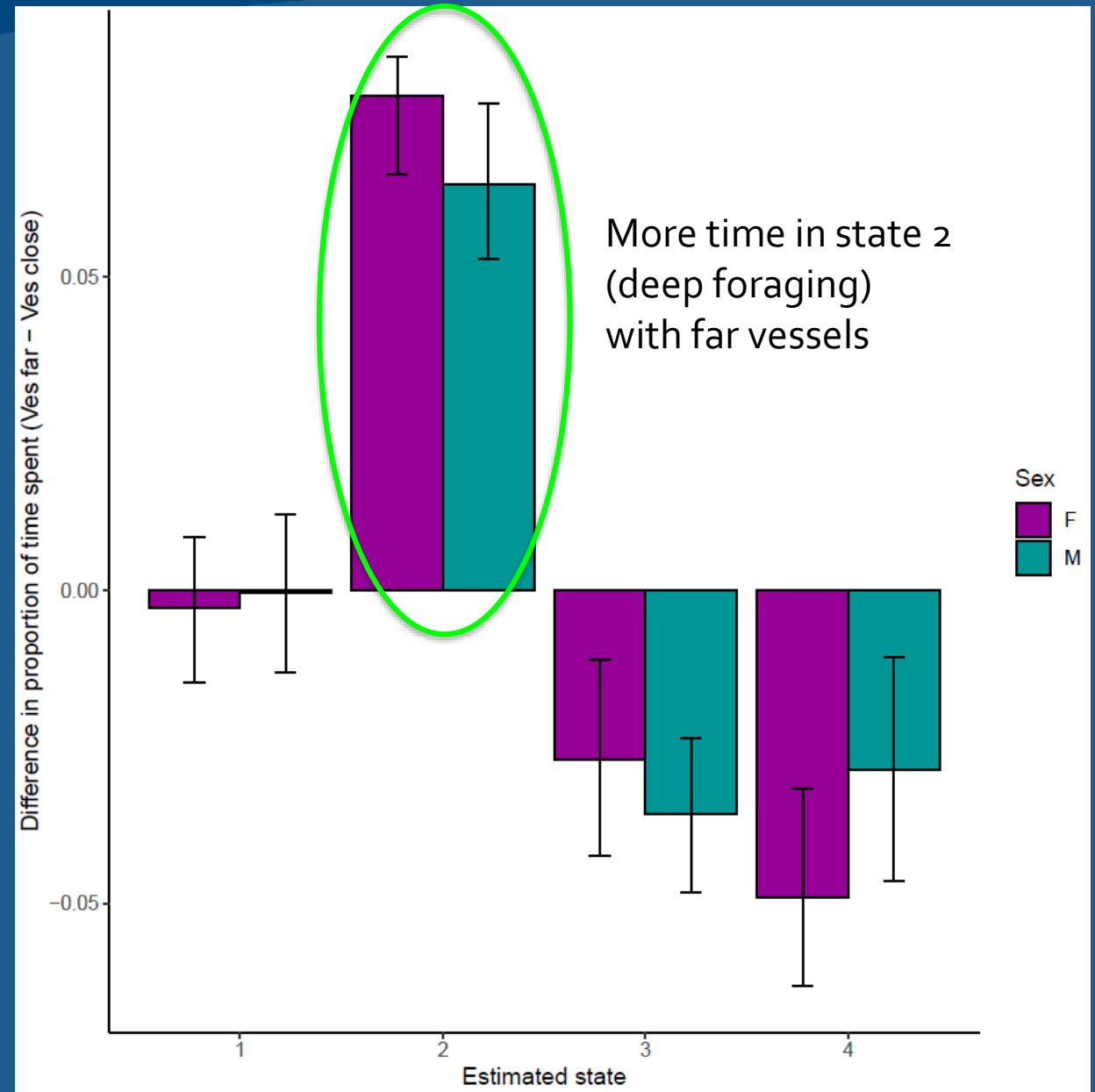
Vessel distance effect

- Behavioral state occurrence

    - More dives in foraging states 2-4 when vessels were far (mean distance ≥ 400 yd), with largest effect for state 2 dives

- Time spent - 95% credible interval of difference

    - More time in state 2 (deep forage) when vessels were far
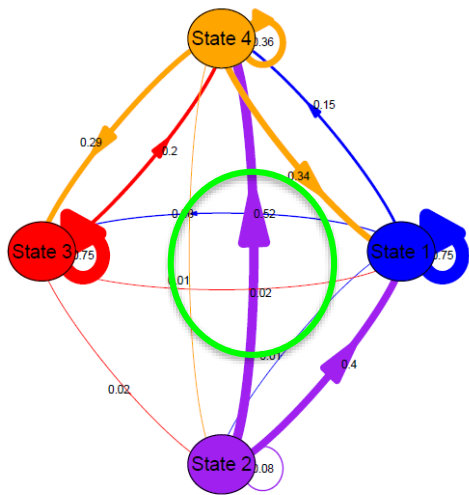
    - Larger effect in females

Holt et al. 2021a

More time in state 2
(deep foraging)
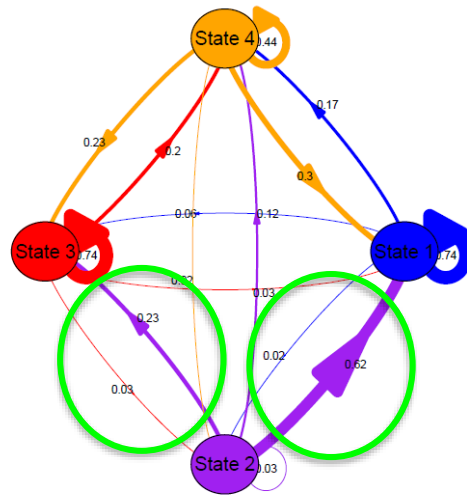with far vessels

Behavior State Transition Probabilities

Key:
State 1 – travel/resp, State 2 – deep forage, State 3 – acoustic search, State 4 – intermed dives
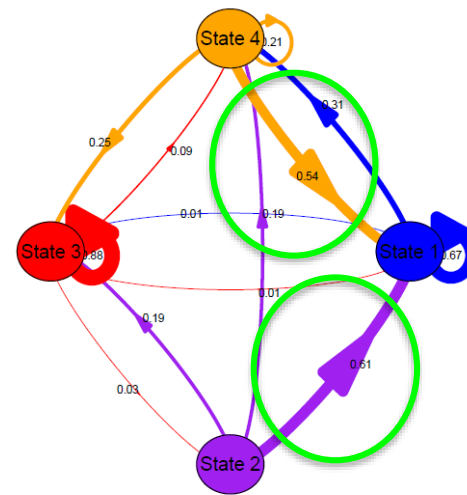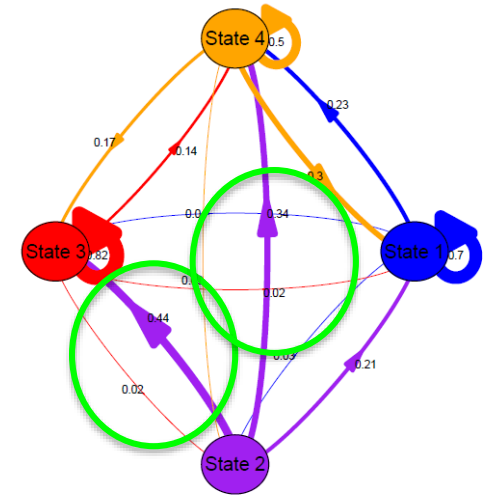

close vessels in males

far vessels in males

close vessels in females

far vessels in females

Holt et al. 2021a

Prey Capture Analysis

Response variables – 17 deployments (2010-14)

- For all dive ≥ 30 m included
  - Was prey capture detected? (Tennessen et al. 2019a)
- For prey capture dives detected
  - Dive duration (log transformed)
  - Rate of descent
  - Also explored vessel/sound effects on rate of ascent, heading variance

Vessel, sound, other tested explanatory variables

- Received noise level, max. 1 sec SPL in 10-65 kHz band
- Presence of echosounder signals
- Vessel count, distance, speed
- Demographic & environmental – sex, year, daily estimates abundance (Ford et al. 2016)
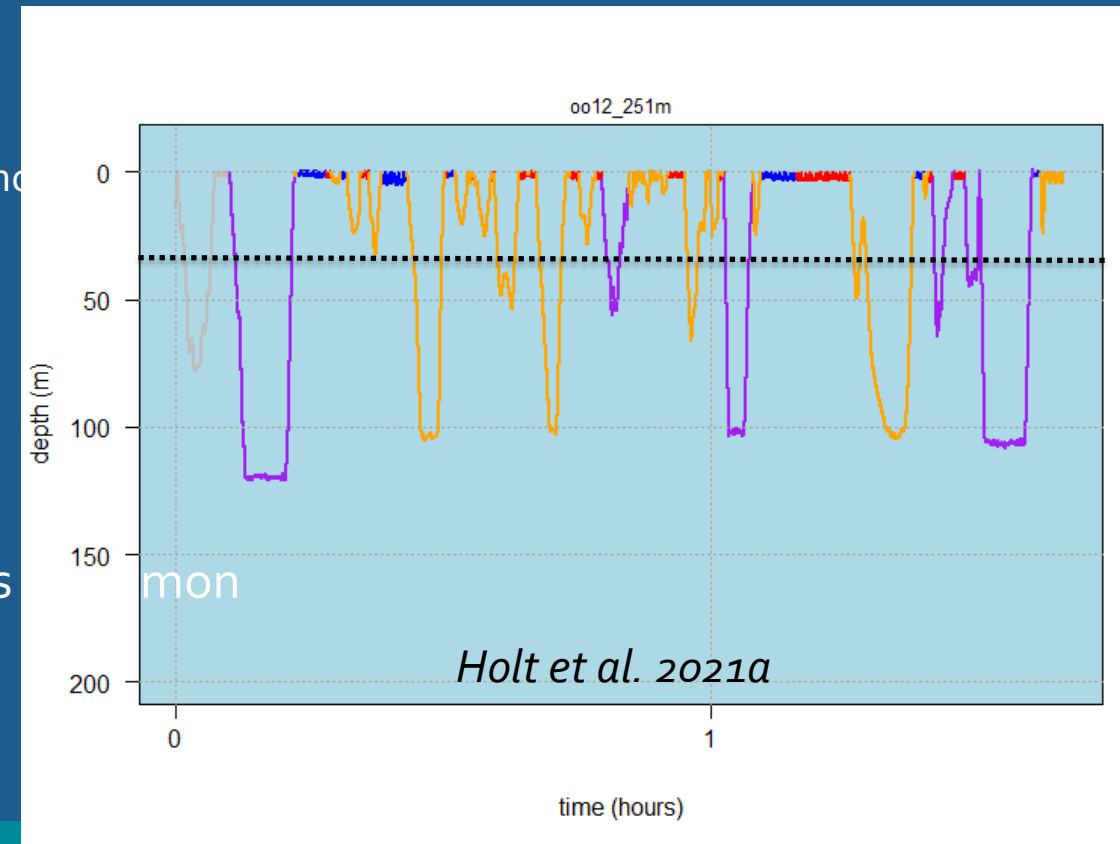

Marine Environmental Research

journal homepage: www.elsevier.com/locate/marenvrev

Vessels and their sounds reduce prey capture effort by endangered killer whales (*Orcinus orca*)

Marla M. Holt [a,*], Jennifer B. Tennessen [a,b], M. Bradley Hanson [a], Candice K. Emmons [a], Deborah A. Giles [c,d], Jeffrey T. Hogan [e], Michael J. Ford [a]
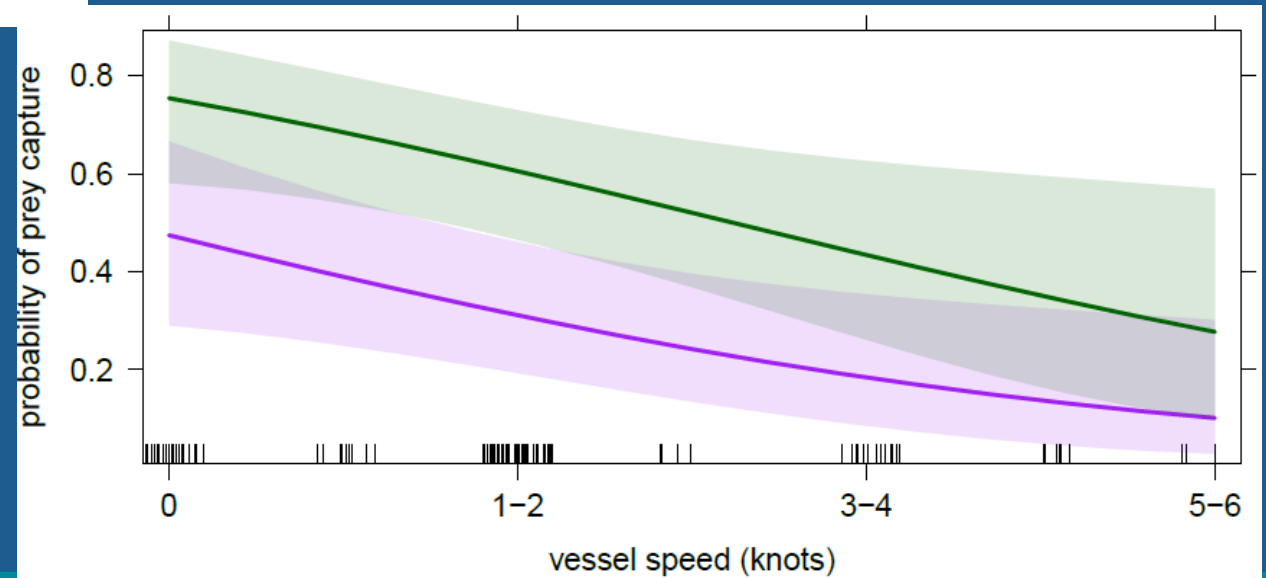

Holt et al. 2021a

Probability of Prey Capture Results
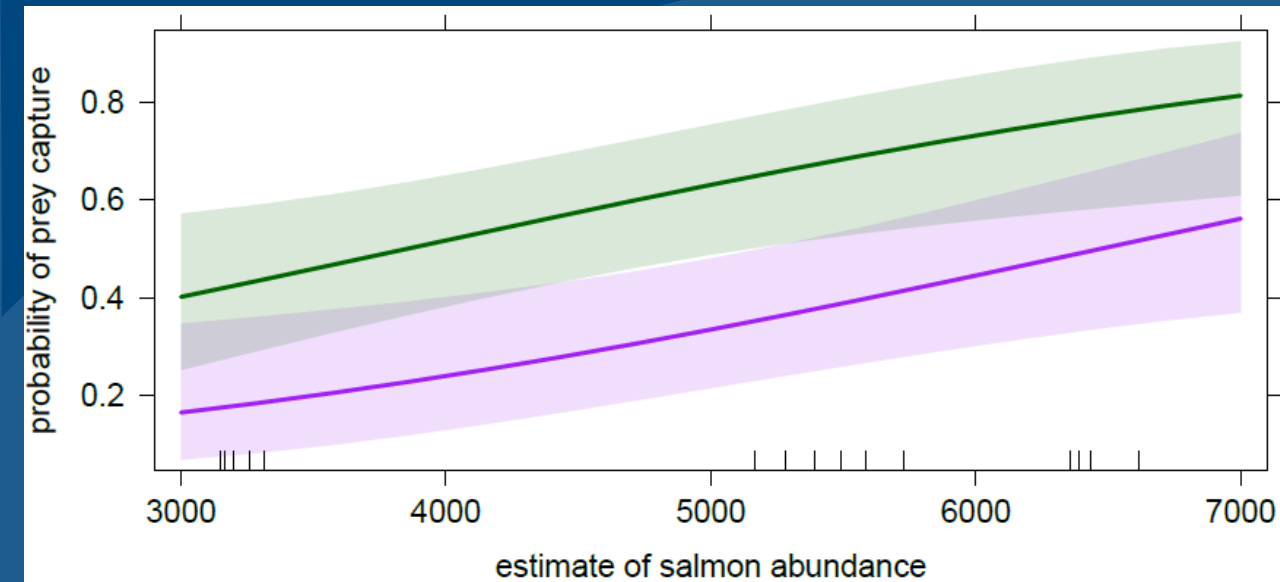
Males in green
Females in purple

Holt et al. 2021b

Probability of prey capture
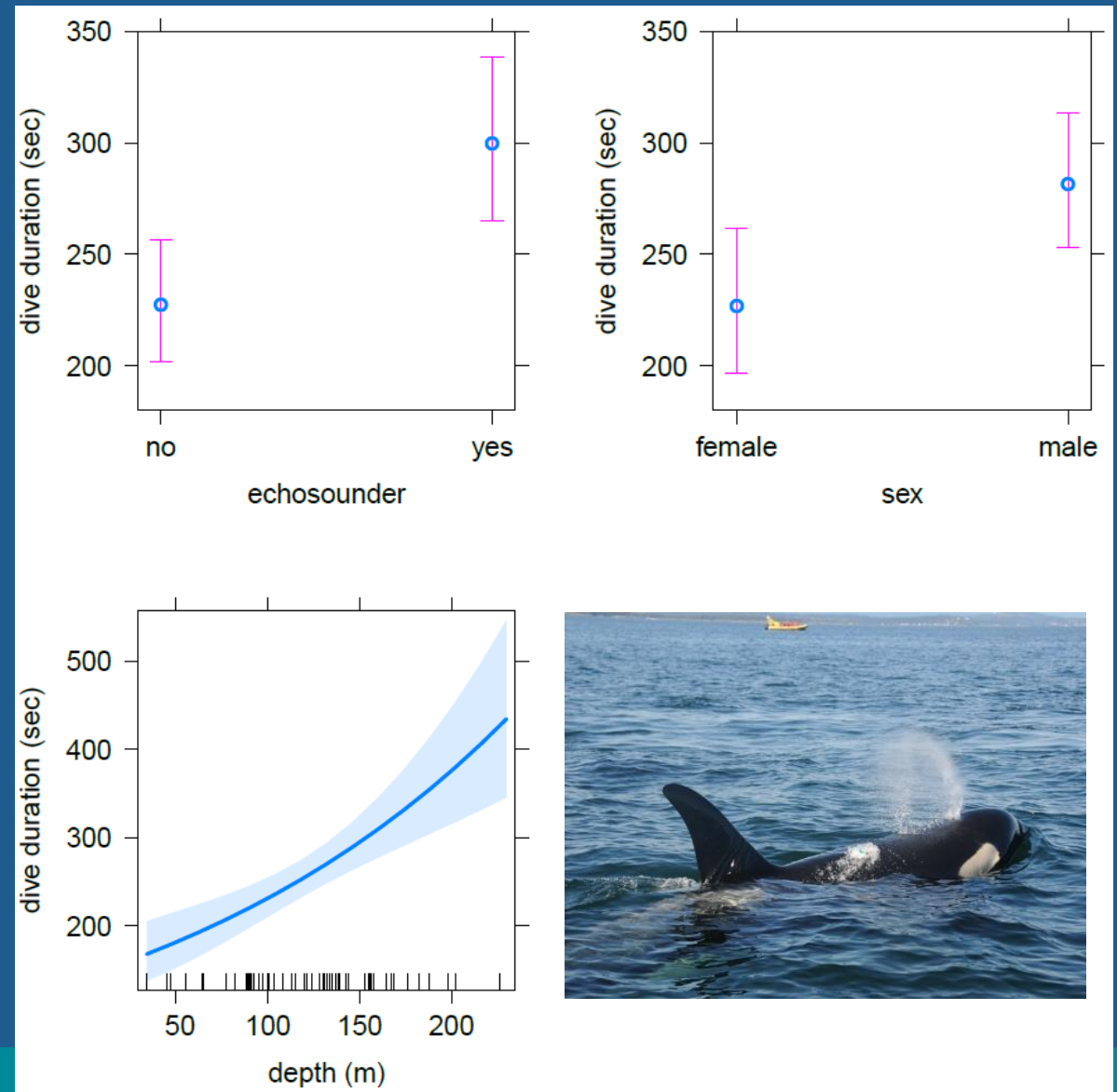↑ as salmon abundance ↑
↓ as vessel speed ↑

Effects on Duration of Prey Capture Dives

Dive Duration
↑ Echosounder presence
↑ Males
↑ As dive depth ↑

Holt et al. 2021b

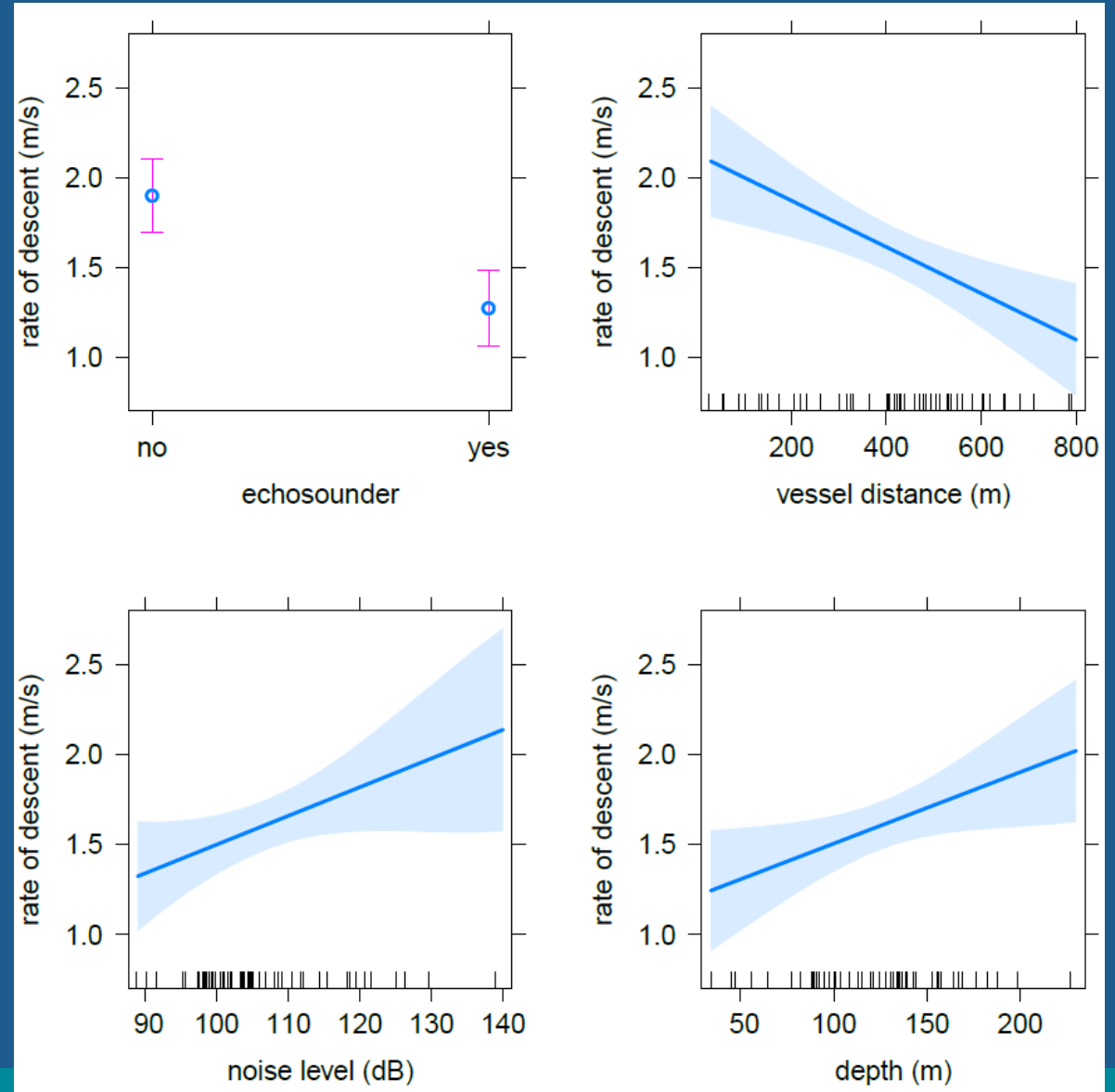# Effects on Rate of Descent of Prey Capture Dives

Rate of descent
↓ Echosounder presence
↑ as vessel distance ↓
↑ max noise level ↑
↑ as dive depth ↑

Holt et al. 2021b

Summary

- SRKW made fewer & spent less time in deep feeding dives with close vessels (av. distance < 400 yd/363 m)

  ➢ Females more likely to switch to a non-foraging dive with close vessels

- Prey capture

  ➢ Chance of prey capture higher with more salmon but lower with faster vessels, interactive threats of prey abundance and disturbance

  ➢ Vessel & sound effects on the duration & descent rate of prey capture dives indicate potential interference/prolonged effort to successfully forage, perhaps due to acoustic masking

- Management implications – informs vessel regulations, efforts to increase prey available to the whales
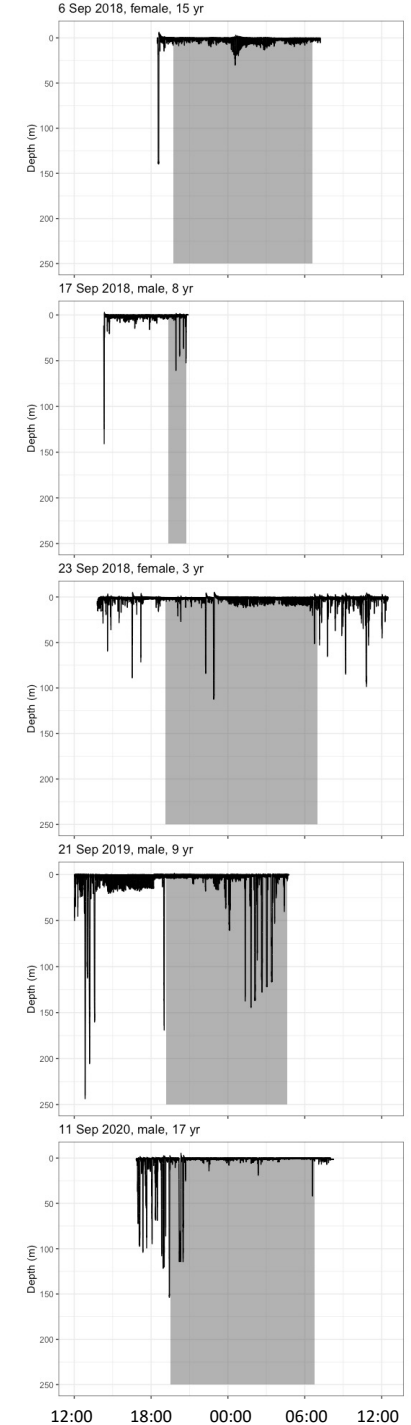
Comparative Work

- How does SRKW foraging & noise exposure compare with Northern Resident killer whales (NRKW)?

  ➢ Collaborative approach with DFO (Wright et al. 2017, 2021)

  ➢ Tennessen et al., submitted

  ➢ Tennessen et al., next talk

- What about behavior & noise exposure over a 24 hr cycle?

  ➢ 11 SRKW tag deployments, 2018-2021, 56 nighttime hr (96 hr total tag on time)
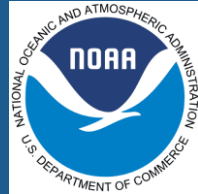
night hours in gray

Acknowledgments

Funding

People

- Juliana Houghton, Dave Haas, Robert Hunt, Alessandro Bocconcelli, Tom Hurst, Frants Jensen, Alison Stimpert, Stacy DeRuiter, Patrick Miller, Robin Baird, Jeff Foster, Ken Balcomb, Damon Holzer, UW Friday Harbor Labs, and many others for field & tag logistics & analysis

Permits

- Data and photos taken under U.S. NMFS #781-1824, 16163, 21348, Canada DFO SARA/MML #2010-01/SARA-106(B)/#2020-02