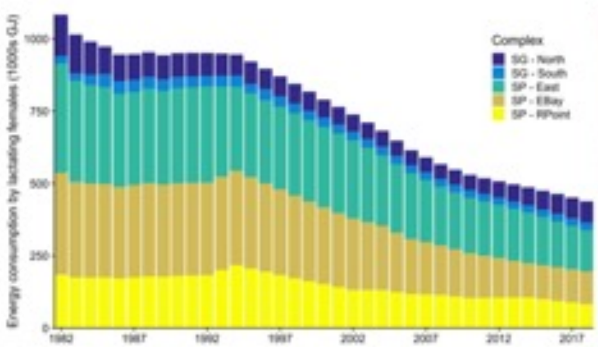
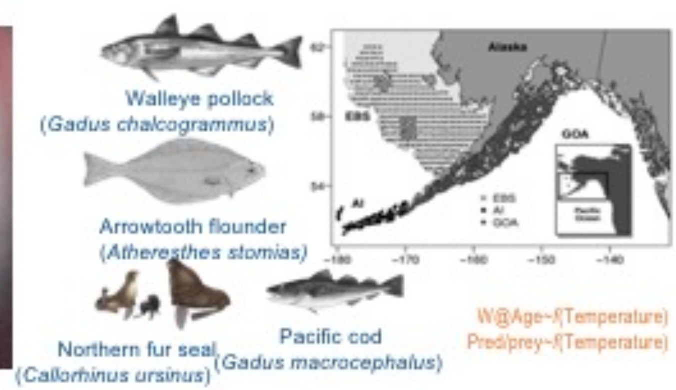
Northern fur seal update

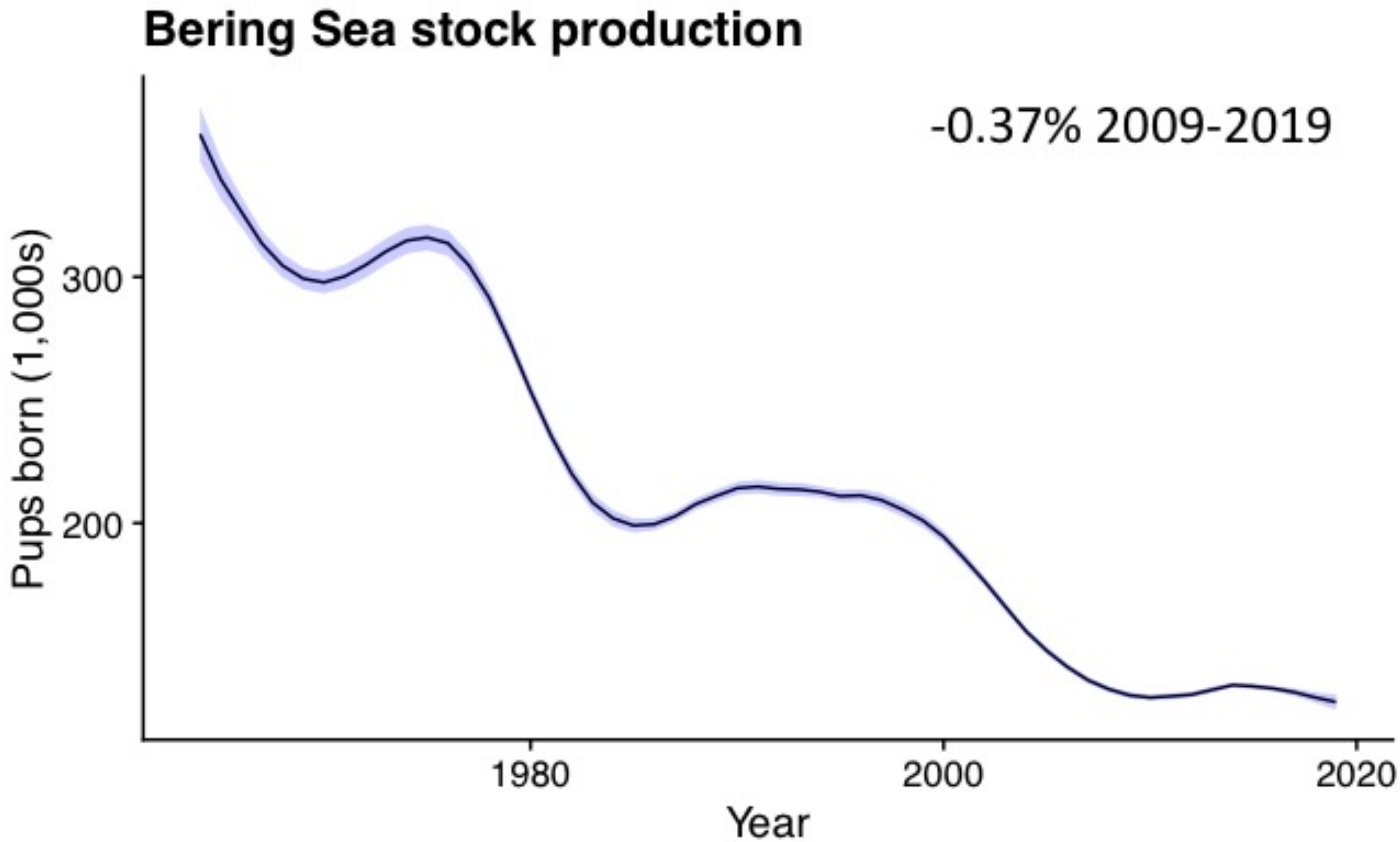
1. Population status (Sterling)
2. Saildrone and fur seal foraging studies (Kuhn)
3. Lenfest Ocean Program, UW, NOAA project update (McHuron)



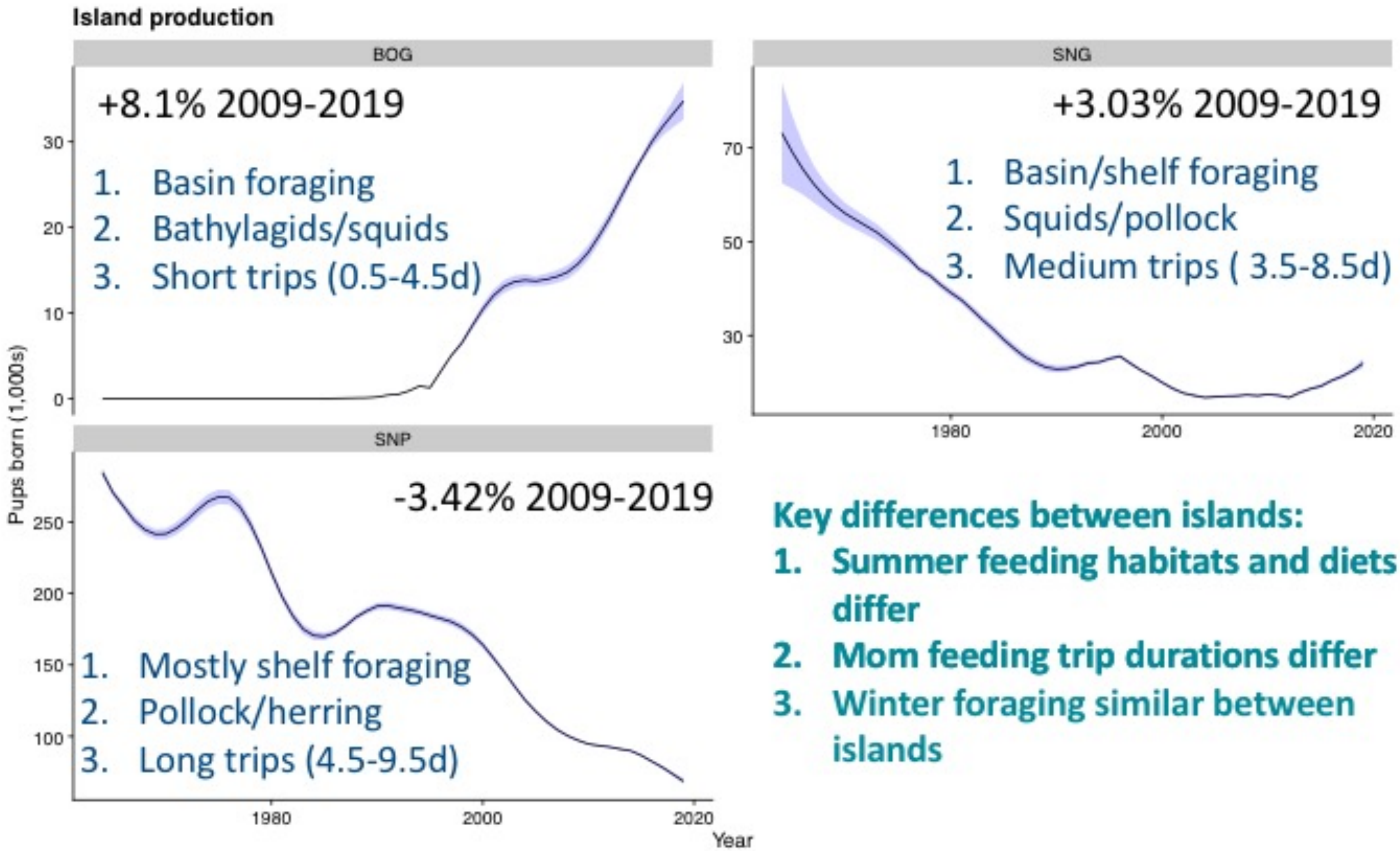


NPFMC Seattle 27-28 January 2020

Northern fur seal eastern Pacific stock pup production



Northern fur seal island pup production

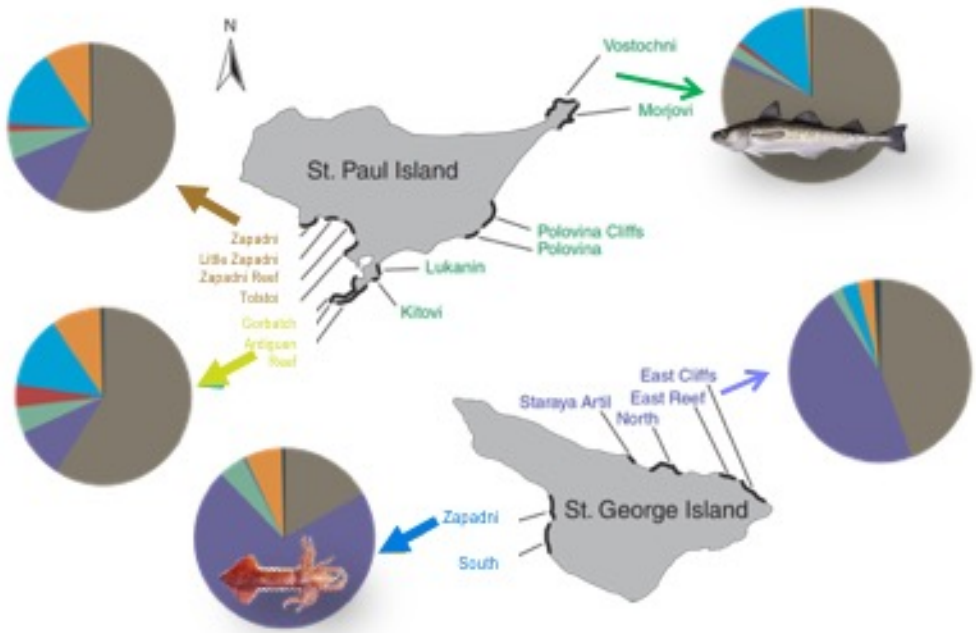


Key differences between islands:

1. **Summer feeding habitats and diets differ**
2. **Mom feeding trip durations differ**
3. **Winter foraging similar between islands**

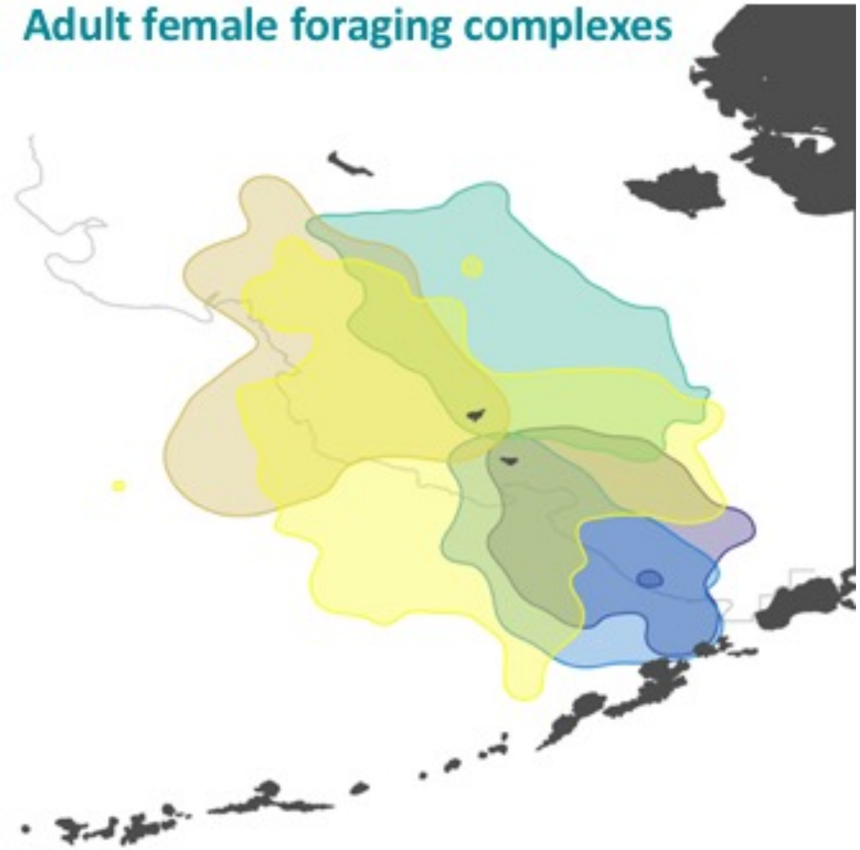
Northern fur seal complexes defined by diets and foraging location

Diet complexes and diet composition



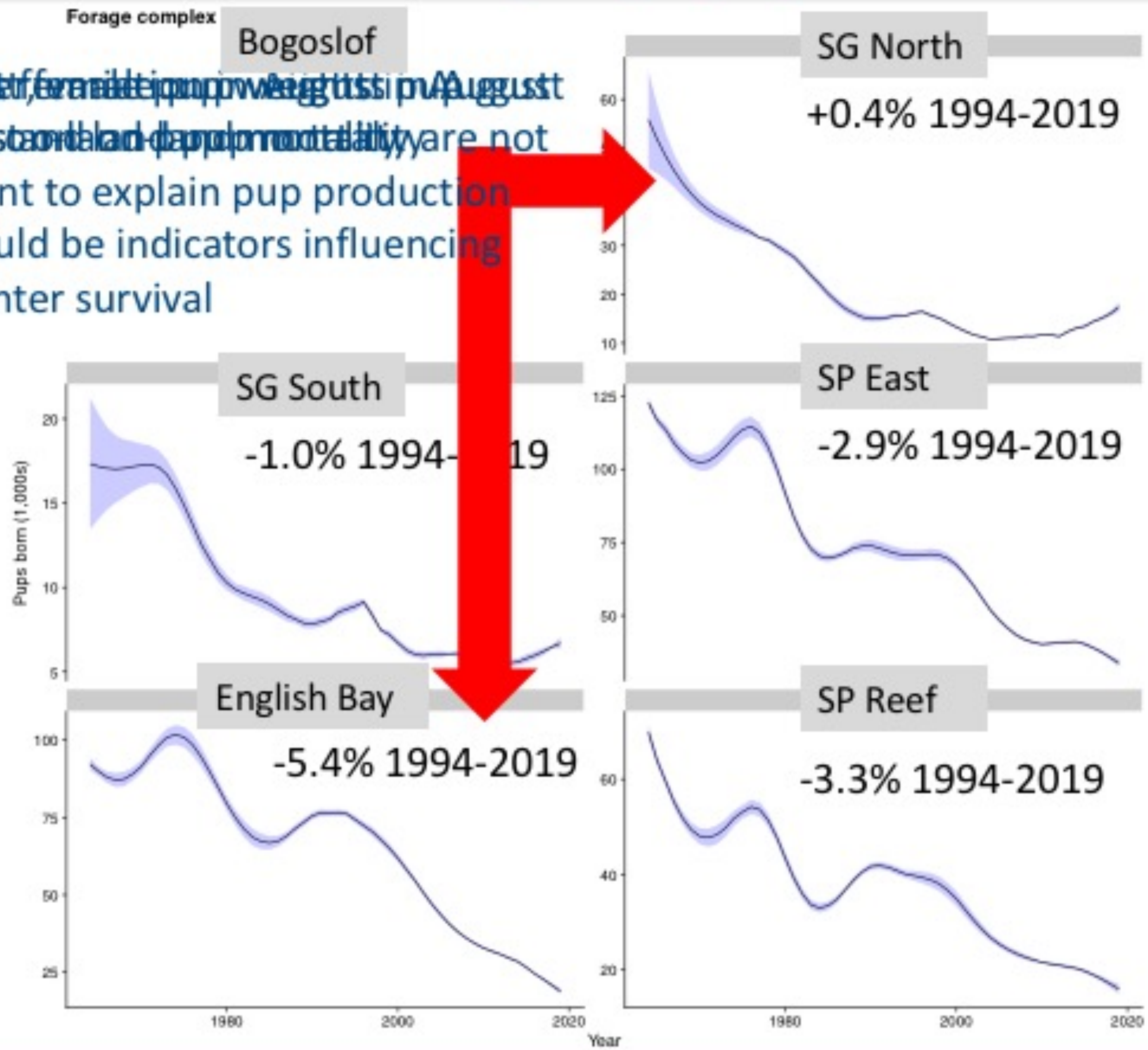
Zeppelin and Ream 2006 & McHuron et al. under AFSC review

Adult female foraging complexes

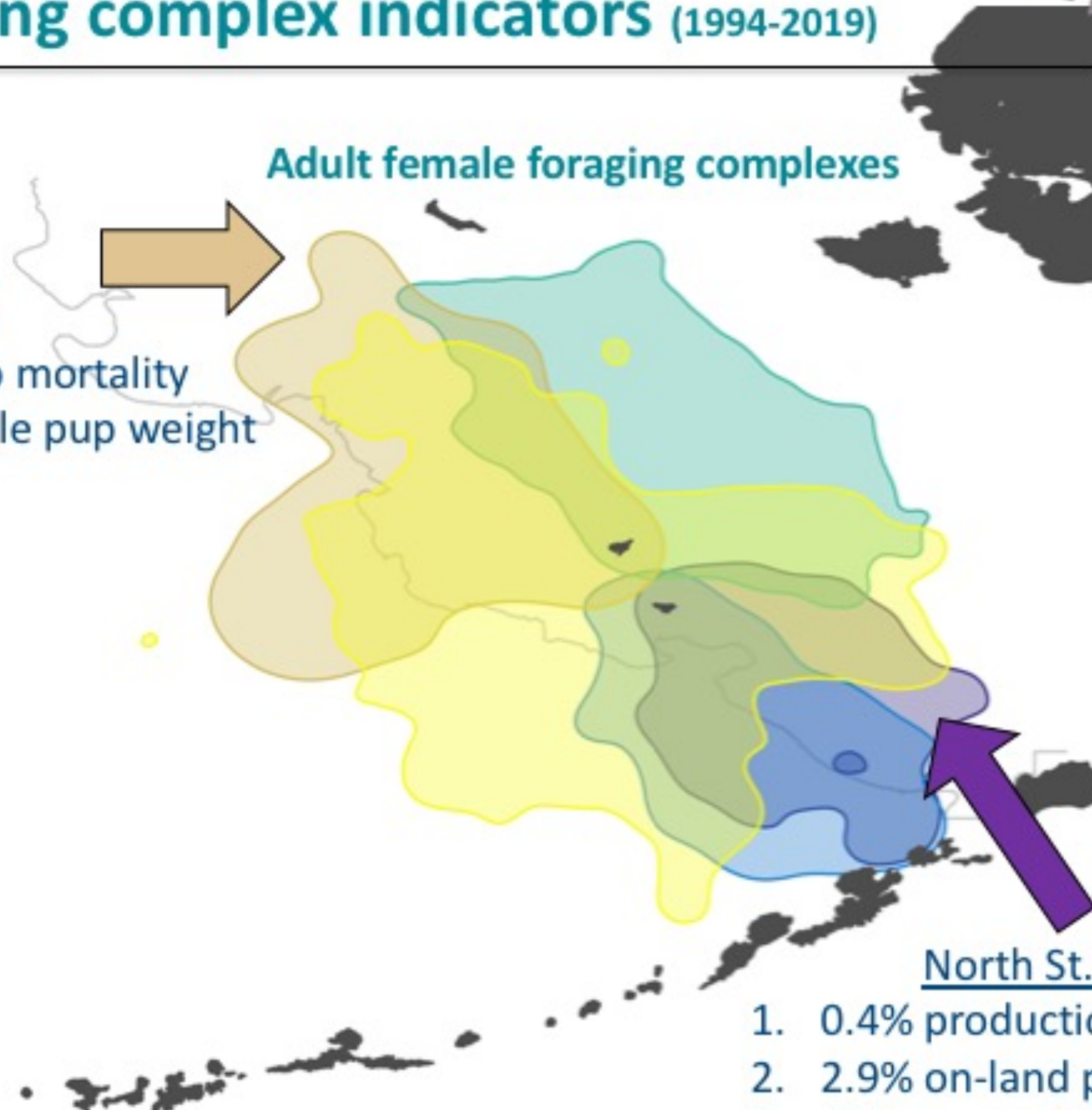


Northern fur seal complex pup production

1. [illegible]
2. [illegible] are not sufficient to explain pup production
2. But, could be indicators influencing overwinter survival



Contrasting complex indicators (1994-2019)



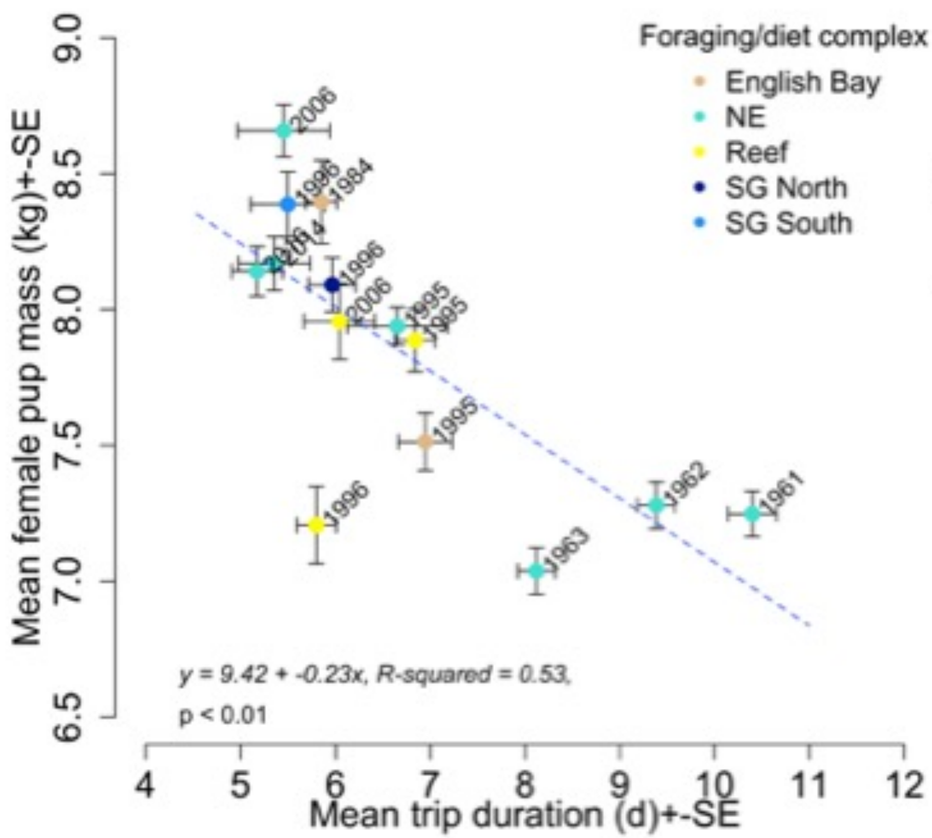
English Bay, St. Paul
1. -5.4% production
2. 4.5% on-land pup mortality
3. 7.9kg mean female pup weight

North St. George
1. 0.4% production
2. 2.9% on-land pup mortality
3. 8.5kg mean female pup weight

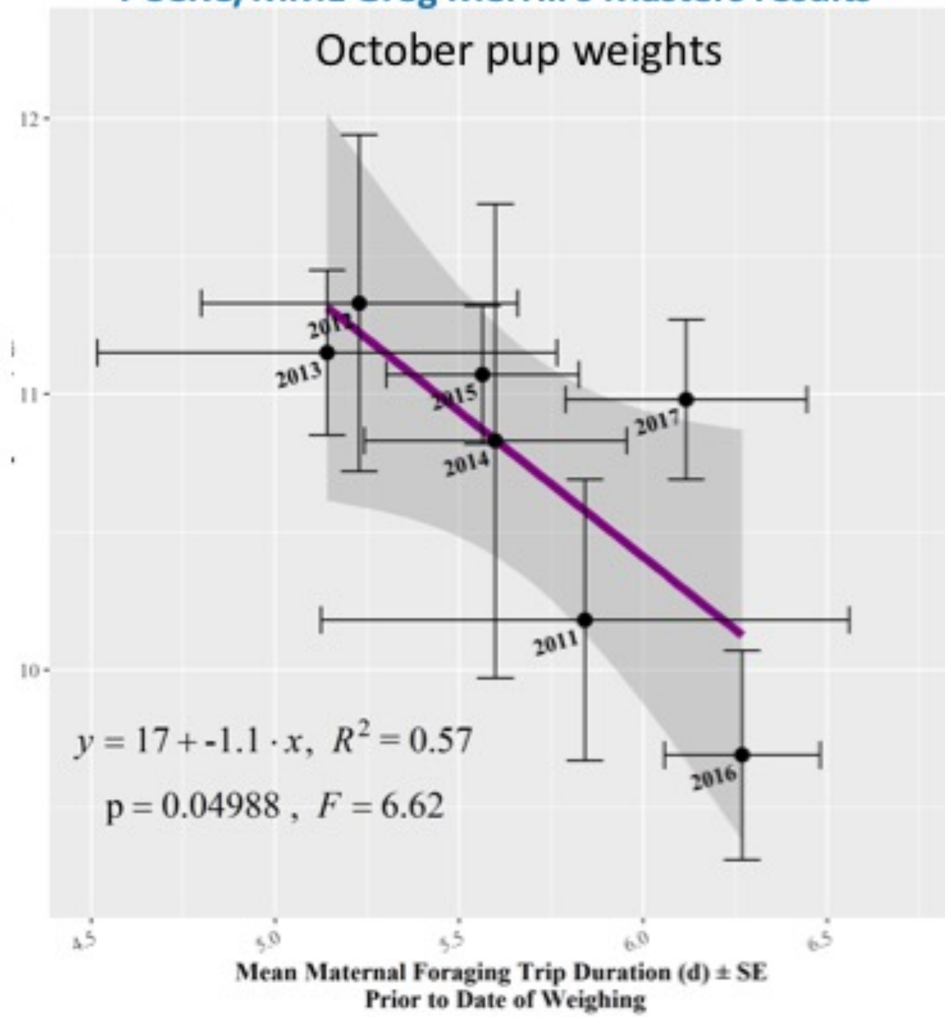
Cross sectional observations of adult female trip duration and pup weights

MML long term monitoring observations

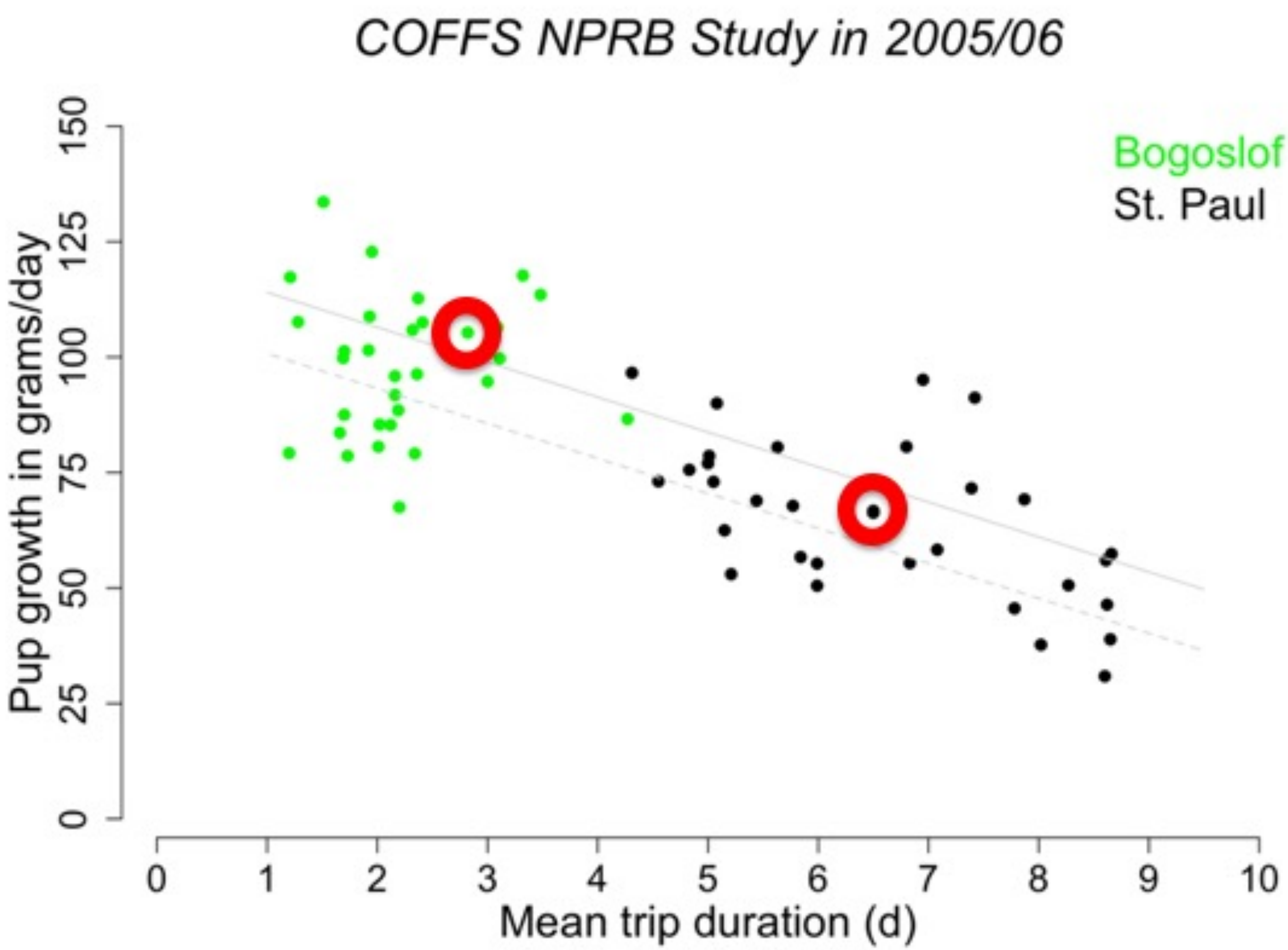
August 24 female pup weights



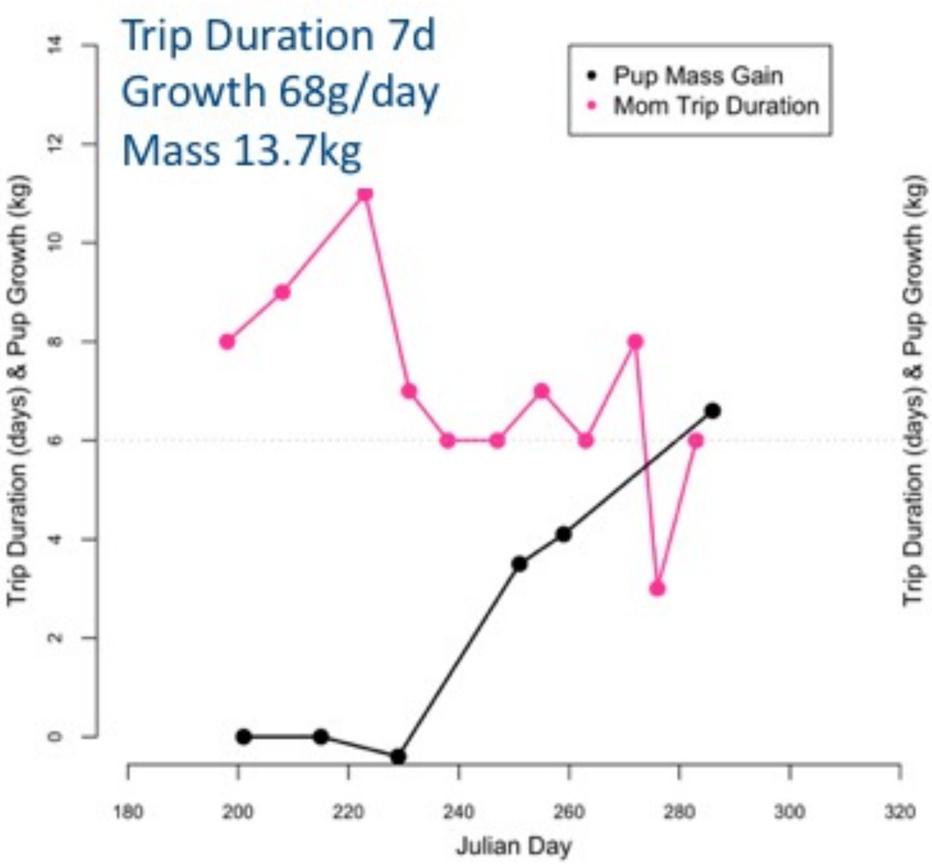
PCCRC/MML Greg Merrill's Masters results

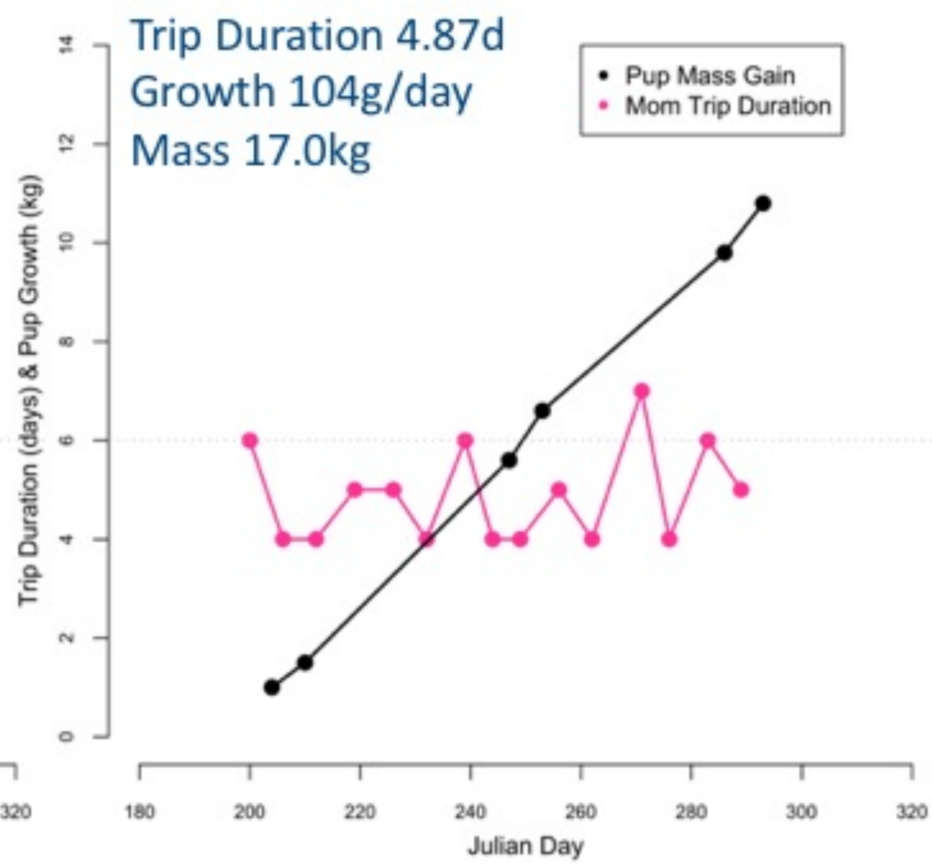


Longitudinal observations of trip duration and pup growth



Fine scale observations of female trip durations and pup growth





Unmanned surface vehicles map prey landscapes to elucidate northern fur seal behavioral responses to prey availability

Carey Kuhn (Carey.Kuhn@noaa.gov)

J. Sterling, A. De Robertis, M. Levine, C. Mordy, H. Tabisola, N. Lawrence-Slavas, C. Meinig, R. Jenkins

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Innovative Technology for Arctic Exploration

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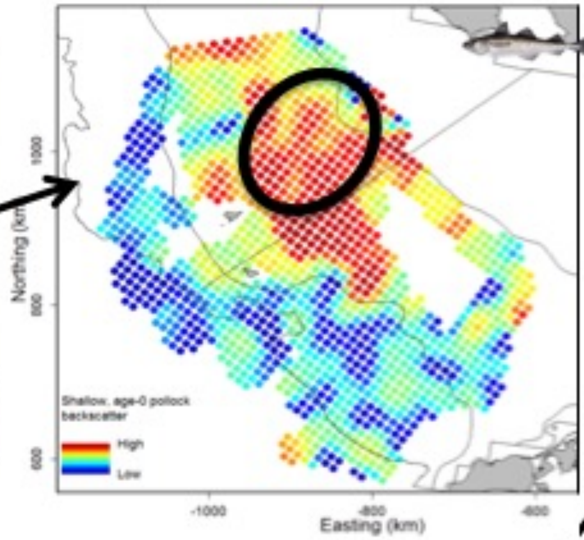
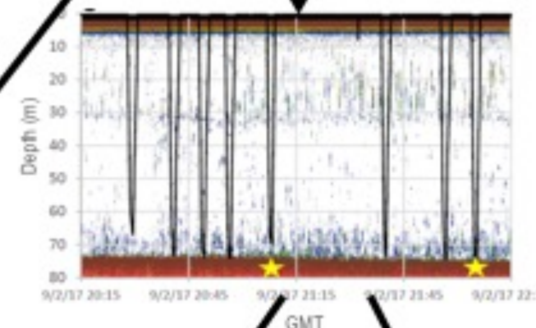
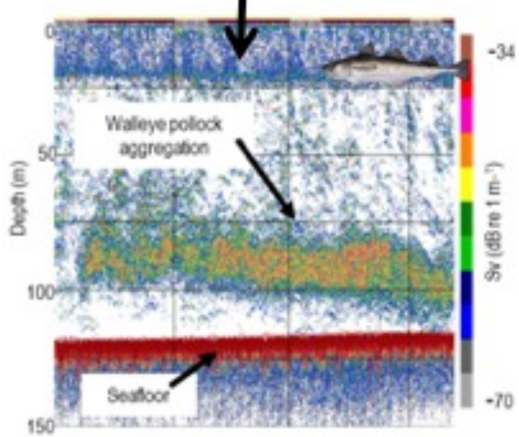
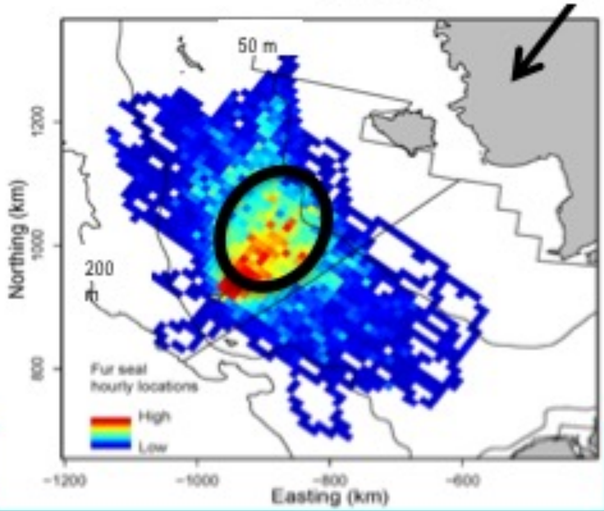
Northern fur seal Conservation Plan

Improve knowledge of the numerical and functional relationships between fur seals, fisheries, and fish resources



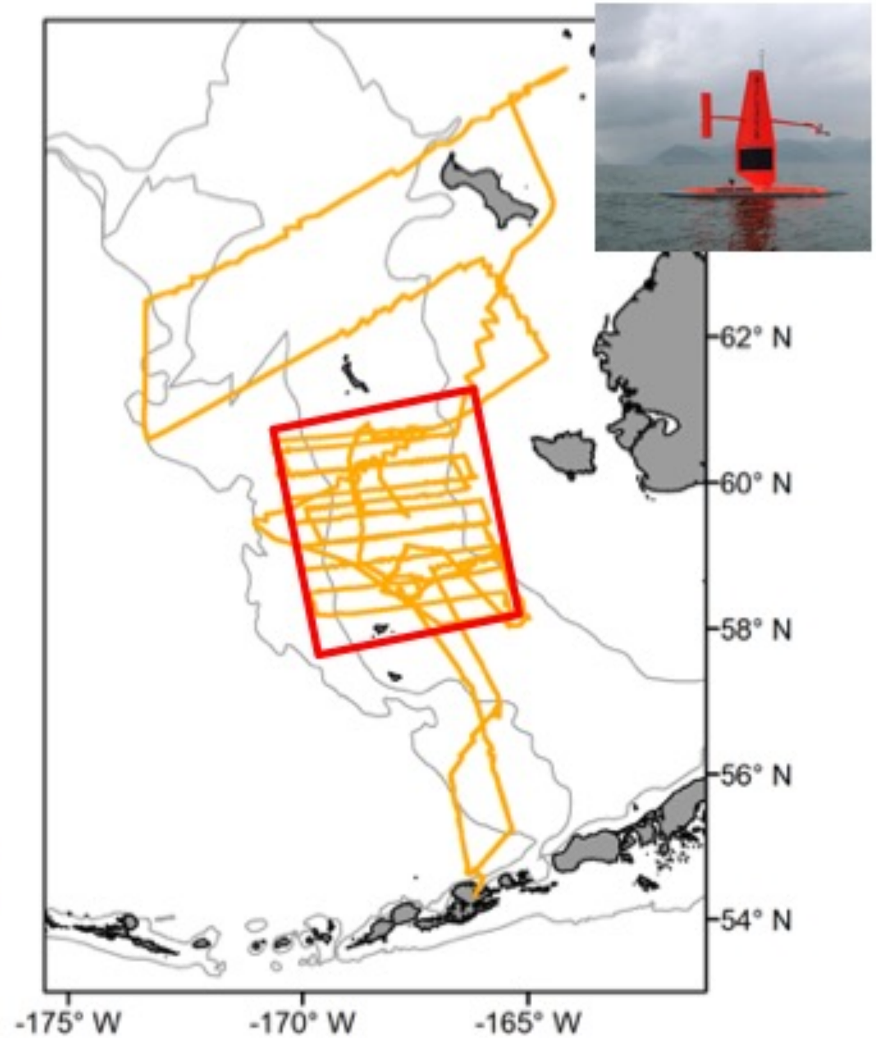






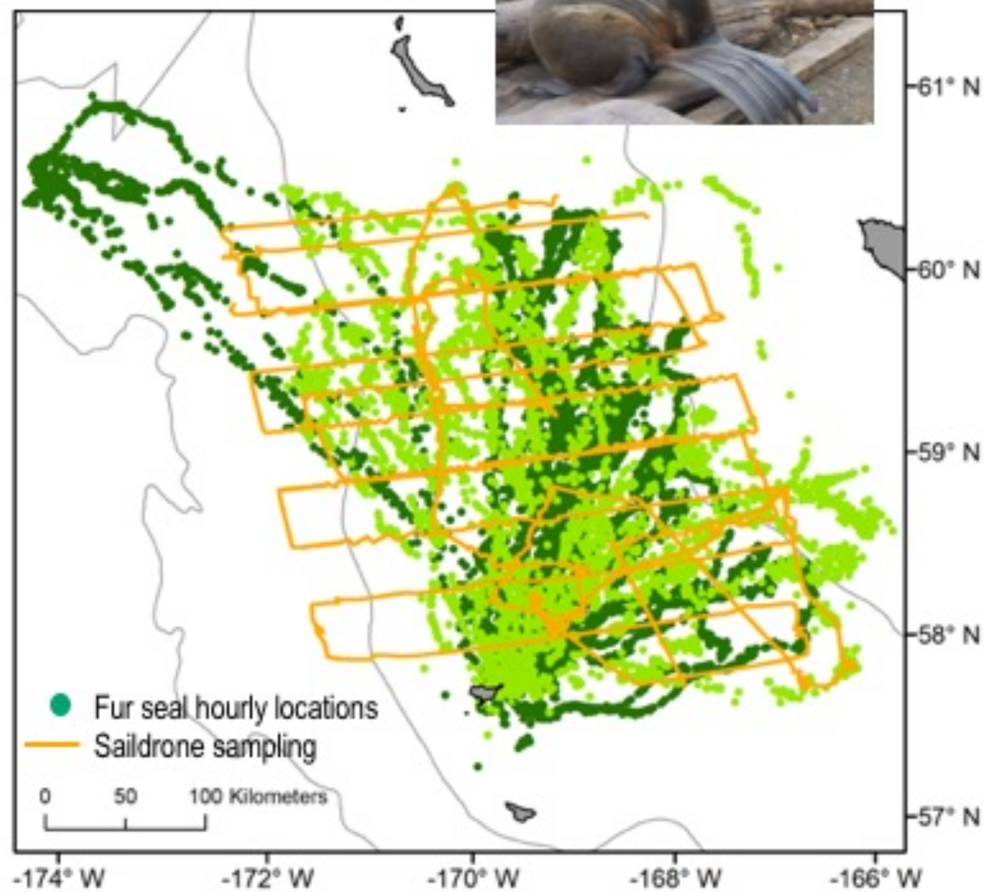
2019 Research

- Continuation of Saildrone project
    - 2016- 2 Saildrones (May-Sept)
    - 2017- 1 Saildrone (July-Sept)
- 1 Saildrone
- 16 May to 10 Oct, 6,900+ km
- 95 days in core fur seal area
- 1 full survey, 6 focal follows, & 1 partial survey



2019 Research

- 10 adult females tracked (13 Aug-23 Sept)
- 4 instrumented with accelerometers, 3 with video cameras
- Video recorded on 900+ dives (2.5 to 5 d)
- Foraging trips 8.0 ± 0.2 d



Focal follow study

- Tested feasibility of using Saildrone to conduct r
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Inter-Research > > Prepress Abstract

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Marine Ecology Progress Series

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MEPS prepress abstract - DOI: https://doi.org/10.3354/meps13224

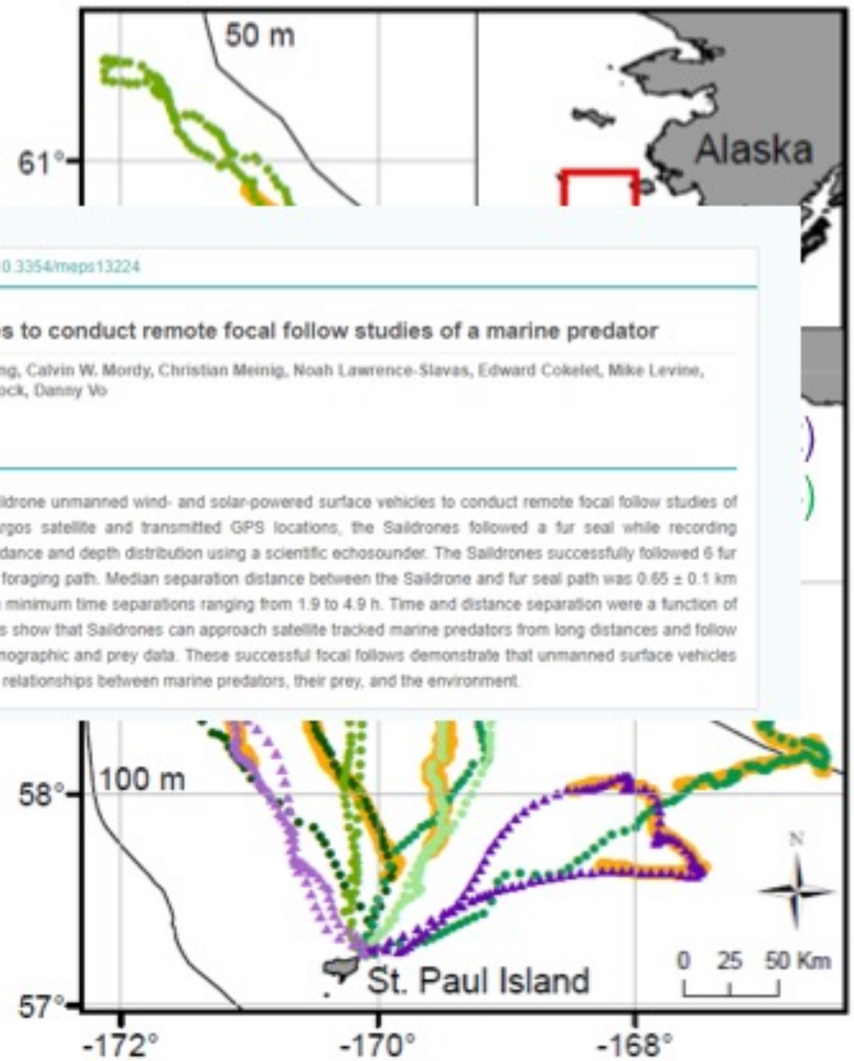
Test of unmanned surface vehicles to conduct remote focal follow studies of a marine predator

Carey E. Kuhn, Alex De Robertis, Jeremy Sterling, Calvin W. Mordy, Christian Meinig, Noah Lawrence-Slavas, Edward Cokelet, Mike Levine, Heather Tabisola, Richard Jenkins, David Peacock, Danny Vo

*Corresponding author:

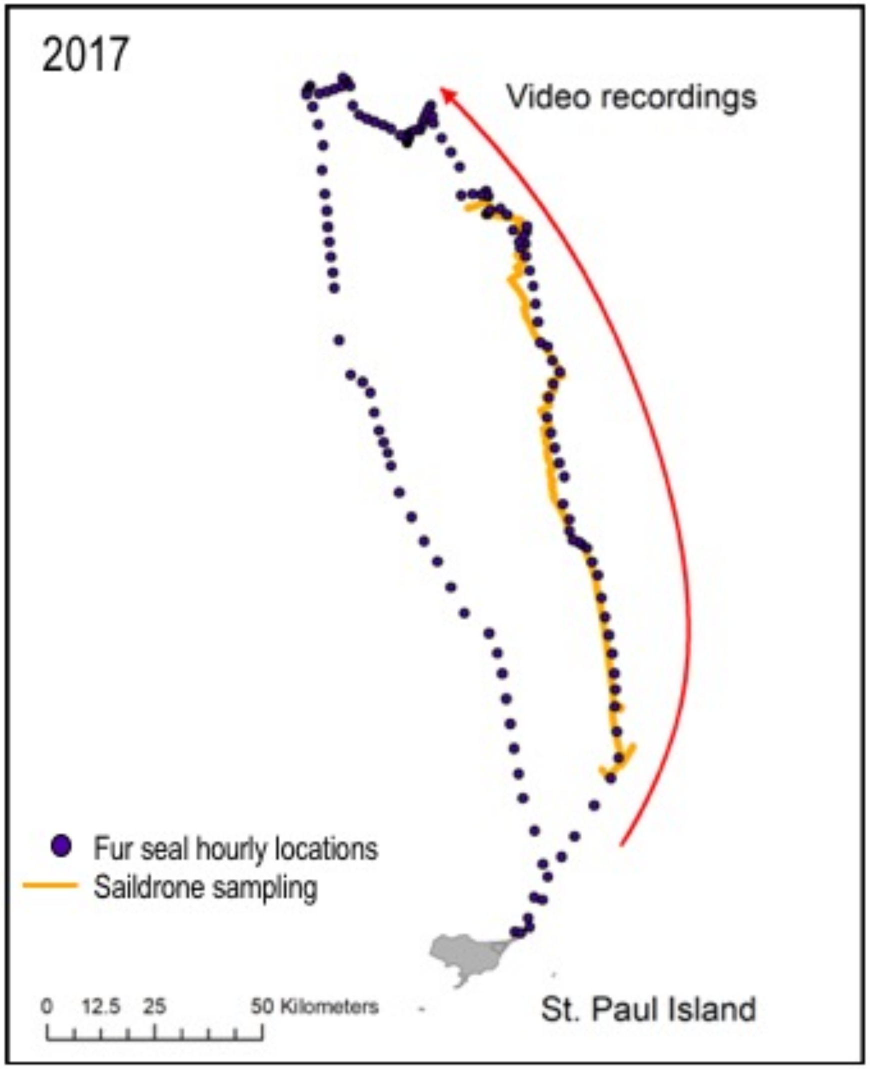
ABSTRACT: We tested the feasibility of using Saildrone unmanned wind- and solar-powered surface vehicles to conduct remote focal follow studies of northern fur seals *Callorhinus ursinus*. Using Argos satellite and transmitted GPS locations, the Saildrones followed a fur seal while recording oceanographic conditions and mapping prey abundance and depth distribution using a scientific echosounder. The Saildrones successfully followed 6 fur seals over 2.4 ± 0.2 d and 149.7 ± 16.3 km of the foraging path. Median separation distance between the Saildrone and fur seal path was 0.65 ± 0.1 km and average time separation was 9.9 ± 1.4 h, with minimum time separations ranging from 1.9 to 4.9 h. Time and distance separation were a function of both animal behavior and study design. Our results show that Saildrones can approach satellite tracked marine predators from long distances and follow them over extended periods while collecting oceanographic and prey data. These successful focal follows demonstrate that unmanned surface vehicles are a valuable tool for collecting data on fine-scale relationships between marine predators, their prey, and the environment.

- 6 focal follows in 2019



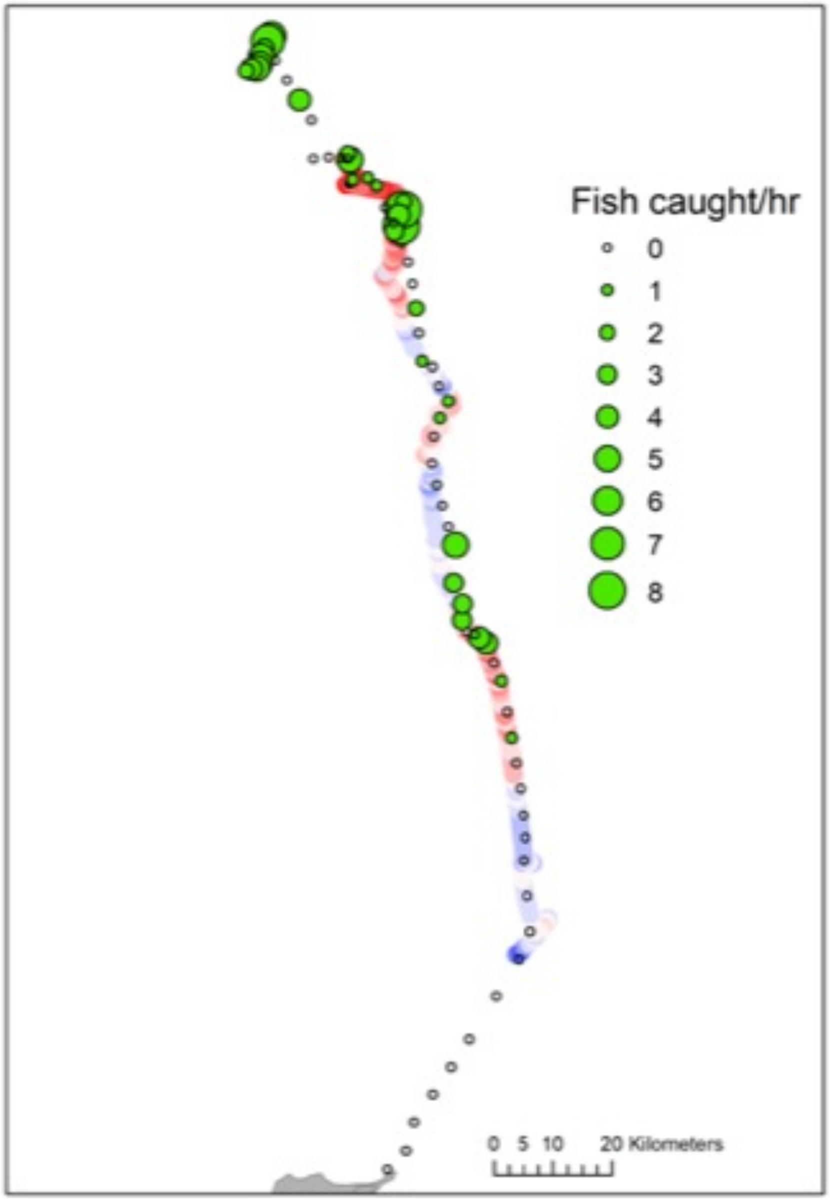
Preliminary video results

- Prey capture results from single fur seal (video 2.5+ d)
- 259 dives with recorded video
  - 73% of dives in recording period
  - 44.5% of all dives in the foraging trip

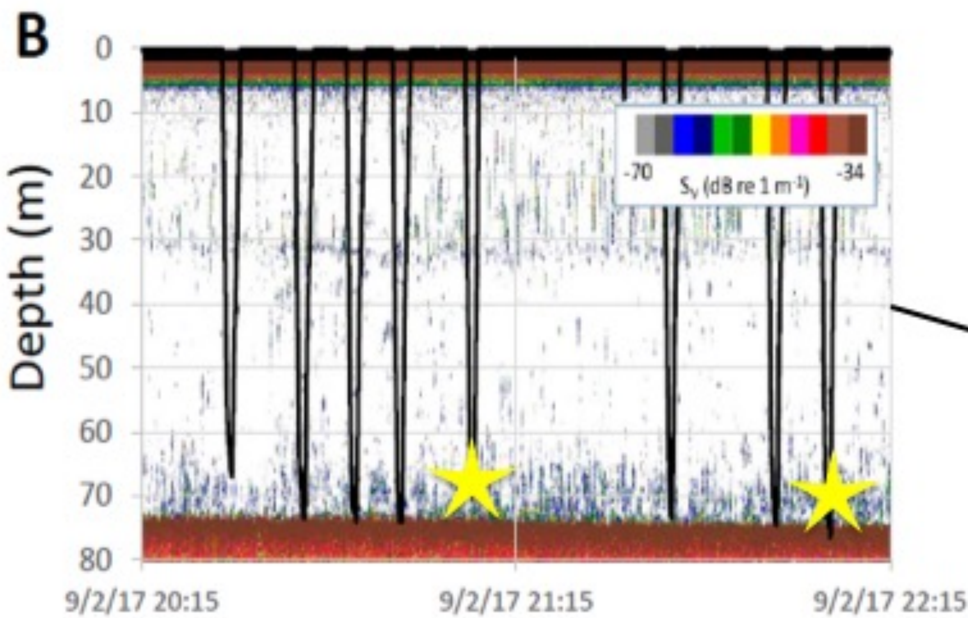


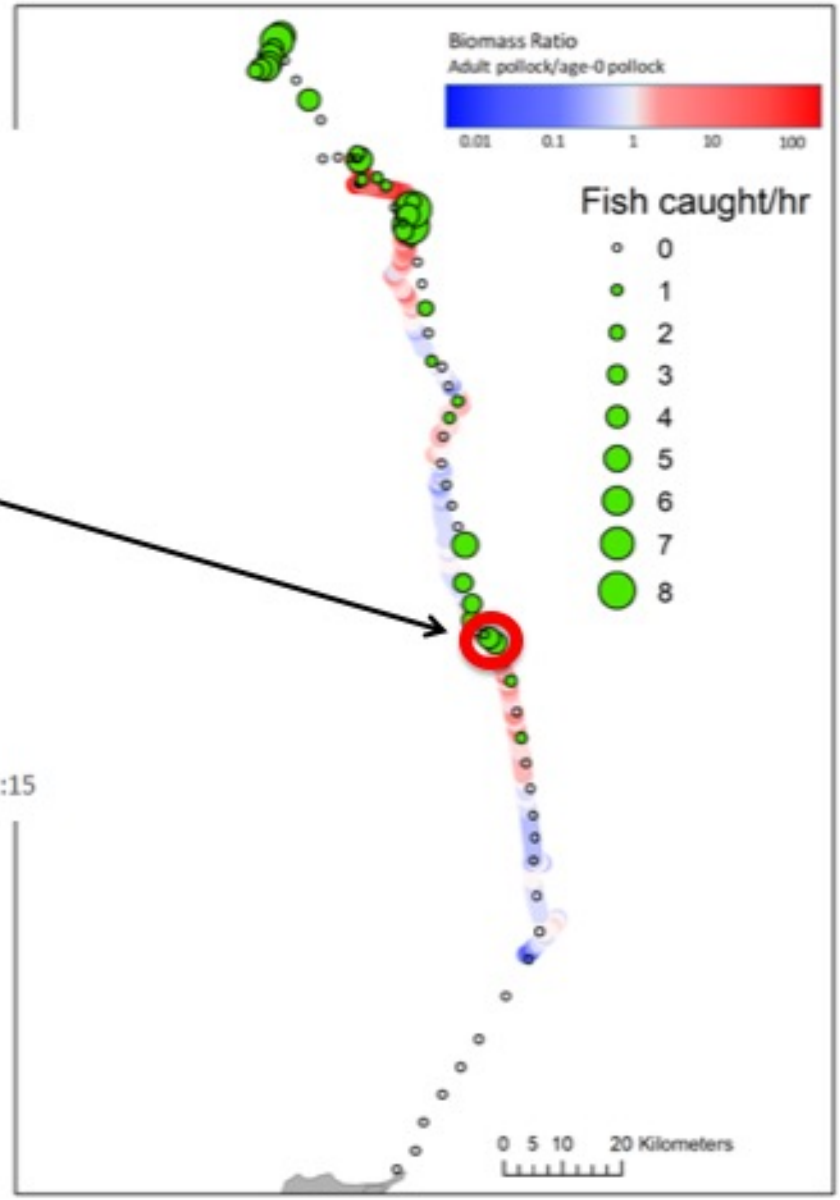
Preliminary video results

- Prey capture results from single fur seal (video 2.5+ d)
- 259 dives with recorded video
    - 73% of dives in recording period
    - 44.5% of all dives in the foraging trip
- 107 fish captured in 93 dives (0-3 fish/dive)
- 35.9% of recorded dives with prey capture



Preliminary video results





- 99% of fish captured classified as large

Large pollock capture

Small fish capture

Bogoslof Island foraging study

- Tracked 6 females (Aug-Dec)
- Preliminary analysis

Contrasting Trends in Northern Fur Seal Foraging Effort Between St. Paul and Bogoslof Islands: 2019 Preliminary Results

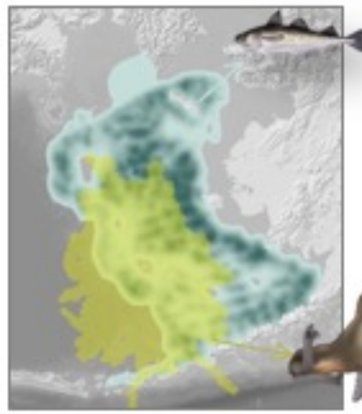
The Eastern Stock of northern fur seals (*Callorhinus ursinus*), which is comprised of three breeding islands (St. Paul [SP], St. George [SG], and Bogoslof [BG] islands), is listed as depleted under the Marine Mammal Protection Act. Since 1998, pup production on the Pribilof Islands (SP and SG) has declined by 51% or at an annual rate of 3.4% (Towell et al., 2019). In contrast, pup production on BG has increased at an annual rate of 10% since 1997 (Towell et al., 2019). While the ultimate cause(s)

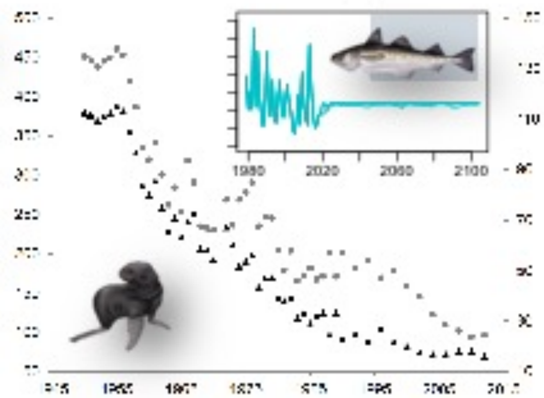
- trips from St. Paul Island (~ 8 d in 2019)

Ongoing steps…

- Preliminary 2019 echosounder data expected in Feb
- Complete analysis of 900+ videos collected in 2019, including investigating AI/Machine learning options
- Continued analysis and integration of datasets- fur seal behavior (dive, tracking, video, acceleration), fish abundance and depth distribution, and oceanographic data
- Exploring ways to integrate these data into the ongoing Lenfest project

Using bioenergetics and spatial data to quantify how northern fur seals interact with prey, fisheries, and climate





A collaboration between the **JOINT INSTITUTE FOR THE STUDY OF ATMOSPHERE AND OCEAN AT THE UNIVERSITY OF WASHINGTON** and the **RESOURCE ECOLOGY AND FISHERIES MANAGEMENT AND MARINE MAMMAL LABORATORY AT THE ALASKA FISHERIES SCIENCE CENTER** with support from **THE LENFEST OCEAN PROGRAM**

JISAO W NOAA FISHERIES LENFEST OCEAN PROGRAM

UW Contact: Ivonne Ortiz
Ivonne.Ortiz@noaa.gov

AFSC Contact: Jeremy Sterling
Jeremy.Sterling@noaa.gov

Lenfest Contact: Emily Knight
eknight@pewtrusts.org

The Team

Nick Bond
UW/JISAO
Variability in climate and atmospheric forcing

Kirstin Holsman
REEM/AFSC
Climate specific multispecies stock assessments
CEATTLE
ACLIM

Elizabeth McHuron
UW/JISAO
Marine mammal bioenergetics and population dynamics modeling

Ivonne Ortiz
UW/JISAO
Food-web, ecosystem and fisheries modeling
FEAST

Kerim Aydin
Program Manager for REEM
Food-web, ecosystem and fisheries modeling, EBFM, FEAST

Jeremy Sterling
MML/AFSC
Fur seal ecology

Contribution of energetics manuscript

Conservation Physiology https://doi.org/10.1093/conphys/coz103

- Retrospective analysis of metabolic rates collected on lactating females in 1995 and 1996
- Primary findings
  - At-sea metabolic rates increased from summer to fall by ~7.2%
  - At-sea metabolic rates not related to mass gain, dietary variation, or diving behavior
- Conclusions
  - May have reached a metabolic ceiling by early in the population decline
  - Limited physiological flexibility to respond to environmental change
  - High metabolic overhead of lactating females likely reduces energy available for lactation
- Key inputs into bioenergetic model

Bioenergetic model data streams

Physiology and morphology

- Metabolic rates
- Milk intake
- Mass and mass changes
- Molt timing
- Metabolic efficiency

→ Energy intake

Behavior

- Trip and shore durations
- Arrival and departure times

→ Energy intake

Demographics

- Pup counts
- Survival and reproductive rates

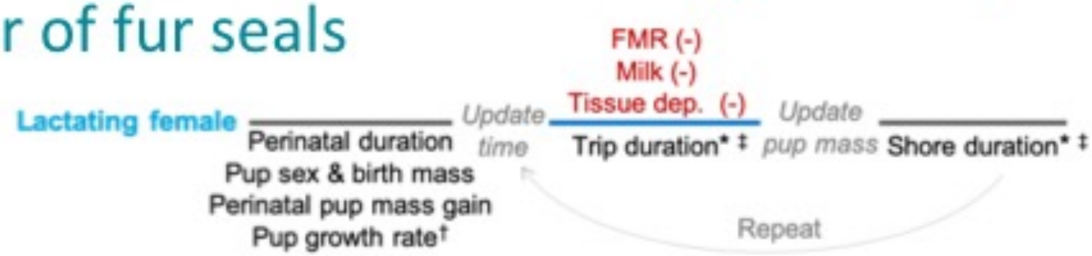
→ Distribution
Population size

Diet

→ Prey consumption

General Approach

- Five groups based on size and energetic demands
    1. Lactating females
    2. Non-lactating females
    3. Adult males
    4. Subadult males
    5. Juveniles
- Individual-based simulations designed to capture natural behavior of fur seals

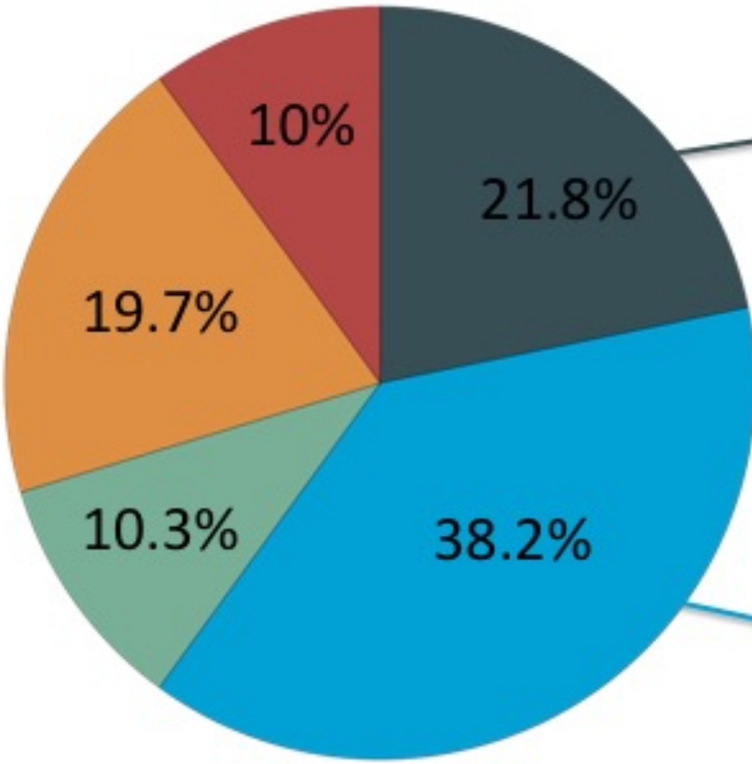


- Summed by year and rookery complex and combined with diet estimates from a biomass reconstruction model

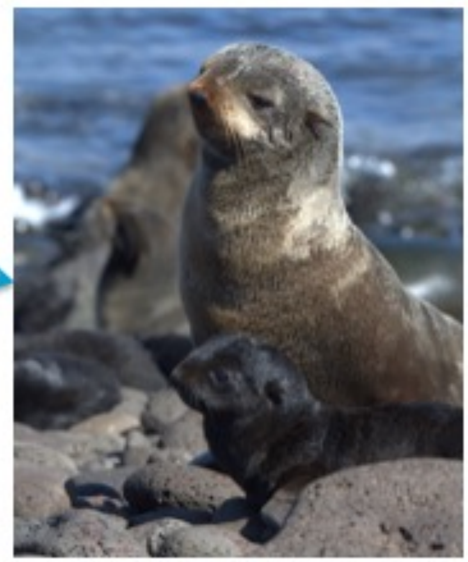
Incorporating uncertainty

- Population size drawn from 11 different models
  1. Life history tables
  2. Pup and adult survival rates
  3. Overall approach
- Parameter values largely drawn from distributions to account for individual, temporal, and spatial variation within the population
  1. Arrival and departure times
  2. Trip and shore durations
  3. Lactation duration and pup growth rates
  4. Mass and mass changes
  5. Etc
- Bootstrap resampling to estimate variation around point estimates of diet

Who's contributing the most?

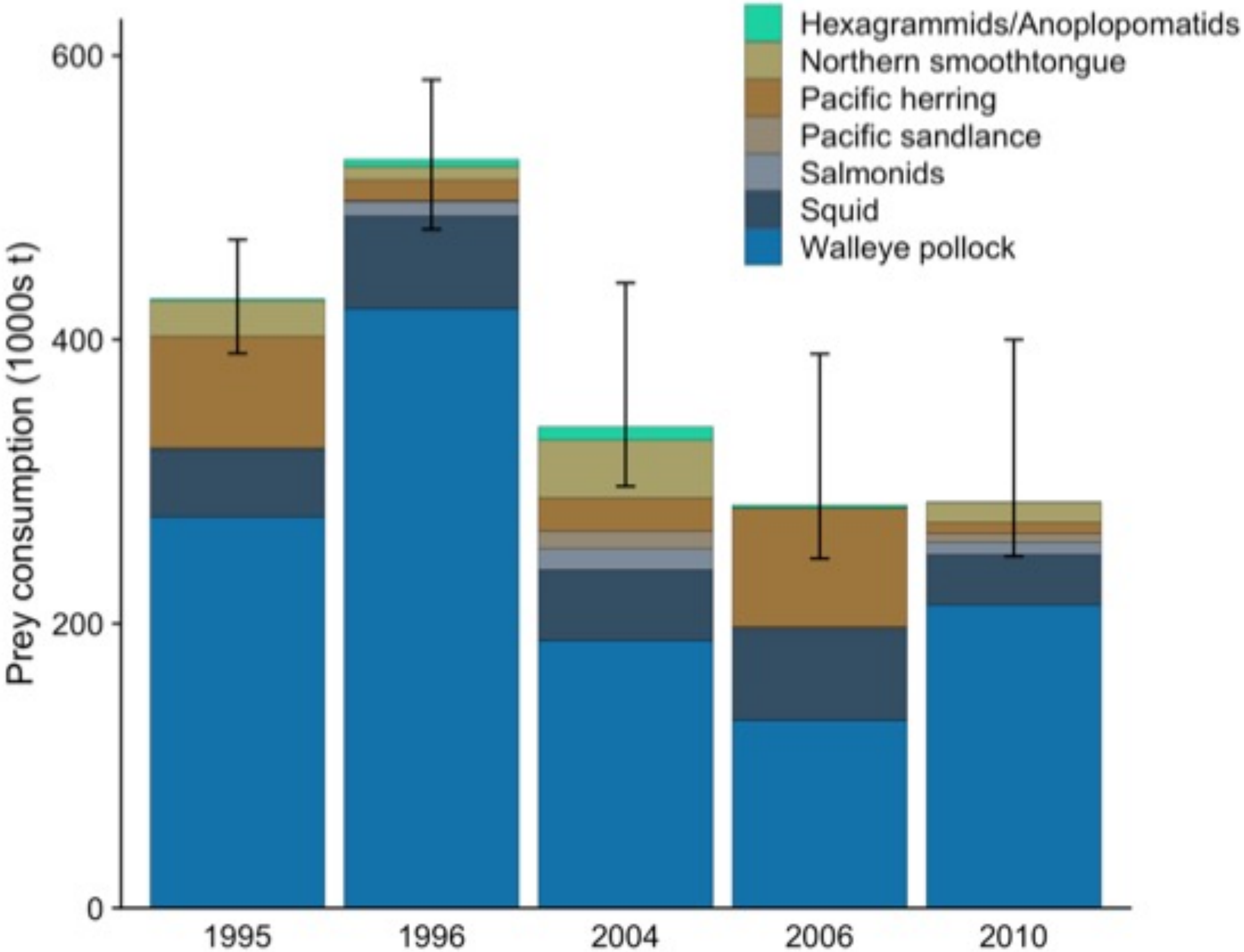


- 9.8%
- Body size
- Tenure

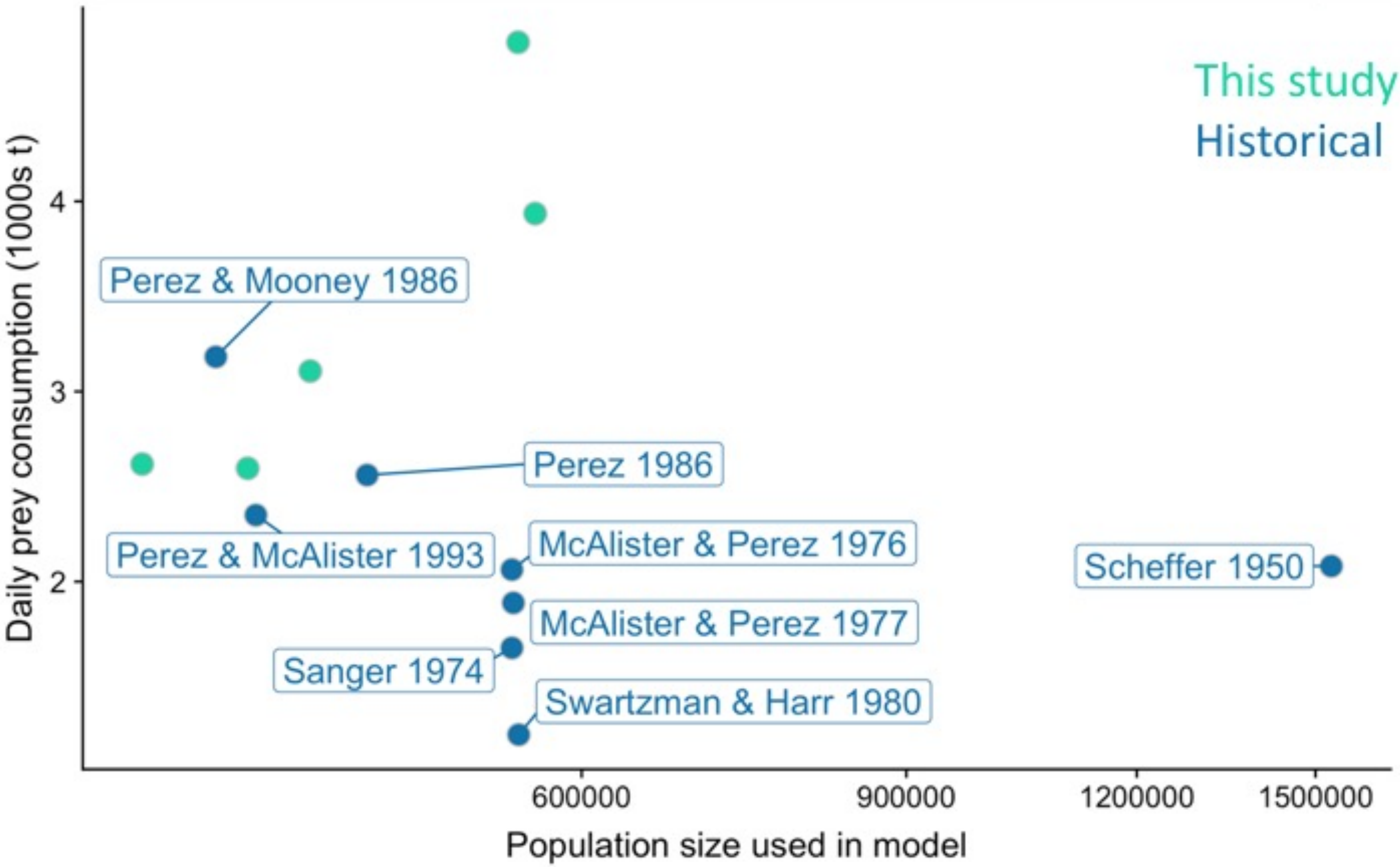


- 33.8%
- Cost of lactation

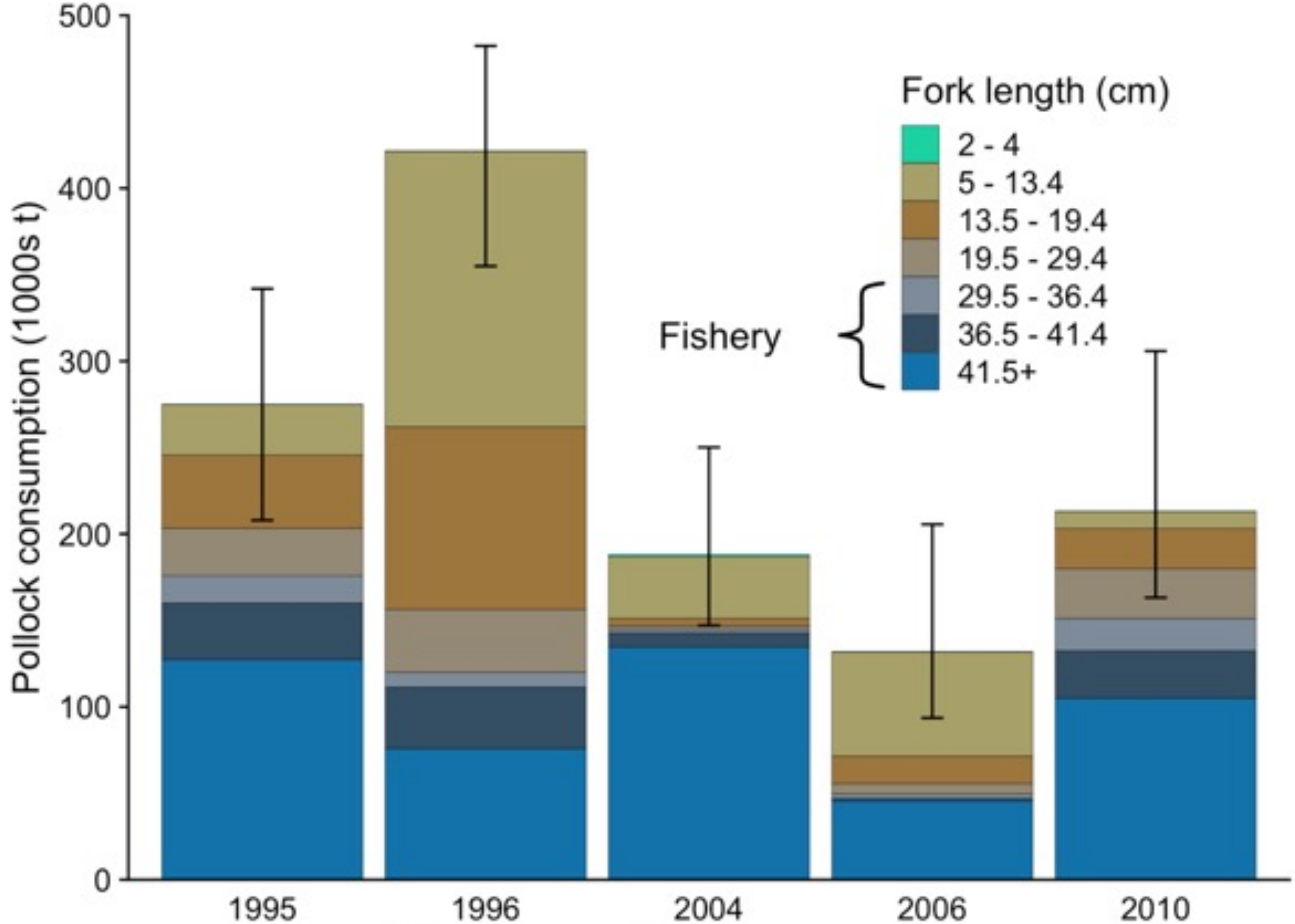
How much prey did fur seals consume?



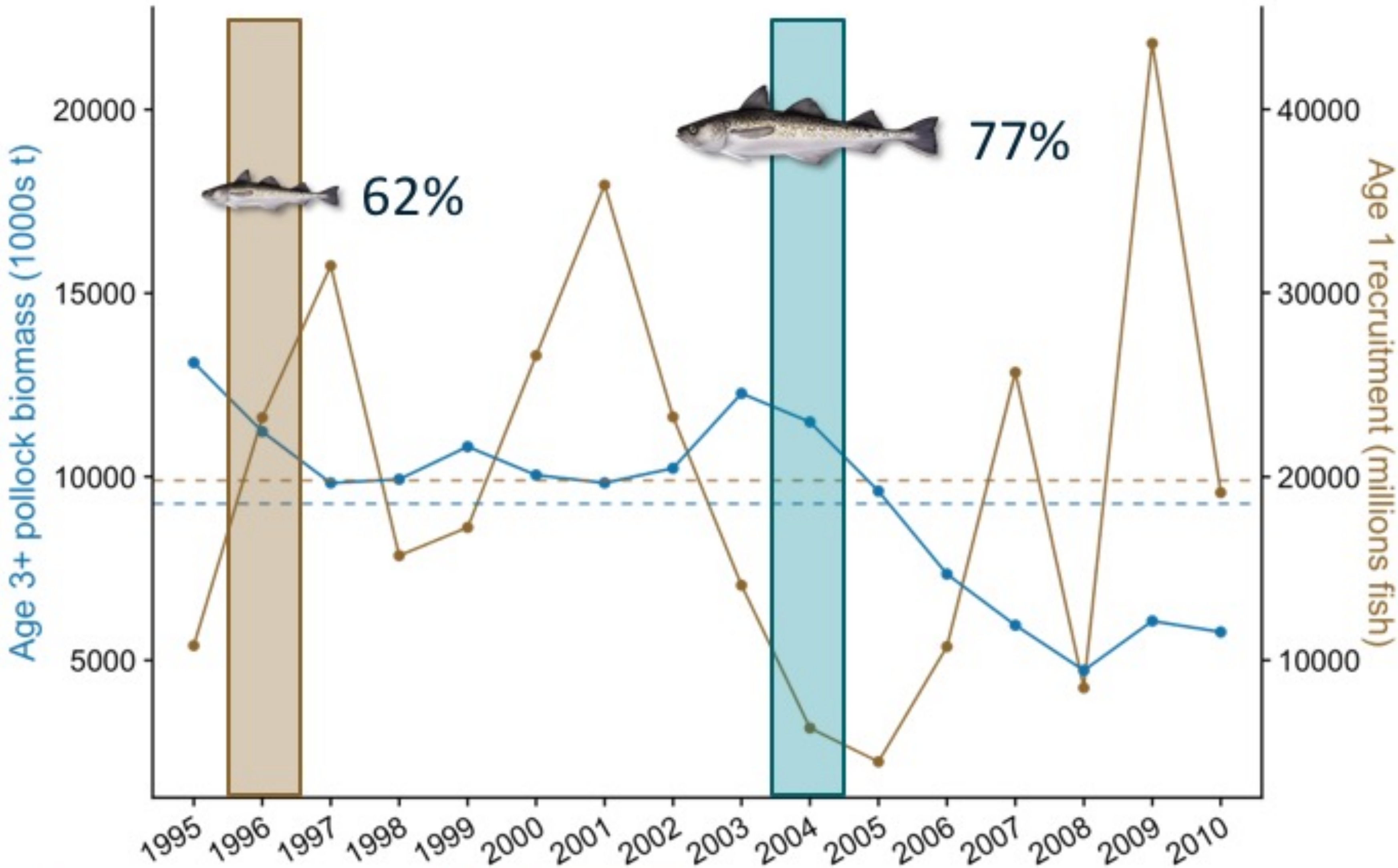
How do our consumption estimates compare with past efforts?



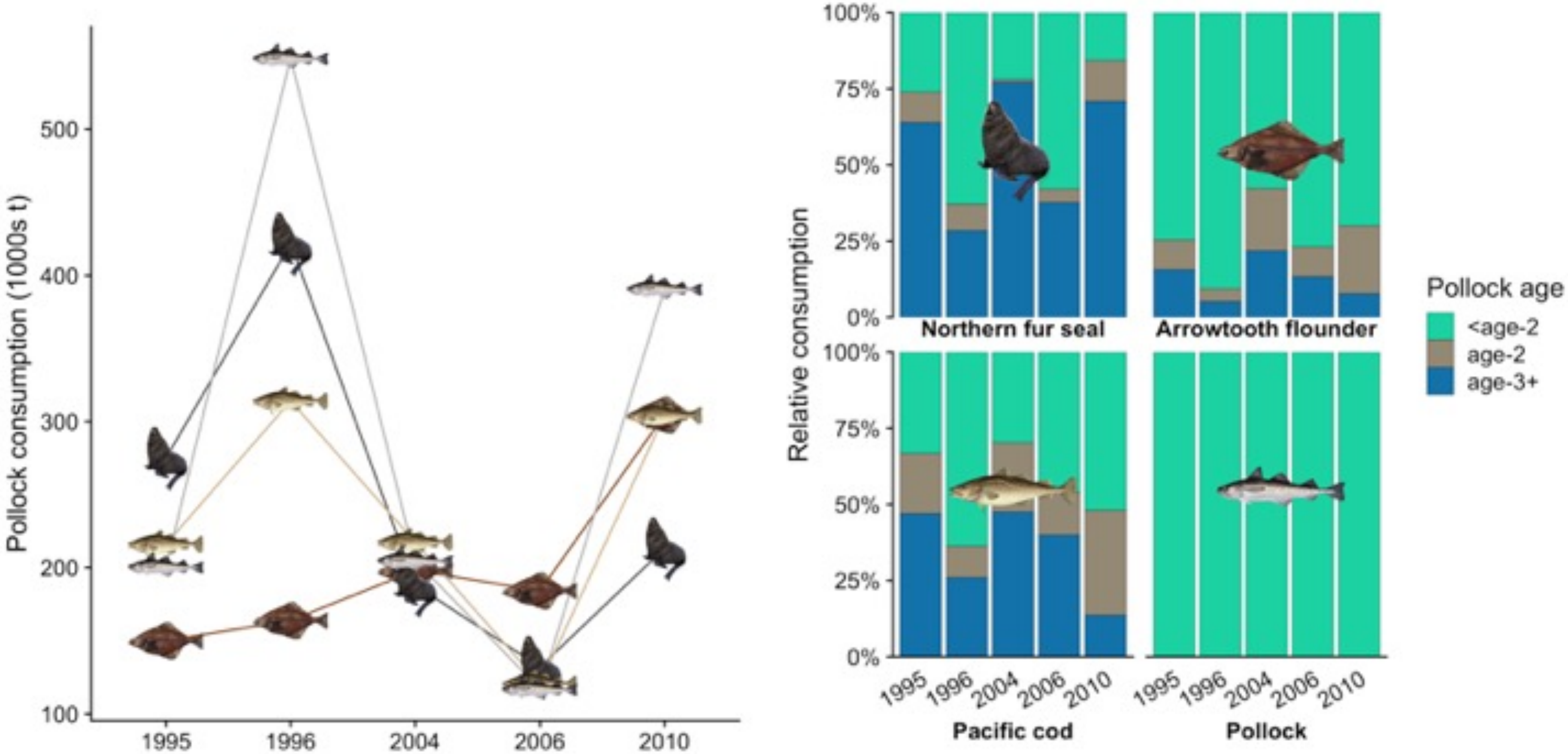
What is the size-specific consumption of pollock?



Does consumption reflect availability?



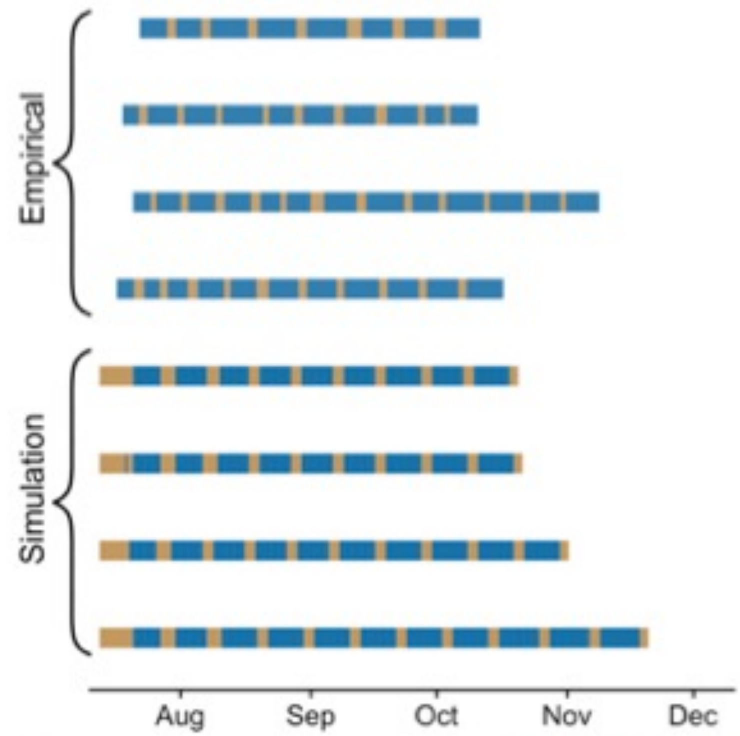
How do fur seals compare to other pollock predators?

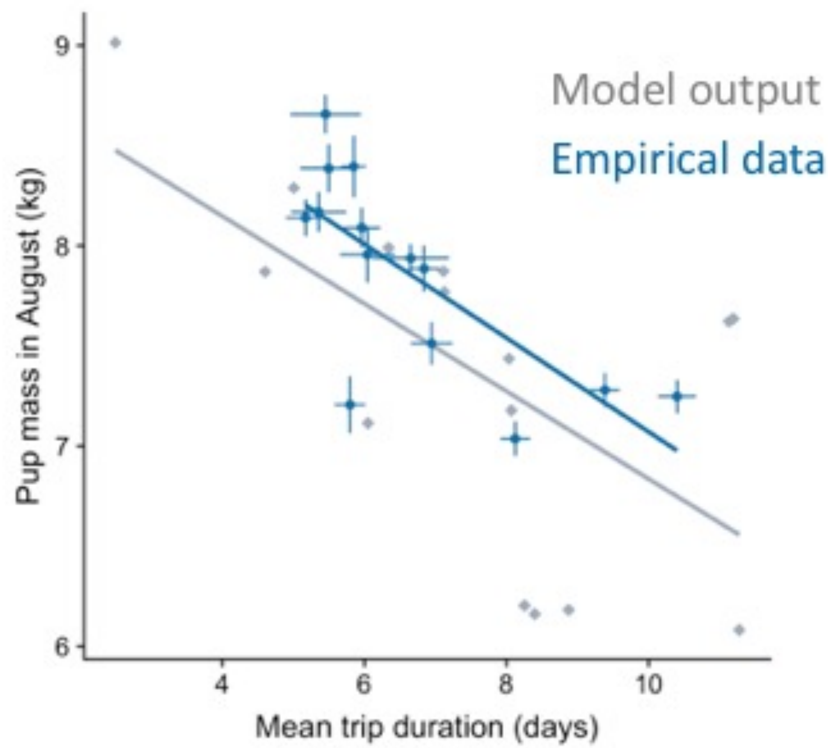


Lenfest ongoing steps….

Dr. Liz McHuron – Fur seal behavioral model

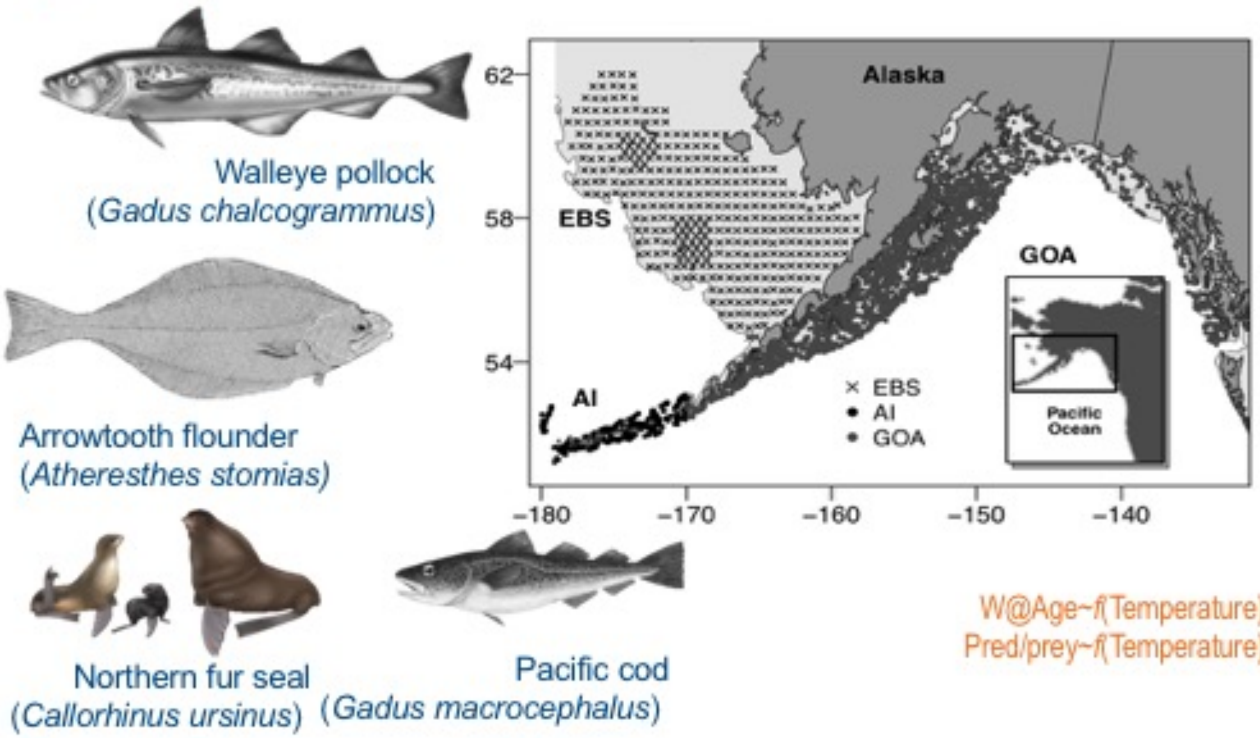
1. Develop a behavioral model to predict the foraging behavior of lactating female fur seals
2. Working version that involves a simplified environment
3. Next step is to use FEAST to characterize environment





Lenfest ongoing steps….
Dr. Kirstin Holsman – CEATTLE multi-species

1. 5 high resolution years used to couple NFS bioenergetic model to CEATTLE (analyses underway)
2. New diet analyses will add 8 more years of fur seal consumption estimates (February 2020)



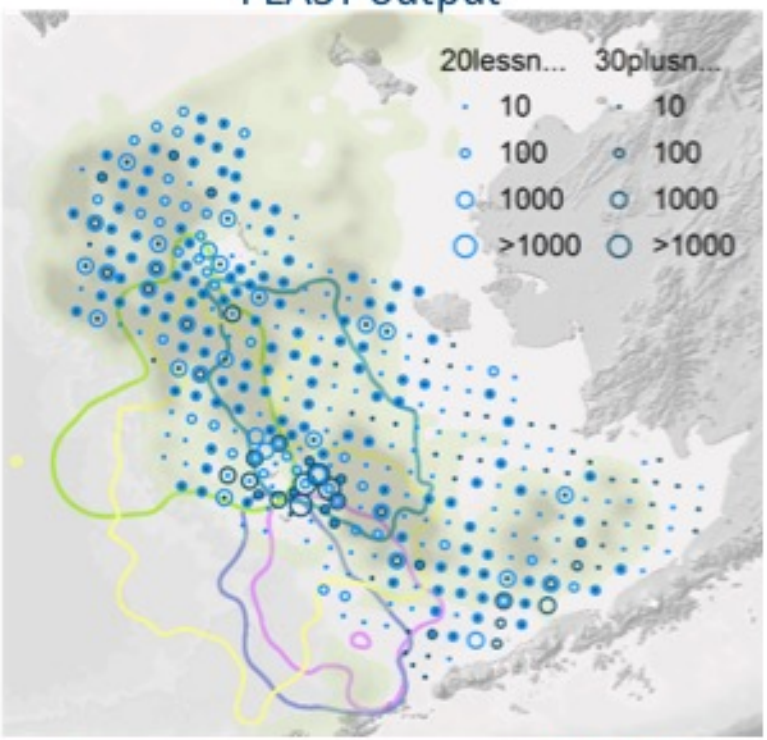
Climate-Enhanced, Age-based model with Temperature-specific Trophic Linkages and Energetics

Lenfest ongoing steps…

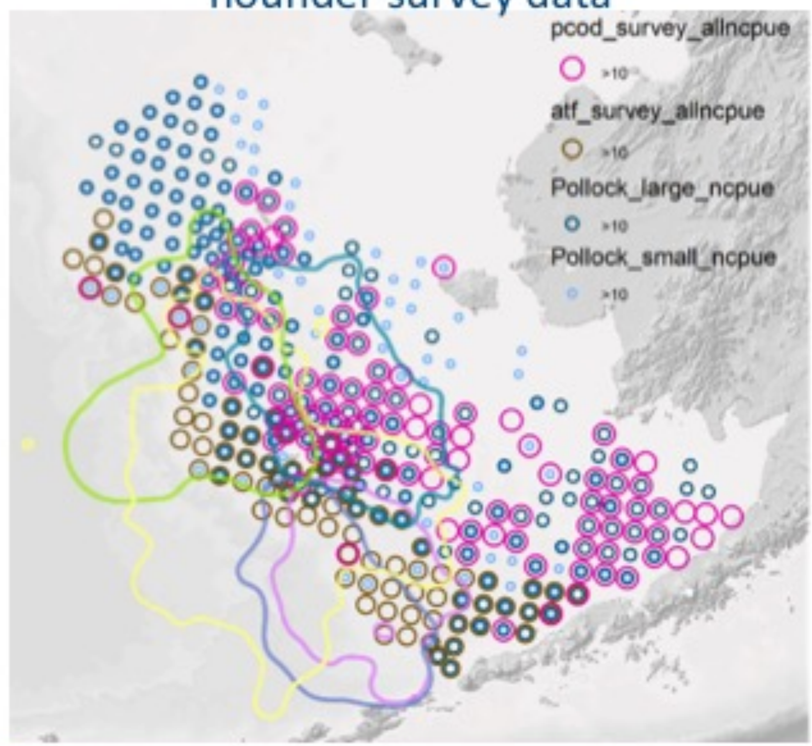
Dr. Ivonne Ortiz, Dr. Nick Bond

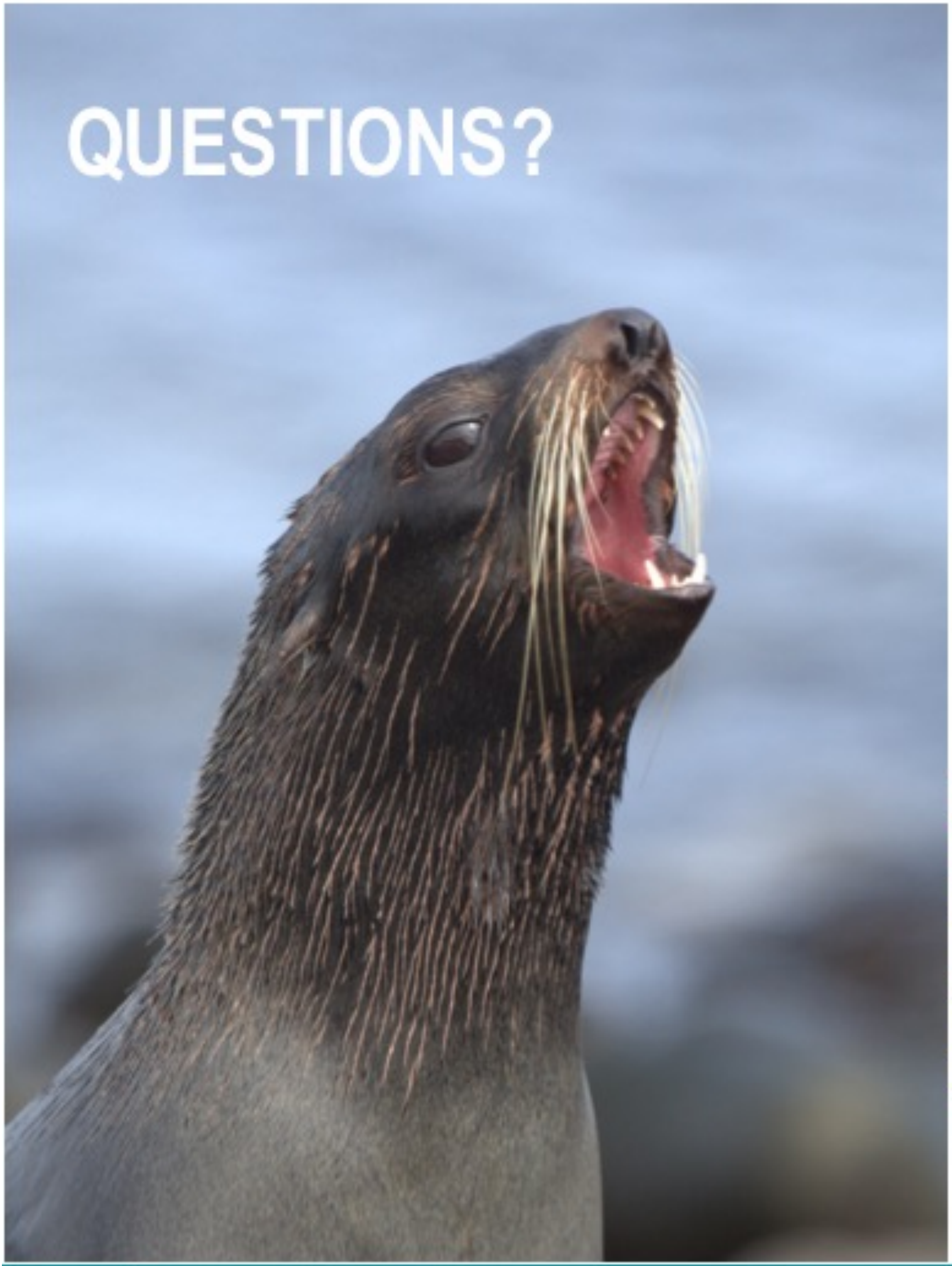
1. Survey Observations (analyses underway)
2. FEAST (planned spring 2020)
3. Fishing in each complex (planned summer 2020)
4. Biophysical processes explaining key fur seal summer indices

1996 pollock survey data & FEAST output



1996 pollock, cod and arrowtooth flounder survey data





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More information at:

https://www.afsc.noaa.gov/Science_blog/FurSeals_2016_main.htm

https://www.pmel.noaa.gov/itae/follow-saildrone-2017

https://www.lenfestocean.org/en/research-projects/quantifying-relationships-of-northern-fur-seals-pollock-and-climate-change-in-alaska

https://www.fisheries.noaa.gov/feature-story/partnerships-alaska-models-explore-decline-bering-sea-fur-seals