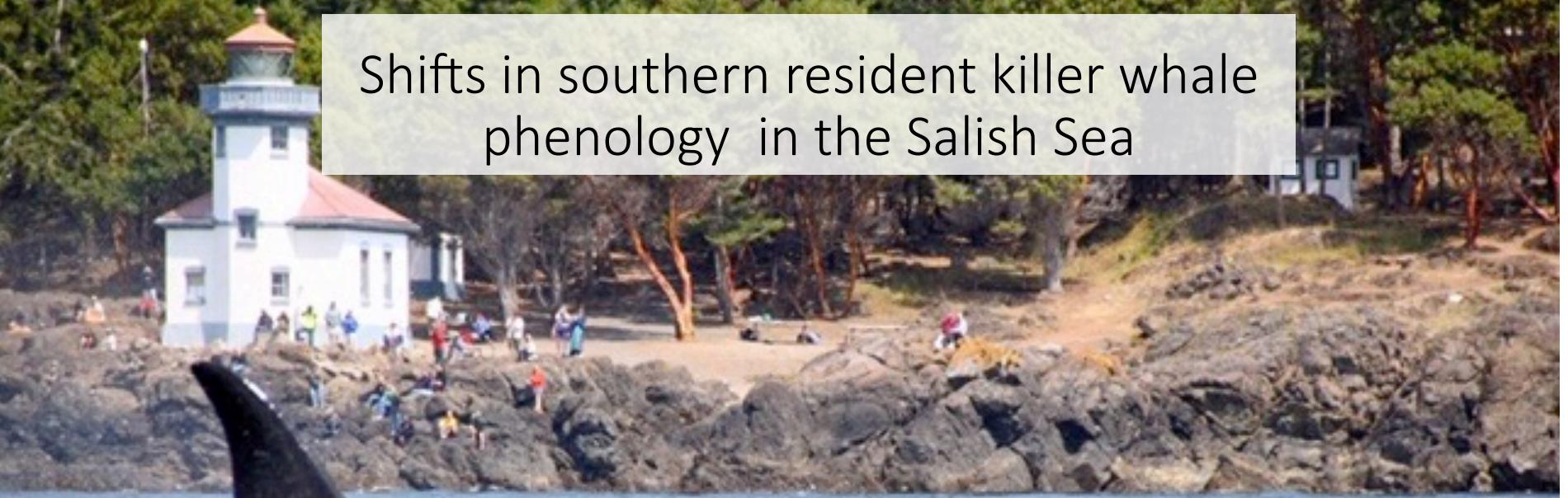


Shifts in southern resident killer whale phenology in the Salish Sea

Ailene K. Ettinger
NRC Research Associate
CB Division Meeting
August 14, 2019



Shifts in southern resident killer whale phenology in the Salish Sea

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NRC Research Associate

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Southern resident killer whales (*Orcinus orca*) are an endangered population

Killer whales are widespread, with different populations

Resident killer whales = fish-eating

Southern residents (SRKWs) listed as endangered in 2005

3 pods: J,K,L

Threats have included shooting, live capture, lack of food, vessel noise, pollution, small



Southern resident killer whales may be shifting their activity in the Salish Sea

Where are the southern resident orcas? Researchers see longest absence ever from summer waters

July 3, 2019 at 4:22 pm | Updated July 4, 2019 at 3:00 pm



1 of 3 | This 26-year-old female transient orca tosses around the pelt of a Stellar sea lion after the kill. Taken May... (Jeff Friedman / Pacific Whale Watch Association) [More](#) ▾

Where are the salmon and the orcas? Tribe, scientists grapple with unprecedented disappearance in Washington waters

Aug. 6, 2019 at 6:00 am | Updated Aug. 6, 2019 at 3:46 pm



1 of 13 | Lummi Nation spiritualist Richard Solomon offers a prayer for the southern-resident orcas on a private beach in the San Juan... (Alan Berner / The Seattle Times) [More](#) ▾

By [Lynda V. Mapes](#) 

Seattle Times environment reporter

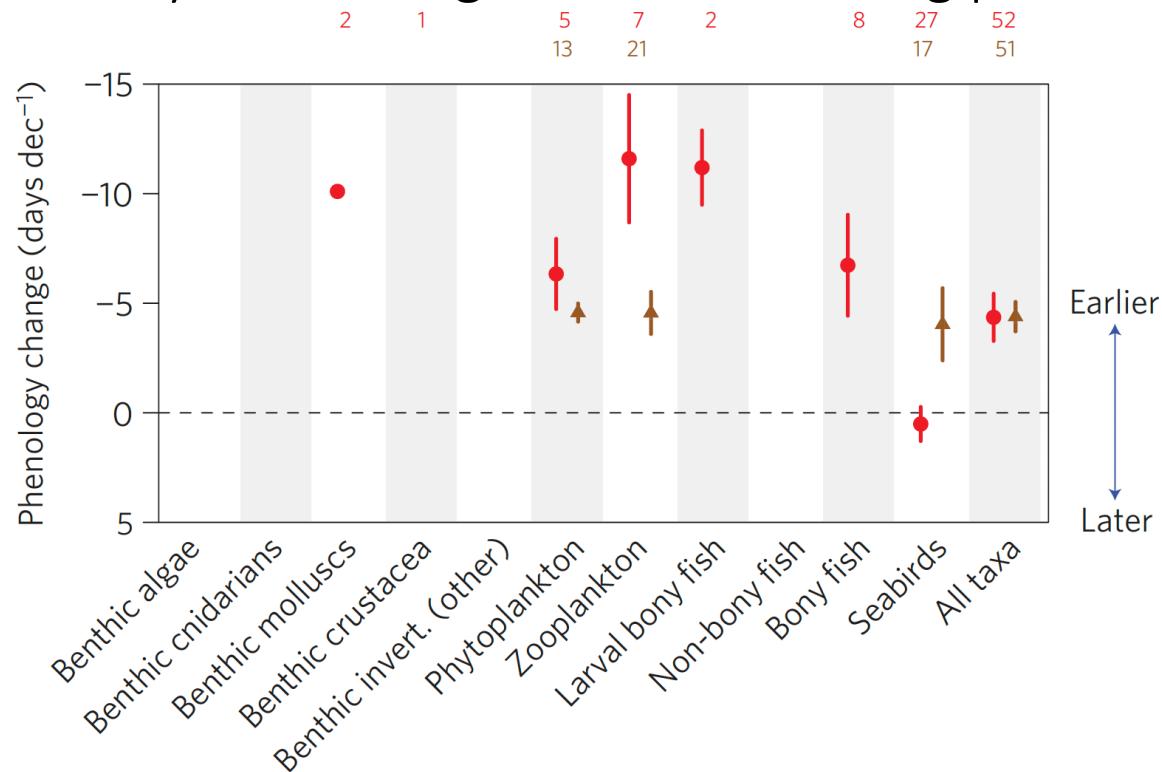
ABOARD THE LENGESOT IN THE SALISH SEA — The tote was loaded and full of water, the cedar boughs cut and stacked on deck. But as Lummi tribal members headed out on their traditional waters to offer a ceremonial feeding of live chinook salmon to the endangered southern-resident killer whales, neither whale nor fish was anywhere to be found.

In this historic summer of unthinkables, day after day is passing without the orcas and fish that normally enliven the waters of the inland Salish Sea.

Are these recent events part of long-term phenological shifts?

Are these recent events part of long-term phenological shifts?

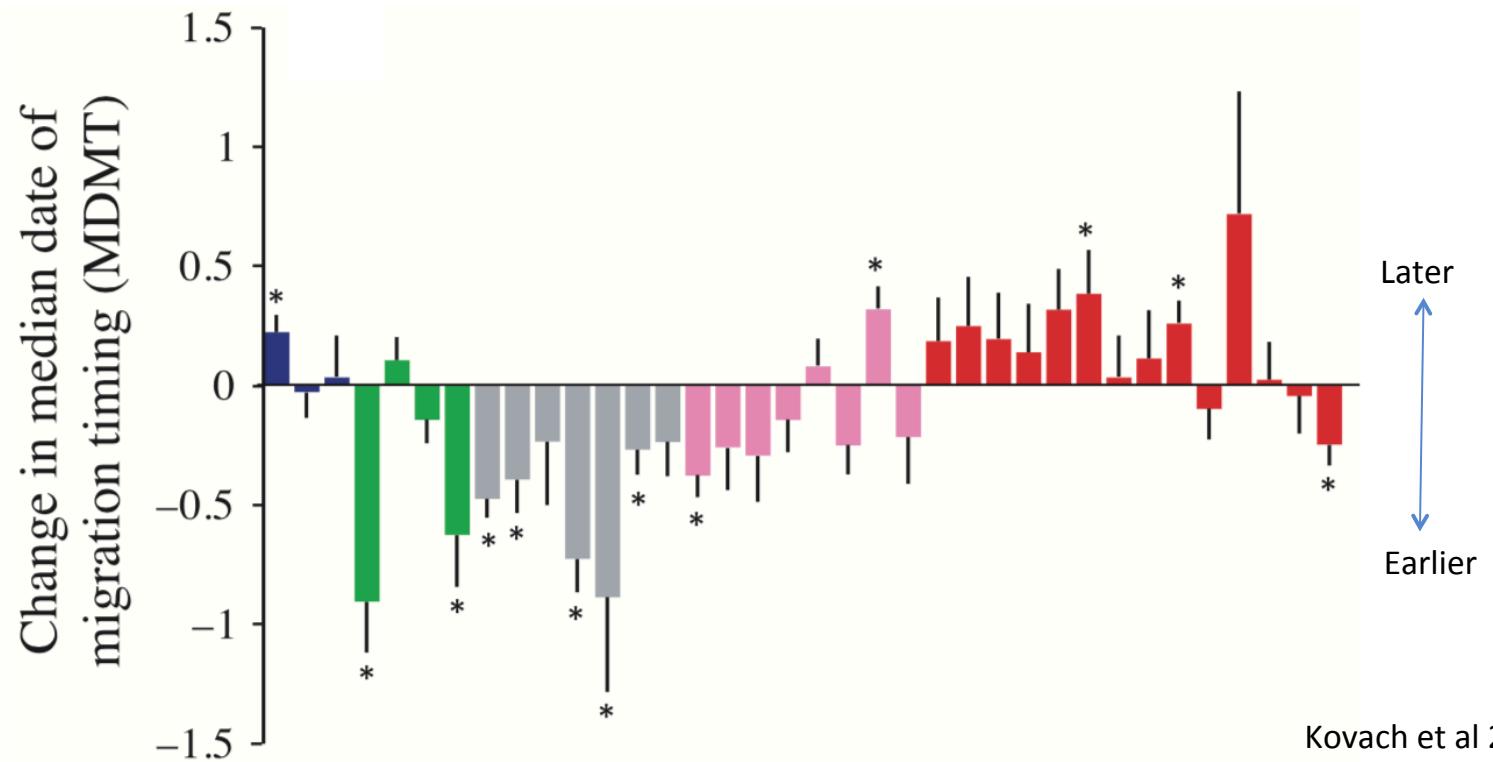
Many marine organisms are shifting phenology



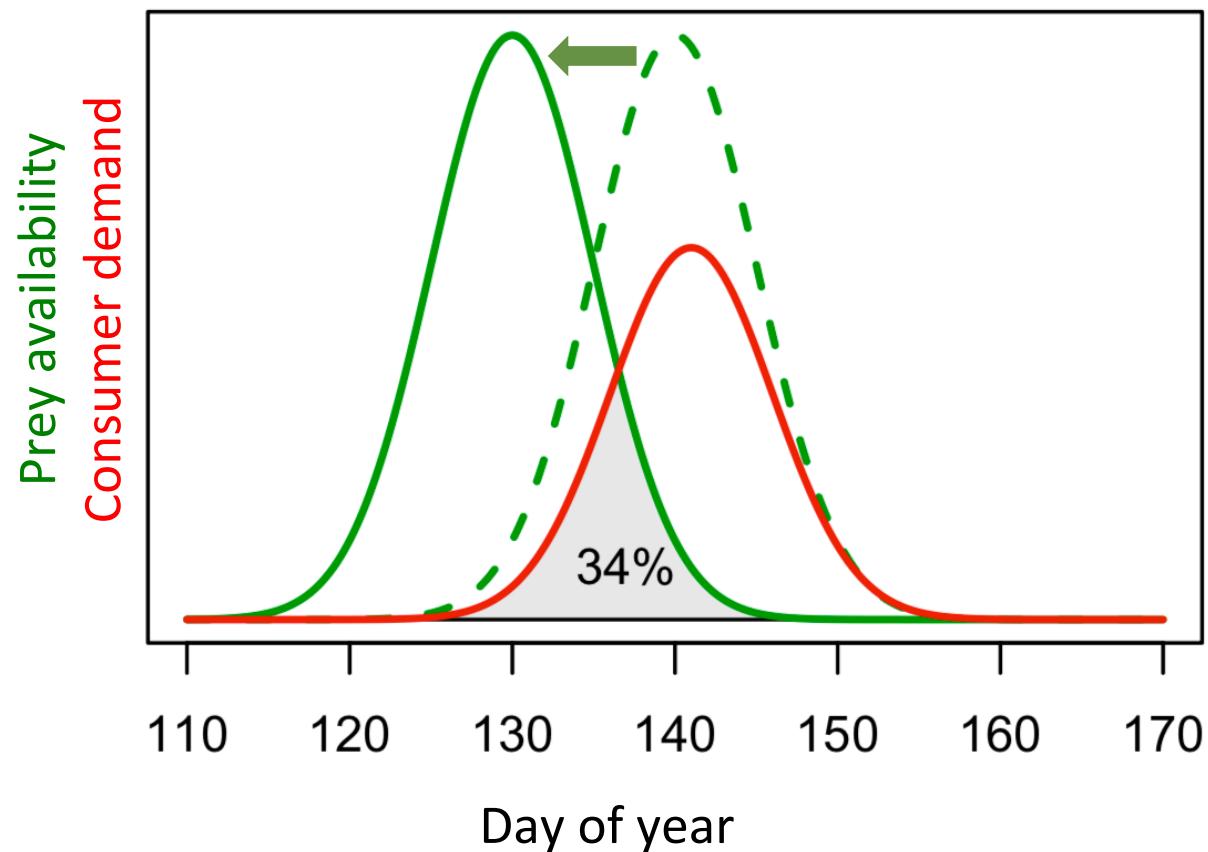
Poloczanska et al 2013

Are these recent events part of long-term phenological shifts?

Many salmon species are shifting phenology



Asynchronous shifts between SRKWs and their prey could reduce prey availability (phenological “mismatch”)



Linden 2018

Can we detect phenological shifts in SRKW activity in the Salish Sea?

The Orca Master Database

Vol. 37: 105–118, 2018
<https://doi.org/10.3354/esr00918>

ENDANGERED SPECIES RESEARCH
Endang Species Res

Published October 10



Sightings of southern resident killer whales in the Salish Sea 1976–2014: the importance of a long-term opportunistic dataset

Jennifer K. Olson^{1,*}, Jason Wood², Richard W. Osborne³, Lance Barrett-Lennard⁴,
Shawn Larson¹

¹The Whale Museum, Friday Harbor, WA 98250, USA

²SMRU Consulting, Friday Harbor, WA 98250, USA

³University of Washington, Olympic Natural Resources Center, Forks, WA 98331, USA

⁴Coastal Ocean Research Institute, Ocean Wise, Vancouver, BC, V6B 3X8, Canada

ABSTRACT: Southern resident killer whales (SRKWs) *Orcinus orca* may be present year round in the Salish Sea, i.e. the inland waterways of Washington State (USA) and southern British Columbia (Canada). SRKWs were listed as endangered in 2005 under the US Endangered Species Act. The Whale Museum (Washington, USA) has been collecting opportunistic sightings reports on SRKWs since 1976 with a goal of providing managers and regulatory agencies with reliable spatial and temporal data on this population. Information in this dataset comes from 5 classes of killer whale sighting sources and is systematically evaluated for accuracy before integration into the dataset. From 1976 to 2014, The Whale Museum's Orca Master dataset documented a total of 82 447 SRKW sightings in the Salish Sea. Sightings were concentrated in a few key hot spots, with an overall pattern of consistent presence in the Central Salish Sea during the summer months and a presence in Puget Sound proper during the fall and early winter months. A shift in SRKW presence in Puget Sound was documented in the late 1990s, possibly driven by increased foraging on fall chum salmon *Oncorhynchus keta* by 2 pods ('K' and 'L'), and is consistent with the hypothesis that the movement patterns of these whales may be driven by prey availability. The Whale Museum's dataset highlights the importance of long-term monitoring to document shifts that may take decades, and shows how opportunistic datasets can be valuable tools for illuminating spatial and temporal trends.

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Sightings



Recent whale sightings in the Salish Sea
(Puget Sound, Northwest Straits, Gulf Islands and Georgia Strait)

[Sightings Summaries Archives](#)
[Sighting Report Archives](#)

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To find viewpoints along shorelines from Deception Pass to Olympia, go to:
[Whale Sightings Viewpoints Map Page](#)

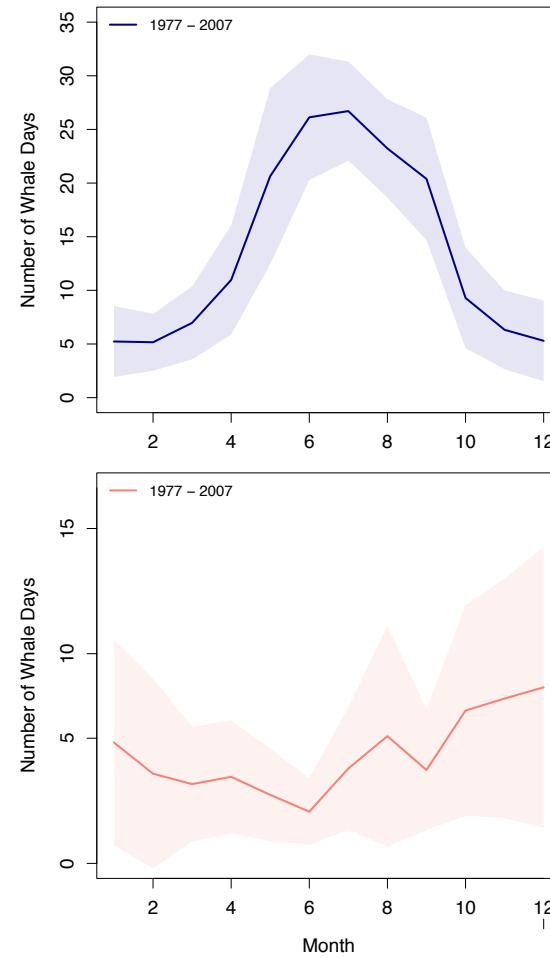
To report whales please go to the [Orca Network Sightings Report Page](#).

The purpose of Orca Network's Whale Sighting Network and Education Project is to encourage observation and increase awareness and knowledge about the Southern Resident Community of orcas (J, K and L pods), and foster a stewardship ethic to motivate a diverse audience to take action to protect and restore these orcas' critical habitat.

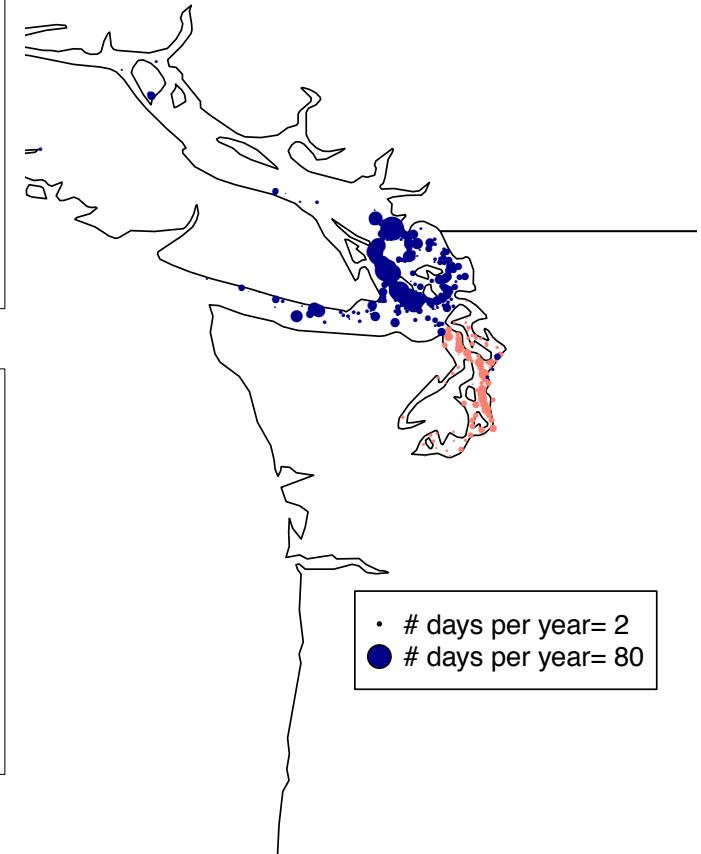
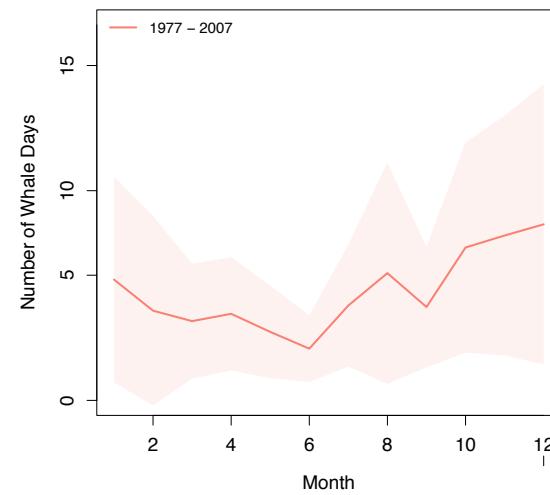
The orcas' steep population decline of 20% from 1995 to 2001 is a reflection of the problems and issues facing the greater Puget Sound marine and watershed ecosystems: *declining salmon runs, PCB contamination, and the effects of a rapidly increasing human population including habitat loss and resource depletion*. Through a volunteer Whale Sighting Network, sightings and observations of this orca community are gathered and disseminated to researchers and volunteers, and posted on our website.

SRKW activity varies seasonally across two areas

Central Salish Sea
(Summer)

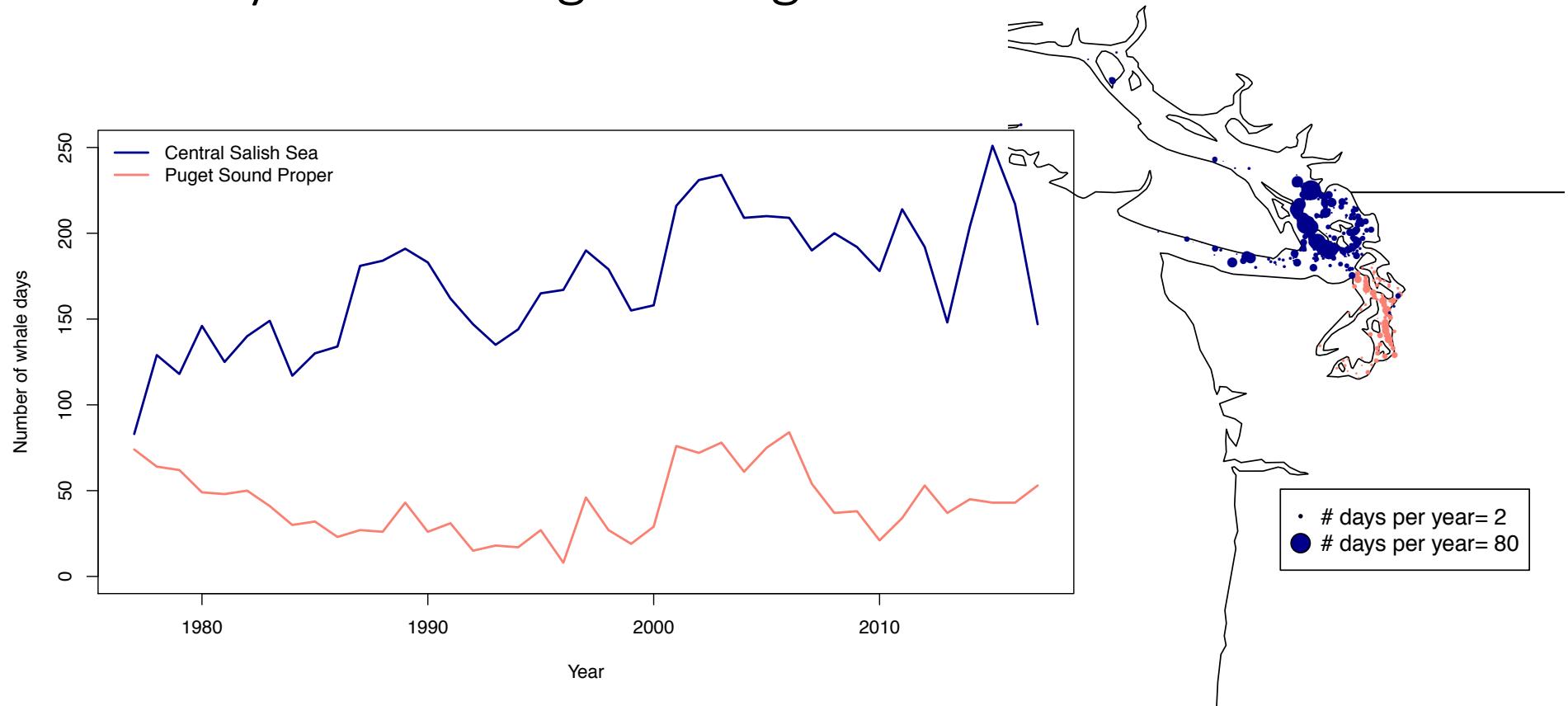


Puget Sound Proper
Fall/Winter

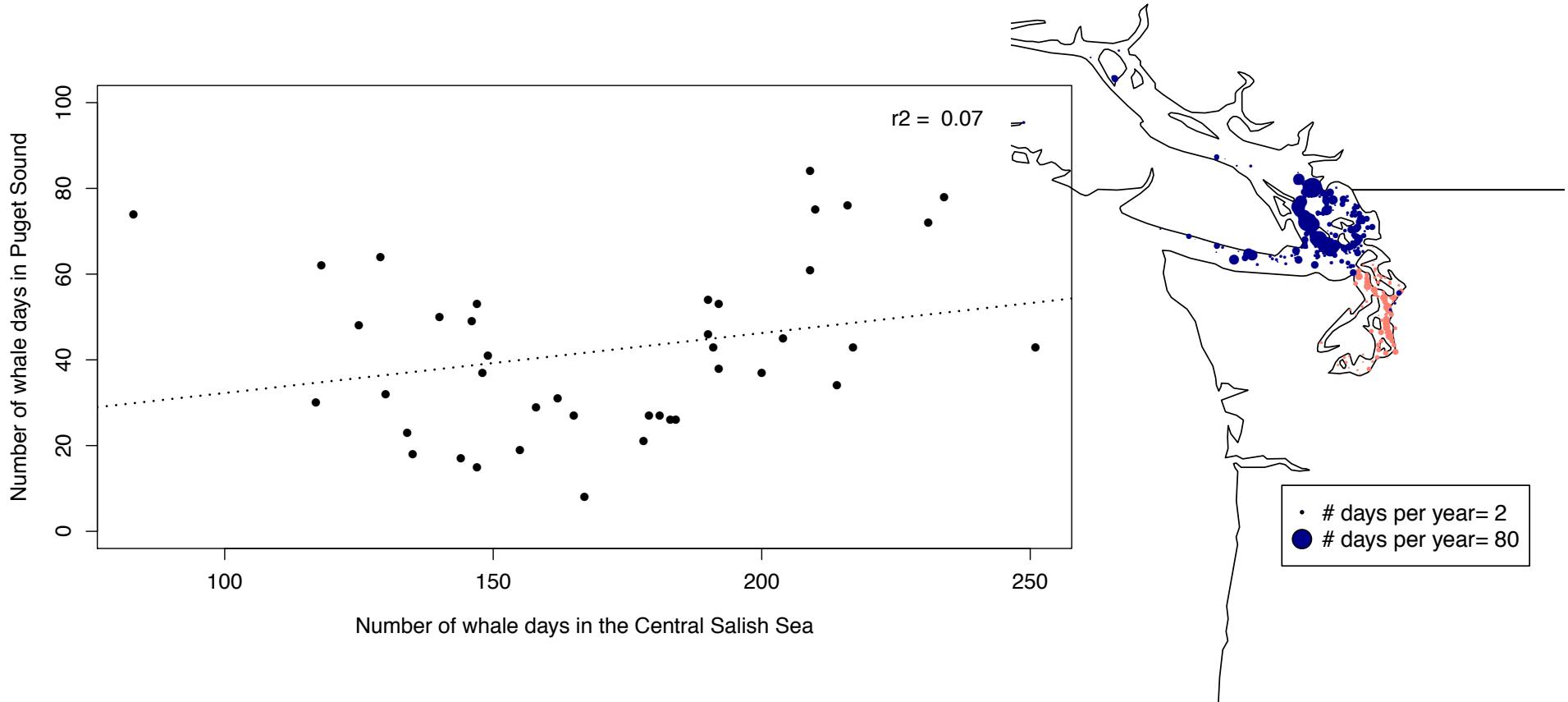


Source: OrcaMaster Database

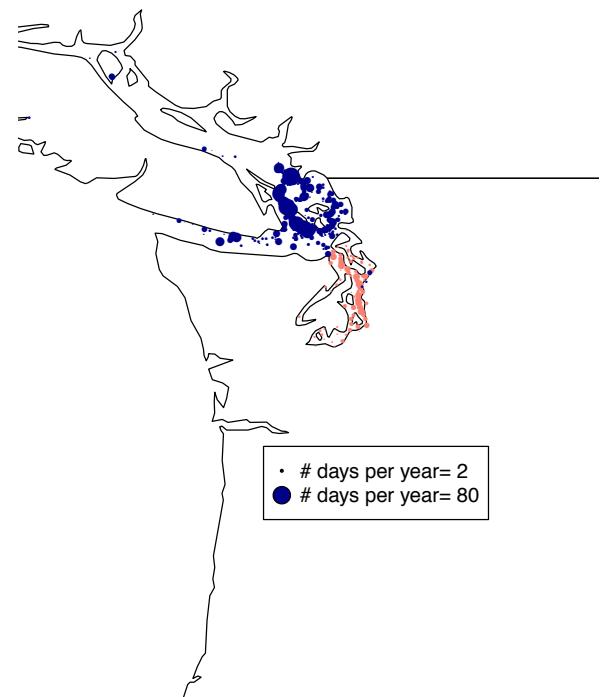
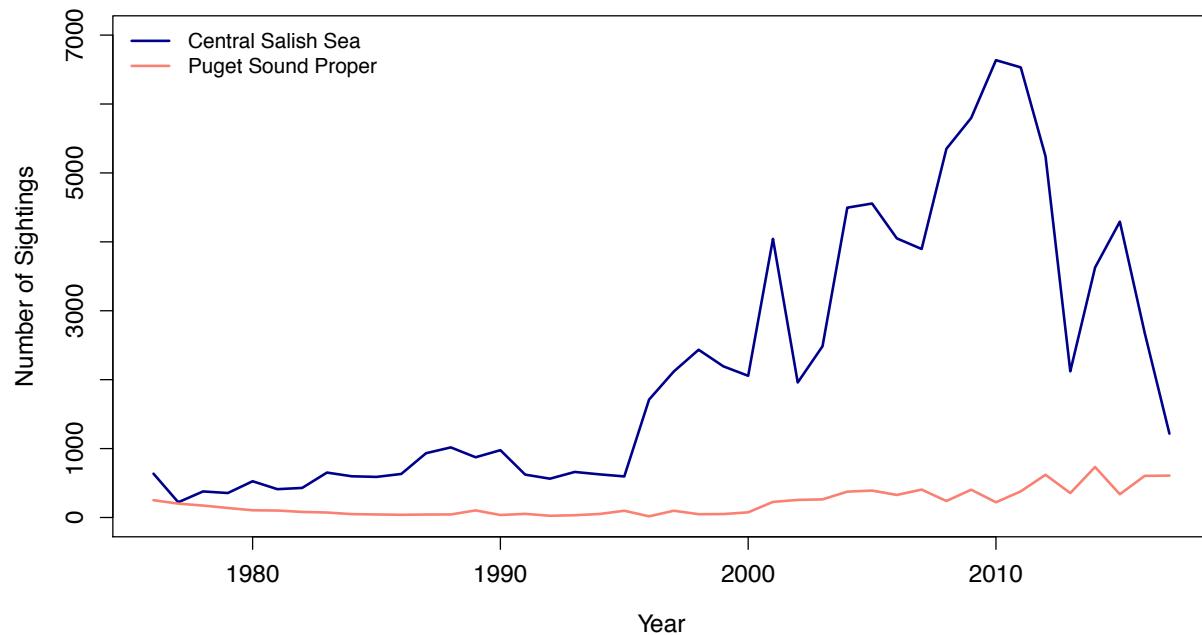
SRKW activity varies seasonally across two regions,
that may have divergent long-term trends



SRKW activity varies seasonally across two regions
that may have divergent long-term trends



SRKW activity varies seasonally across two regions, that may have different long-term trends and varying effort



We used multi-level occupancy models to estimate daily probability of occupancy

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Observation model:

$$y_{area,yr,day} \sim Binomial(T_{yr,day,area}, z_{yr,day} * p_{area,yr})$$

State model:

$$z_{yr,day} \sim Bernoulli(\Psi_{yr,day})$$

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Occupancy modelled as a function of year and date, using splines.

Methods in Ecology and Evolution

Methods in Ecology and Evolution 2014, 5, 483–490

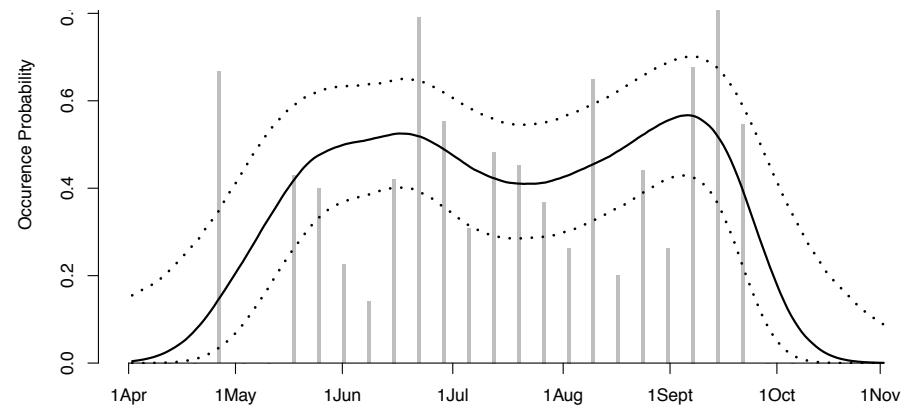


doi: 10.1111/2041-210X.12175

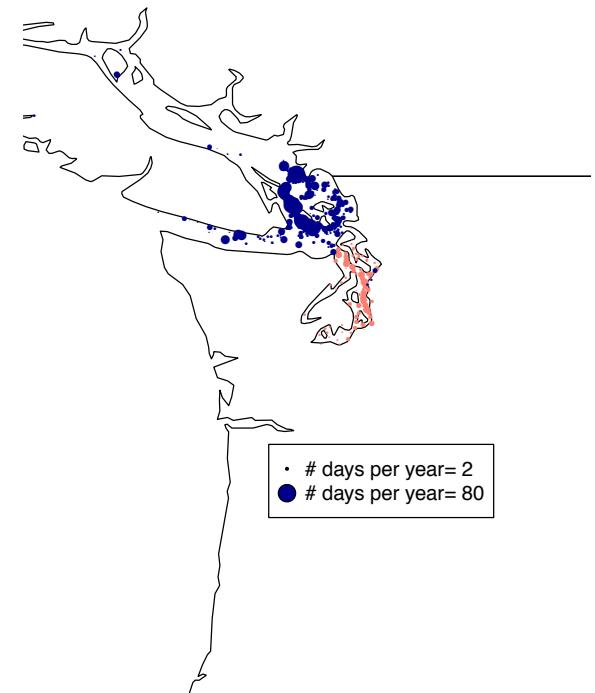
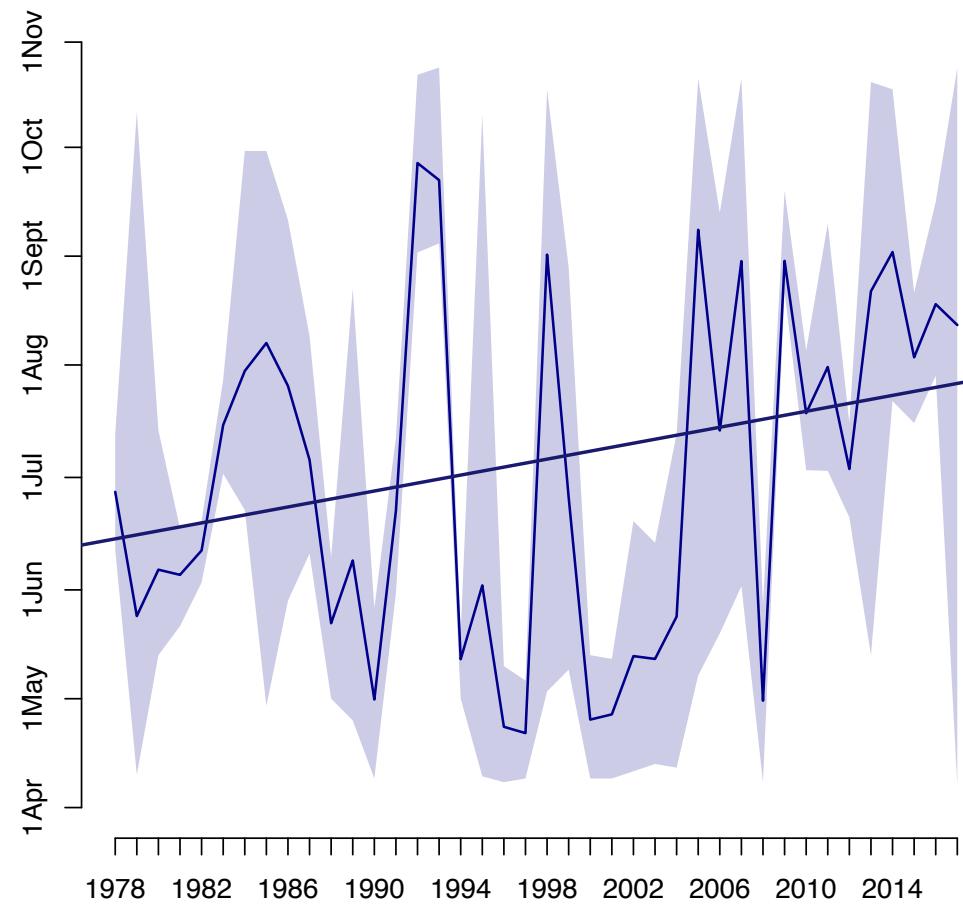
Studying phenology by flexible modelling of seasonal detectability peaks

Nicolas Strelbel^{1,2*}, Marc Kéry¹, Michael Schaub¹ and Hans Schmid¹

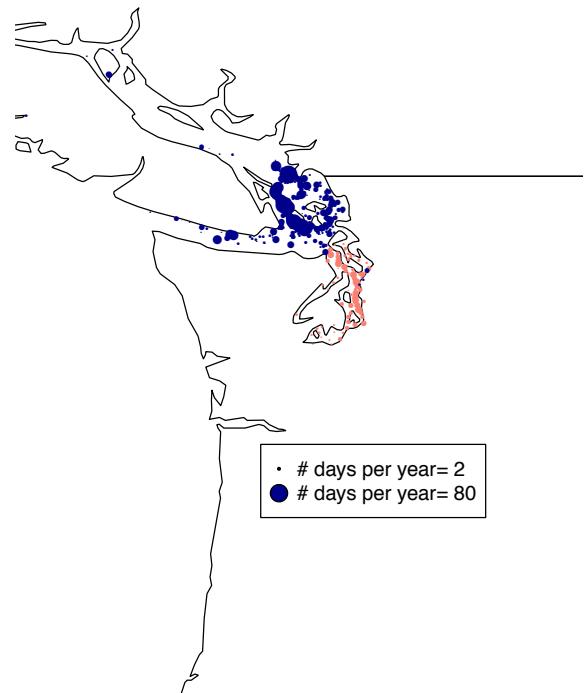
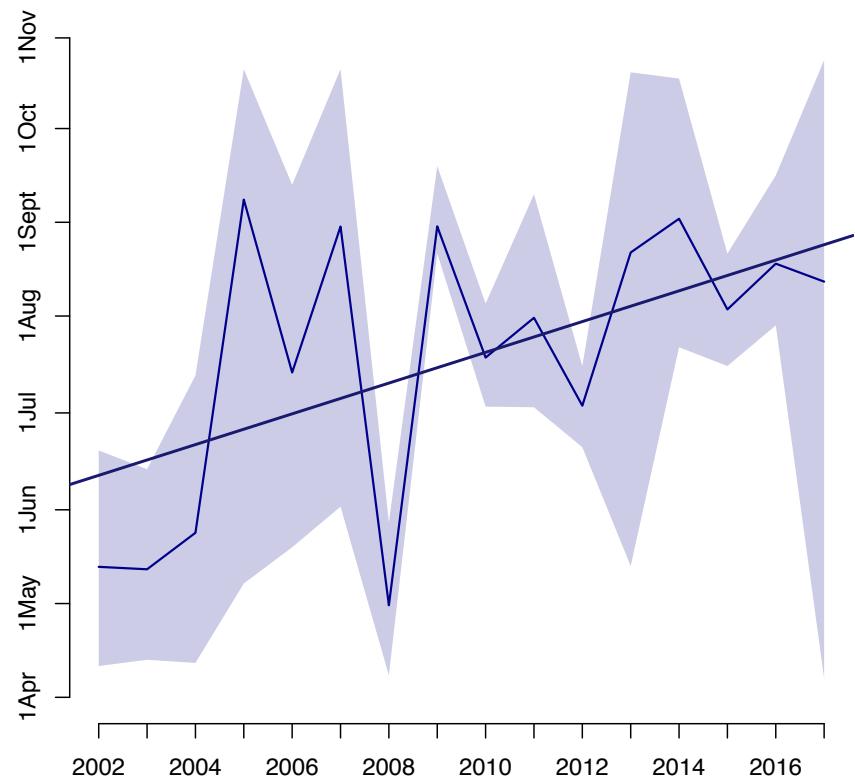
¹Swiss Ornithological Institute, 6204 Sempach, Switzerland; and ²Hintermann & Weber AG, 4153 Reinach, Switzerland



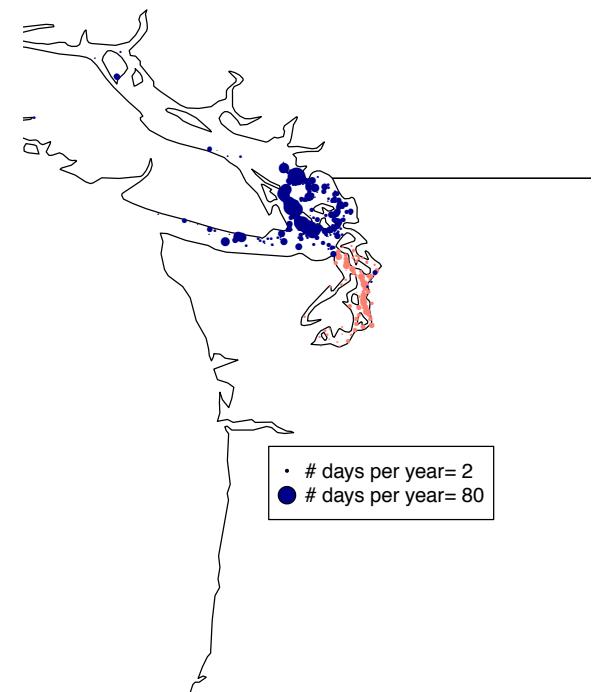
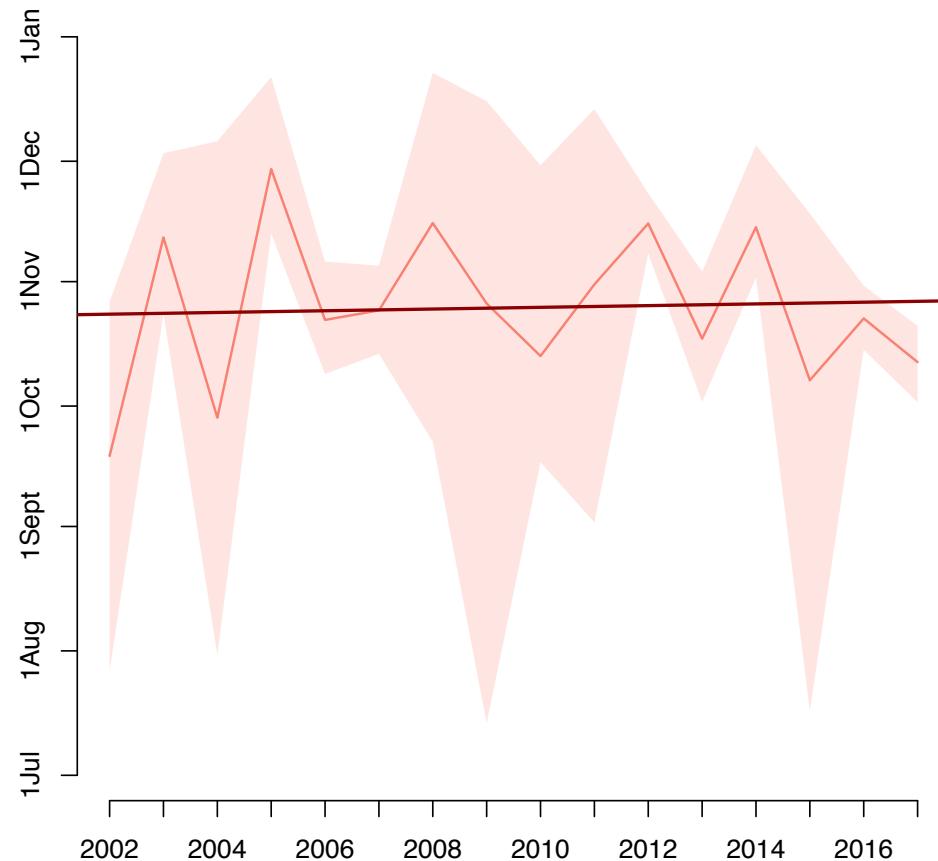
Estimated peak occupancy date varies across the time-series



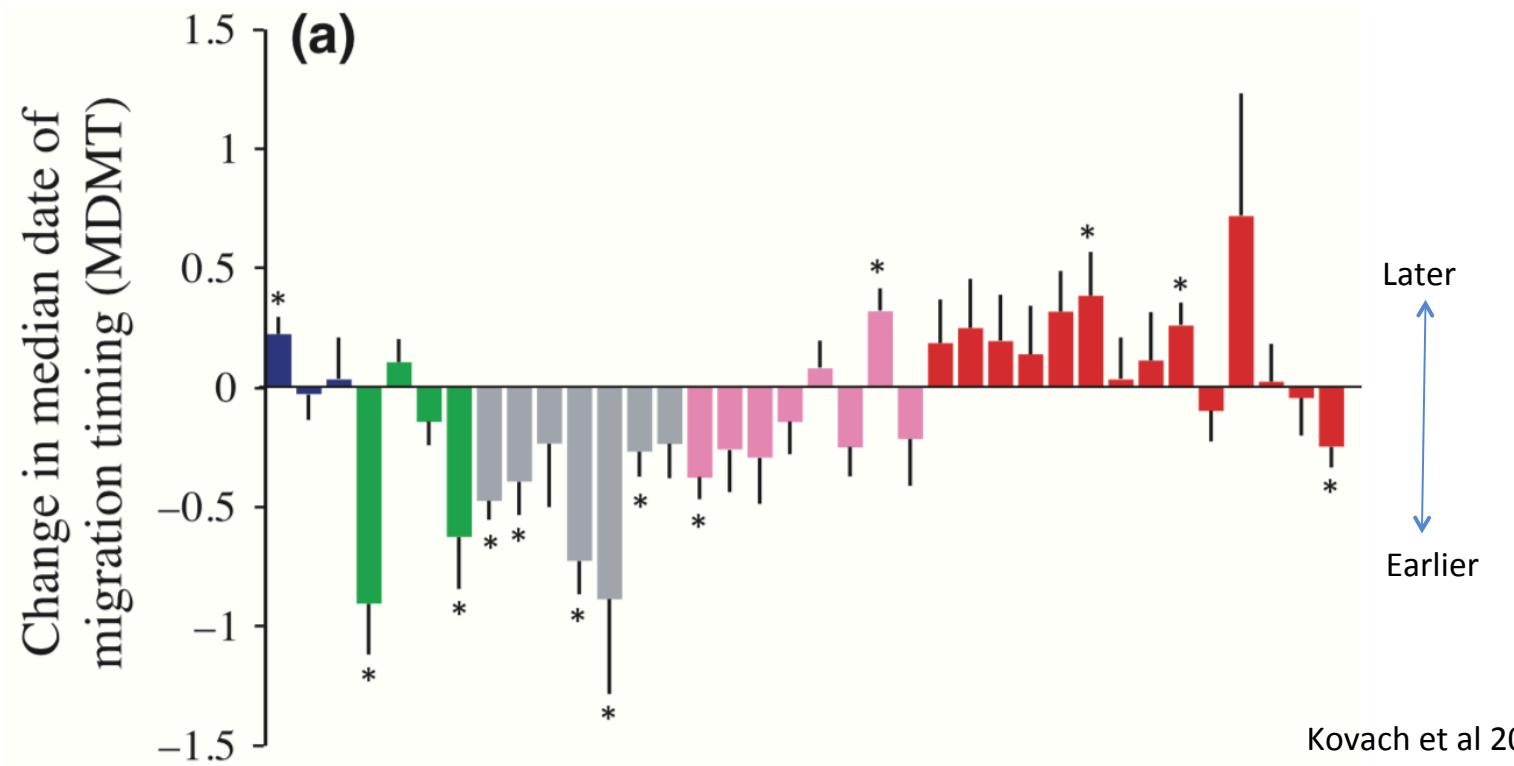
Recently peak occupancy date has delayed strongly in the Salish Sea



No trend in peak occupancy date in Puget Sound...

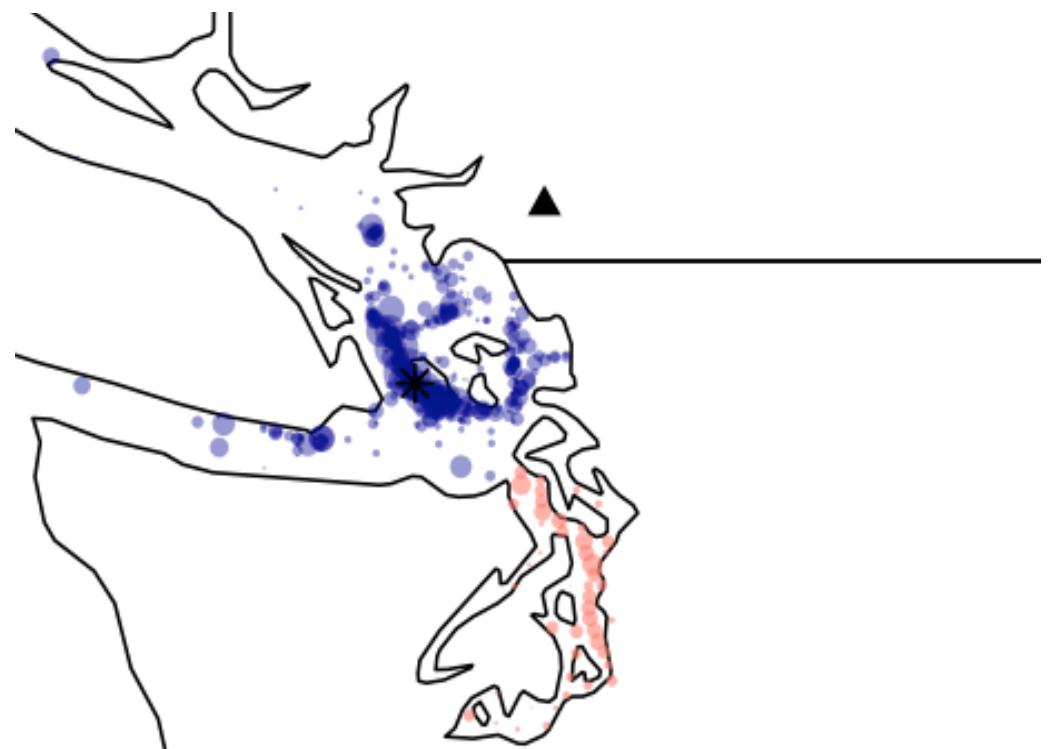


Salmon phenology has shifted across the west coast- could shifts in salmon phenology explain shifts in SRKW phenology?

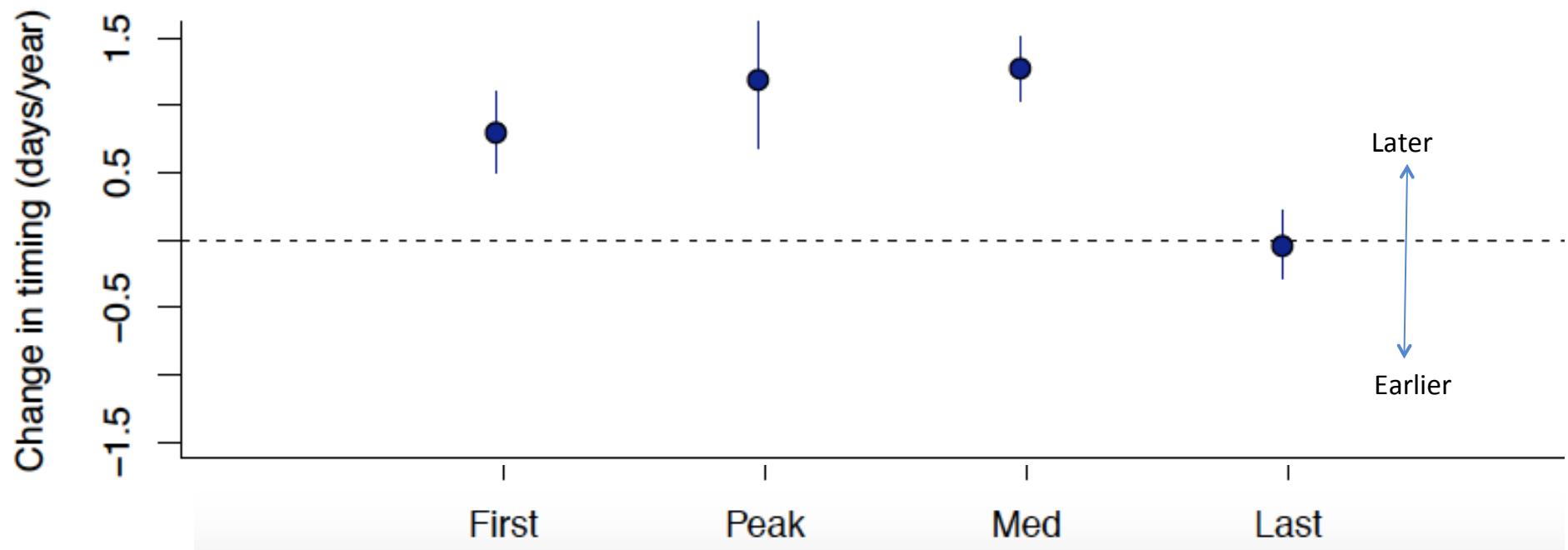


Fraser River Chinook are a preferred prey for SRKWs in the Central Salish Sea

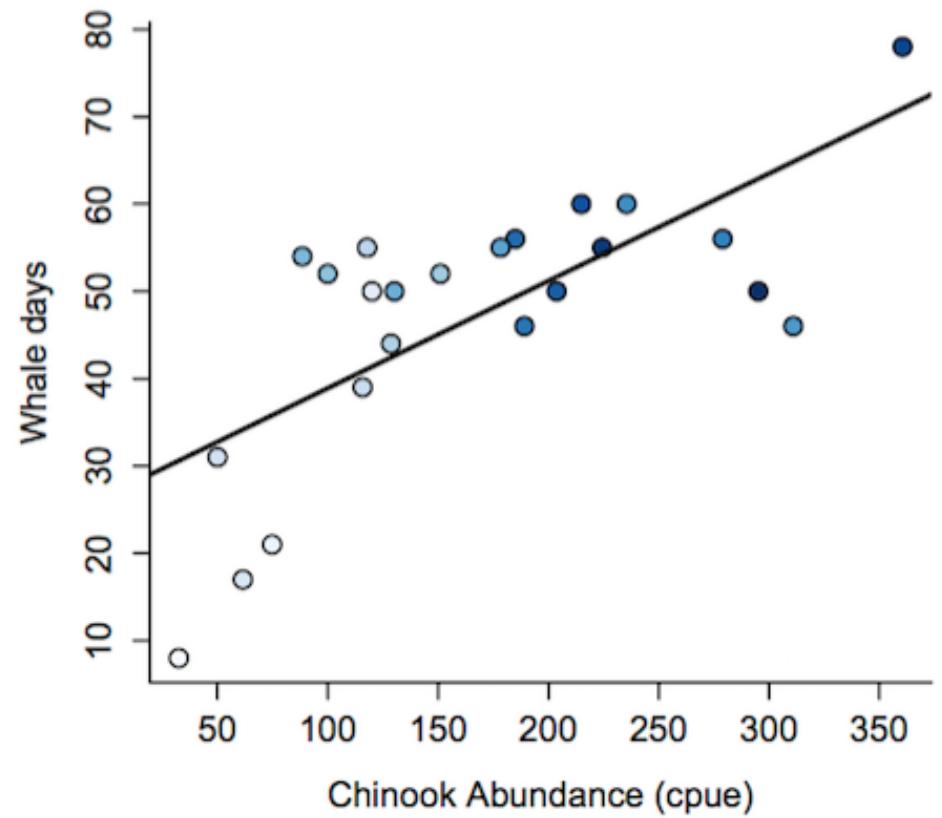
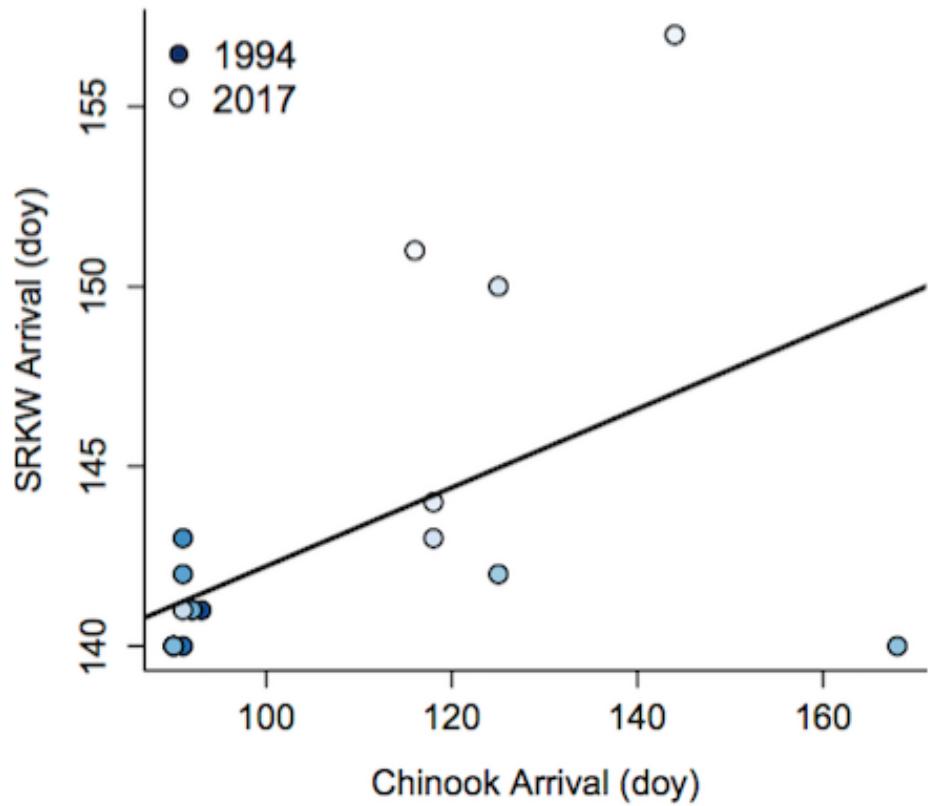
- Central Salish Sea
- Puget Sound proper
- # days per year= 2
- # days per year= 80
- * Lime Kiln
- ▲ Albion Test Fishery



Fraser River Chinook migration timing has also delayed

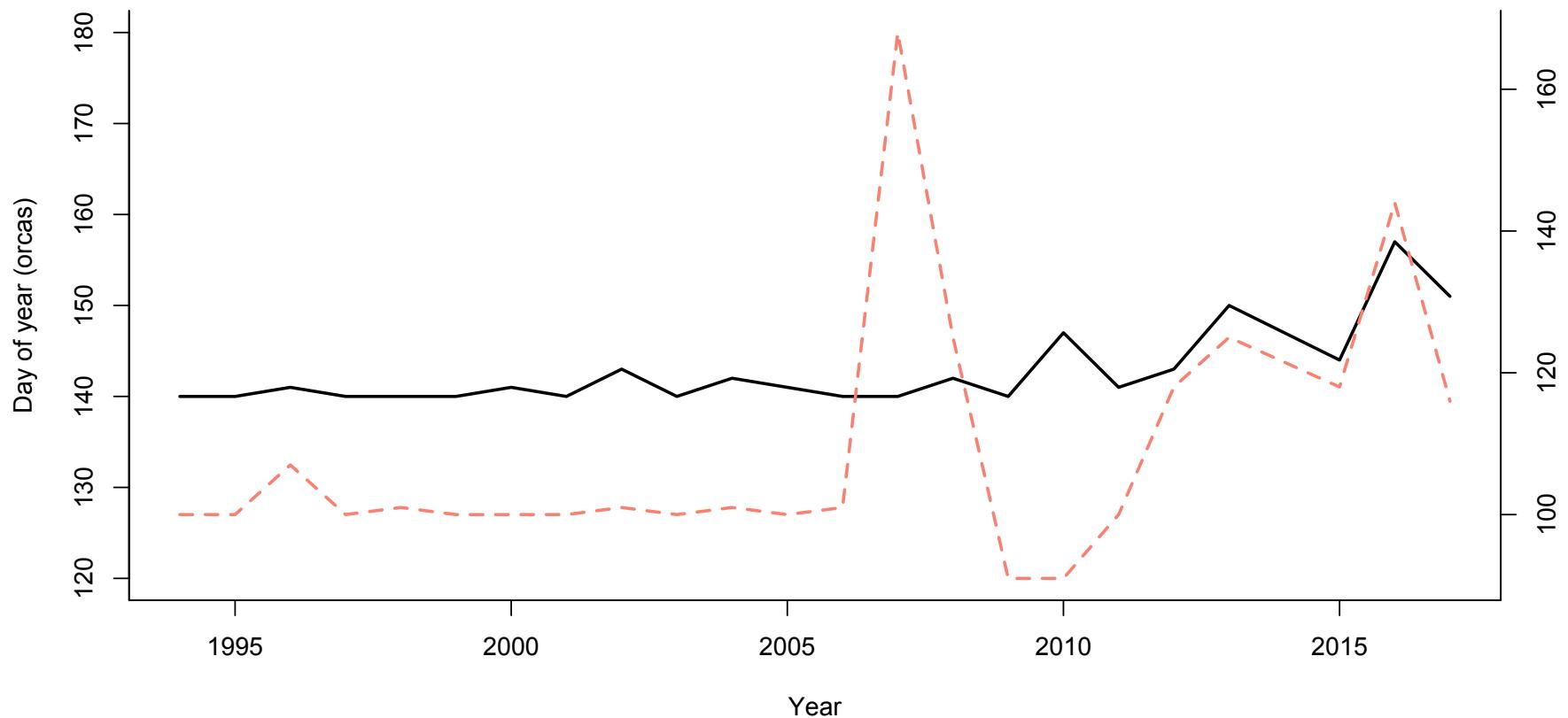


Delays in Fraser River Chinook may explain delays in SRKW in the Central Salish Sea



Delays in Fraser River Chinook may explain delays in SRKW in the Central Salish Sea...but have there been changes in the match/mismatch of SRKWs and their prey?

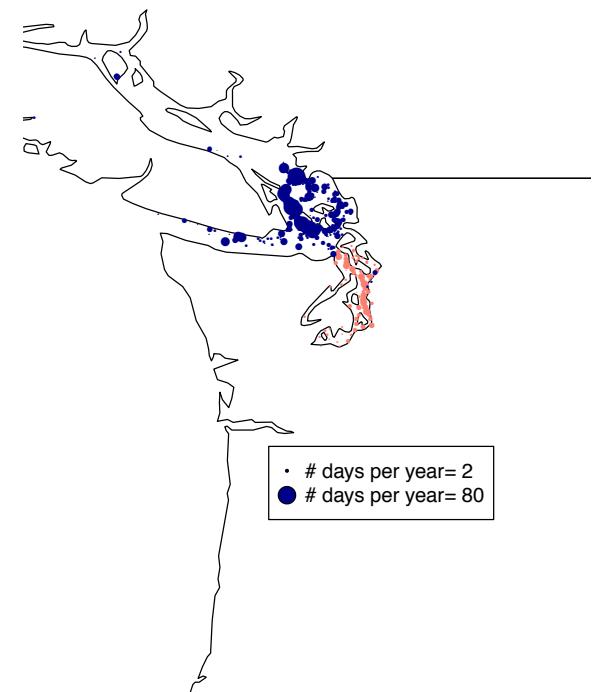
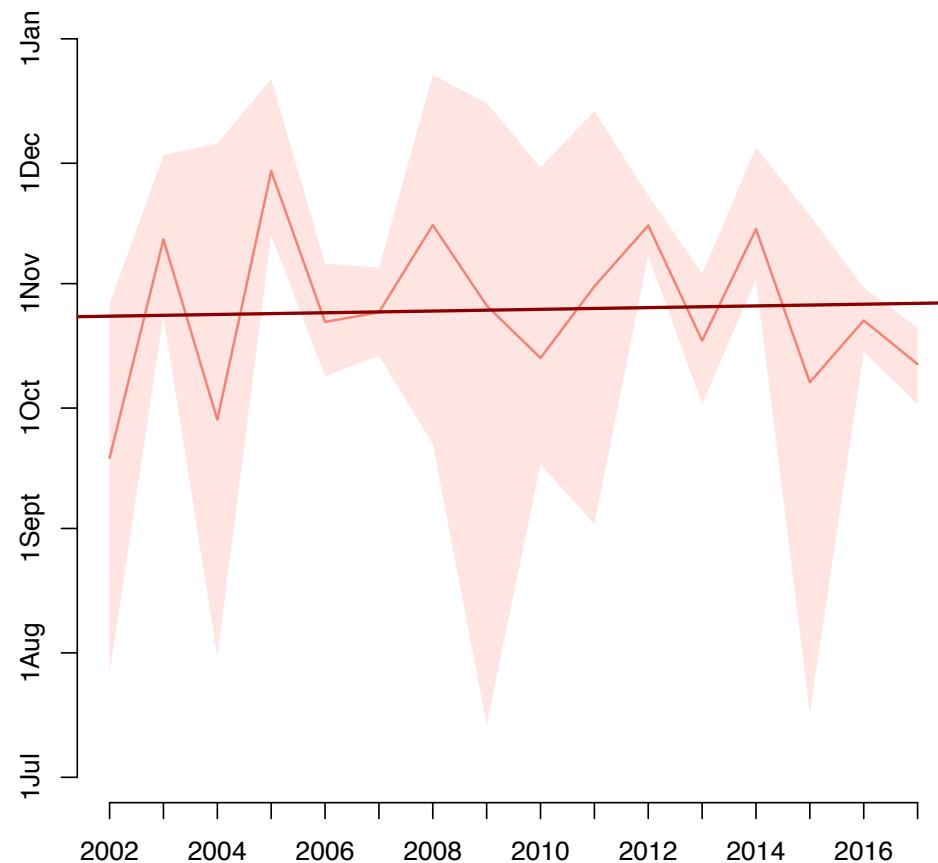
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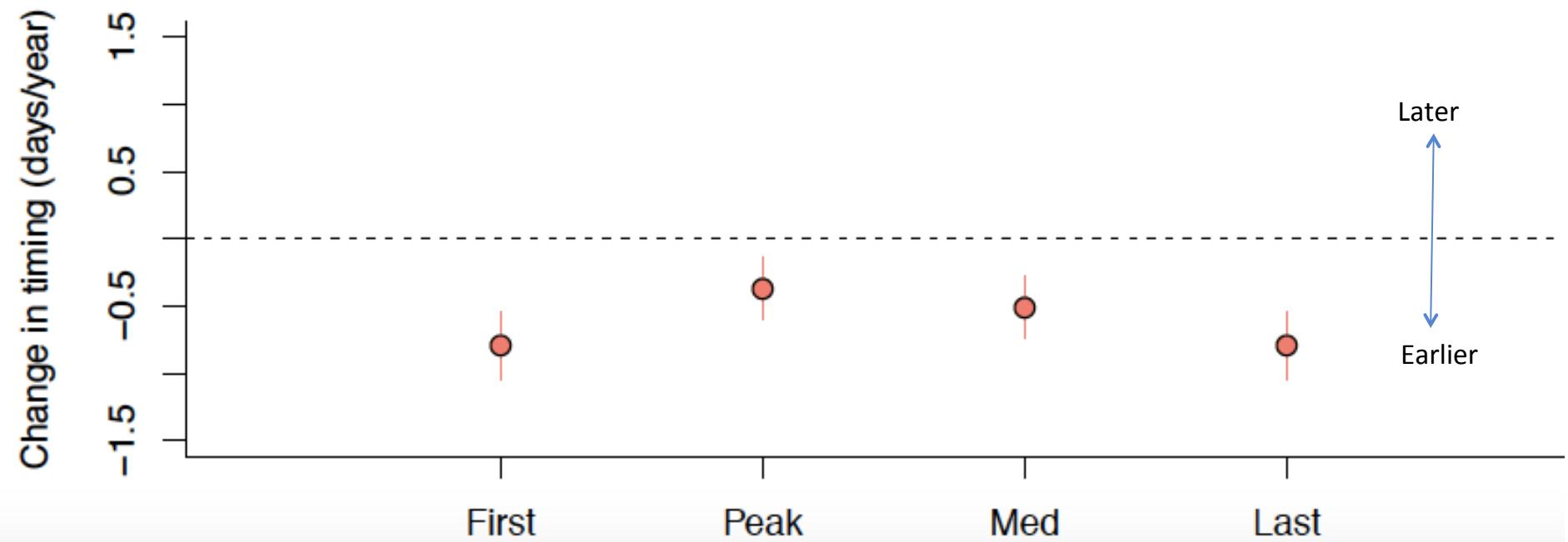
Delays in Fraser River Chinook may explain delays in SRKW in the Central Salish Sea...but have there been changes in the match/mismatch of SRKWs and their prey?

TBD...

No trend in peak occupancy date in Puget Sound...

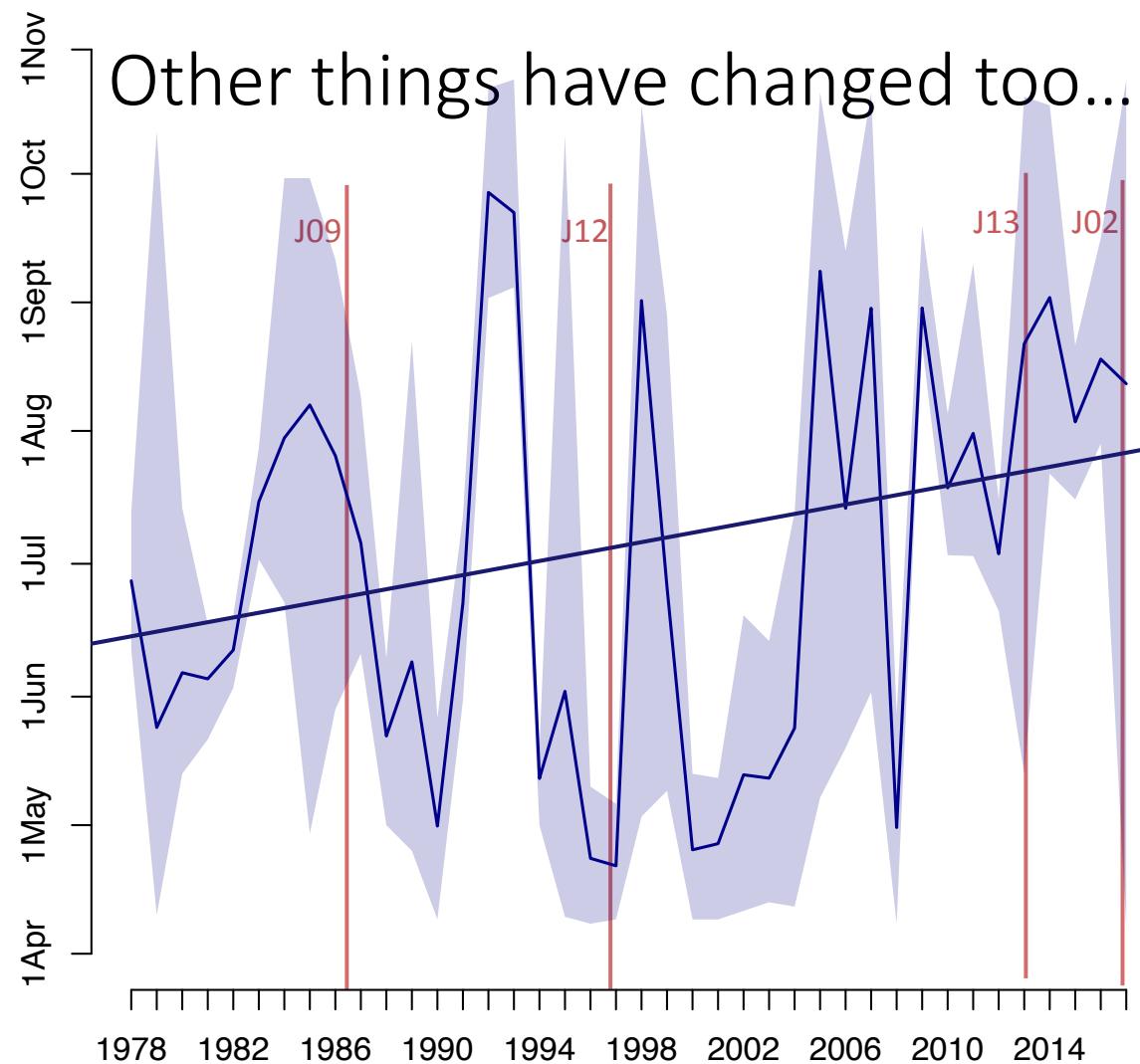


Many Puget Sound salmon have advanced



Other things have changed too...





Summary

- SRKW phenology has shifted, though not linearly
- Recent trends (delays) differ from long-term trends
- SRKWs appear to be responding to shifting phenology of their prey
- Citizen science data can be useful
- Absence data are useful!
- There is a lot that we don't understand about recent shifts in SRKWs and their prey...



A killer whale is breaching the water, its dark dorsal fin visible against the light-colored surface. It is positioned in front of a large, rugged rock formation. A plume of white spray rises from behind the whale, partially obscuring the rocks. The background shows more of the coastline and some greenery. A white rectangular box is overlaid on the upper portion of the image, containing the text "Thank you!".

Thank you!

Some questions...

- Include both regions in a paper, or focus on the CSS (core summer habitat)?
- What other figures would you want to see?