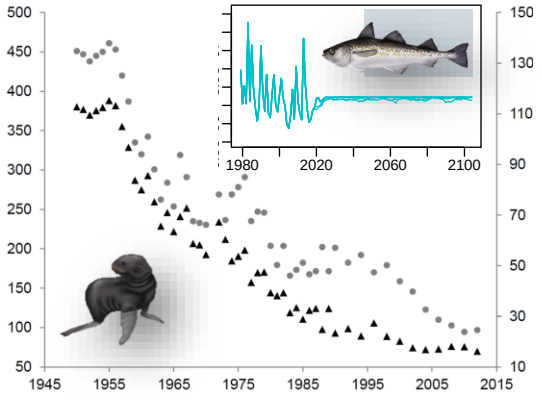
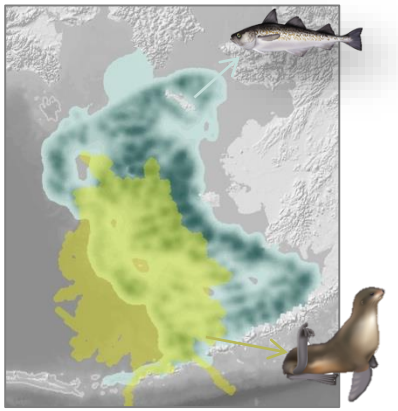
Northern fur seal update

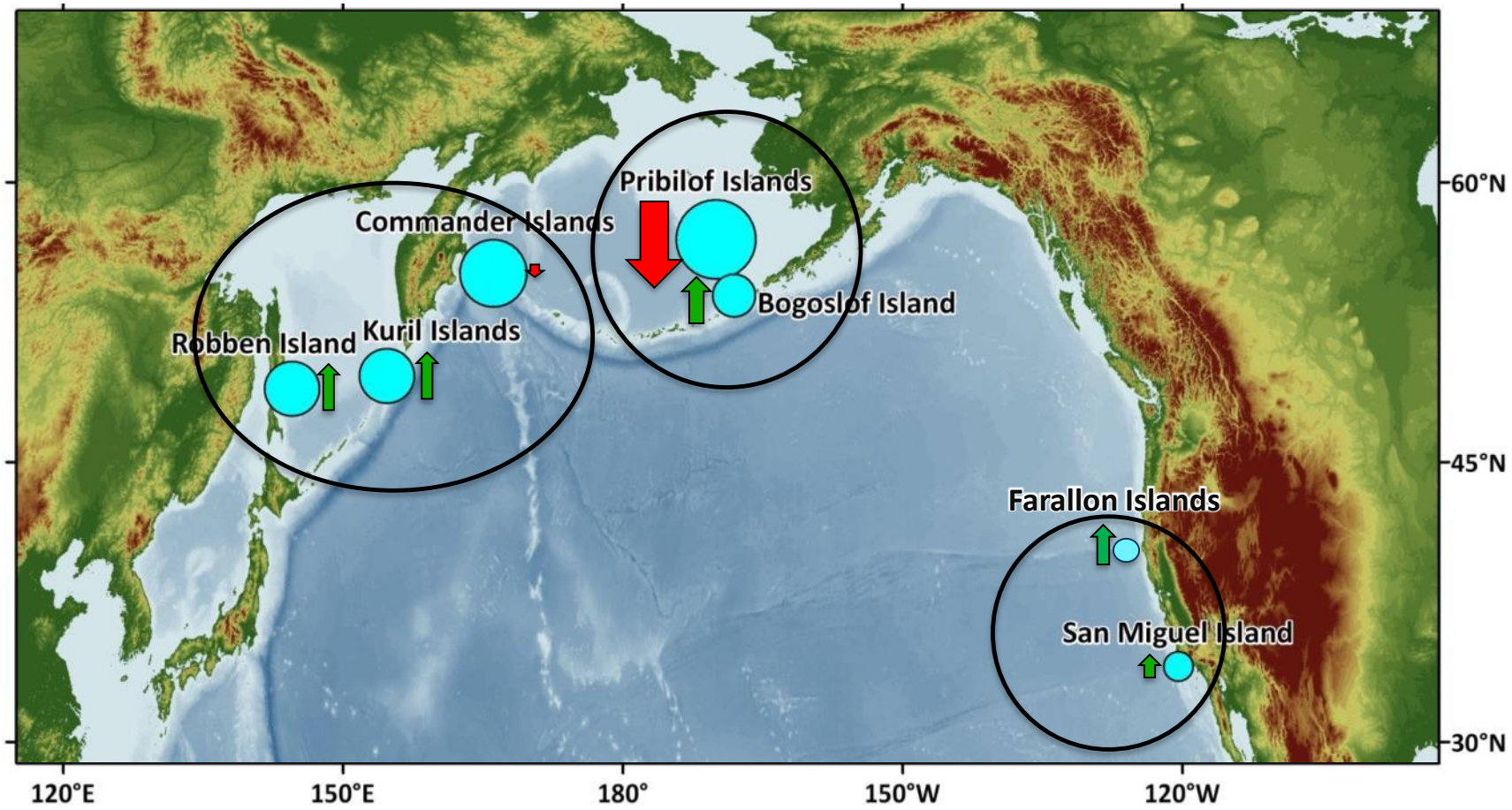
1. Population status
2. Saildrone and fur seal foraging studies
3. Lenfest Ocean Program, UW, NOAA project update





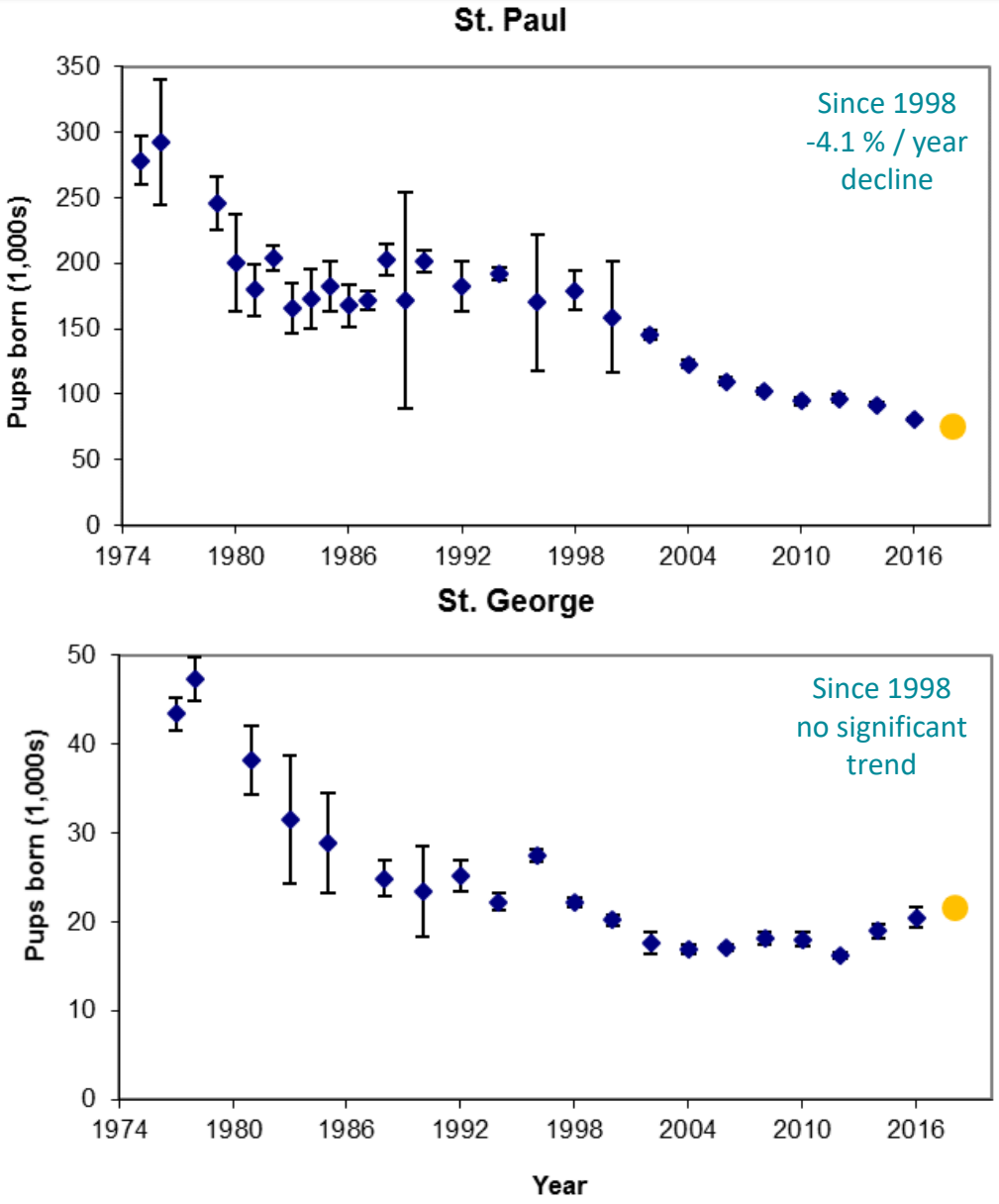
NPFMC Anchorage 1 April 2019

Northern fur seal abundance, stock structure, trends

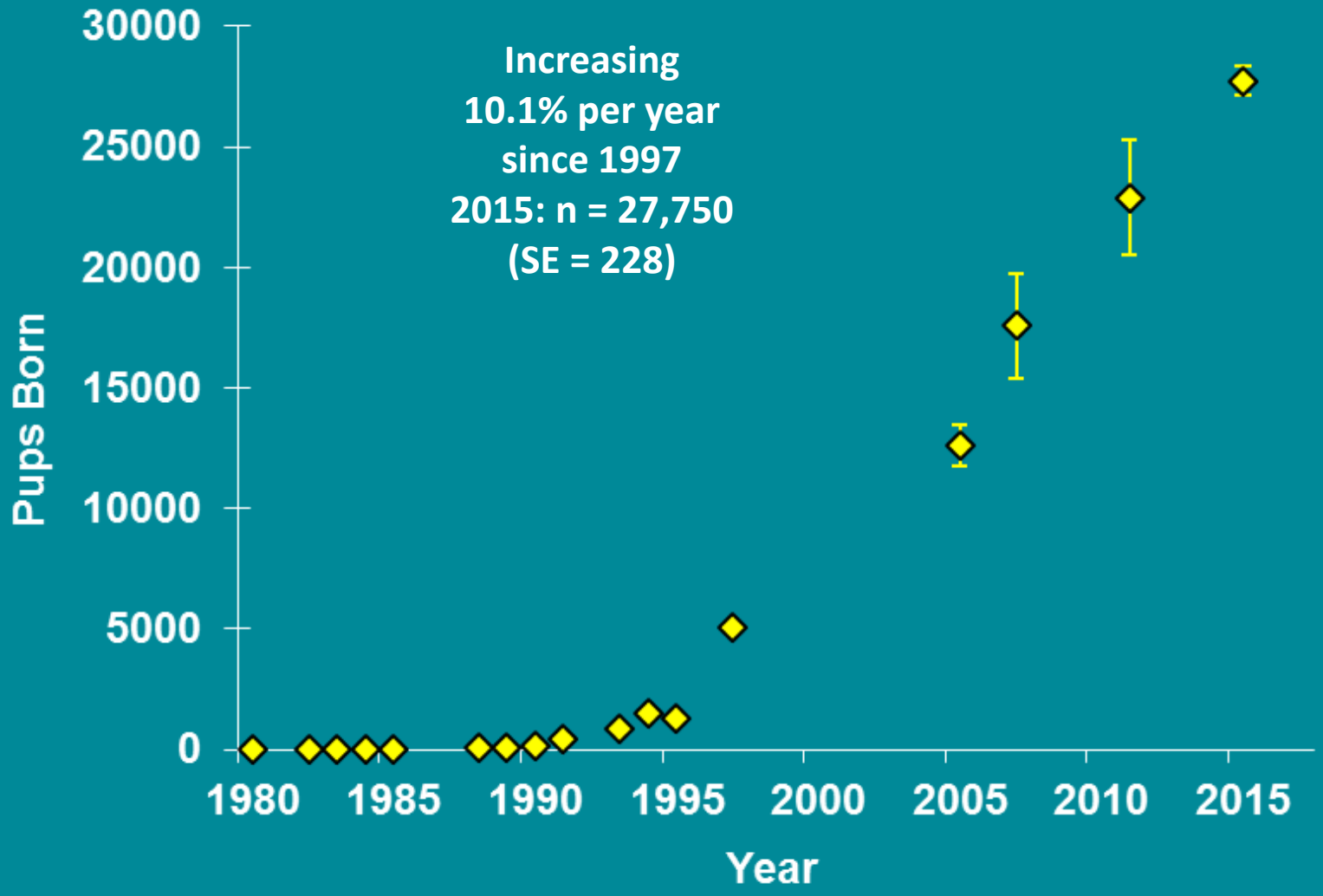


- ~1,100,000 – 1,200,000 northern fur seals in North Pacific
- Two stocks in US: Eastern Pacific, California; mixed during winter migration
- Eastern Pacific stock designated as “depleted” under the MMPA (1988)
- Regional variation in population trends

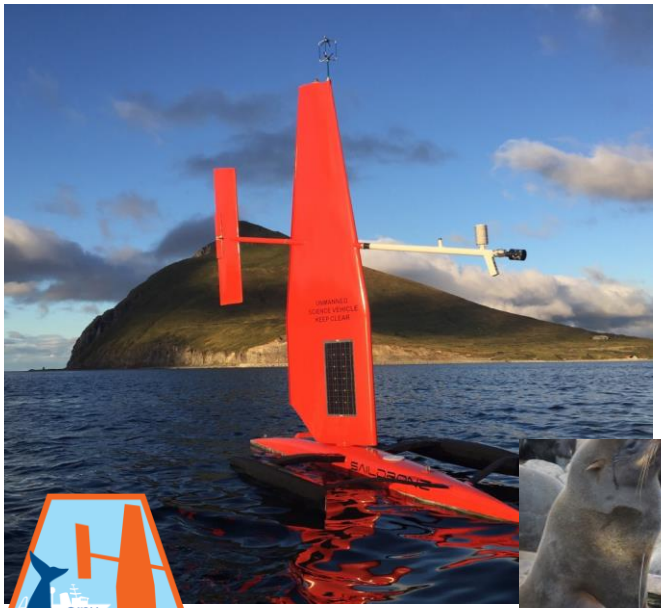
Pup Production Pribilof Islands

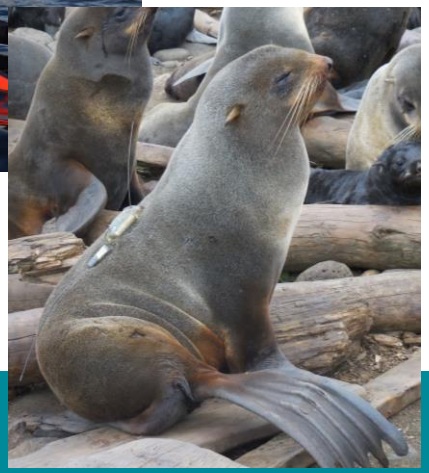


Bogoslof Island



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

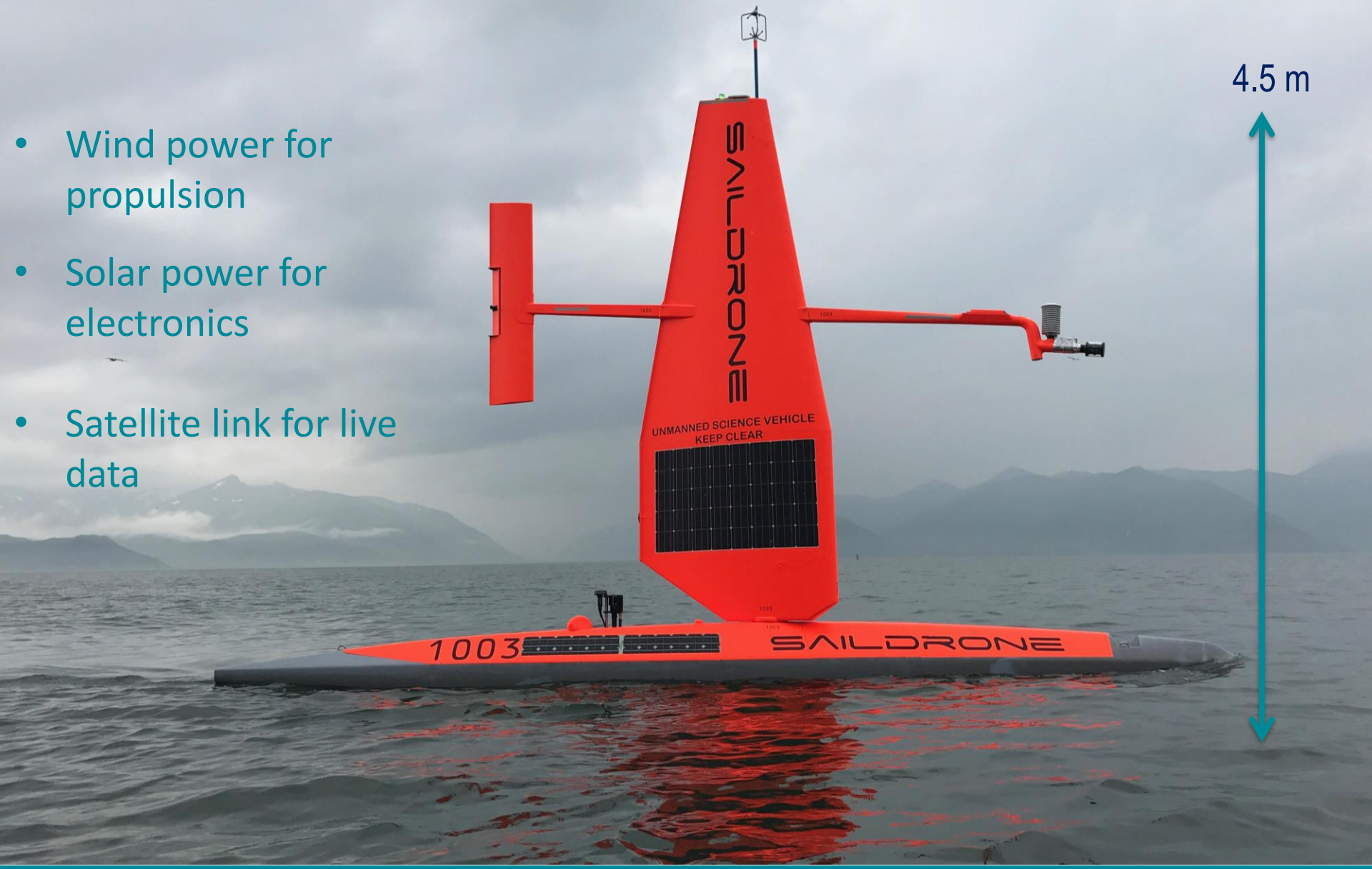
Northern fur seal Conservation Plan:

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

Walleye pollock

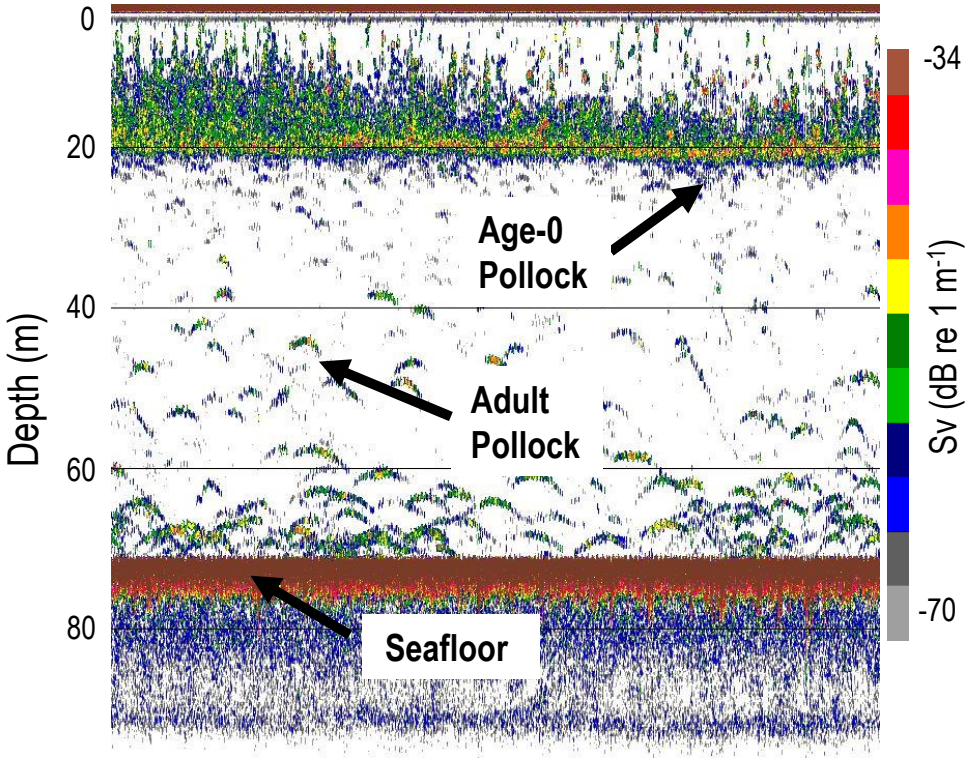
Saildrone: unmanned, wind- and solar-powered surface vehicle

- Wind power for propulsion
- Solar power for electronics
- Satellite link for live data

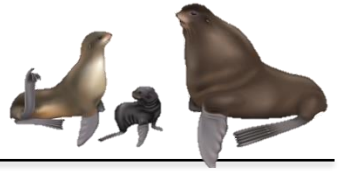


Fisheries echosounder

- Map fish abundance and depth distribution
- Fish species confirmed via trawls
- Backscatter classified as shallow, age-0 and deeper, adult walleye pollock
- Saildrone survey transects conducted within highest fur seal use area



Fur seal at-sea behavior



- Tracked 50 females, July-Sept (2016: 30, 2017: 16, 2018: 4)
- Instrumented with satellite- or GPS-linked dive recorders
- A subset equipped with accelerometers and video cameras during single trip (2017)
- Only cameras and accelerometers deployed in (2018)

2016 Research

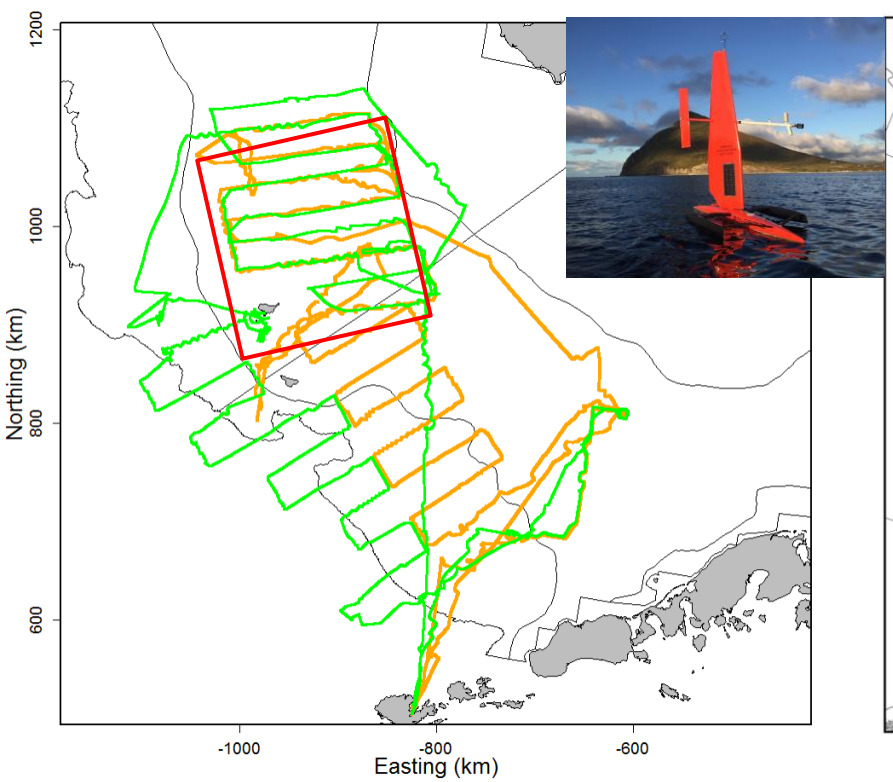
- 2 Saildrones Bering Sea
- 103 day mission
- 11,971 km covered (total)
- Launch: 23 May
- Recovery: 3 Sept
- 65 sampling days in core fur seal area

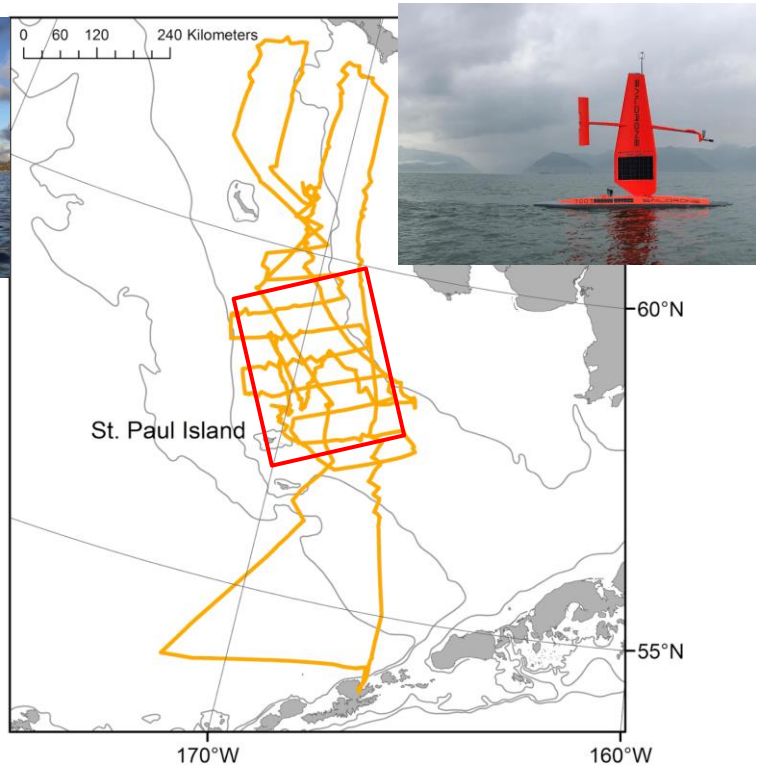
2017 Research

- 1 Saildrone Bering Sea, 2 Arctic
- 76 day mission
- ~14,000 km in Bering
- Launch: 17 July
- Recovery: 29 Sept
- 36 sampling days in core fur seal area

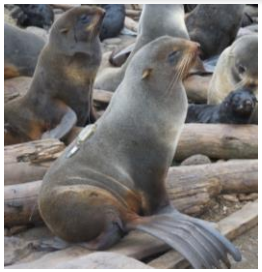
2018

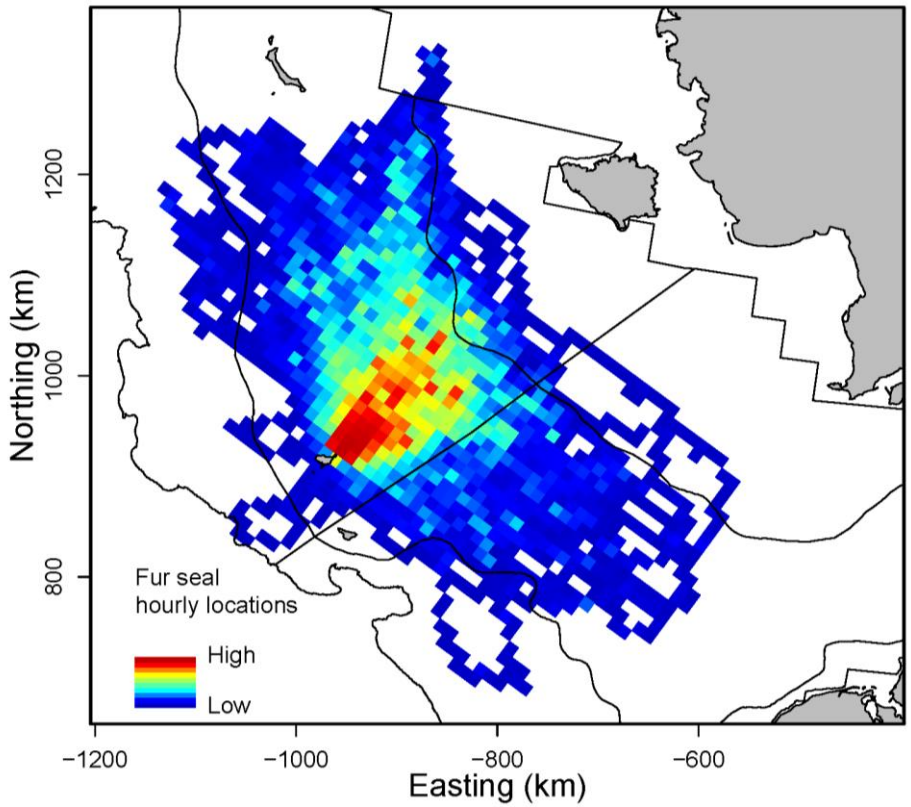
- 0 Saildrone
- 4 seals
- 8 trips to sea
- Cameras
- Accelerometers

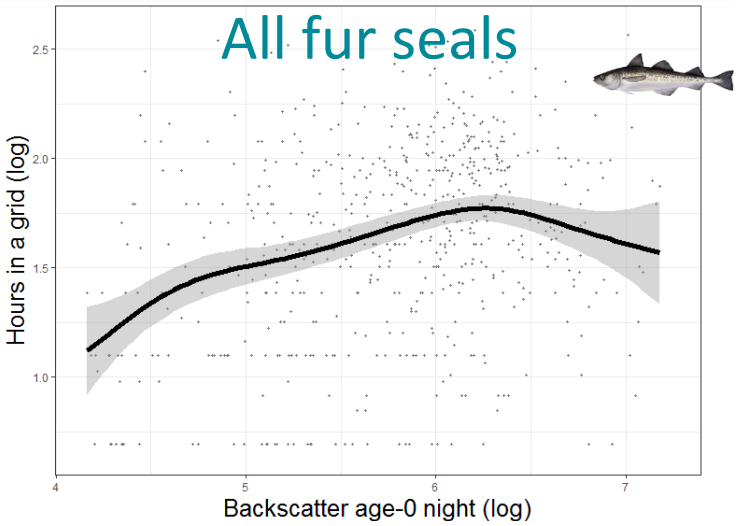


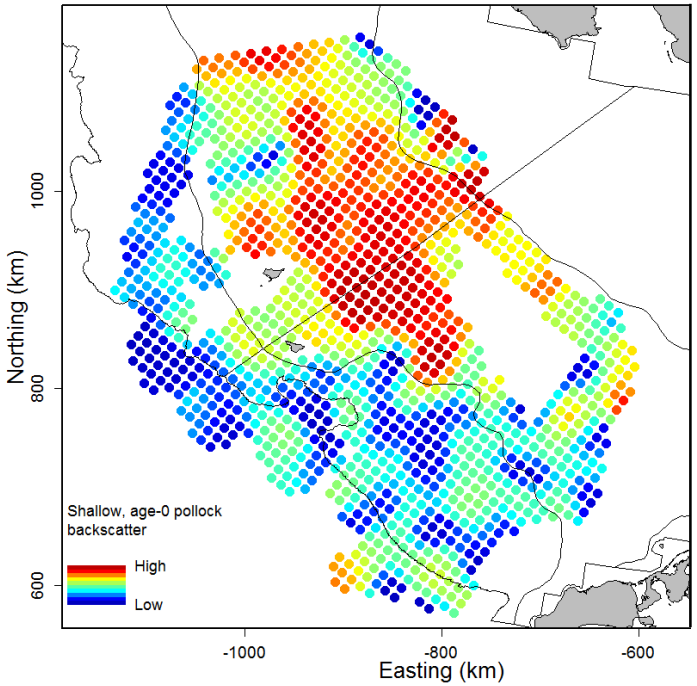


Small pollock and fur seal spatial distributions

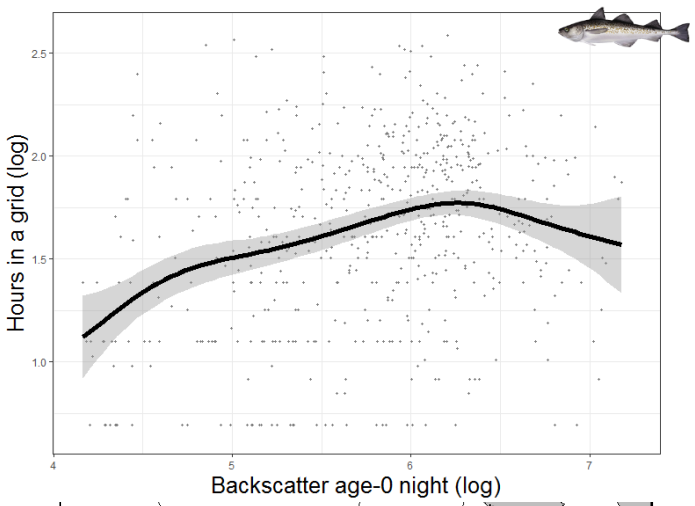


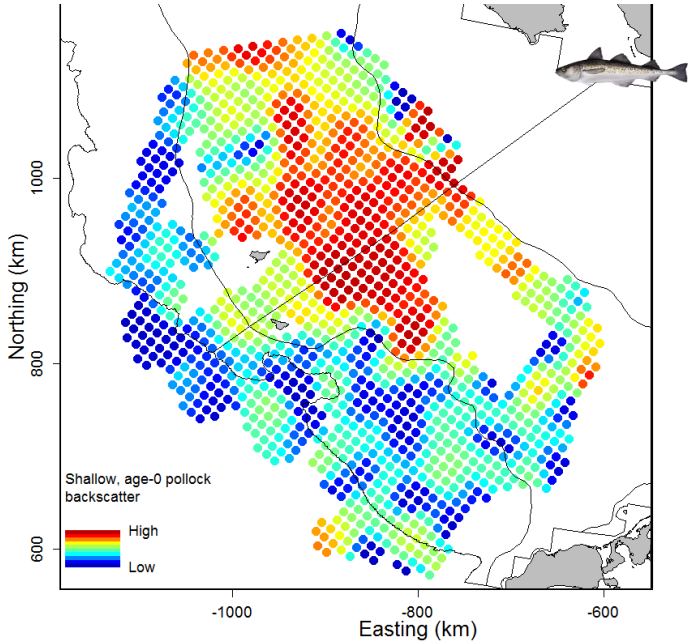




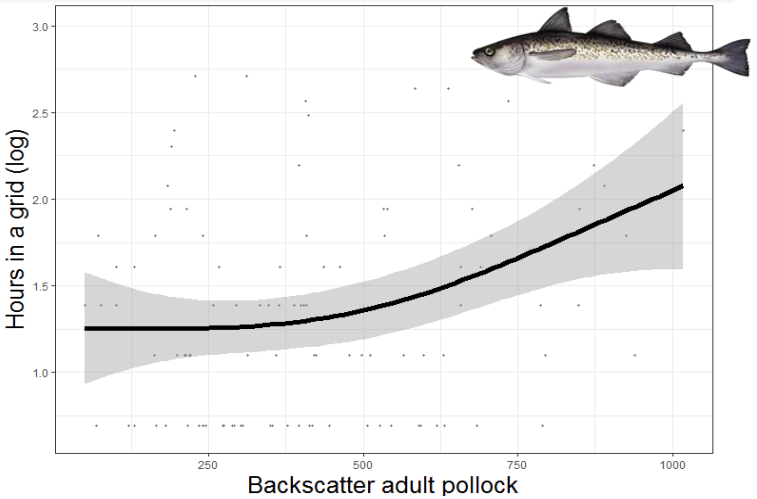


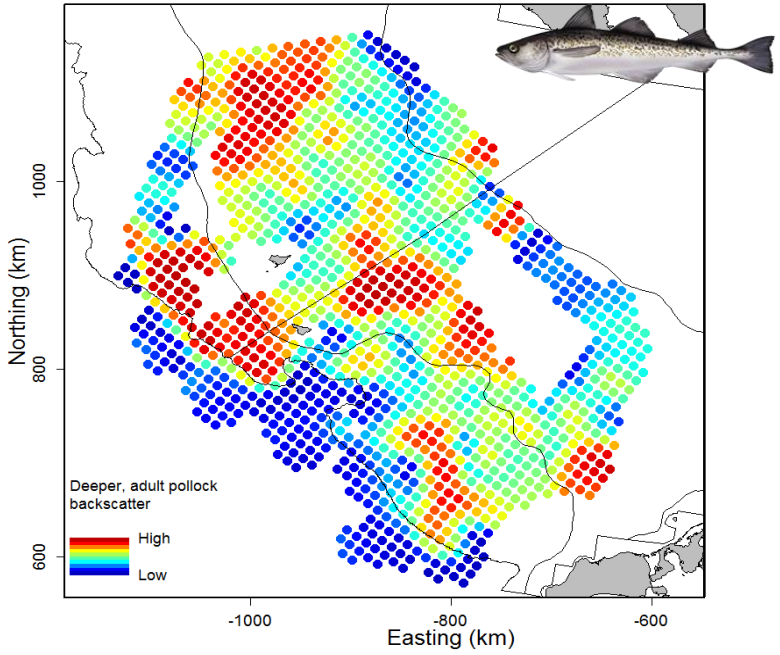
Positive relationship with age-0 pollock



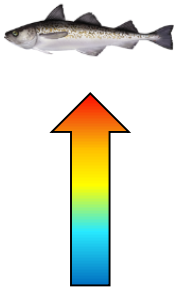


Positive relationship with adult backscatter

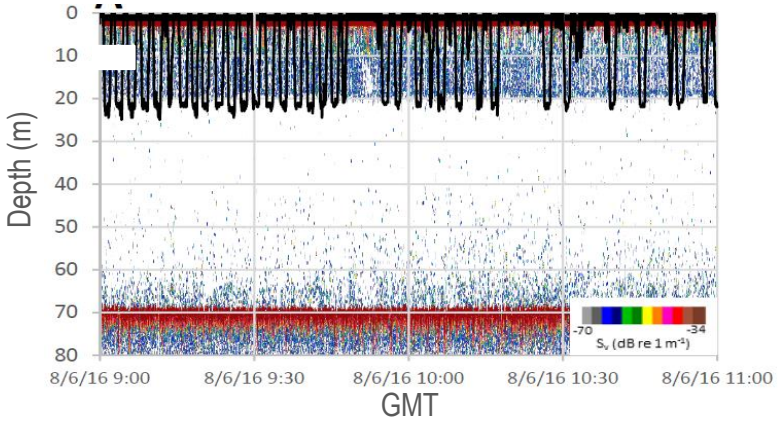


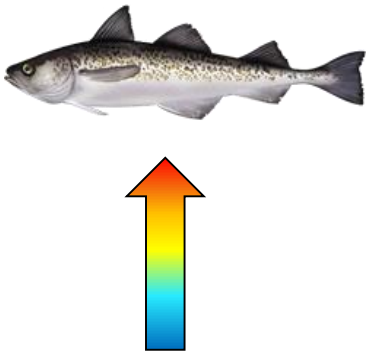


Differences in fur seal dive behavior

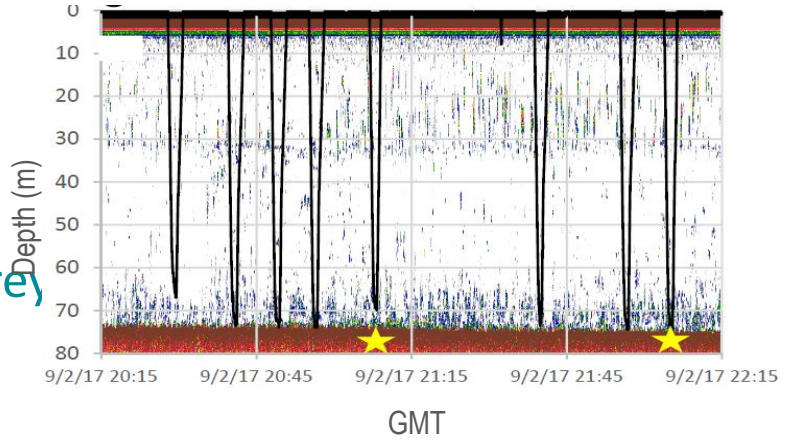


- Mean dive depth decreased
- Dives to the mixed-layer depth increased
- Wiggles increased





- Mean dive depth increased
- Dives per hour decreased
- Wiggles decreased
- Stars denote video recorded prey capture



Small pollock foraging

Accelerometers and video cameras to record prey capture attempts

Large pollock foraging

Accelerometers and video cameras to record prey capture attempts

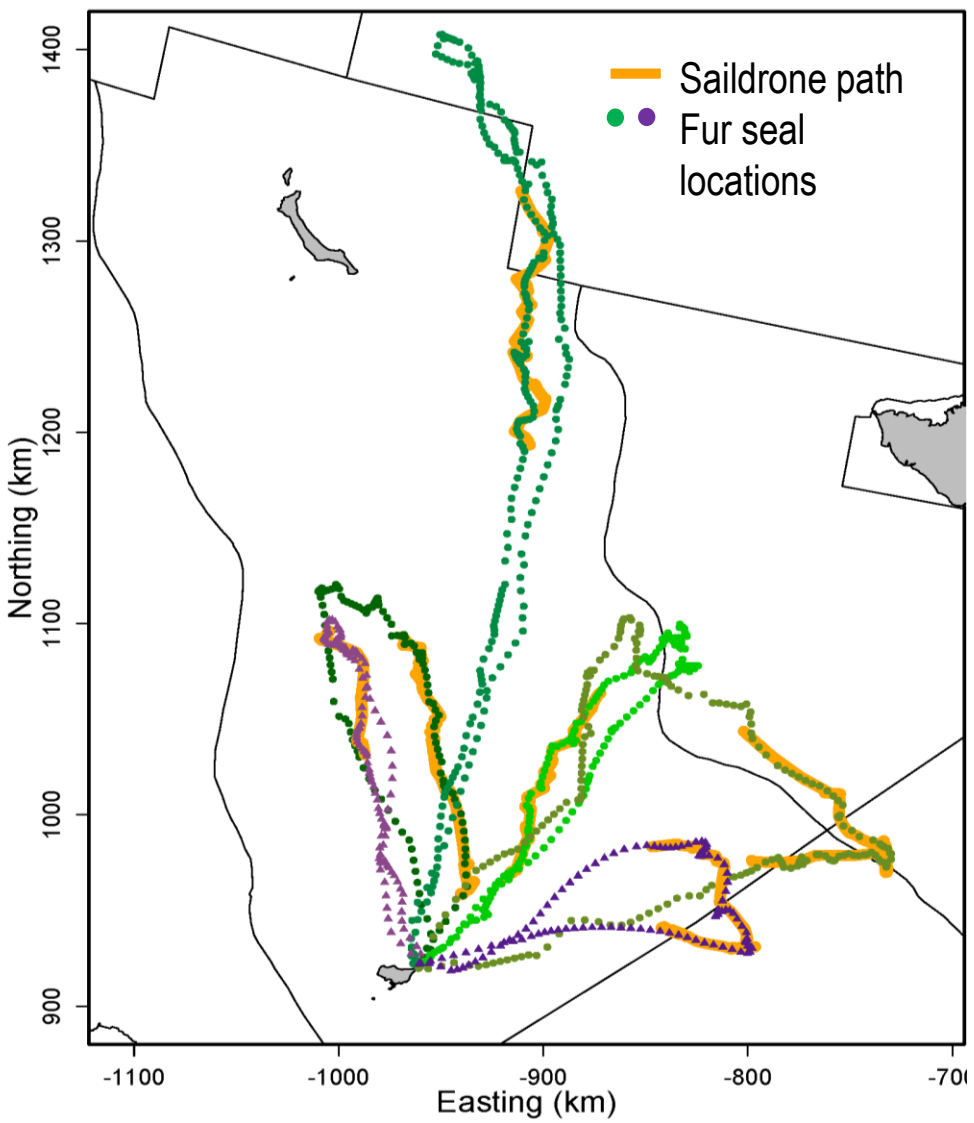
Salmon chase

Accelerometers and video cameras to record prey capture attempts

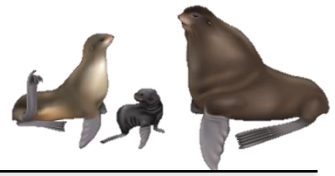
Focal follow study

Draft manuscript

- Tested feasibility of using Saildrone to conduct remote focal follows
- Prey abundance and oceanographic conditions while following tracked fur seals
- Followed foraging path for ~2 days (2016: 2, 2017: 4)

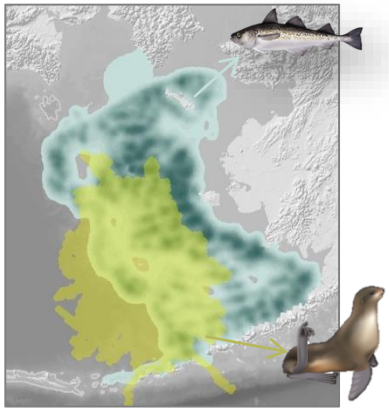


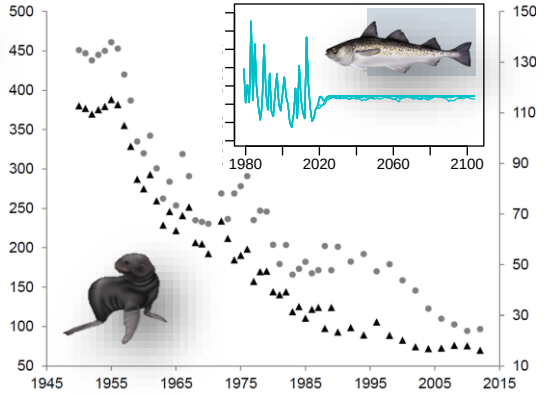
Summary



- Saildrones successfully mapped fur seals prey landscape during the important breeding period
- Simultaneous tracking of fur seals used to examine how fur seals respond to variation in prey resources
- Ultimate goal is to link behavioral changes with measures of foraging and reproductive success
- Results provide essential information that can be used to develop ecosystem-based approaches for northern fur seal conservation and fisheries management
- 2019 more Saildrone and fur seal camera work

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**

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

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

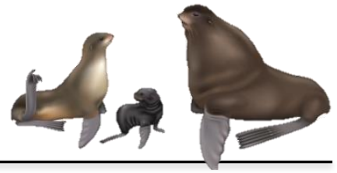
Lenfest Contact: Emily Knight
eknight@pewtrusts.org

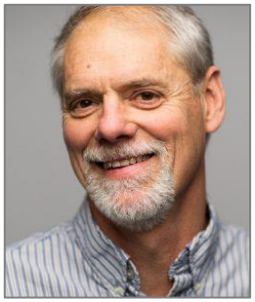
2007 Northern fur seal Conservation Plan

Northern Fur Seal Conservation Action Narrative:

- Compile and evaluate available habitat-use data
- Compile and evaluate existing physical environmental data
- Select appropriate environmental indices
- Quantify environmental effect on behavior and productivity
- Conduct oceanographic and fishery surveys based on pelagic fur seal habitat use
- Ecosystem modeling

The Team





Nick Bond
UW/JISAO
Variability in climate and atmospheric forcing

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

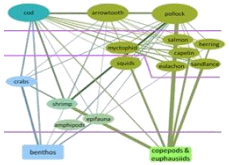
Elizabeth McHuron
UW/JISAO
Marine mammal bioenergetics and population dynamics modeling

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

Project Goal



By combining a spatially explicit fur seal bioenergetics model with ecosystem *and* stock assessment models *we can provide feedbacks between pollock and fur seal stock assessments and contribute to* conservation *goals*

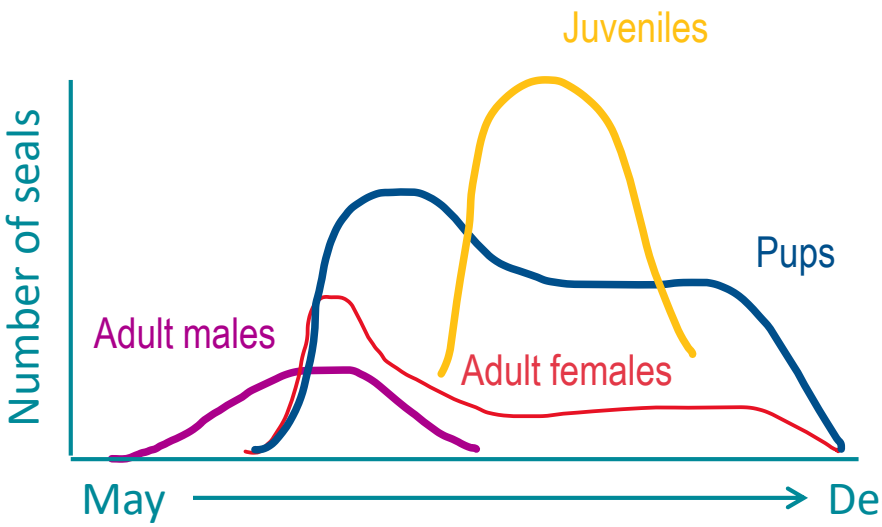
Questions

1. What are the energy requirements of northern fur seals in the Bering Sea?
2. What is the prey species and size allocation needed to match the estimated energy requirements?
3. What are climate-specific northern fur seal based multispecies harvest rates for eastern Bering Sea pollock given observed spatiotemporal relationships between fur seal foraging patterns, estimated predation rates, and pollock availability?
4. What is the expected future availability of pollock and its potential impact on northern fur seals?

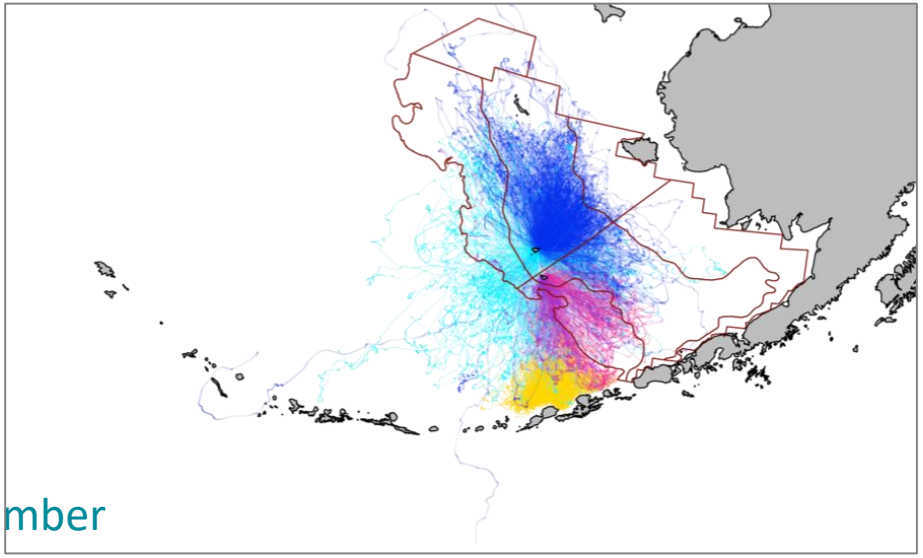
How much energy does a seal need?

Simulation approach to estimate energy intake in previous years given behavior and pup growth rates

Arrival and departure times



Foraging trips



What kind of data is used in the bioenergetic model?

Pup growth rates
Donohue – 1995/1996
Goebel – 1995/1996
COFFS – 2005/2006
Kuhn – 2016/2017

At-sea behavior
863 seals
11.5 million dives
1.6 million tracking hours
1991-2018

Lactation
Milk intake of 41 pups
Donohue – 1995/1996

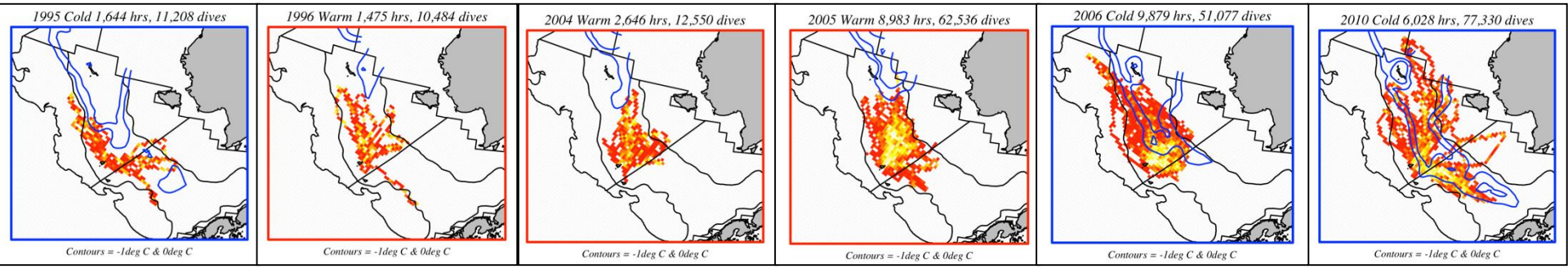
Demography
Numbers by age by year
Multi-model simulation

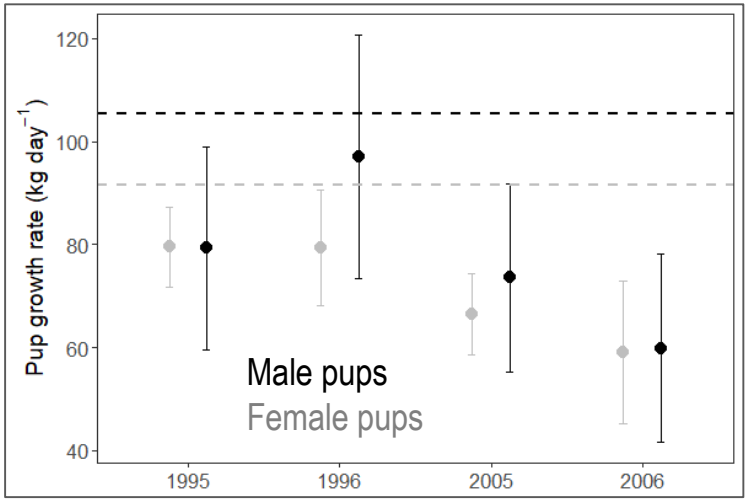
Metabolism
48 free-ranging females
Goebel – 1995/1996

Pup birth parameters
Gentry 1998, Costa & Gentry 1986

Initial target years

1995 | 1996 | 2004 | 2005 | 2006 | 2010





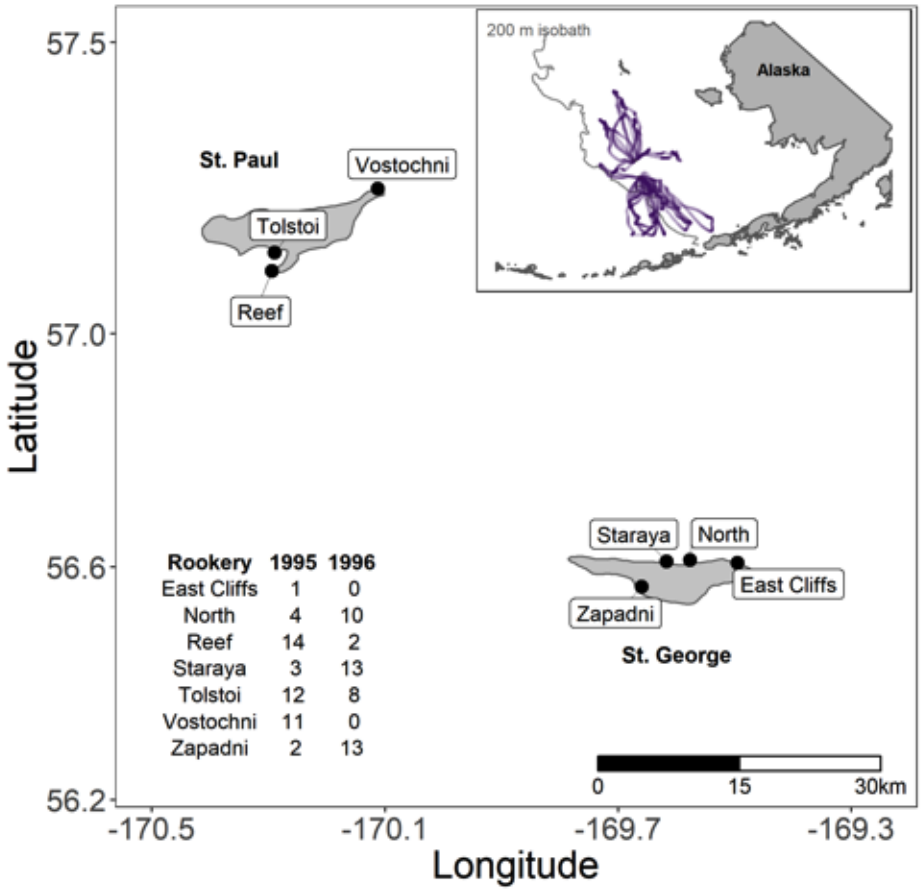
- Initial focus is on years with high resolution data
- Variable environmental conditions that influenced behavior and pup growth

What affects fur seal field metabolic rates?

Draft manuscript

- Mother pup pairs birth to migration
- 1995 (cold) & 1996 (warm)
- Diet – fatty acid & scat/enema
- Diving
- Satellite tracking
- Trip duration
- Energetics
- Pup growth

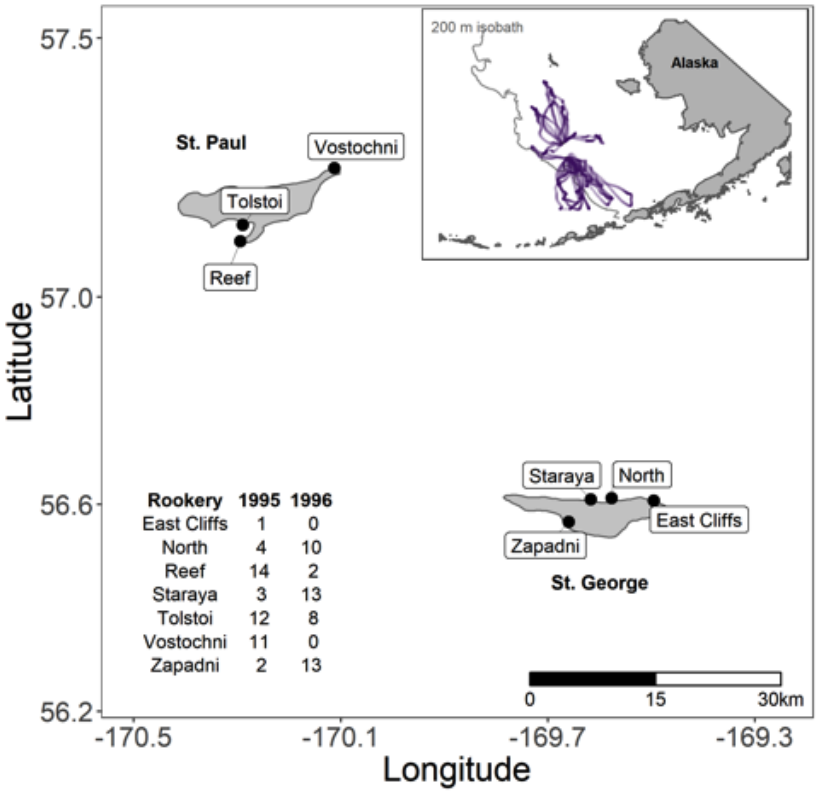
M. Goebel PhD data



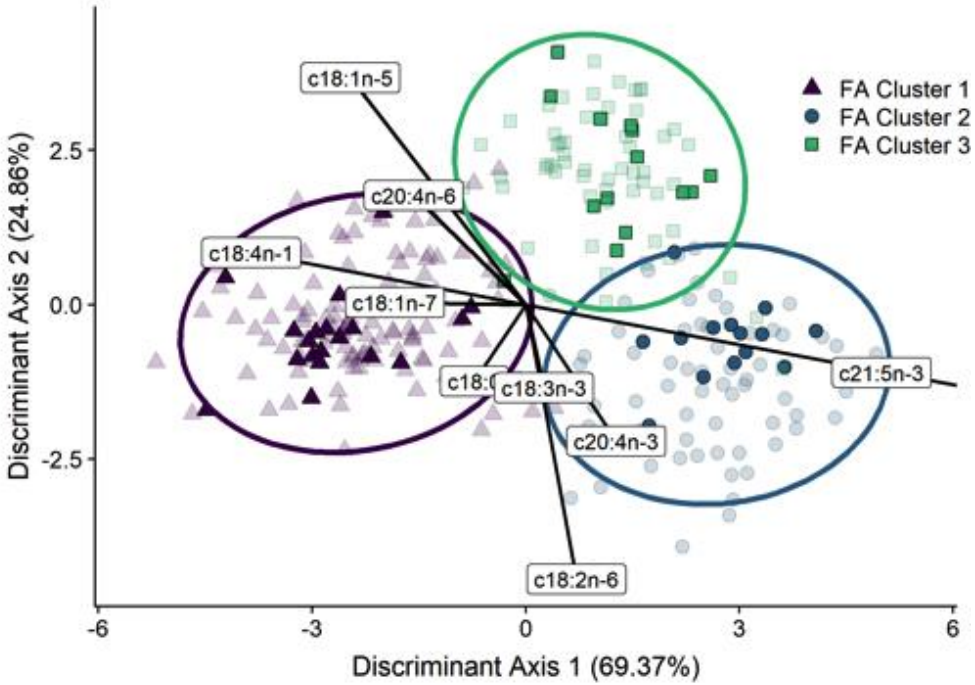
What affects fur seal field metabolic rates?

Draft manuscript

M. Goebel PhD data



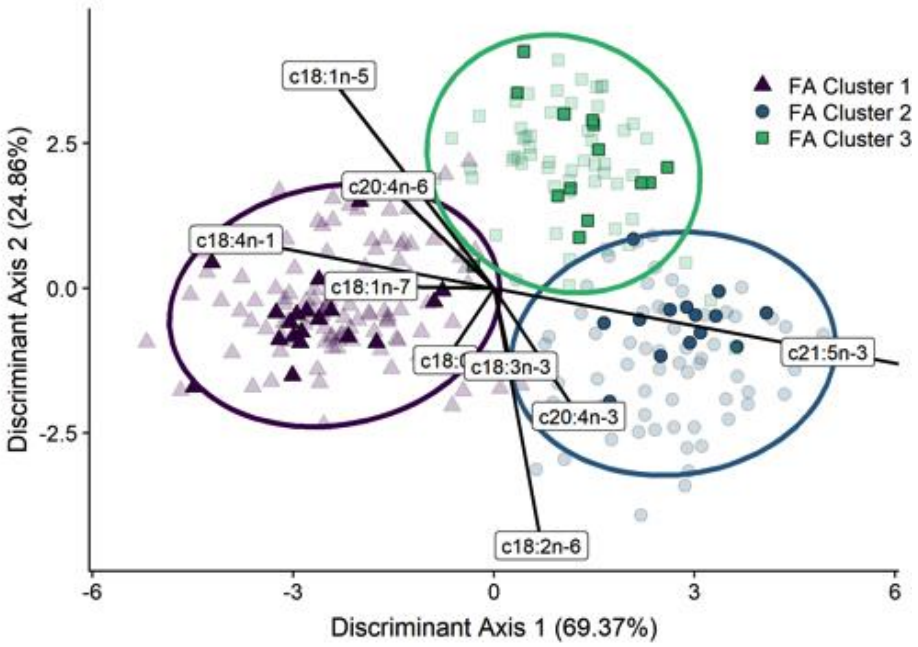
Milk fatty acid clusters – diet



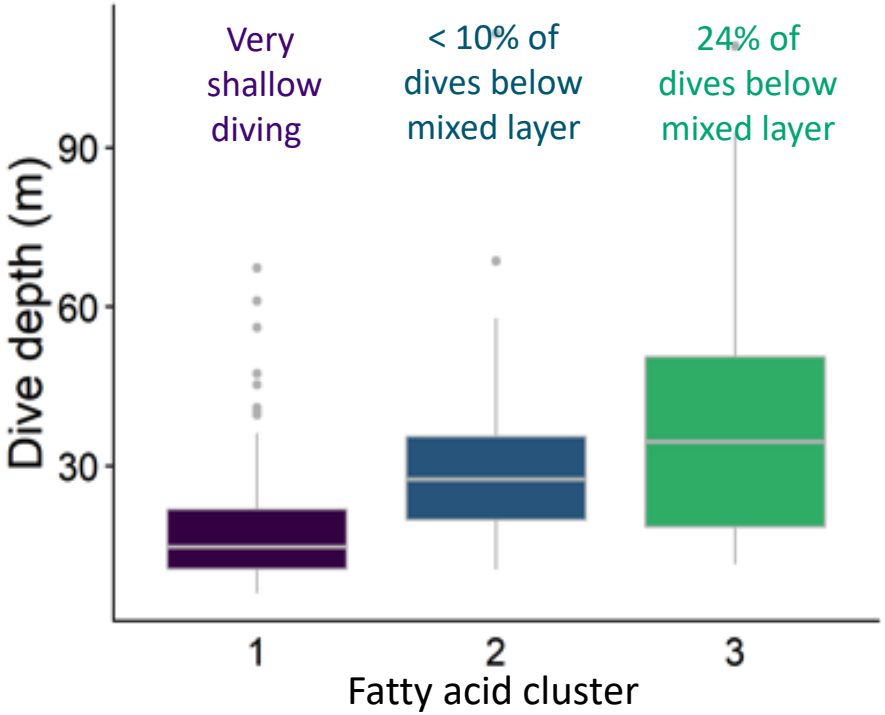
What affects fur seal field metabolic rates?

Draft manuscript

Milk fatty acid clusters – diet



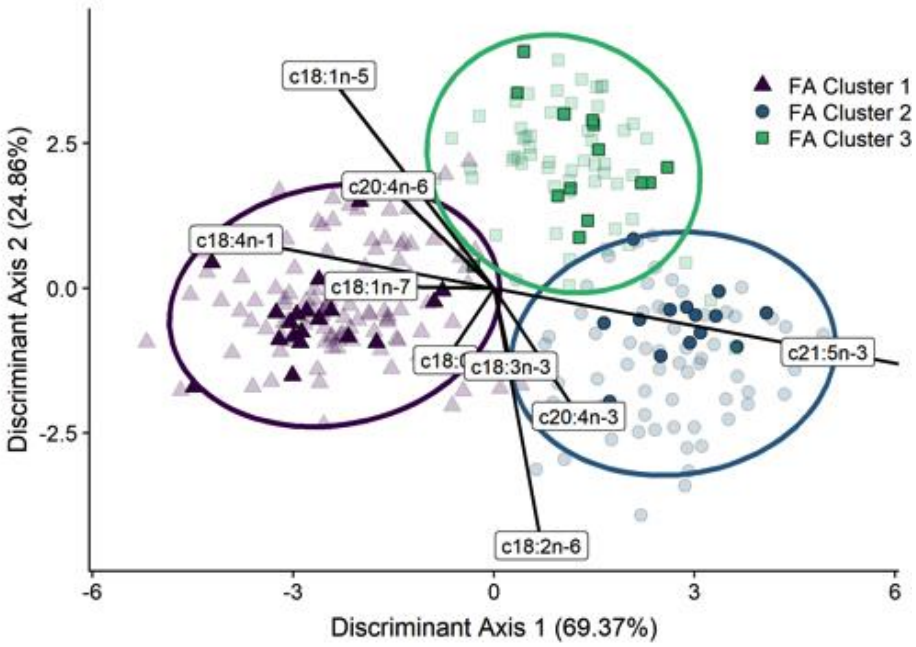
Dive Behavior



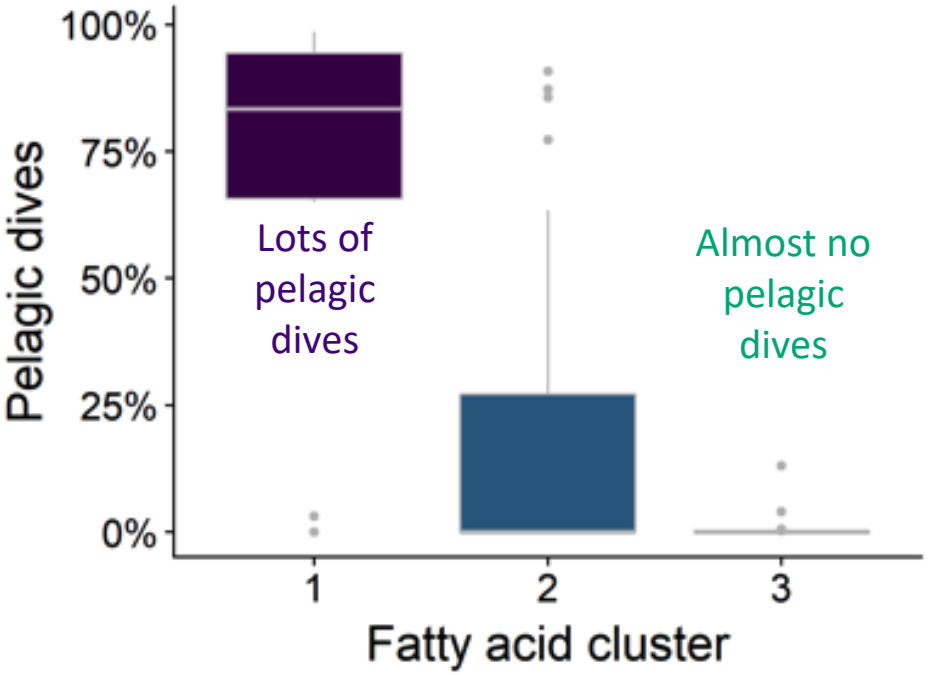
What affects fur seal field metabolic rates?

Draft manuscript

Milk fatty acid clusters – diet



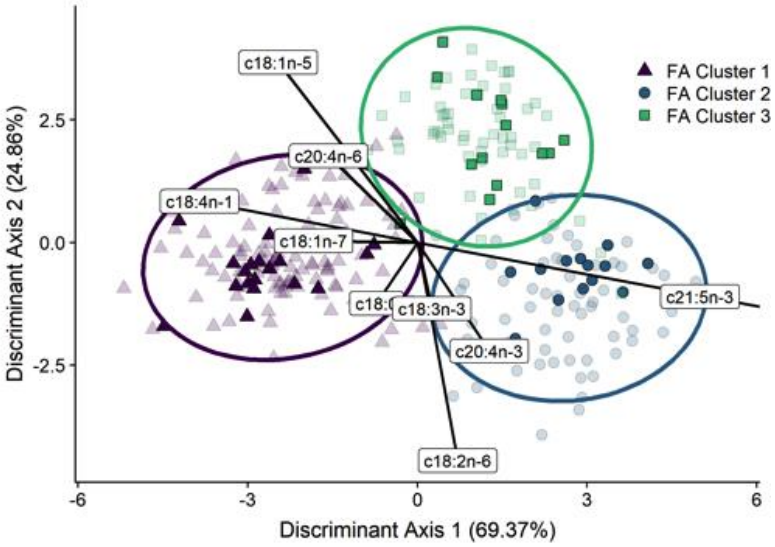
Bering Sea basin or shelf diving



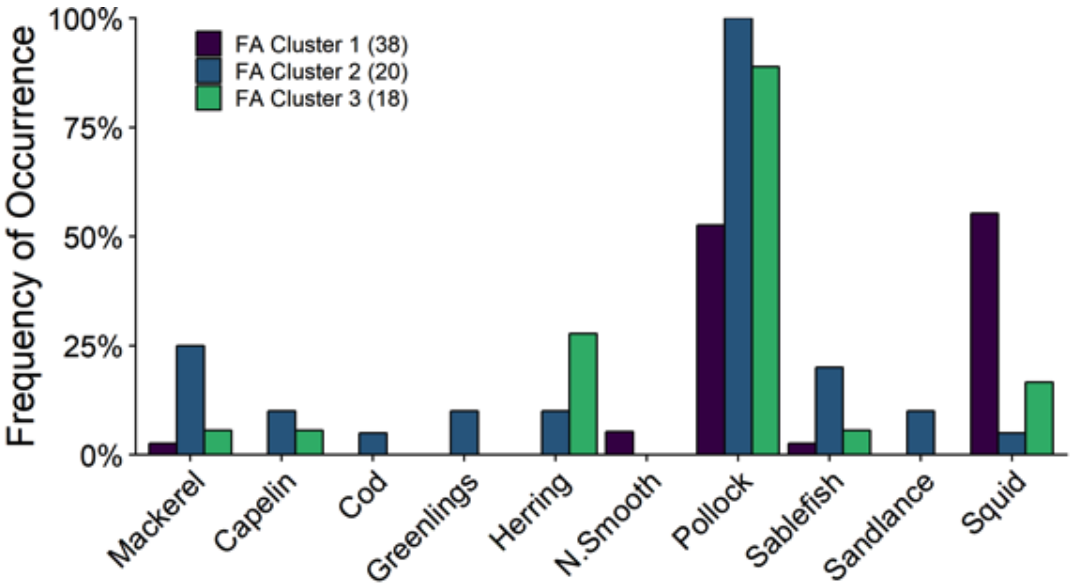
What affects fur seal field metabolic rates?

Draft manuscript

Milk fatty acid clusters – diet



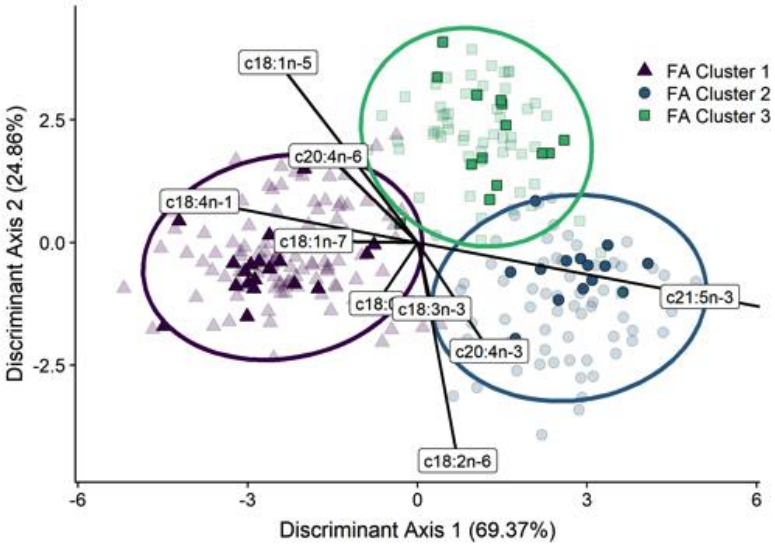
Enema hard parts

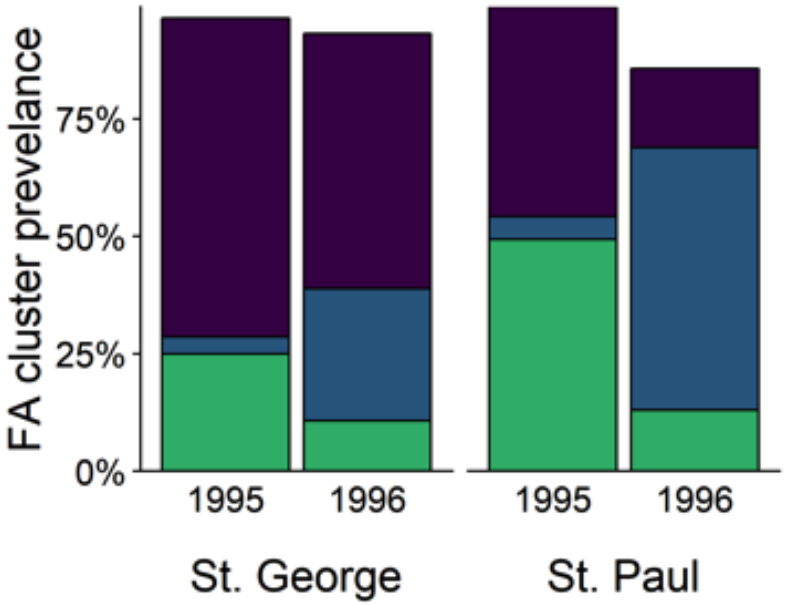


What affects fur seal field metabolic rates?

Draft manuscript

Milk fatty acid clusters – diet





Prevalent in 1995 on St. Paul and in both years on St. George Island

Prevalent in 1996

Prevalent in 1995

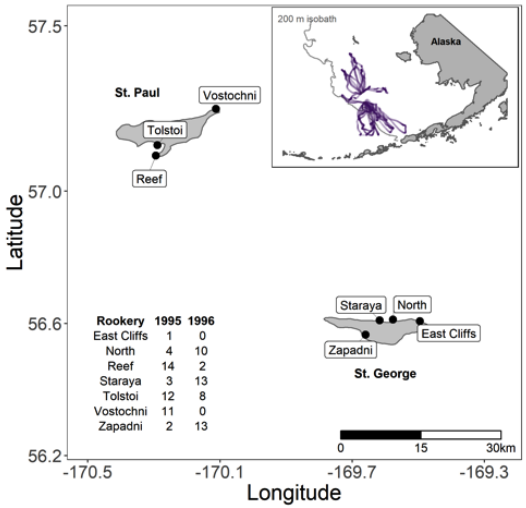
What affects fur seal field metabolic rates?

Draft manuscript

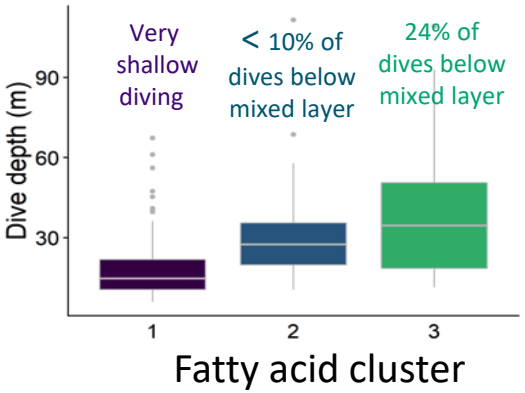
Take-Home: *FA clusters reflect diets dominated by Squid + Pollock, Young pollock, and Older pollock*

- ***Spatial and temporal variation consistent with pollock survey data and oceanographic conditions***

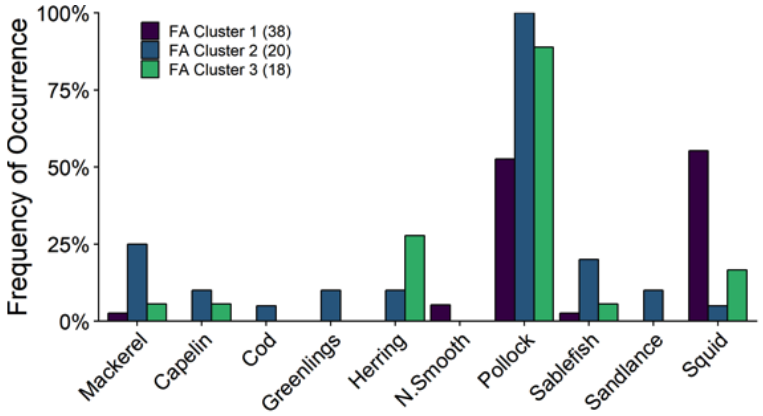
M. Goebel PhD data



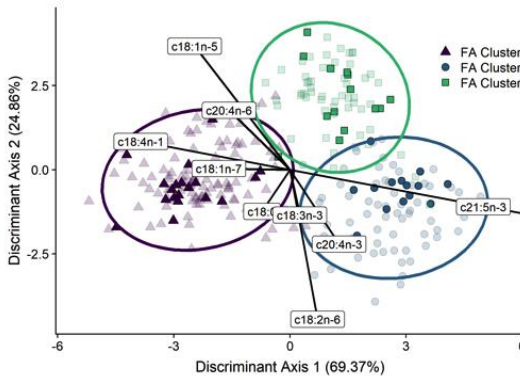
Dive Behavior

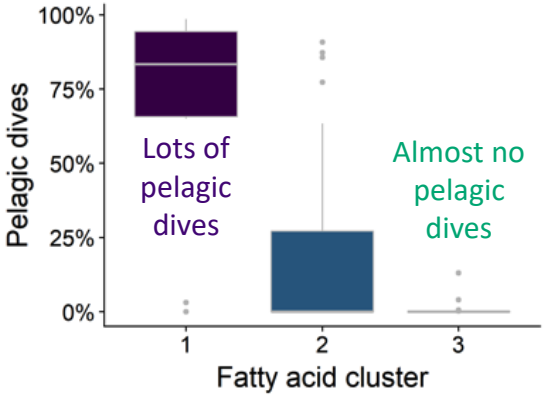


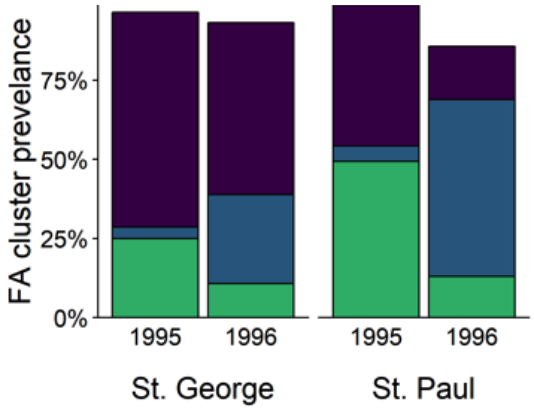
Enema hard parts



Milk fatty acid clusters







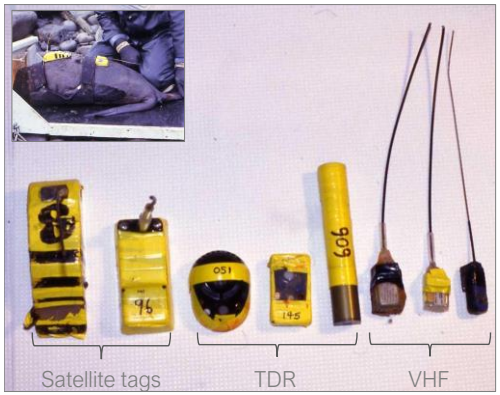
Prevalent in 1995 on St. Paul and in both years on St. George Island

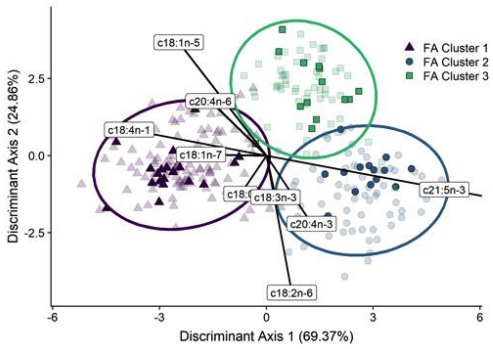
Prevalent in 1996

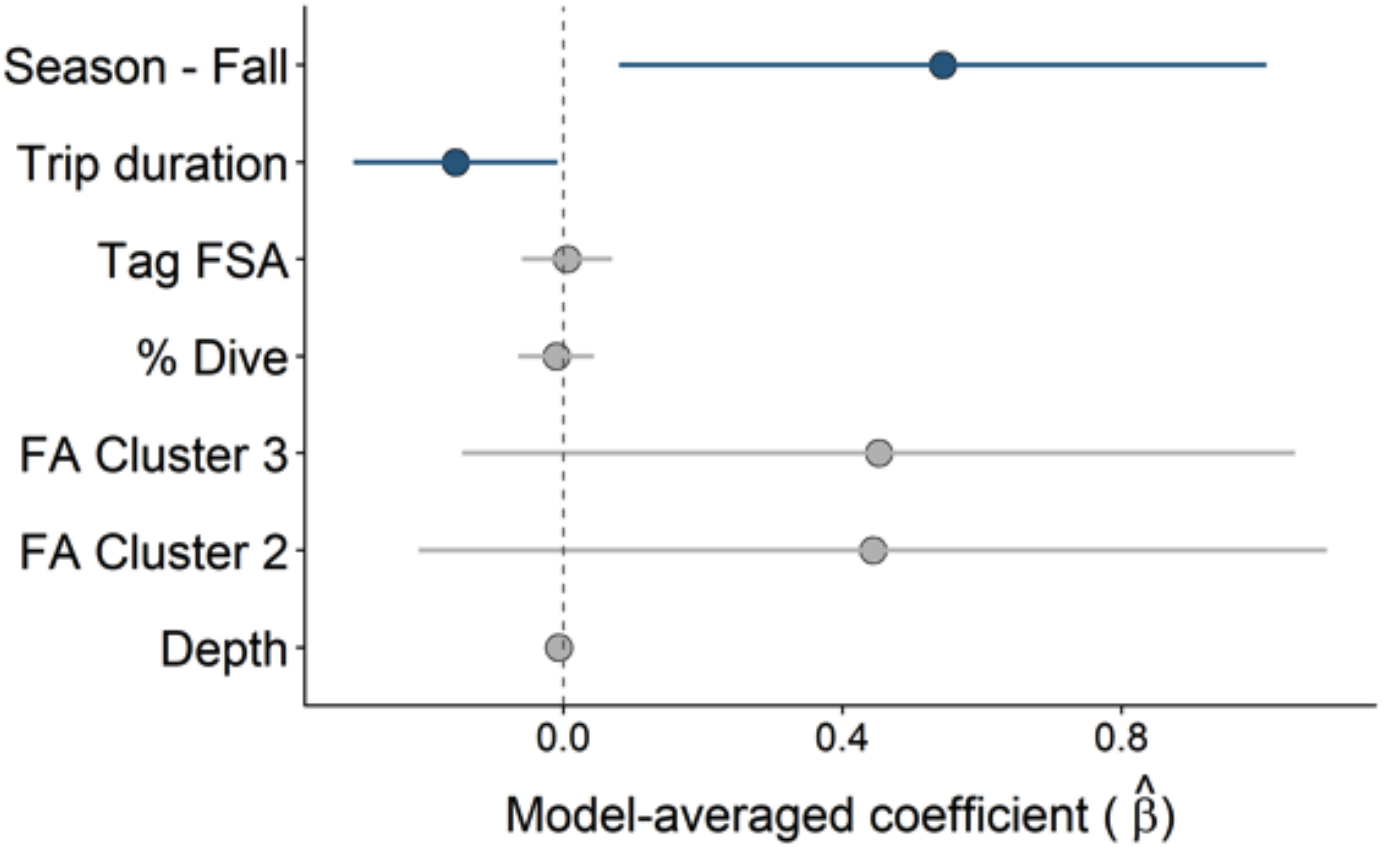
Prevalent in 1995

Effects on adult female field metabolic rate measurements

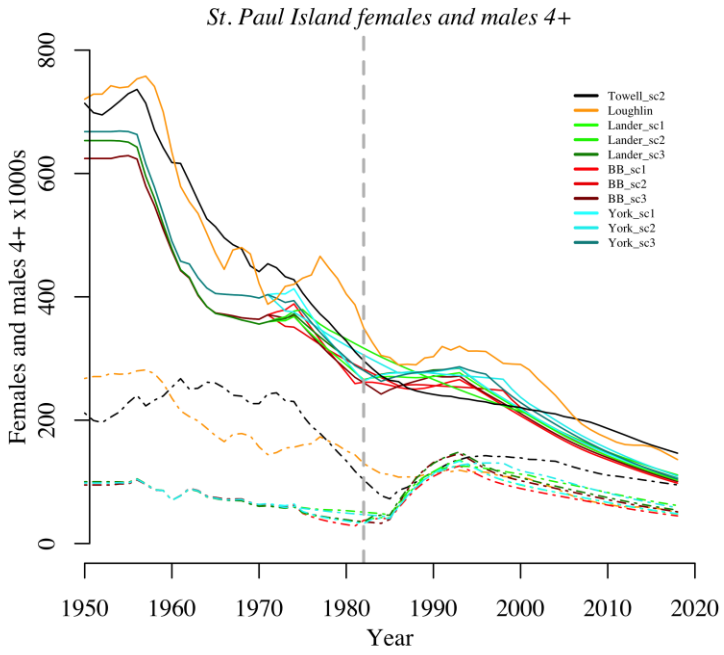
Draft manuscript

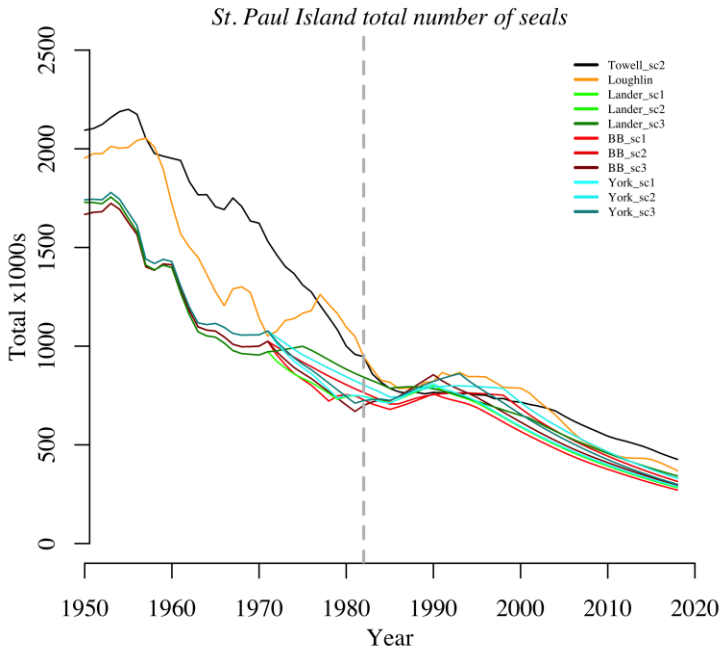


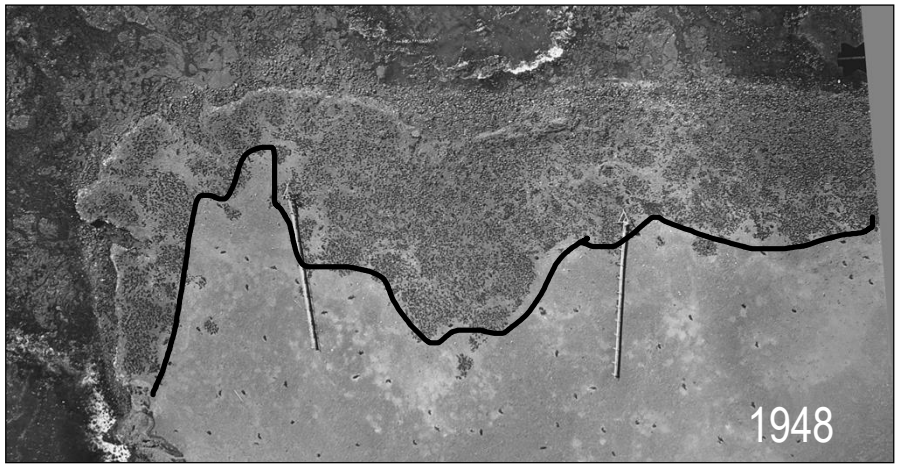




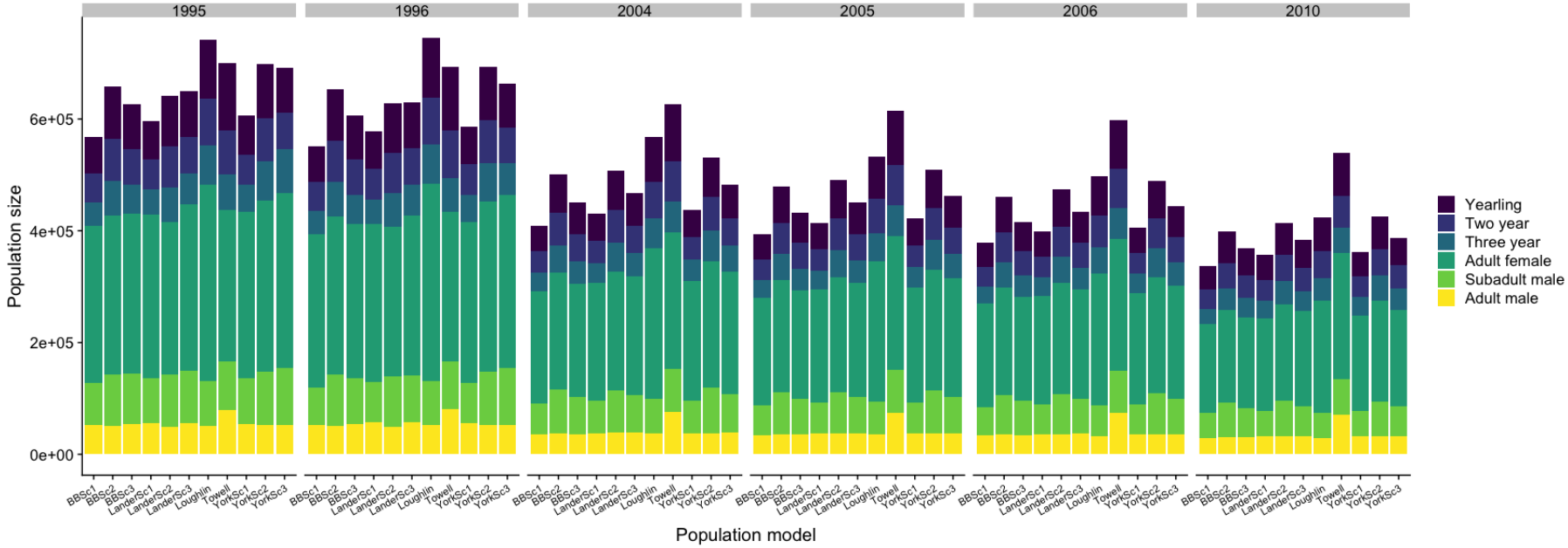
Scaling up to the population level





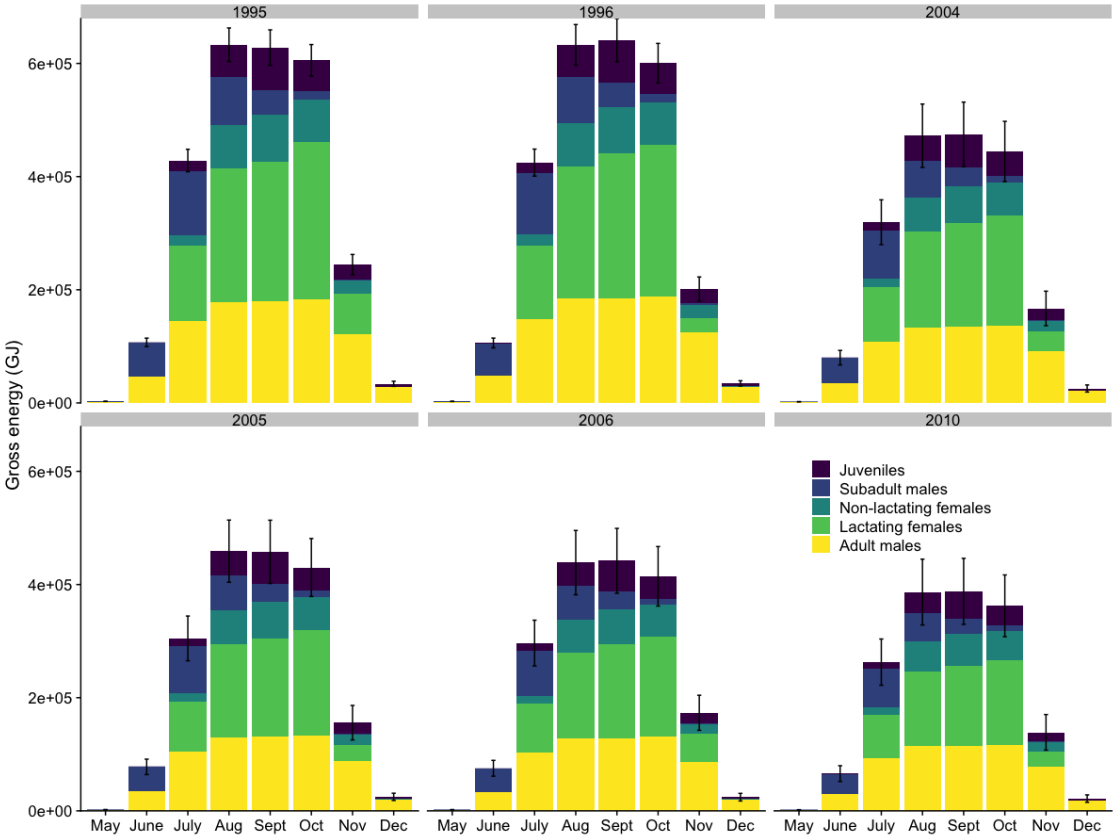


Scaling up to the population level



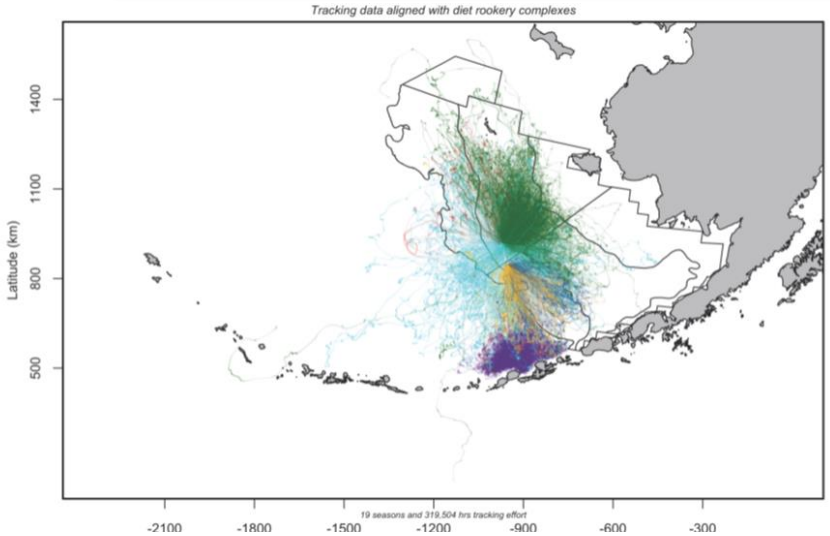
Gross energy intake all age classes

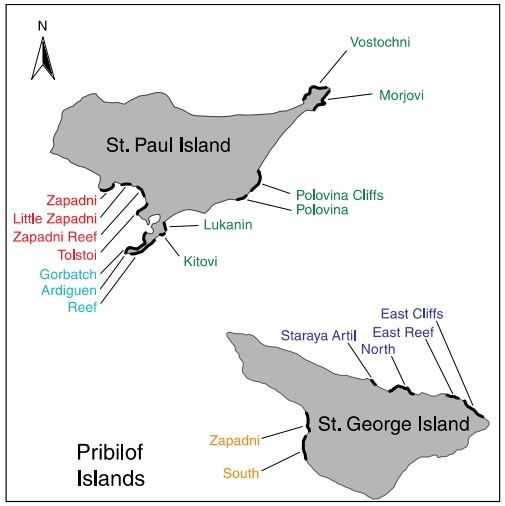
Preliminary results



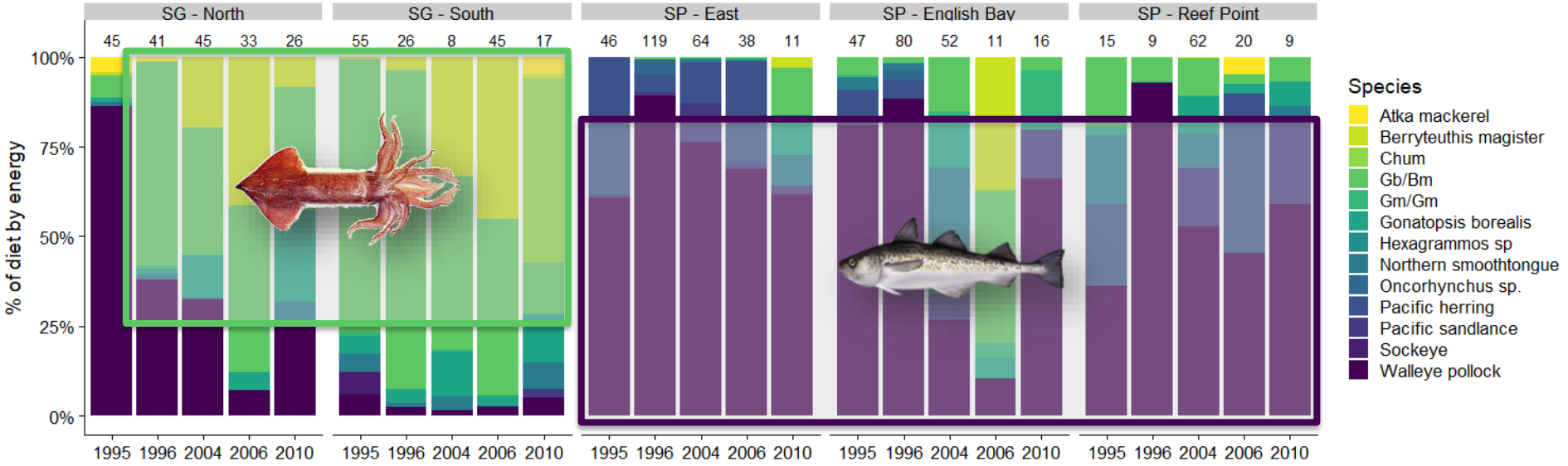
- Separate models for each demographic group that incorporate:
  - ✓ Costs associated with metabolism, growth, reproduction as needed
  - ✓ Interannual variability in behavior
- Models parameterized using data largely collected from free-ranging seals
- Population estimation
  - Loughlin
  - Towell
  - York, Barlow & Boveng, Lander
    - 3 scenarios – adult only, pup only, combo pup/adult
- Monte Carlo simulations for each demographic group
  - ✓ Incorporates variability in parameter estimates

Rookery complex consumption estimates vary due to complex specific foraging areas

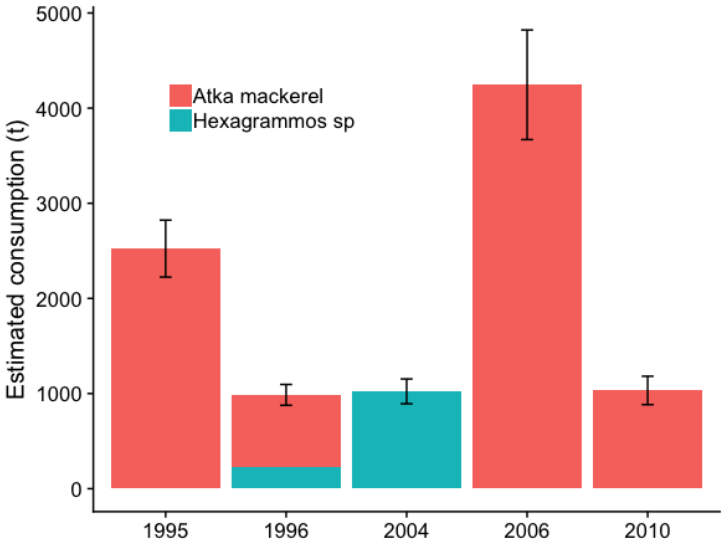




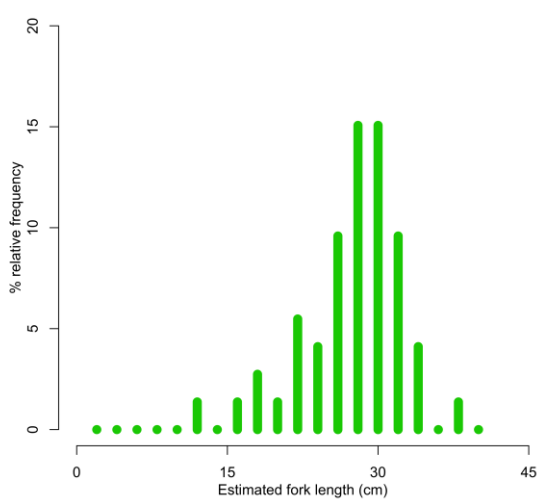
Scat, enema, spew
↓
Hard parts
↓
Prey length
↓
Prey mass
↓
Energy density



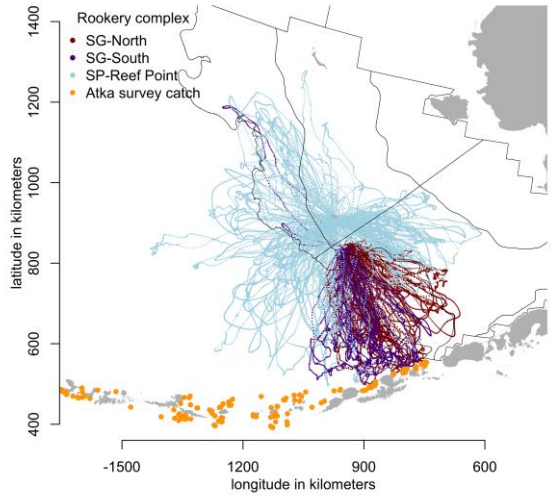
Atka mackerel SSC comments – Portland, OR

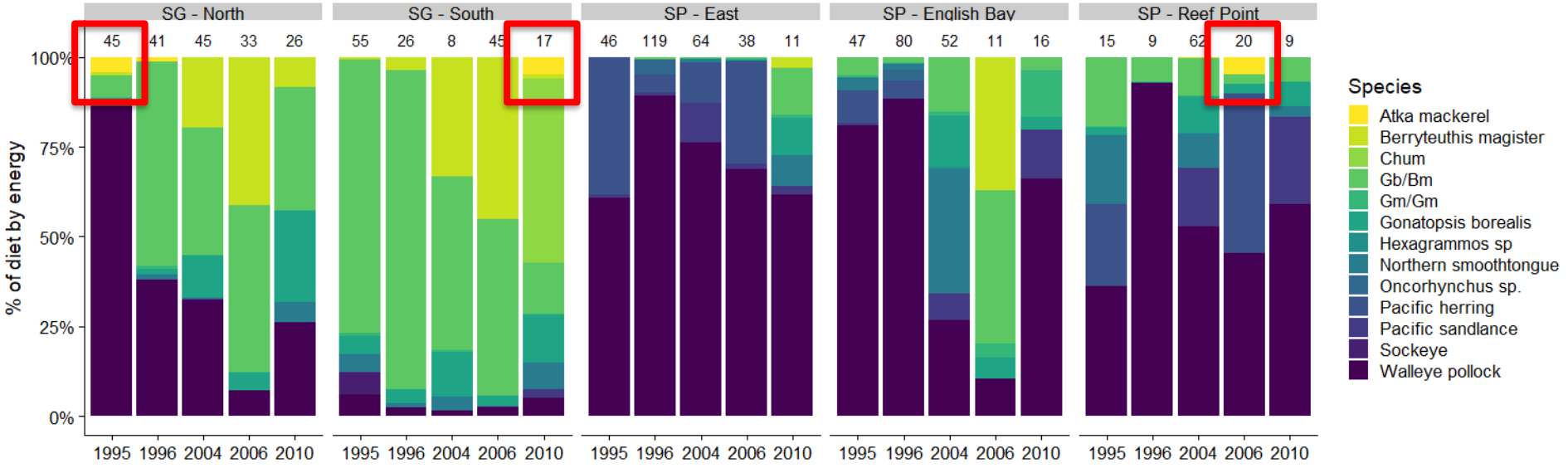


Atka mackerel size distribution (n = 52)



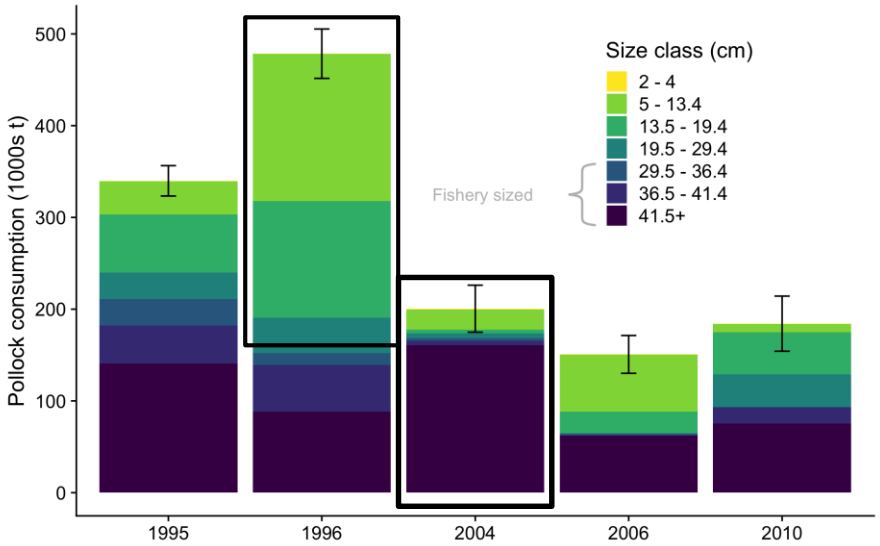
Atka fur seal foraging vs. survey catch

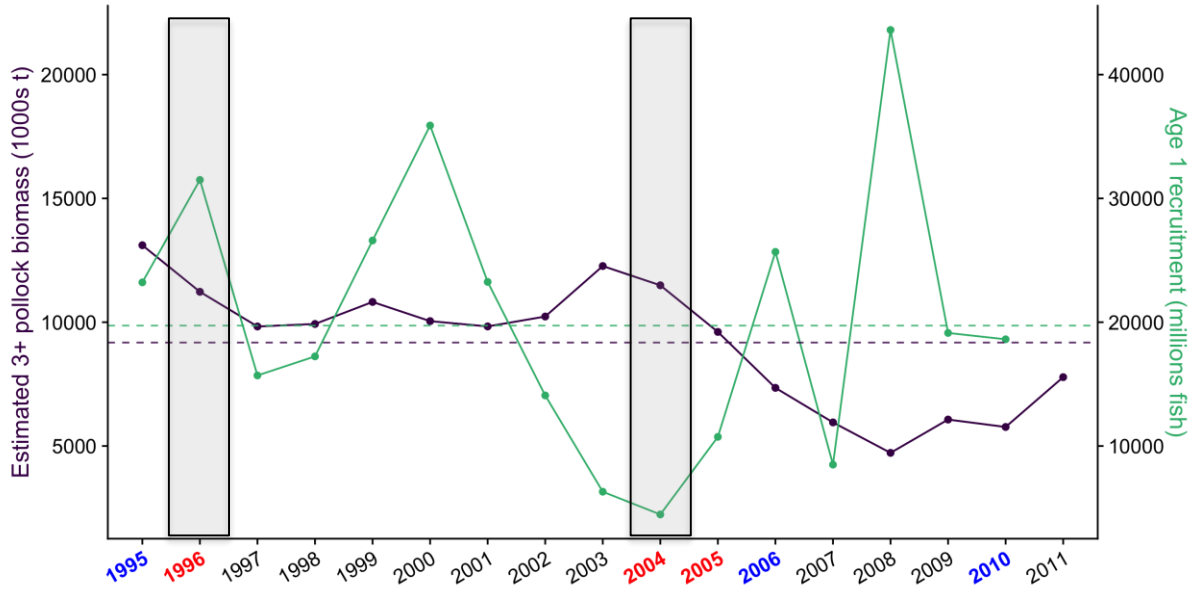




Walleye pollock consumption by size

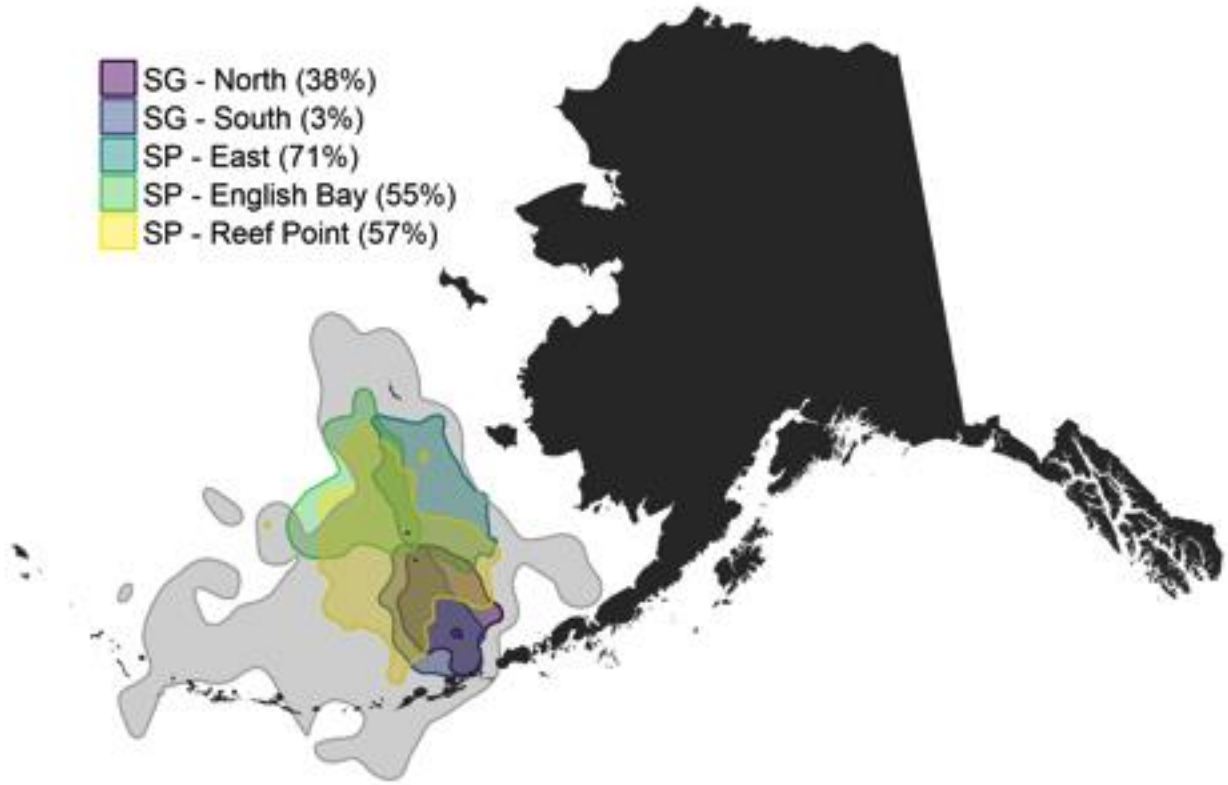
Preliminary results





Average percentage of the diet by energy that is comprised of walleye pollock

Preliminary results

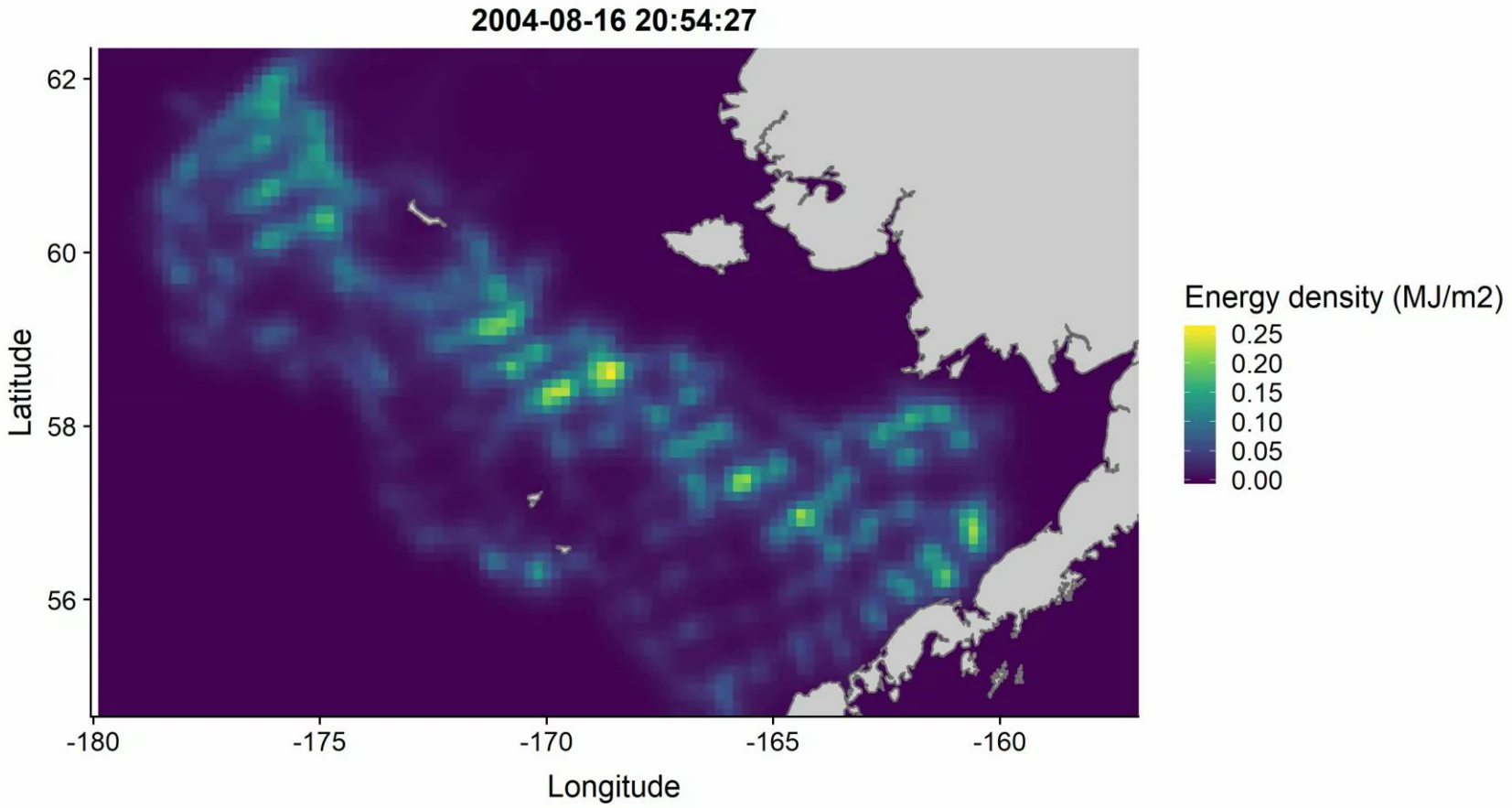


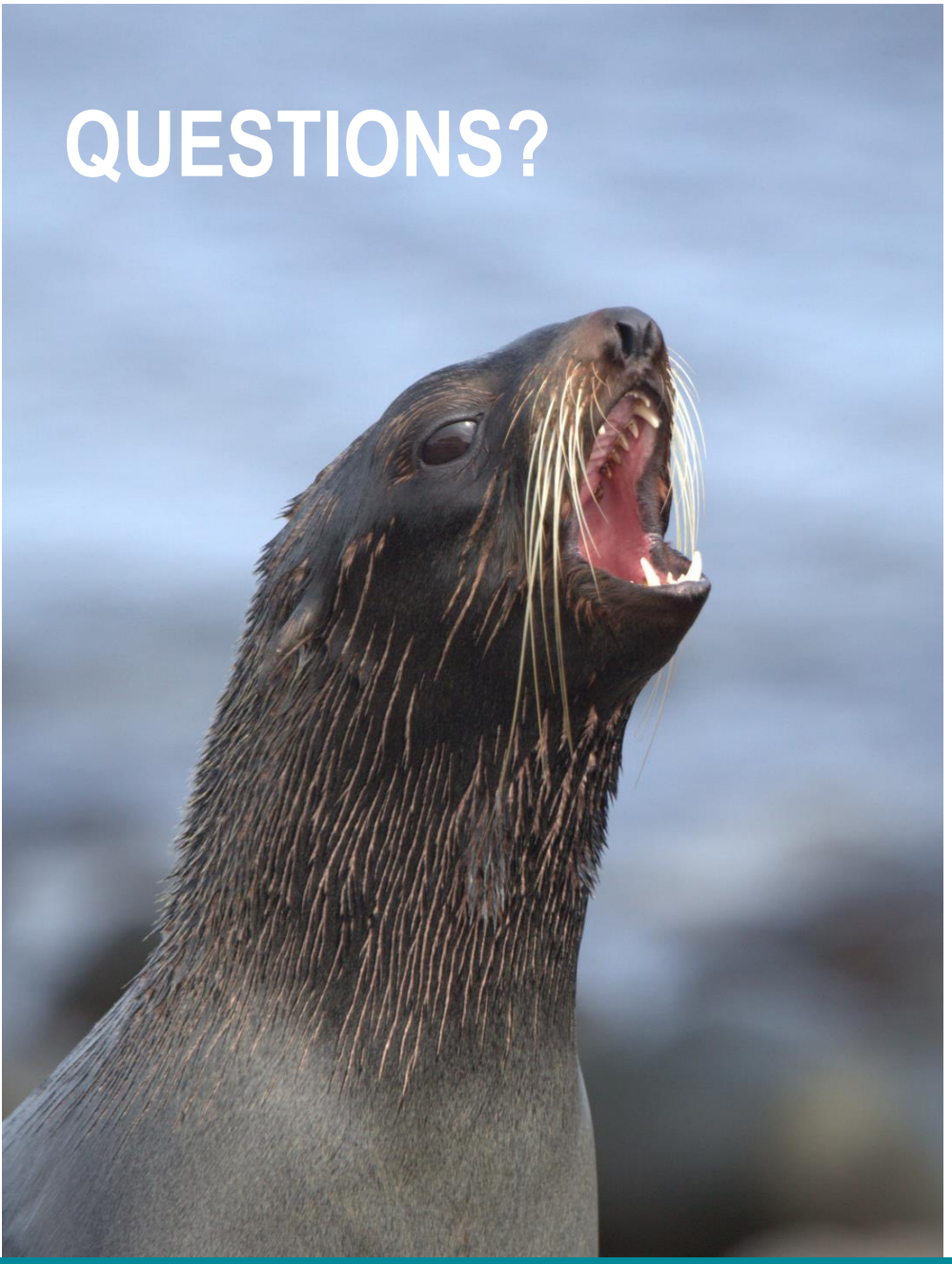
90% UD adult females

Gray = juveniles and sub adult males

Next steps – linking to survey observations and FEAST

FEAST pollock energy density





Funding and support

SAILDRONE

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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

Mordy, C.W., et al. 2017. Advances in ecosystem research: Saildrone surveys oceanography, fish, and marine mammals in the Bering Sea. Oceanography 30(2), https://doi.org/10.5670/oceanog.2017.230.