Spatial patterns of foraging activity in endangered killer whales shift with changes in Chinook salmon abundance

Kimberly Nielsen & coauthors (Ashe et al. *in review*)

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Southern Resident killer whales are a **critically endangered** population

- SRKW face numerous threats, including:
  1. Limited prey
  2. Contaminants
  3. Noise

- As of July 1, 2025, **there are only 74 SRKWs left**

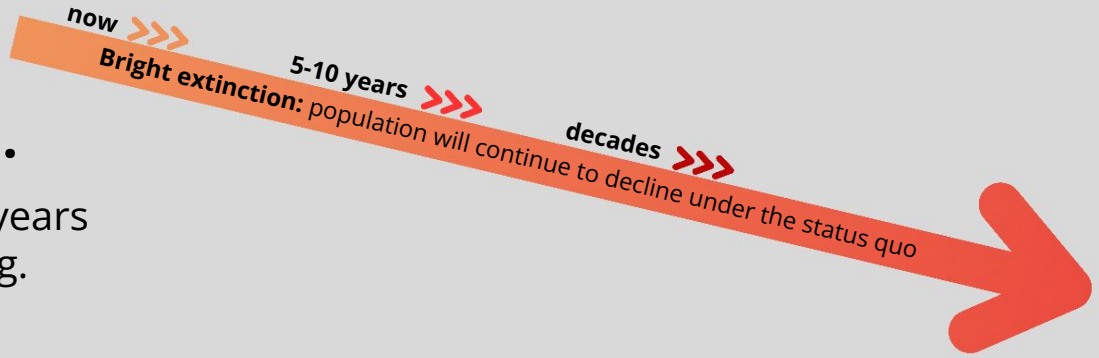
photo: K Nielsen, Oceans Initiative

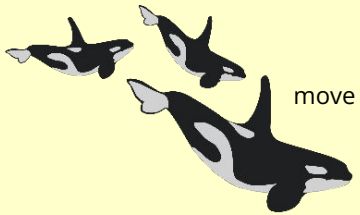
Dark extinction: the loss of a species before it has been discovered or described

Bright extinction

The threats are well documented.

SRKWs will go **extinct** in ~75 years if we don't change anything.

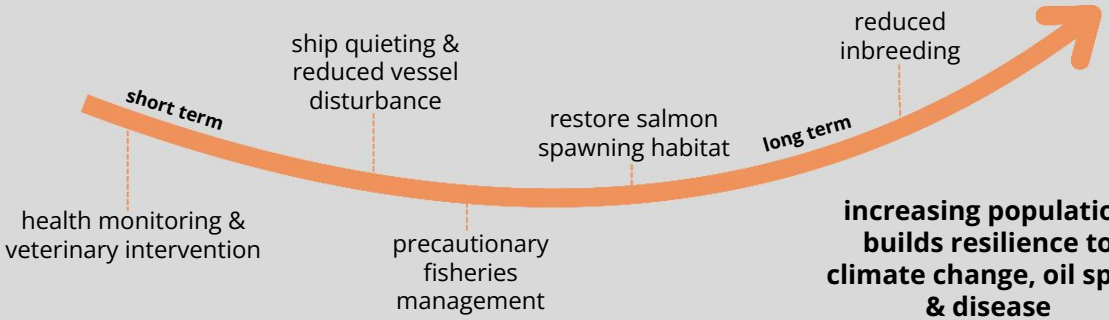




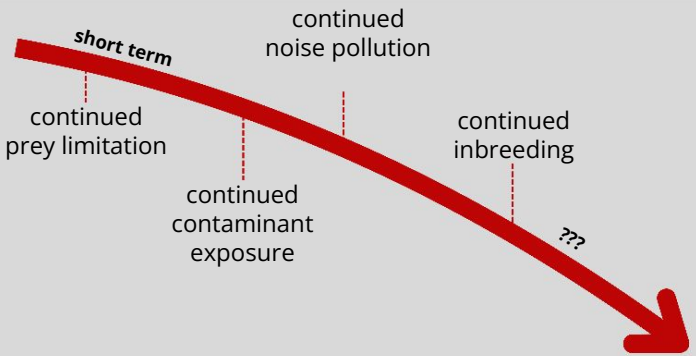
move towards recovery

choices in the short and long term that can bend the curve

extinction



increasing population builds resilience to climate change, oil spills & disease



at any point, a catastrophic oil spill or epidemic could accelerate extinction

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photo: K Nielsen, Oceans Initiative

when exposed to vessel noise, SRKWs spend 60% less time foraging

(Lusseau et al. 2009)

photos: K Nielsen, Oceans Initiative

Protected area design should consider behavior

(Ashe at al. 2010)

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Animal behaviour and marine protected areas: incorporating behavioural data into the selection of marine protected areas for an endangered killer whale population

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Keywords
disturbance; marine protected area; habitat conservation; behaviour; spatial model; hotspot.

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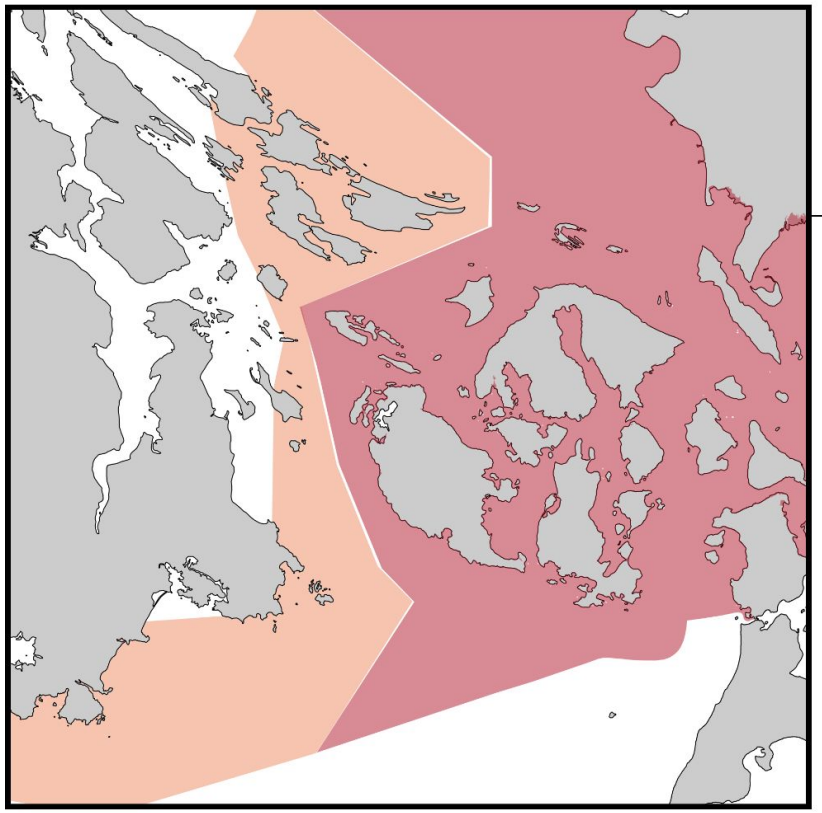
Abstract

Like many endangered wildlife populations, the viability and conservation status of 'southern resident' killer whales *Orcinus orca* in the north-east Pacific may be affected by prey limitation and repeated disturbance by human activities. Marine protected areas (MPAs) present an attractive option to mitigate impacts of anthropogenic activities, but they run the risk of tokenism if placed arbitrarily. Notwithstanding recreational and industrial marine traffic, the number of commercial vessels in the local whalewatching fleet is approaching the number of killer whales to be watched. Resident killer whales have been shown to be more vulnerable to vessel disturbance while feeding than during resting, travelling or socializing activities, therefore protected-areas management strategies that target feeding 'hotspots' should confer greater conservation benefit than those that protect habitat generically. Classification trees and spatially explicit generalized additive models were used to model killer whale habitat use and whale behaviour in inshore waters of Washington State (USA) and British Columbia (BC, Canada). Here we propose a candidate MPA that is small (i.e. a few square miles), but seemingly important. Killer whales were predicted to be 2.7 times as likely to be engaged in feeding activity in this site than they were in adjacent waters. A recurring challenge for cetacean MPAs is the need to identify areas that are large enough to be biologically meaningful while being small enough to allow effective management of human activities within those boundaries. Our approach prioritizes habitat that animals use primarily for the activity in which they are most responsive to anthropogenic disturbance.

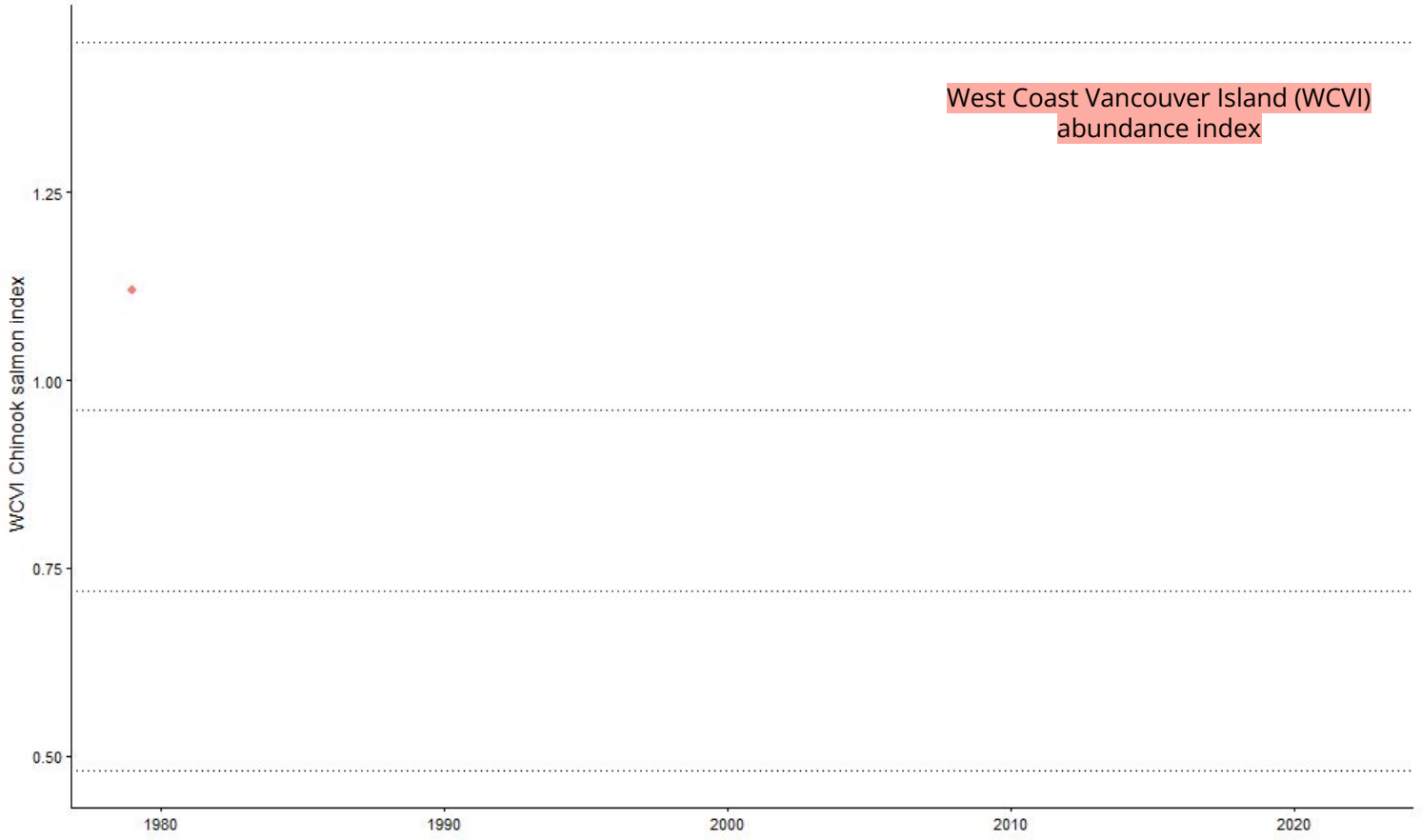


Southern Resident killer whale Critical Habitat

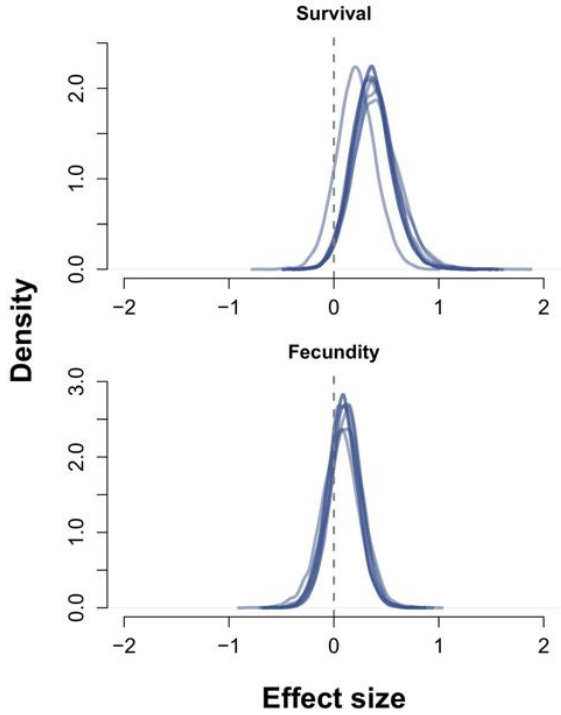
Canada

USA

SRKW demography is correlated with Chinook salmon abundance

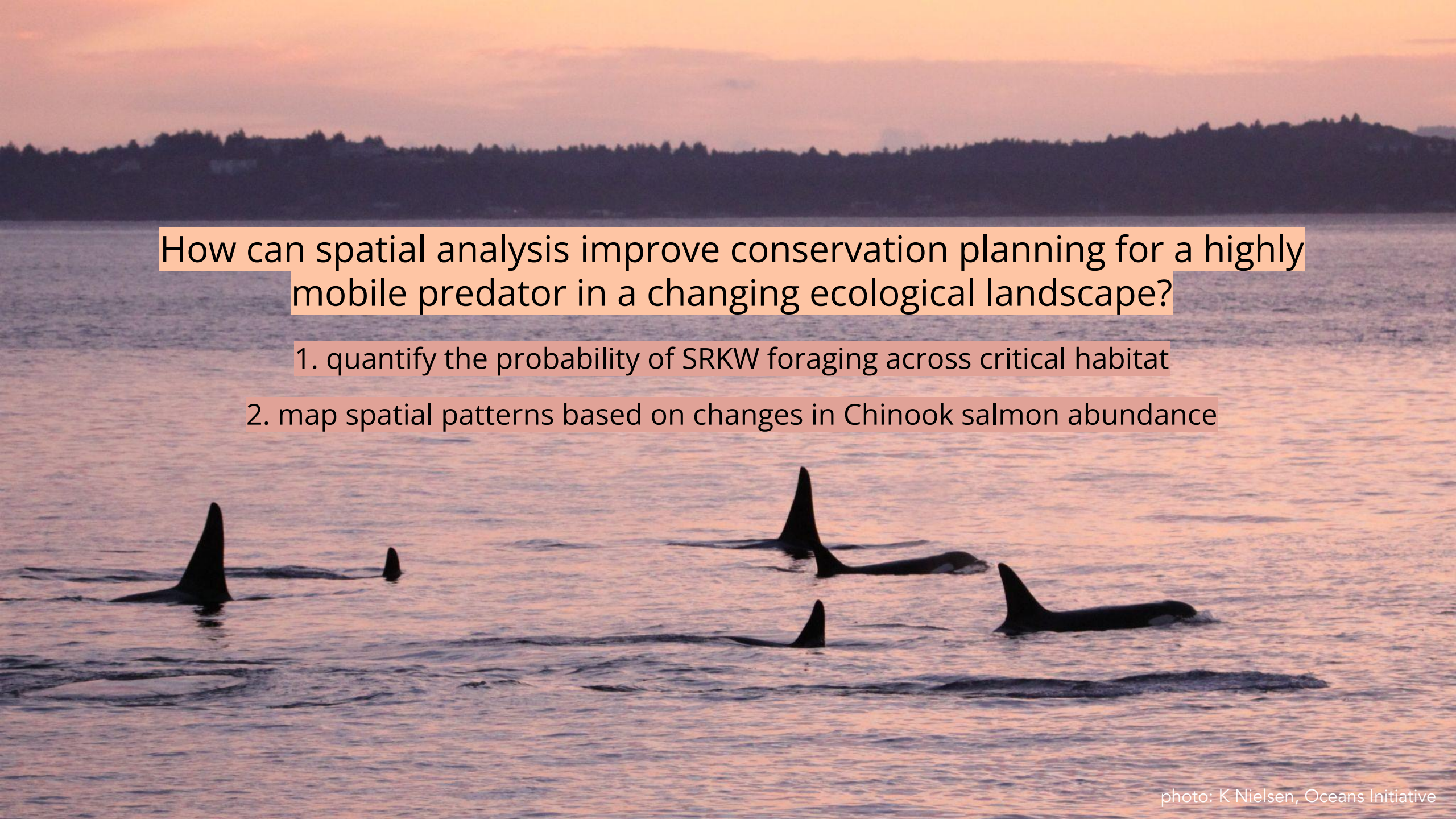


(Chinook Technical Committee 2023)



(Nelson at al. 2024)

photo: J Durban, NOAA



How can spatial analysis improve conservation planning for a highly mobile predator in a changing ecological landscape?

1. quantify the probability of SRKW foraging across critical habitat

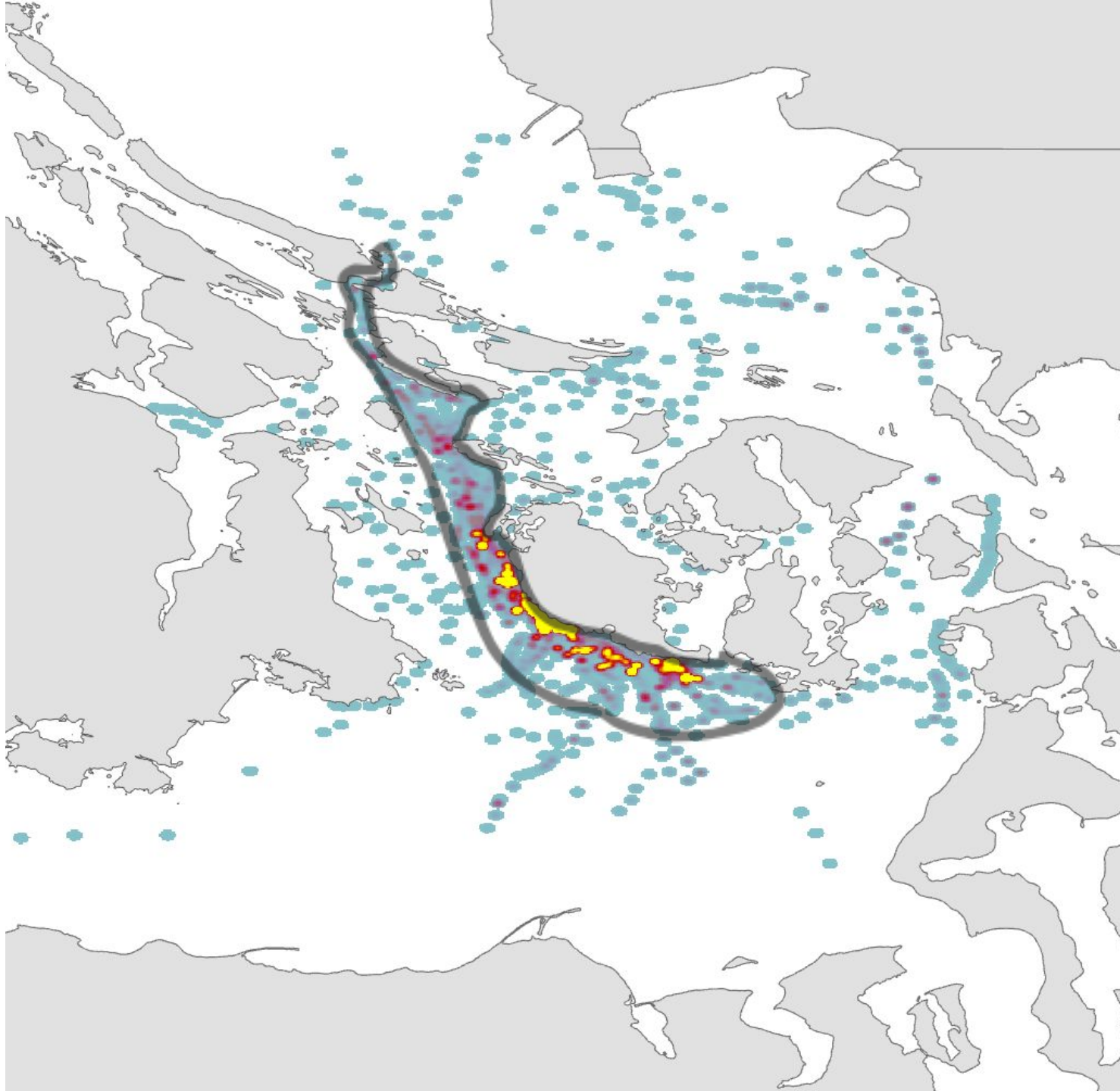
2. map spatial patterns based on changes in Chinook salmon abundance

photo: K Nielsen, Oceans Initiative

data spanning 2003-2022

- killer whales:
  - >20,000 behavioral observations from 6 datasets
  - binned to **foraging** or **non-foraging**
- prey:
  - WCVI Chinook salmon index
  - binned to **typical*** or **low** abundance
- environment:
  - distance to coast (m)
  - depth (m)

*not enough years of “good” prey abundance so we pooled high and average years



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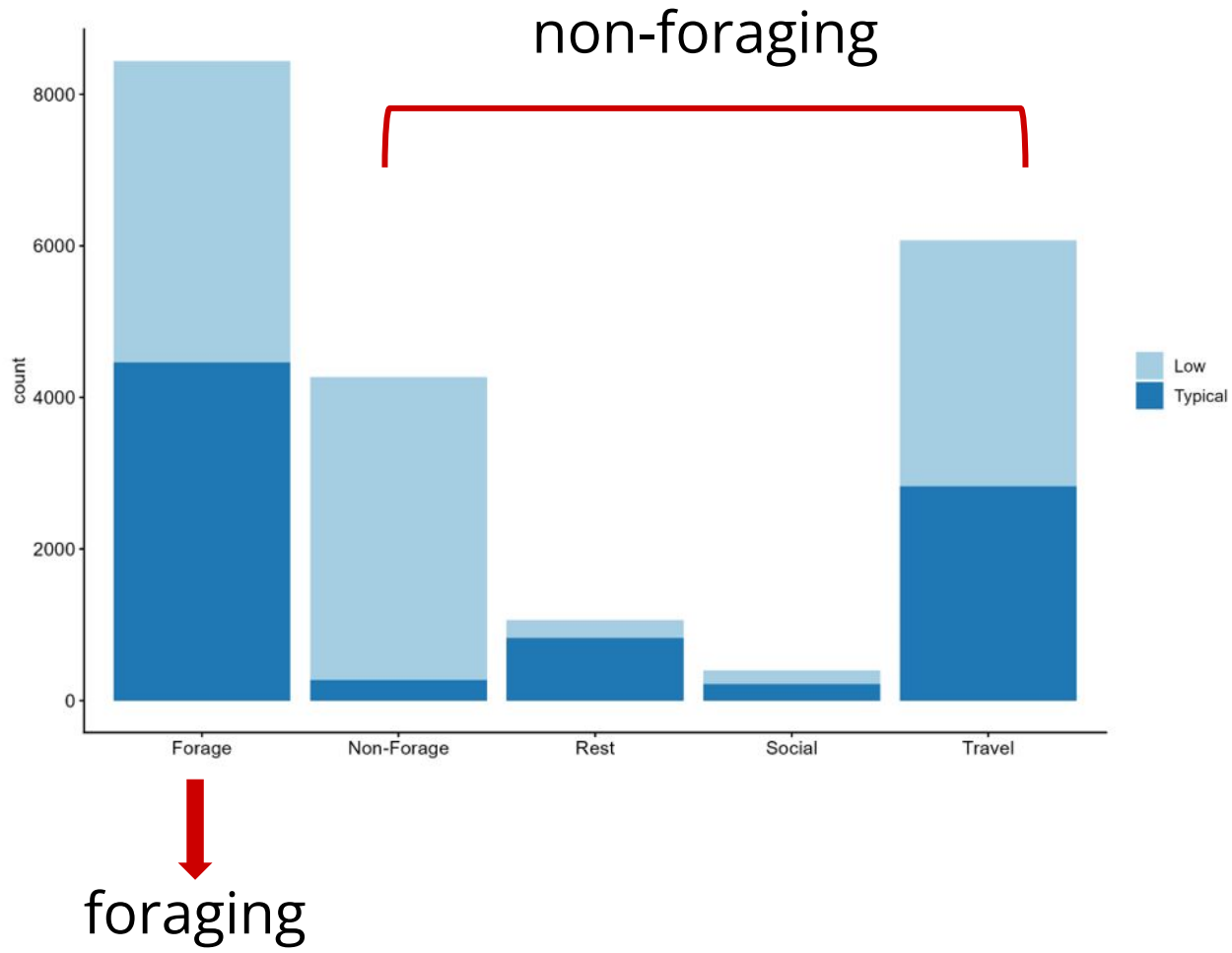
the spatial model

1 whale, prey, habitat data



the spatial model

1. whale, prey, habitat data
2. Spatially Adaptive Smoothing Algorithm (SALSA)
   - two-dimensional smoother (CReSS)
3. Generalized Estimating Equation (GEE) framework

$$y_i = Binomial(n_i, p_i)$$

$$p_i = log(n_i / (1 - n_i)) \rightarrow \text{probability of foraging for grid cell } i$$

$$n_i = \beta_0 + \beta_1 (prey)_i + s_1 (distance\ to\ coast, prey)_i + s_2 (X, Y, prey)$$

1D smooth term 2D spatial term (UTM)

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currently in peer review

the spatial model

1 whale, prey, habitat data

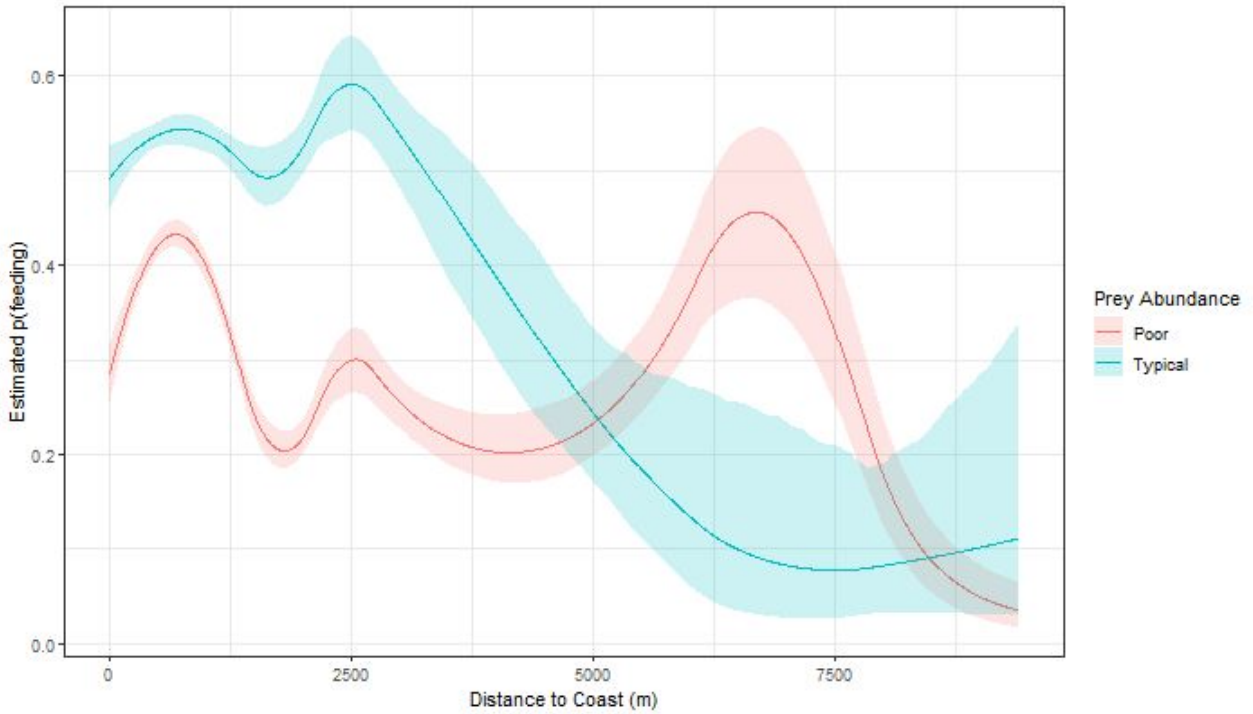
2 Spatially Adaptive Smoothing Algorithm (SALSA)

two-dimensional smoother (CReSS)

3 Generalized Estimating Equation (GEE) framework

4 Predicted probability of foraging

model selection chose distance to coast over depth & included:
B-spline and radial basis functions



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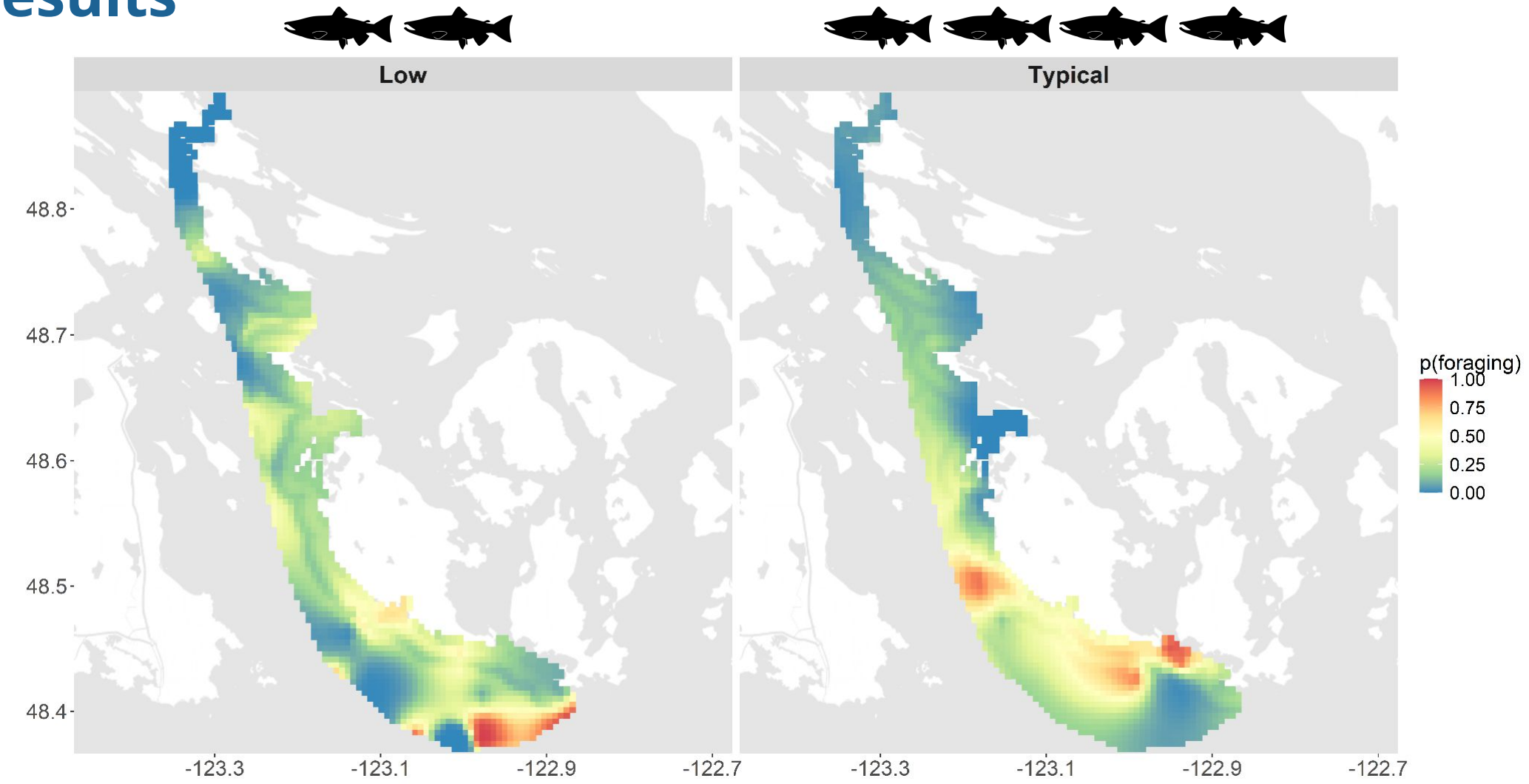
results



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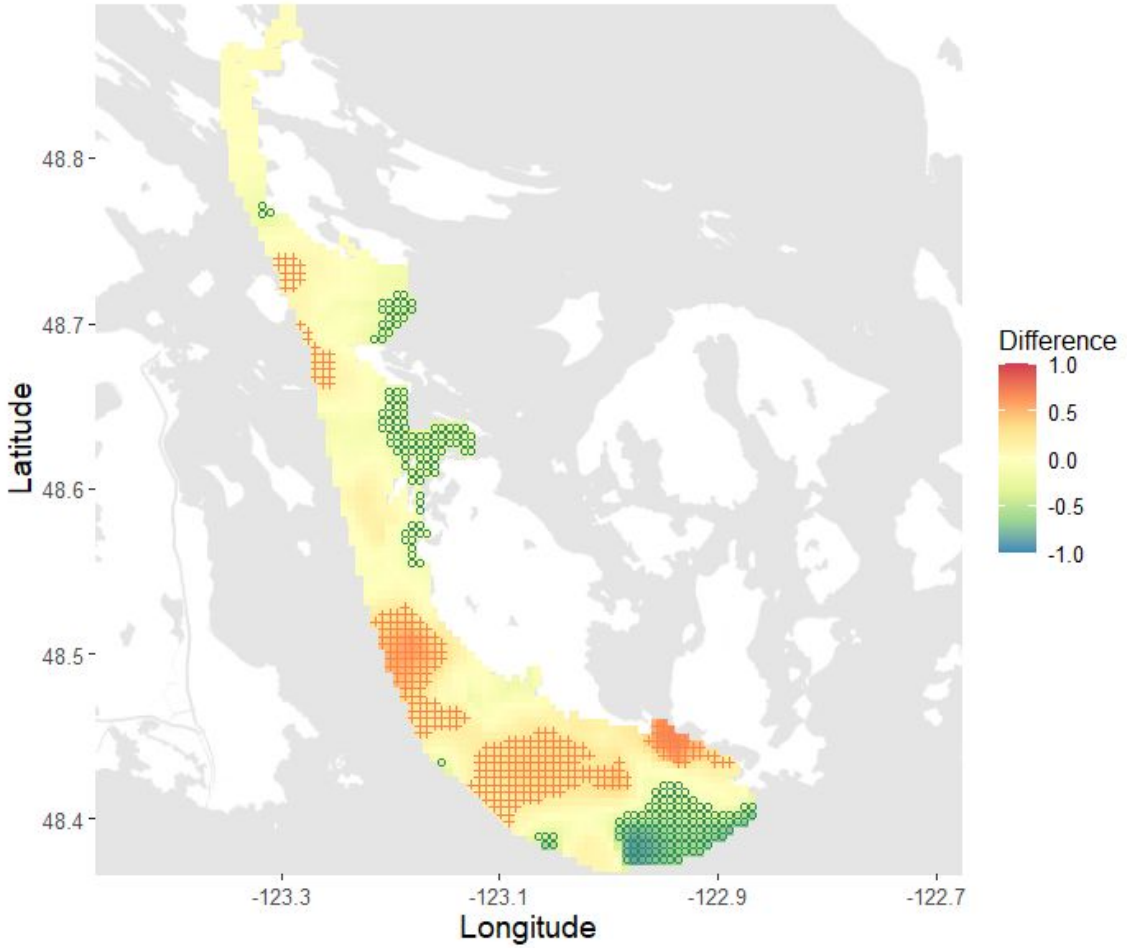

\+ more foraging in typical prey years

\- more foraging in low prey years

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conservation context

are we doing enough to protect foraging habitat?

San Juan County has initiated discussions about an MPA but support is not ubiquitous

as Chinook abundance remains relatively low
& SRKWs look for food elsewhere,
(small) protected areas no longer enclose foraging hot spots

West and south shores of San Juan Island from Mitchell Bay to Cattle Point.

*mandatory for commercial whale watch, voluntary for all other boaters (Washington Department of Fish and Wildlife)

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from maps to action

whales need quieter refuges to forage → these should protect historically important areas & emerging ones

- full time exclusion zones vs. closures triggered by SRKW presence
- restricted activity zones
- mandatory go-slow and no-go zones for ALL vessels, not just commercial

Thank you!

learn more about
our science at
www.oceansinitiative.org

photo: K Nielsen, Oceans Initiative