Acknowledge the Tlingit people upon whose customary lands that my home and office reside.

NOAA FISHERIES

Alaska Fisheries Science Center

2022 Ecosystem Surveys
Bering Sea & Gulf of Alaska

Cross division/agency collaboration focused on ecosystem research to support ecosystem based fisheries management

- Ecosystems and Fisheries-Oceanography Coordinated Investigations (EcoFOCI: PMEL and Recruitment Processes Program), Seattle
- Ecosystem Monitoring and Assessment, Juneau/Seattle
- Recruitment, Energetics & Coastal Assessment, Juneau
- Fisheries Behavioral Ecology, Newport
- Shellfish Assessment Program, Kodiak

Presenters : Rob Suryan, Ellen Yasumiishi, Ali Deary

September 19, 2022

Rob Suryan, PhD (he/him)

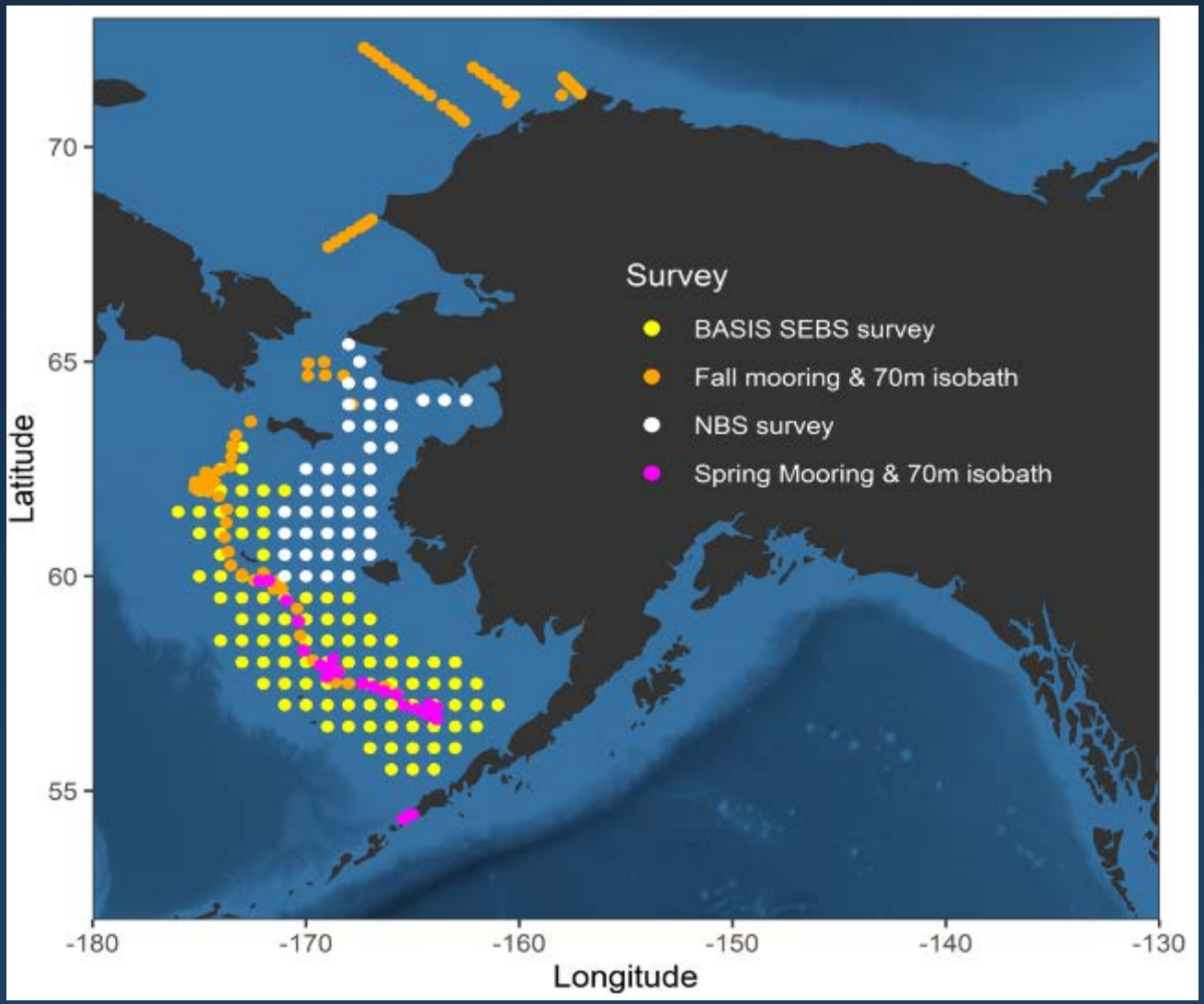
Goal & Objectives

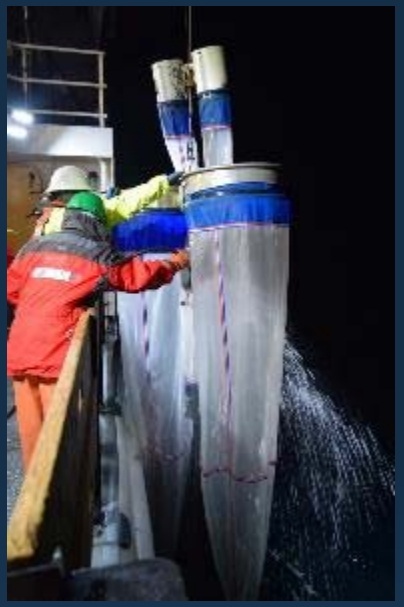
Goal: Provide the most recent information on ecosystem conditions affecting fish recruitment processes.

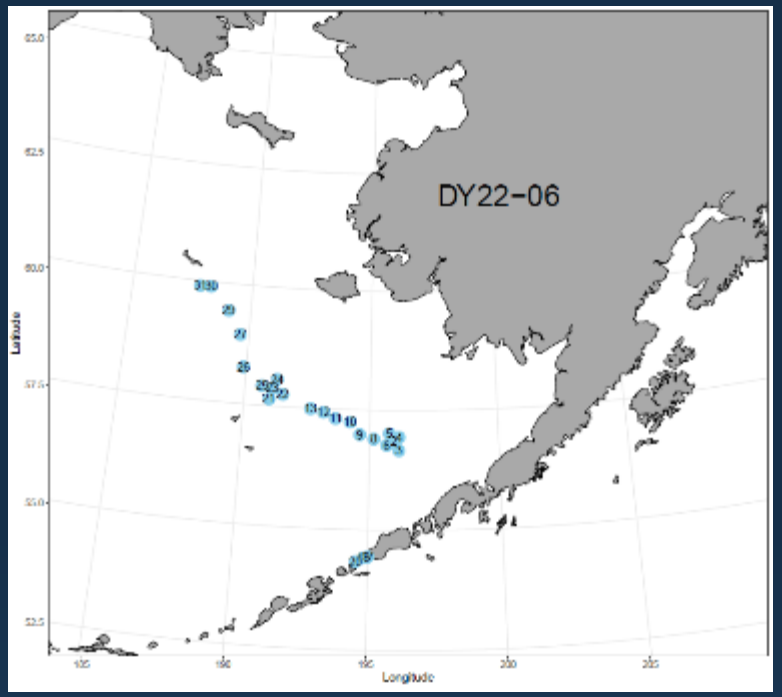
Objectives:

1. Provide an update on 2022 ecosystem surveys.
2. Provide an update on recruitment indicators.
3. Encourage discussions of data/indicators most useful to the Groundfish Plan Teams.

Bering Sea


Survey
BASIS SEBS survey
Fall mooring & 70m isobath
NBS survey
Spring Mooring & 70m isobath
Latitude
70
65
60
55
-180
-170
-160
-150
-140
-130
Longitude





2022 Moorings & 70m Isobath

Focus: Deploy moorings and sample lower trophic levels.

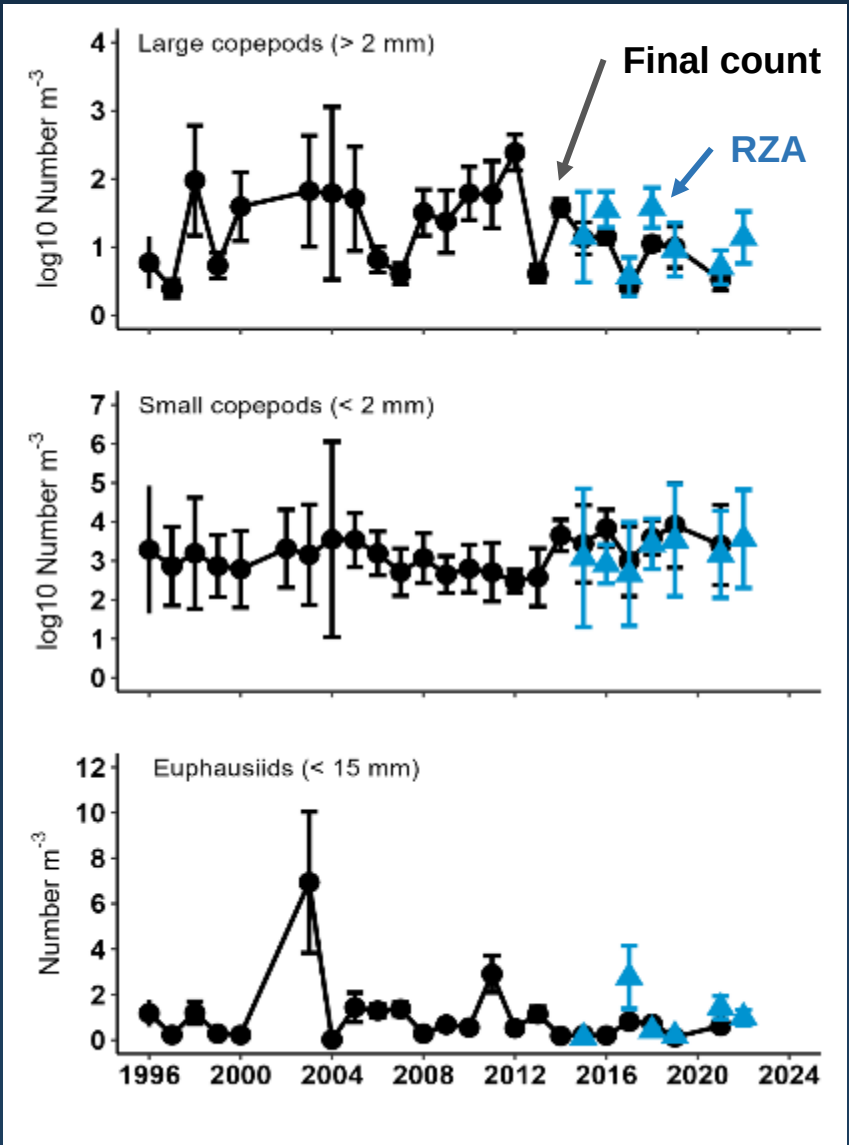
When: Spring and Fall (FALL combined with Distributed Biological Observatory (DBO) Survey)

Operations: Surface, subsurface moorings and instrumentation (incl Prawler), CTDs, Bongos, Pop-up floats.

Indicators: Integrated chlorophyll; temperature, salinity, oxygen, zooplankton.

Contact : Libby Logerwell, Acting PM

Spring - Rapid Zooplankton Assessment



Density

Take home (2022):

Large copepod density

- Still low compared to recent cold period (2006-2011)

Small copepods

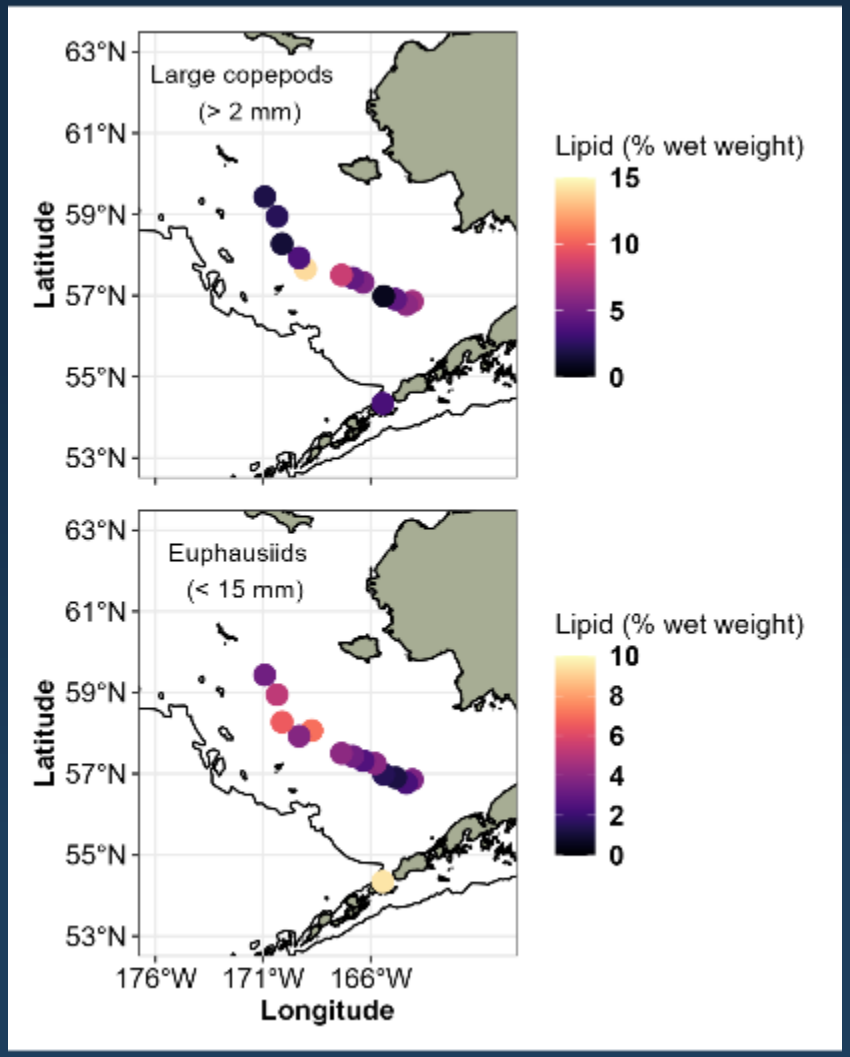
- Still high compared to cold period

Euphausiids

- Slightly higher than recent warm period

Contact : Dave Kimmel

Spring - Zooplankton lipids



Take home (2022)

Large copepods

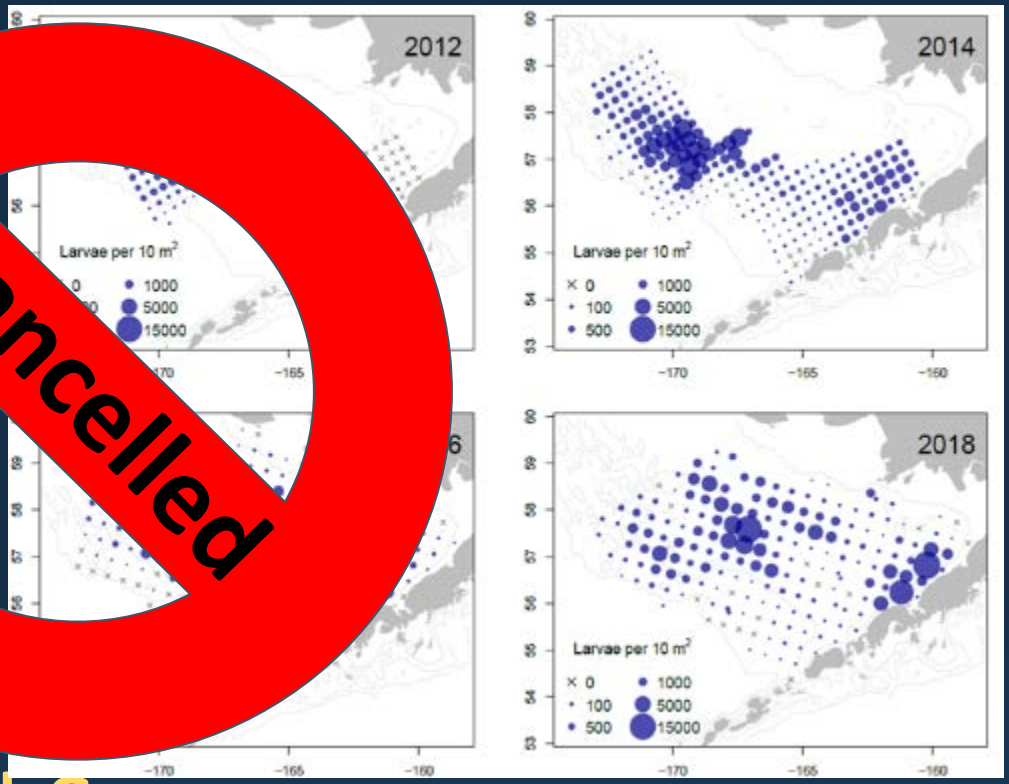
- Low overall, higher is southern stations
- Similar values to last year

Euphausiids

- Higher in northern stations

Lipid time series coming soon

Contact : Cody Pinger



Cancelled

2022 Spring Larval Survey

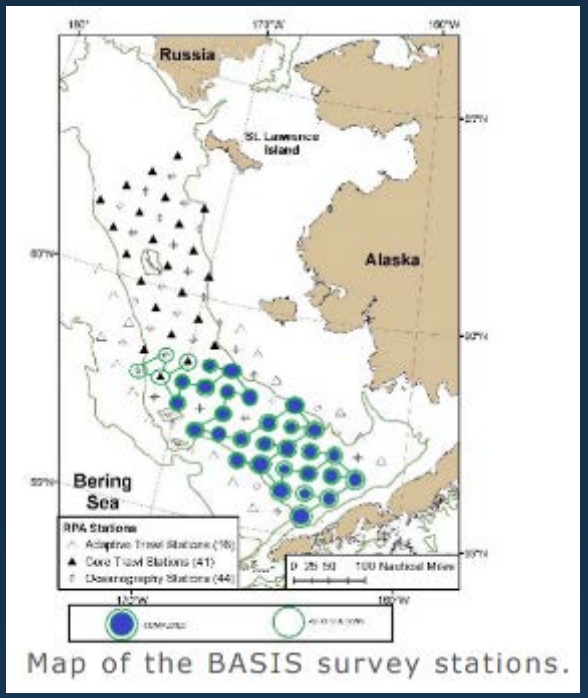
Focus: egg and larval pollock, ATF, sablefish, sand lance, Pacific cod, Arctic cod, saffron cod, crab, zooplankton, phytoplankton

When: Typically mid-May-early June, even years

Operations: CTD, Bongos

Indicators: Abundance, distribution, condition, diets. Integrated chlorophyll; temperature, salinity, oxygen, zooplankton, ichthyoplankton.

Contact : Libby Logerwell, Acting PM



Map of the BASIS survey stations.

2022 BASIS Survey

Focus: Age-0 pollock, juvenile salmon, capelin, herring, ATF sablefish, sand lance, YOY Pacific cod, Arctic cod, saffron cod, crab, zooplankton, phytoplankton

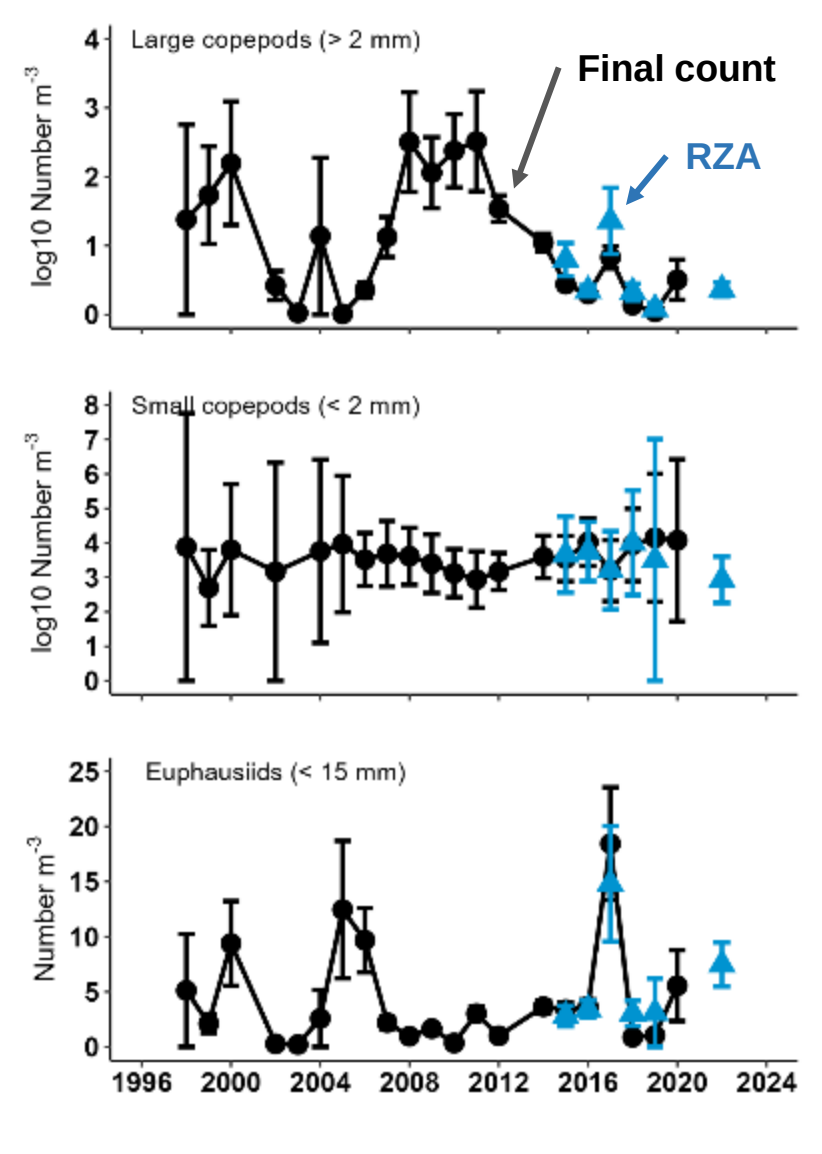
When: August 17- September 11, 2002-2022, excluding 2013, 2017, 2019-2021 spans 21 years

Operations: Phys Ocn, Phyto/Zooplankton, benthic infauna, surface trawl, beam trawl

Indicators: Fish abundance, condition, diets. Integrated chlorophyll; temperature, salinity, oxygen, zooplankton.

Contact : Ed Farley

Fall BASIS - Rapid Zooplankton Assessment



Density

Take home (Fall 2022):

Large copepod density

- Still low compared to recent cold period (2006-2011)

Small copepods

- Low, more similar to recent cold period

Euphausiids

- Slightly higher than recent warm and cold periods

Contact : Dave Kimmel

Fall BASIS Juvenile Fish

Qualitative Assessment - cruise just returned

- Large coccolithophore bloom.
- Large catches of age-0 Atka Mackerel near Pribilof Islands.
- More age-0 Pacific cod than usual.
- Large catches of age-0 pollock
- Large catches of juvenile sockeye, and *Chrysaora melanaster* (age-0 pollock are a major food source for juvenile sockeye salmon during warm years)

Contact : Alex Andrews

2022 North Bering Sea Survey

Focus: YOY Pacific cod, Arctic cod, saffron cod, pollock, juvenile salmon, capelin, herring, ATF sablefish, sand lance, crab, zooplankton, phytoplankton

When: August 27- September 28, 2003-2022, excluding 2008, spans 20 years

Operations: CTD, bongo tows, benthic grabs, surface trawl, beam trawl

Indicators: Growth and consumption model output. Fish abundance, conditions, diets. Salmon forecasting. Crab EFH. HABs. eDNA

*Cruise just finished ahead of Typhoon Merbok

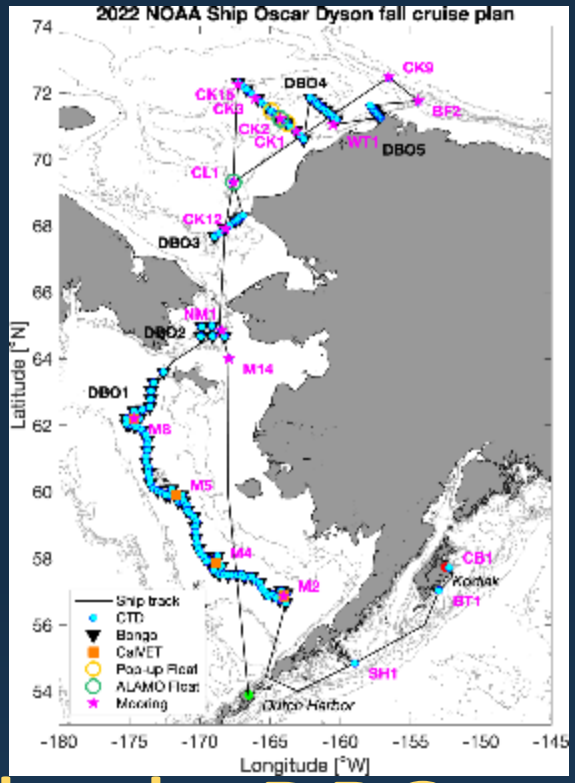
Contact : Ed Farley

2022 NBS survey observations

Qualitative Assessment - cruise just completed

- Herring dominated catches, age-0 herring atypically large
- Capelin catches up from previous years
- Jellyfish down considerably from previous years
- Salmon catches atypical, mostly in northern stations, juv chum and pink were very low

Contact : Jim Murphy



Fall mooring, 70m isobath, DBO survey

Focus: Deploy moorings and sample lower trophic levels.

When: late Summer, early Fall; two surveys merged

Operations: SE Bering Sea mooring operations moved to a charter (survey complete), deploy/retrieve Arctic moorings and instrumentation, CTDs, Bongos.

Indicators: Integrated chlorophyll; temperature, salinity, oxygen, zooplankton.

Cruise Departing Soon

Contact: Libby Logerwell

2022 Bering Sea summary

SE Bering Sea Zooplankton

- Typical warm year conditions of fewer large copepods, more smaller copepods (spring only). Increased euphausiids.

SE Bering Sea Juvenile Fish

- Typical warm year conditions of large catches age-0 pollock, juvenile sockeye. Unusual occurrences of age-0 Pacific cod.

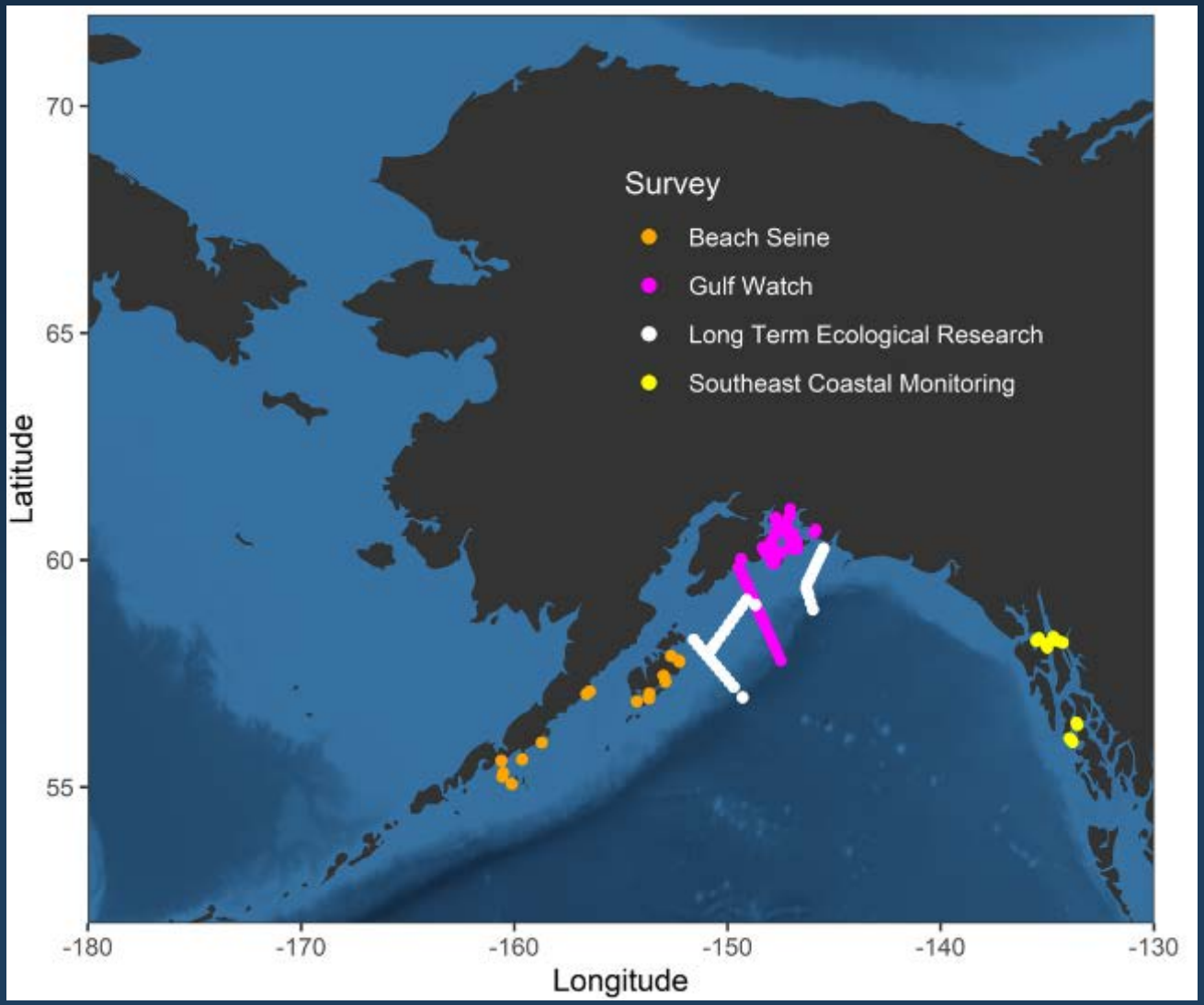
Northern Bering Sea Juvenile Fish

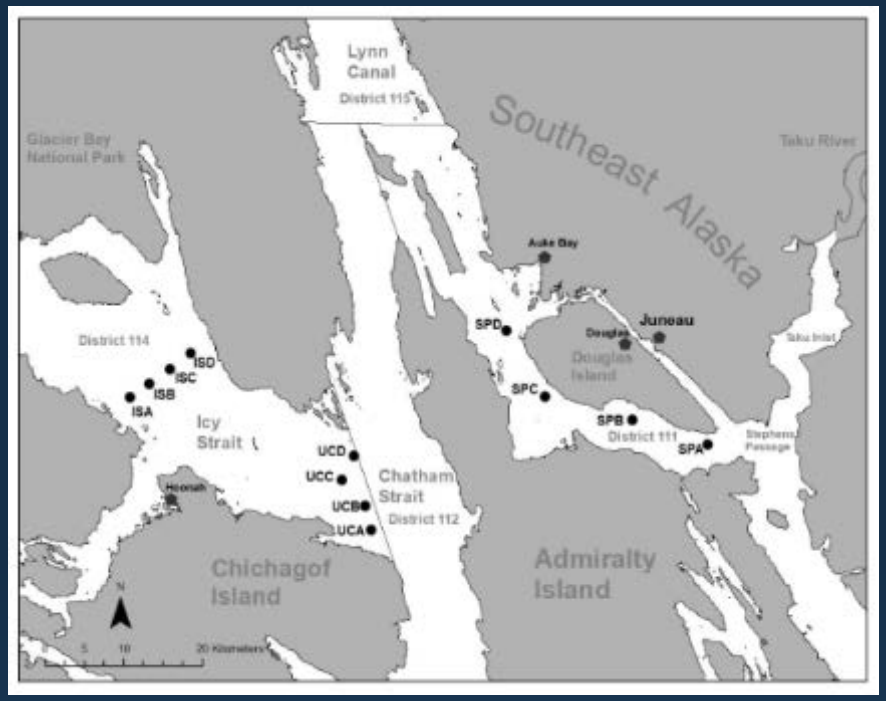
- Increased forage fishes of herring and capelin, salmon appeared shifted north, pink and chum very low

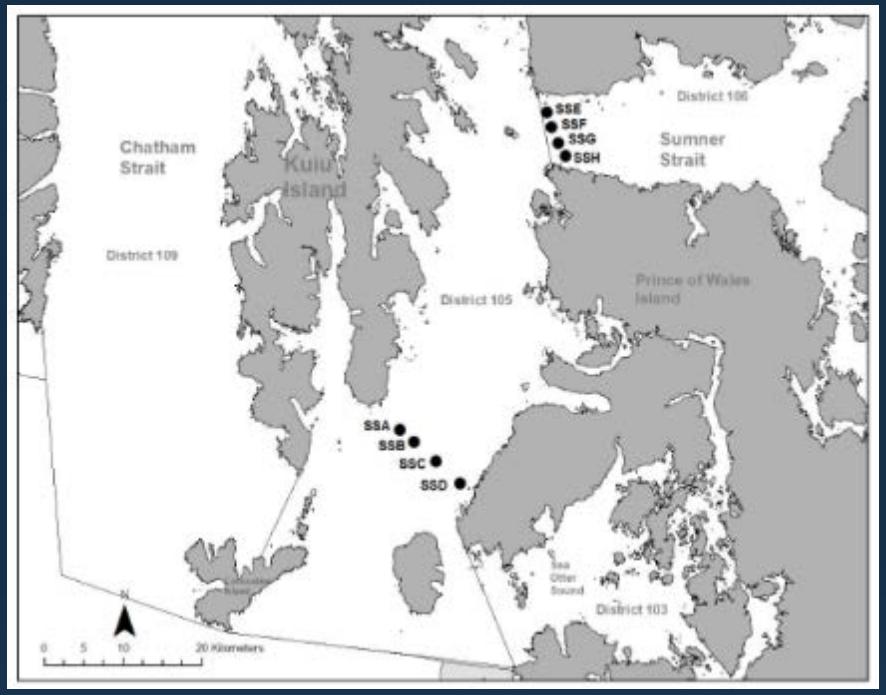
Fish Condition

- Metrics will assess if resources are limited and potentially affecting survival

Gulf of Alaska







EGOA Southeast Coastal Monitoring

Focus: Juvenile salmon, YOY gadids (Pacific cod, saffron cod, pollock), sablefish

When: 1 day in May, June 13-August 6, 2022. 1997-2022, 26 years

Where: Northern SEAK expanded to southern SEAK

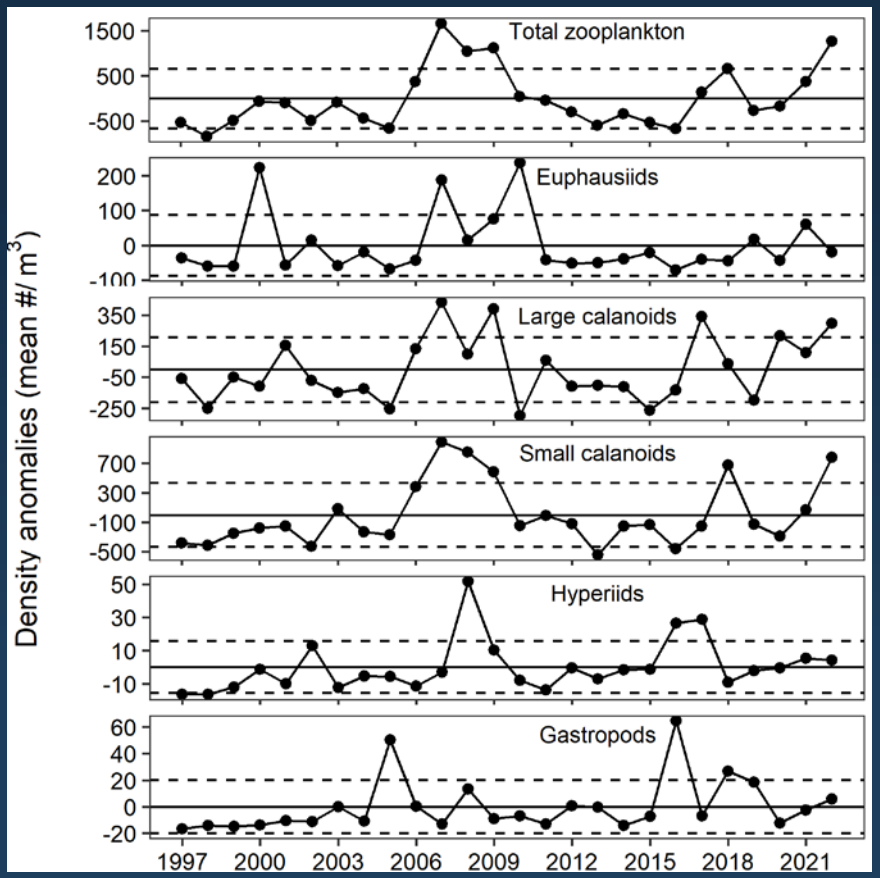
Operations: Surface trawl, CTD, zooplankton/phytoplankton

Indicators: Onshore-offshore gradient of juvenile gadid growth and energetics. Feeding ecology of southern coastal age-0 groundfish, HABs

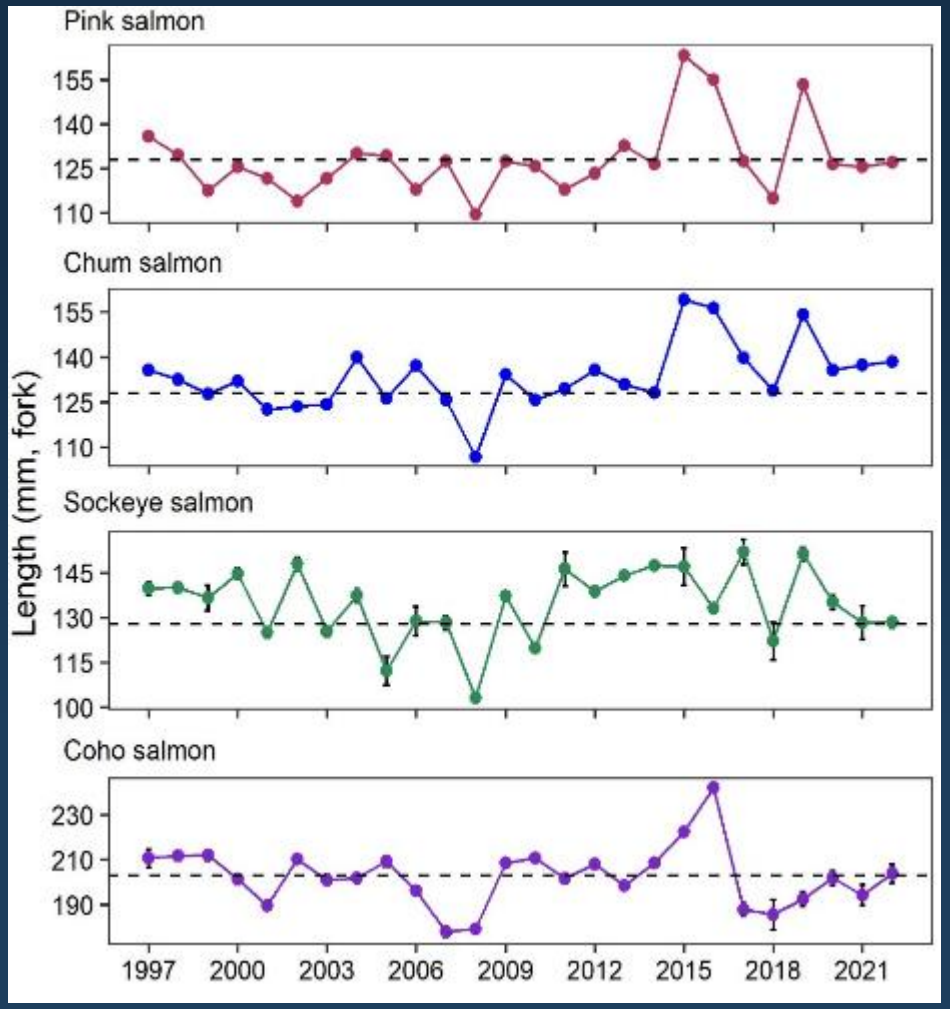
Contact: Andrew Gray

SECM 2022 observations

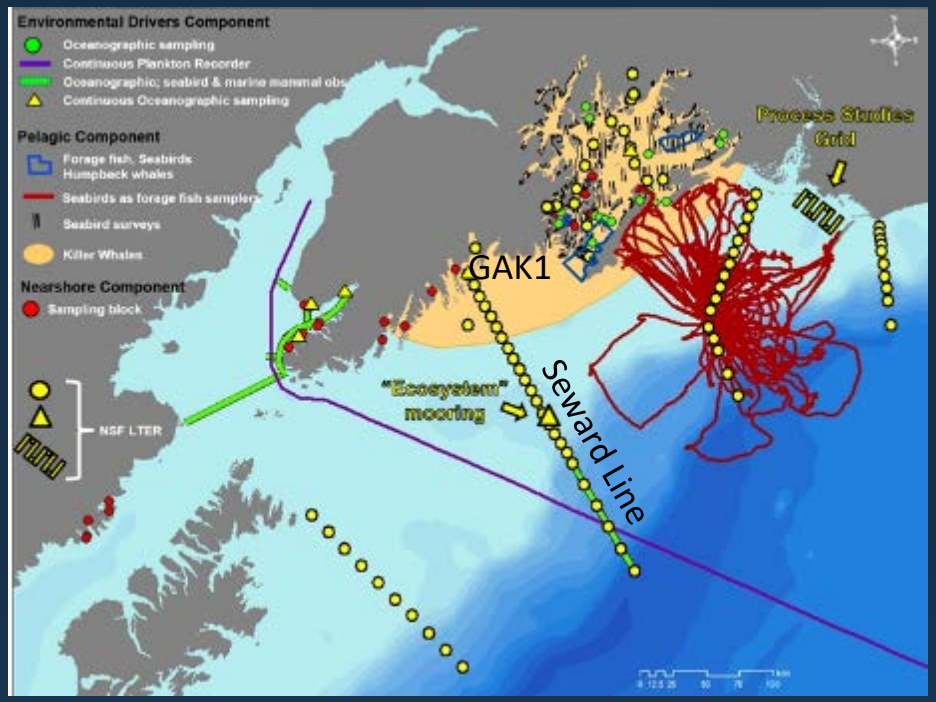
- Copepod density above average, Euphausiids at or below



- Juvenile salmon average size, except chum slightly above average.



Contacts: Wes Strasburger, Emily Fergusson, Andrew Gray



Gulf Watch & LTER surveys

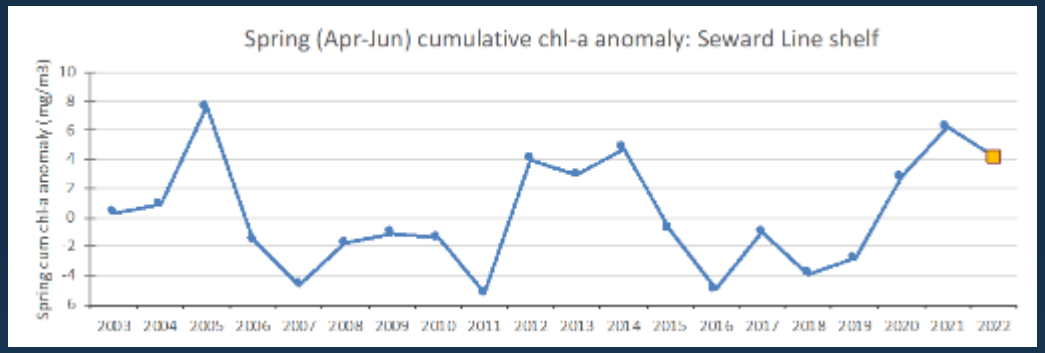
Gulf Watch Alaska is the long-term ecosystem research and monitoring program of the *Exxon Valdez* Oil Spill Trustee Council to understand factors affecting recovery of resources affected by the 1989 oil spill.

The Northern Gulf of Alaska Long-term Ecosystem Research site is funded by the National Science Foundation to understand processes that drive GOA ecosystem production and foster its resilience

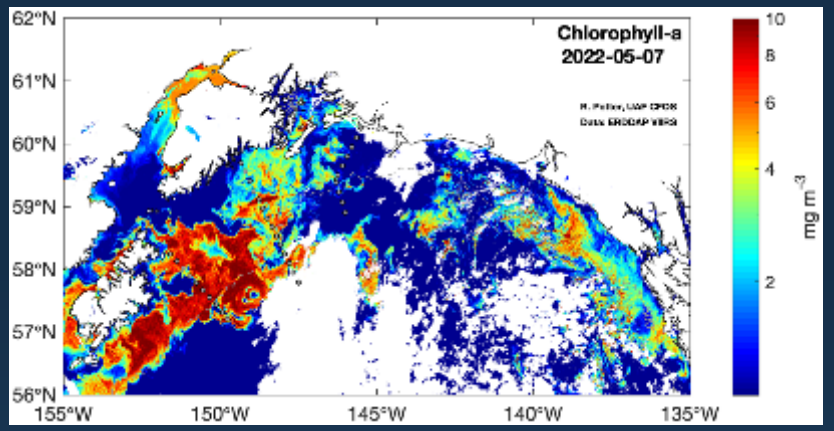
Contact: Rob Suryan

Environmental Drivers

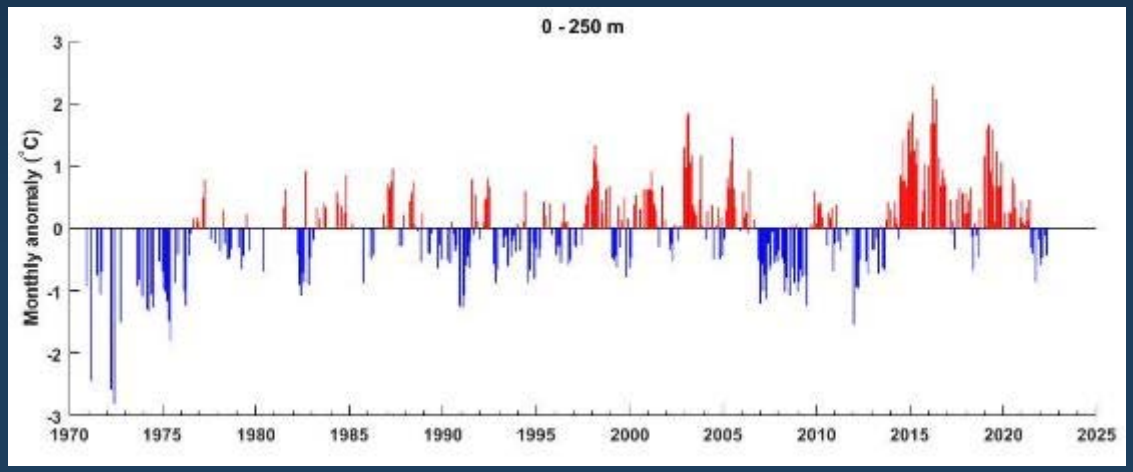
Seward Line
Spring chl-a 2022 - another high chl-a year



Chl-a highest in west (Kodiak line)



GAK1 thru April 2022 - negative anomalies



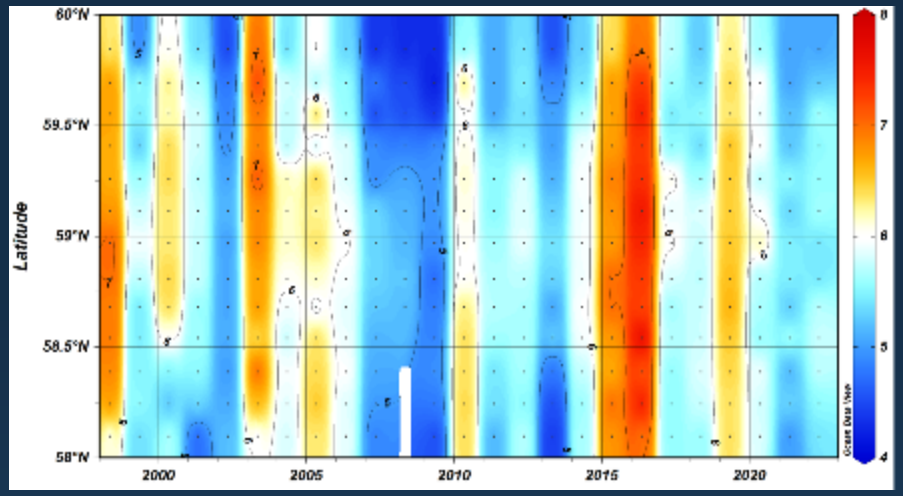
Take home (Spring 2022):

- Highest chl-a was in the west, compared to east in 2021
- Wind mixing pushed chl-a > 100 m deep. Contrast to upper 20 m in 2021.
- High chl-a mostly in large cells (chain diatoms)
- GAK1 temp below average

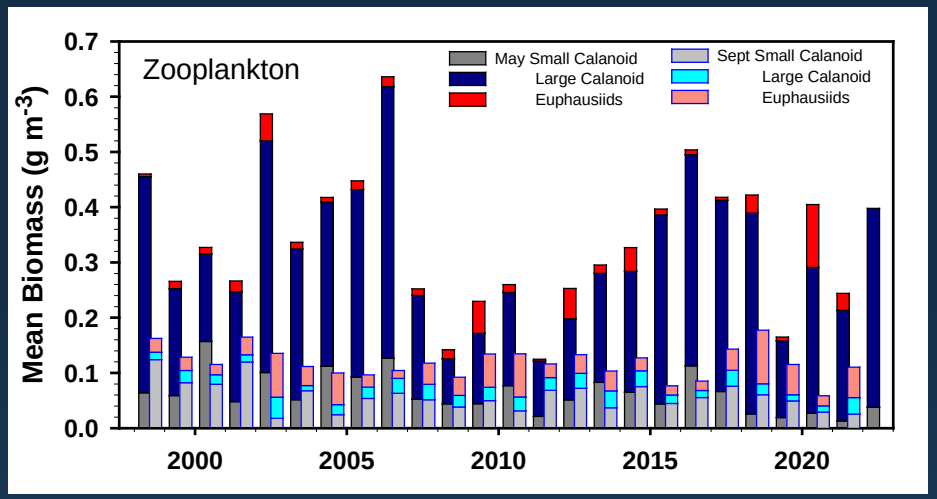
Contributors: Suzanne Strom, Seth Danielson, Russ Hopcroft

Seward Line: May

1998-2022 0-100-m integrated temperatures



1998-2022 0-100-m integrated temperatures



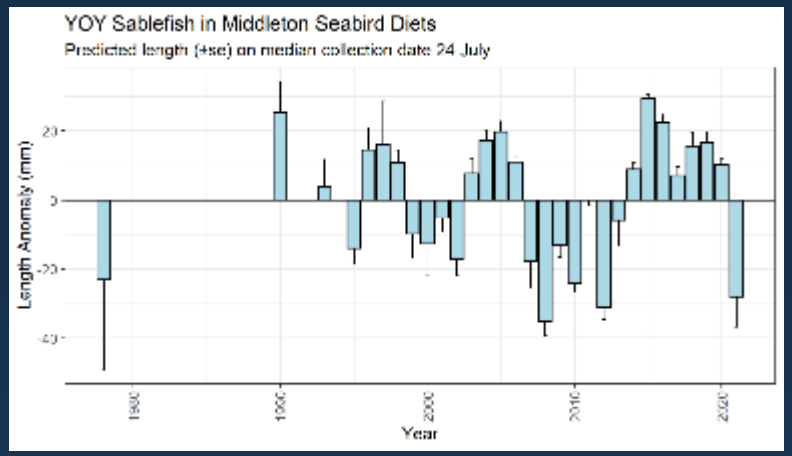
Take home (Spring):

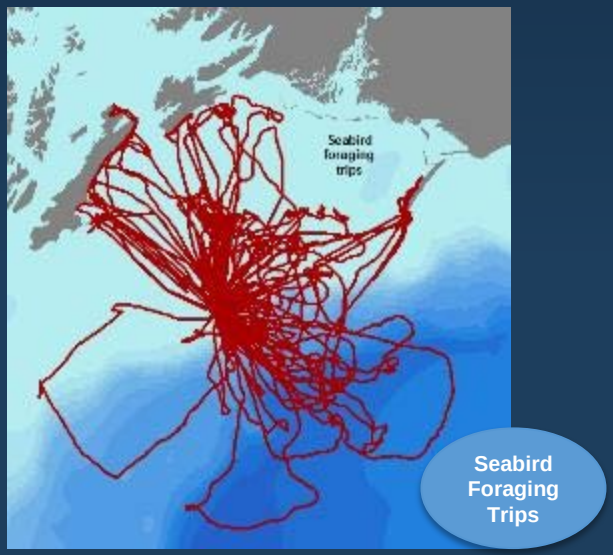
- Cooler 0-100m across and beyond shelf
- Moderate numbers of large copepods
- Euphausiids average in 2021 (not yet counted 2022)

Contact: Russ Hopcroft, Seth Danielson

Prey as indicators

- ↑ age-0 sablefish growth in warm years
- ↓ capelin biomass in warm years – still no return post heatwave





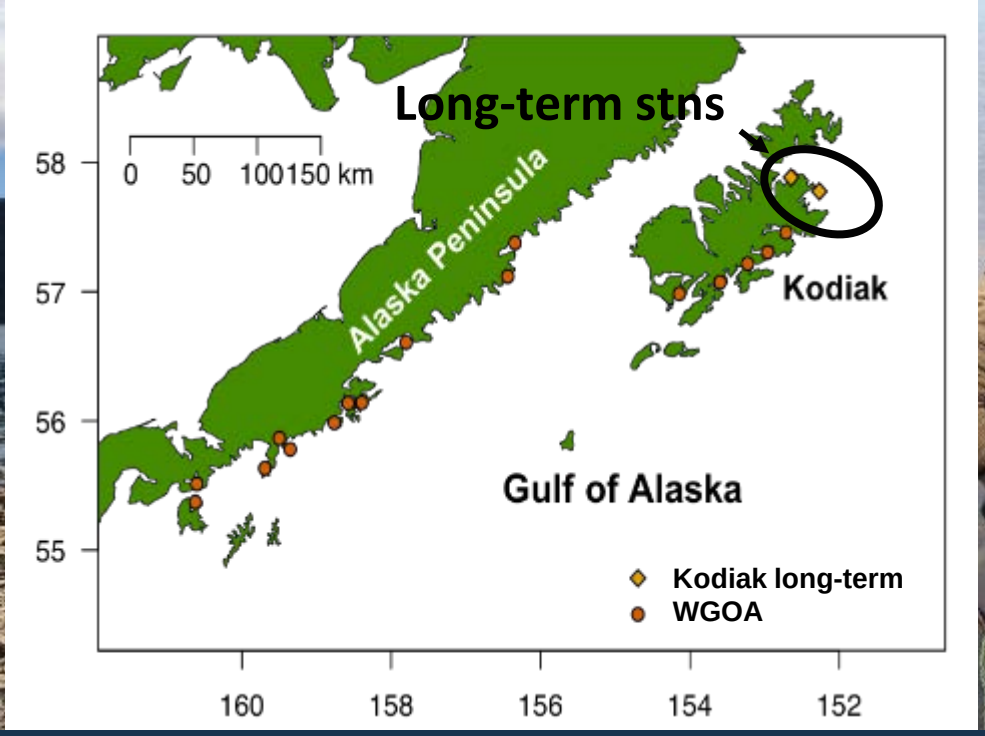
Sablefish:

- 2021: age-0 sablefish size below average. Few sablefish in diets (n=5)
- 2022: many more age-0 sablefish diets (n > 100)

Sand lance & Capelin

- 2022: Positive trend for sand lance, but surprisingly still very few capelin in 2022

Contact: Yumi Arimitsu, Scott Hatch



Western GOA Summer Beach Seine

Focus: YOY gadids (Pacific cod, saffron cod, pollock)

When: **Kodiak:** July/Aug (4 surveys, 16 sites across 2 bays) 2006-2022

Expanded WGOA: July/Aug (75 sites across 14 bays) 2018-2022

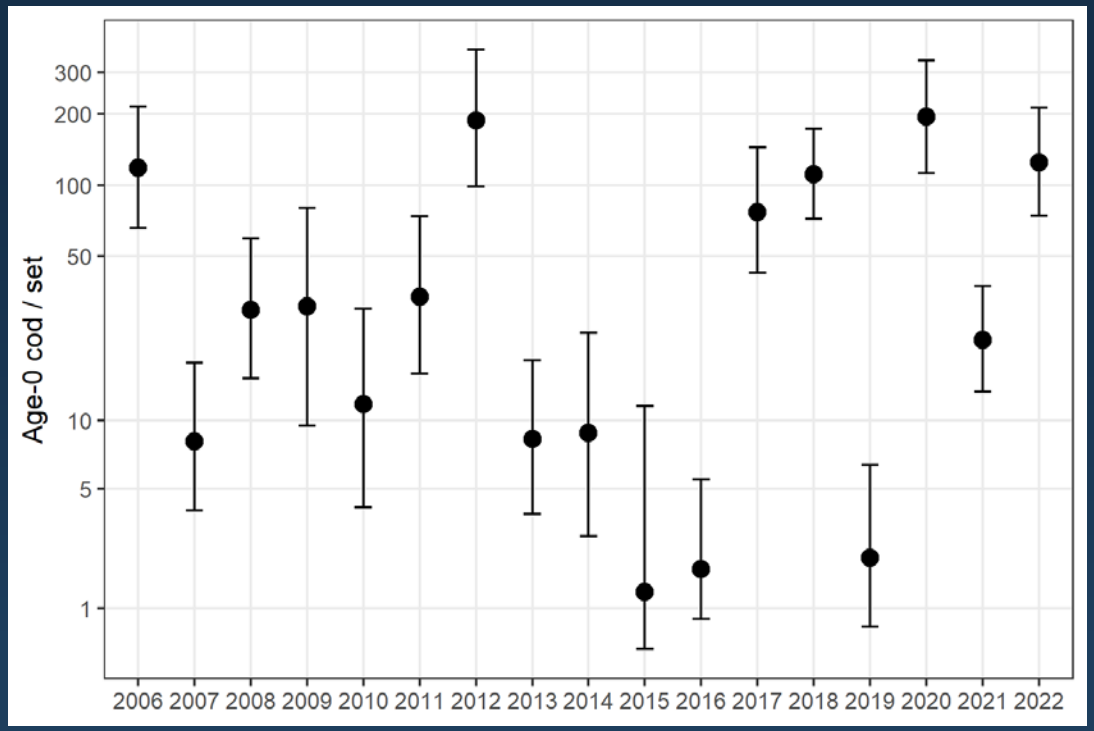
Operations: Beach seine, CTD, baited cameras

Indicators: abundance & size, genetics, diets, temperature, salinity, oxygen

Contact : Ben Laurel, Mike Litzow, Alisa Abookire

Age-0 Pacific cod (Kodiak and WGOA survey combined)

Estimated beach seine CPUE
Posterior means with 95% CI



- Combined data from 2 Kodiak bays (2006-2022) and 13 western GOA bays (2018-2022)
- Year-class strength estimated from zero-inflated negative binomial Bayesian regression model

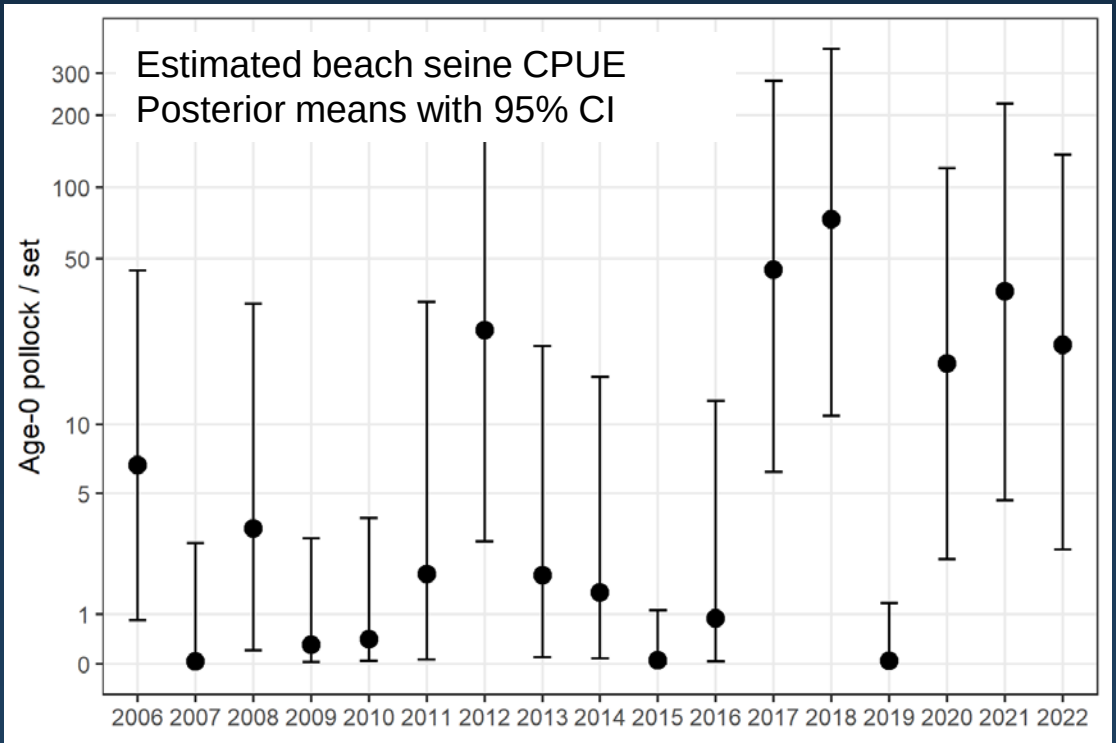
Take home: 2022 Age-0 Pacific cod abundance significantly higher than long-term *log* mean.

Code and data: github.com/mikelitzow/seine-data

Litzow, M.A., Malick, M.J., Abookire, A.A., Duffy-Anderson, J., Laurel, B.J., Ressler, P.H., Rogers, L.A. (2021) Climate attribution statistics inform judgments about changing fisheries sustainability. Scientific Reports 11, 23924. https://doi.org/10.1038/s41598-021-03405-6

Contact: Ben Laurel, Mike Litzow, Alisa Abookire

Age-0 Pollock (Kodiak and WGOA survey combined)



- Combined data from 2 Kodiak bays (2006-2022) and 4 AK Peninsula bays (2018-2022)
- Survey has captured strong year-classes of pollock.
- Greater uncertainty than cod seine results

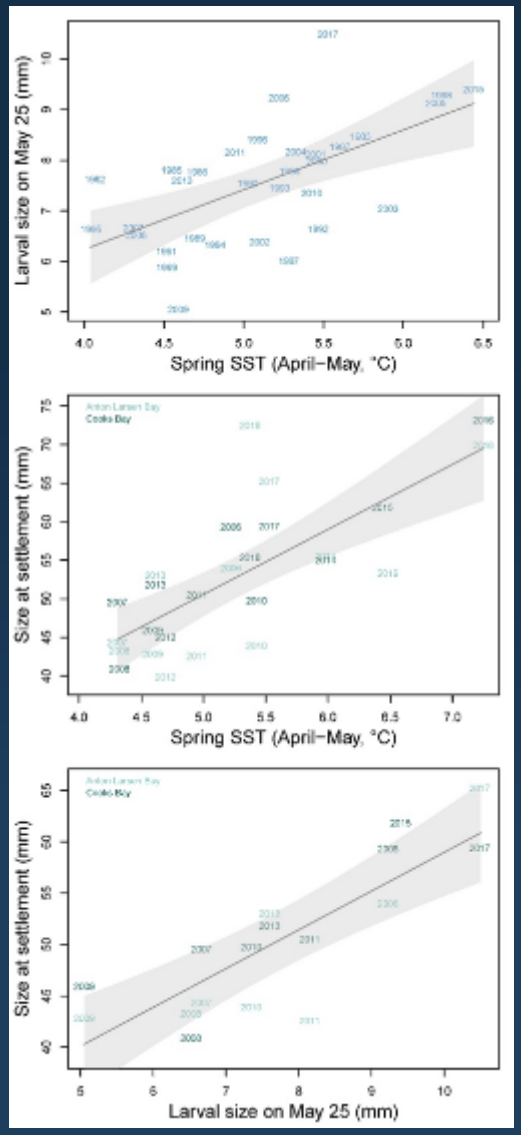
Take home: 2022 age-0 abundance relatively high, but spatially variable. High uncertainty.

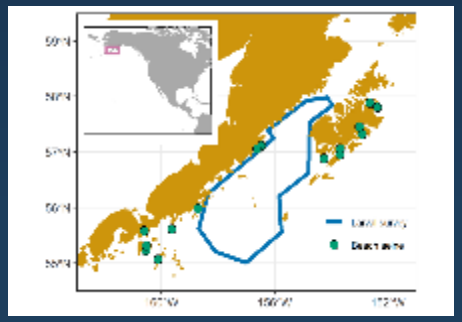
github.com/mikelitzow/seine-data

Litzow, M.A., Malick, M.J., Abookire, A.A., Duffy-Anderson, J., Laurel, B.J., Ressler, P.H., Rogers, L.A. (2021) Climate attribution statistics inform judgments about changing fisheries sustainability. Scientific Reports 11, 23924. https://doi.org/10.1038/s41598-021-03405-6

Contact: Ben Laurel, Mike Litzow, Alisa Abookire

Pacific cod pre-recruits are getting larger with warming





Earlier spawning and increased growth are leading to larger larvae and juveniles in CGOA and WGOA (Almeida et al. in prep)

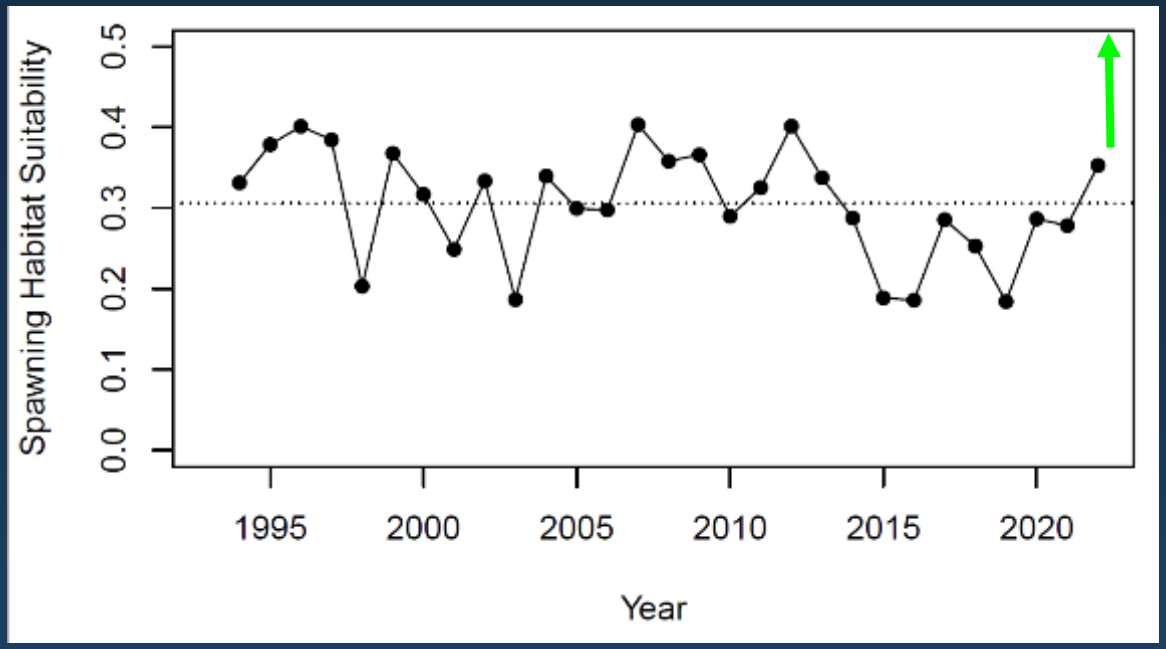
Take home:

Carry-over effects into older classes are likely but unknown e.g., overwintering survival, size-at-age, maturity schedules, etc.

Laurel, B.J., Abookire, A., Barbeaux, S., Almeida, Z., Copeman, L.A., Duffy-Anderson, J., Hurst, T.P., Litzow, M., Kristiansen, T., Miller, J.A., Palsson, W., Rooney, S., Thalmann, H., Rogers, L.A. (in revision) Towards a recruitment paradigm for Pacific cod in the Anthropocene: an early life history perspective under changing thermal habitats. Fish and Fisheries

Climate-driven changes to Pacific cod spawning habitat in the Gulf of Alaska

Use GAK1 data coupled with an experimentally-derived relationship between temperature and hatch success to understand how suitable spawning habitat varies across space and time



[Optimal bottom temperatures: 3 - 6 °C]

Take home: Increase in suitable spawning habitat for Pacific Cod in 2022

→ Developing indicators for ESPs, inform risk tables
→ Future projections of changes in timing and location of spawning

Lauren Rogers & Ben Laurel

Gulf of Alaska summary

Zooplankton

- Cool conditions of more large copepods, but also more smaller copepods. Average or fewer euphausiids.

Juvenile Fish

- Gadids: More age-0 Pacific cod and age-0 pollock
- P. cod above average spawning habitat suitability
- Salmon: Average size, except Chum (larger) – SE Alaska
- Sablefish: 2021 age-0 fish are were small (birds and LTER trawls). 2022 fish were more prevalent in seabird diets at Middleton Island

Fish Condition

- Condition metrics and additional studies will assess if larger fish have greater survival potential

Highlighted projects

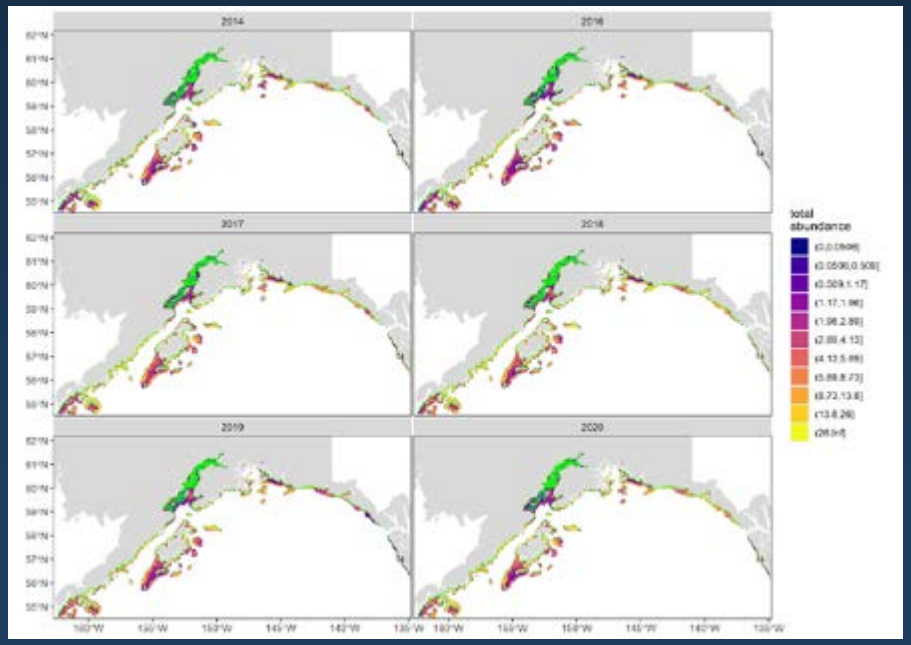
- Predicting gadid year-class strength from larval and age-0 surveys
- Climate-driven changes to Pacific cod spawning habitat
- Starvation resiliency and temperature-dependent growth of Sablefish larvae

Contact : Ed Farley, Libby Logerwell, Rob Suryan, Tom Hurst

Validating a biophysical Individual Based Model of juvenile Pacific cod settlement, growth & survival in the GOA

NPRB Project 1806

OBJECTIVE: Validate a biophysical IBM for Pacific cod in the Gulf of Alaska using field data of settled YOY and age-1 juveniles.



Annual spatial distributions indicating successful settlement in suitable nursery habitat

Take home: Age-at-settlement (simulated) was ~ 5.3 days shorter in heatwave years due to faster growth. Correlation between and the IBM and field data was strongest for age-1 cod (0.71, R^2= 0.46, p< 0.005)

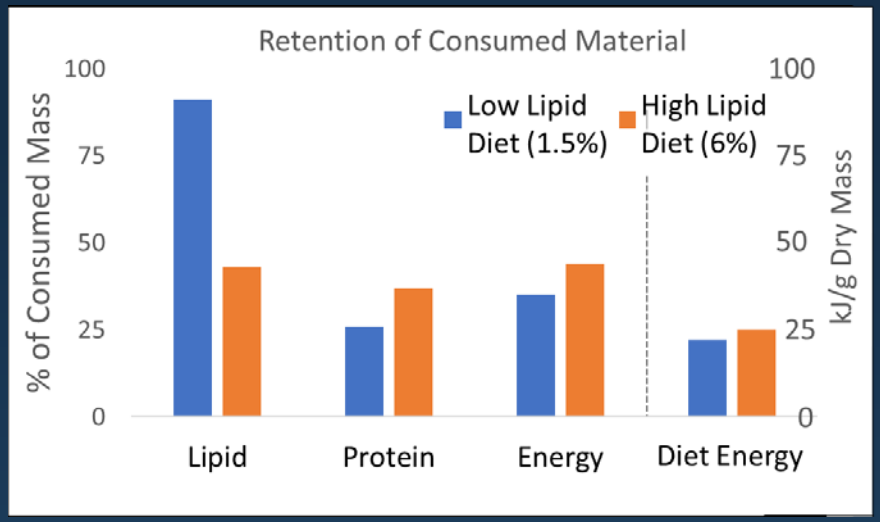
William Stockhausen, Katharine Miller, Johanna Page, Ken Coyle, Al Herman, Darcie Neff, David Hill, Karen Endres

Young-of-the-year Pacific cod growth and survival under heatwave conditions

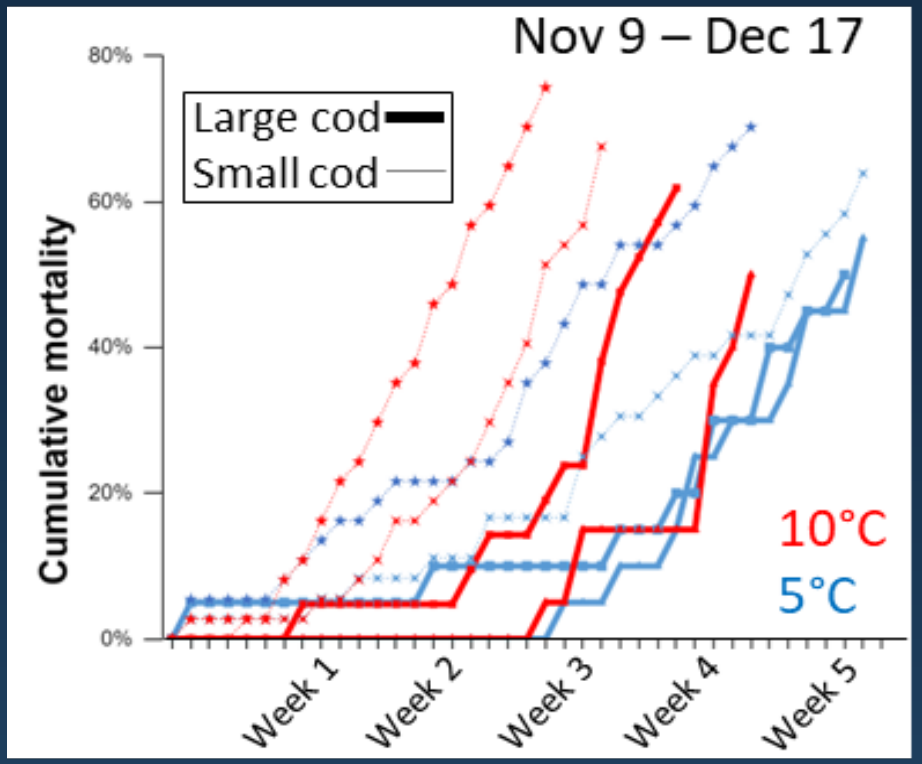
SUMMER GROWTH AND BODY CONDITION:

- Elevated temperature
- Changes to zooplankton communities

→ reduced lipid levels in preyfield



WINTER FASTING AND ENERGY USE:



Cod consuming low-lipid heatwave diet:

1. Incurred low trophic transfer efficiency
2. Catabolized protein to meet energy needs (high lipid used lipid from diet)
3. Did not amass lipid stores (high lipid doubled their lipid content)

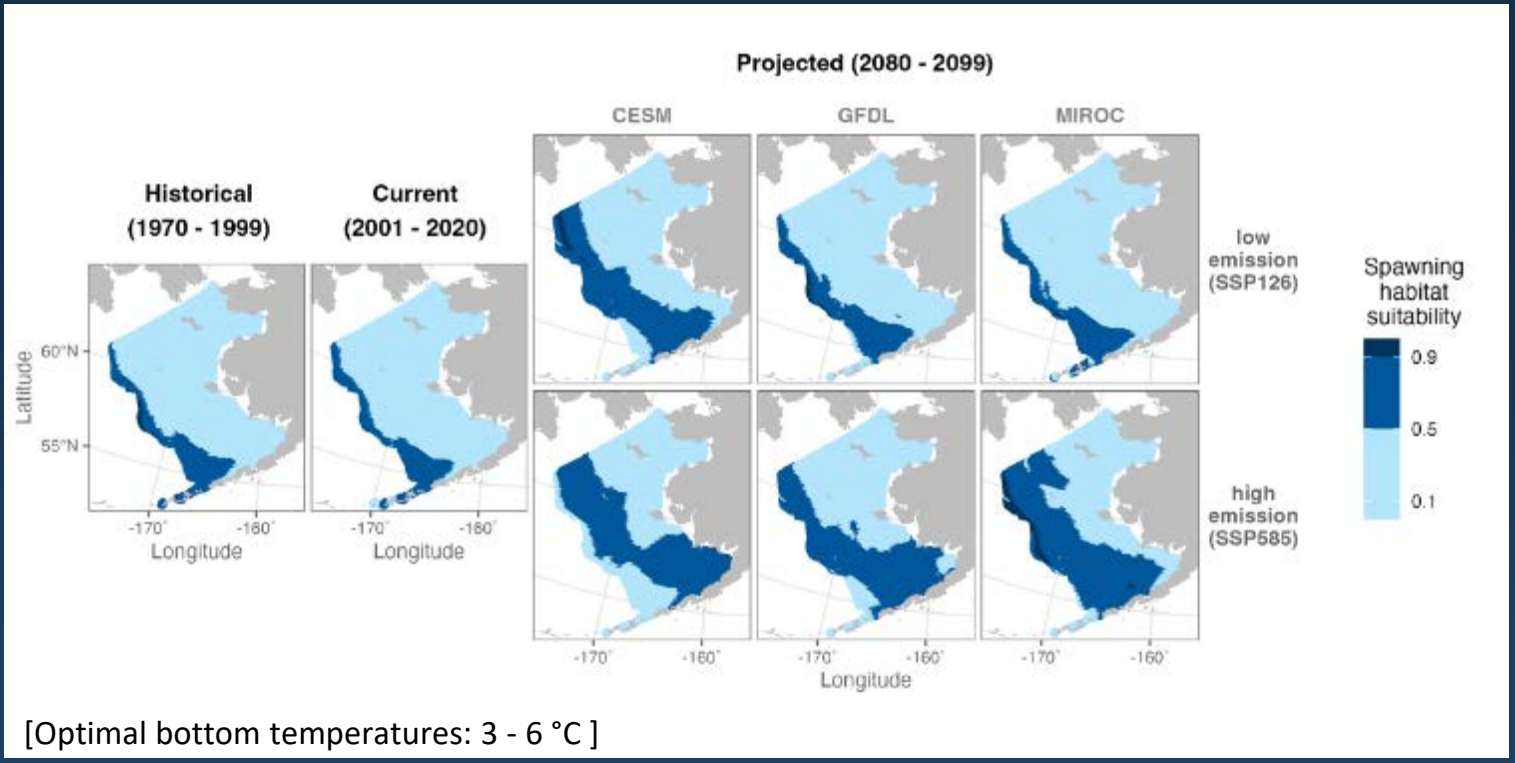
Accelerated starvation from:

1. Small size
2. Low lipid content
2. Warm temperatures

Ron Heintz, Ashwin Sreenivasan, Johanna Page, Fletcher Sewall, Matt Rogers, Katharine Miller

Climate-driven changes to Pacific cod spawning habitat in the Bering Sea

Coupling the Bering 10K ROMS model bottom temperature hindcasts and projections with an experimentally-derived relationship between temperature and hatch success to understand how suitable spawning habitat varies across space and time



[Optimal bottom temperatures: 3 - 6 °C]

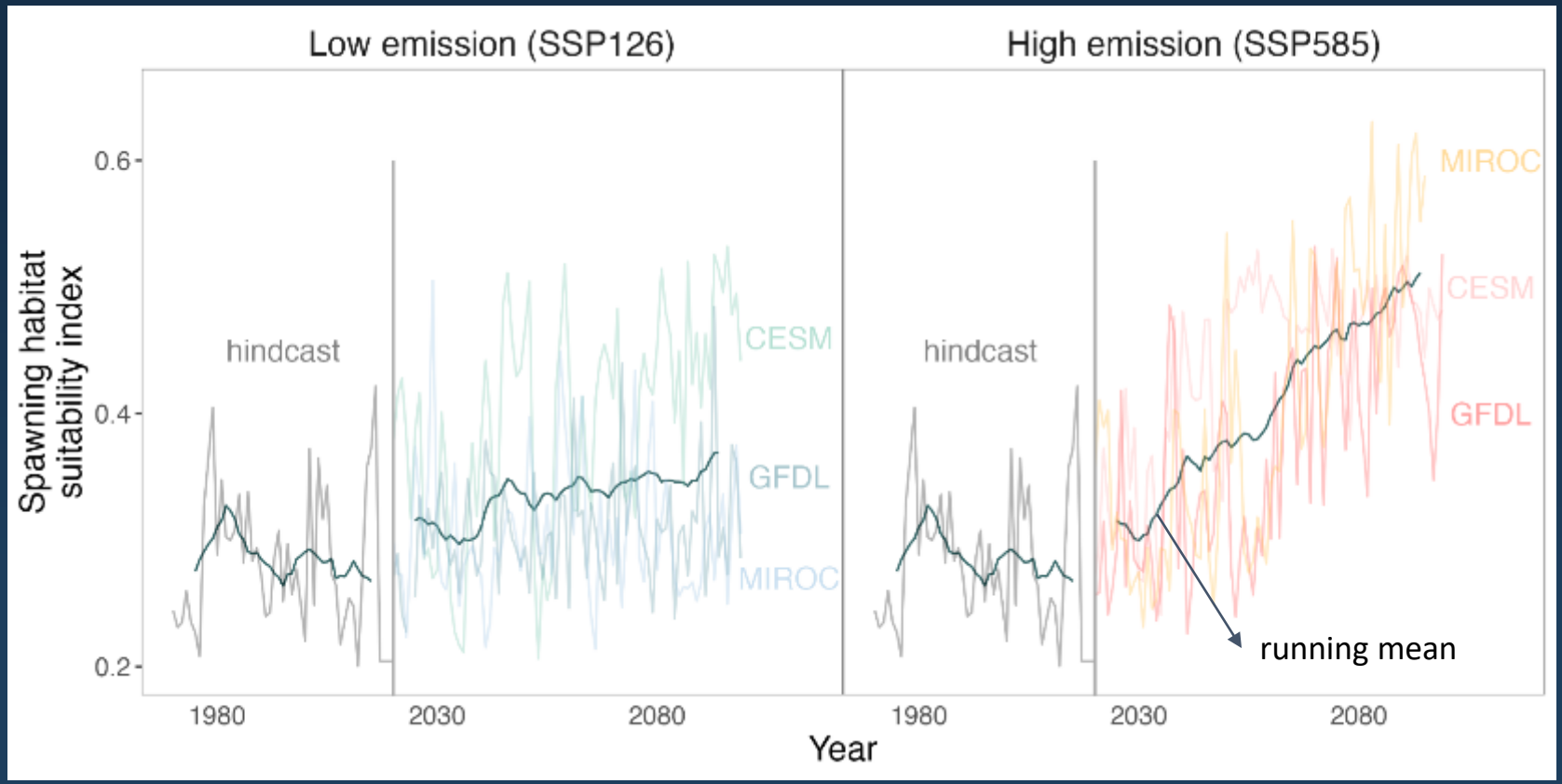
→ Developing indicators for ESPs, inform risk tables

→ Future projections of changes in timing and location of spawning

Jennifer Bigman, Lauren Rogers, Ben Laurel, Kirstin Holsman, Kelly Kearney, Al Hermann, Wei Cheng

Climate-driven changes to Pacific cod spawning habitat in the Bering Sea

Coupling the Bering 10K ROMS model bottom temperature hindcasts and projections with an experimentally-derived relationship between temperature and hatch success to understand how suitable spawning habitat varies across space and time



Jennifer Bigman, Lauren Rogers, Ben Laurel, Kirstin Holsman, Kelly Kearney, Al Hermann, Wei Cheng

Starvation resiliency and temperature-dependent growth of Sablefish larvae

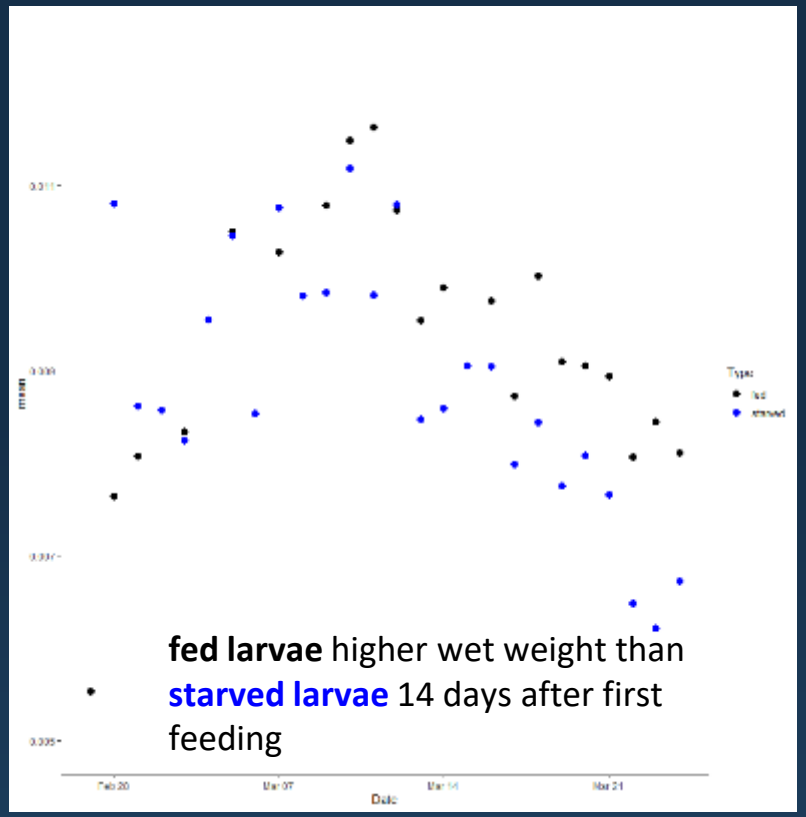
NPRB-funded lab study to examine factors that influence early survival

Focused on two factors-

1. Prey Availability
2. Temperature

FY2023 Plans- Repeat starvation resiliency experiment at higher temperature

Take Home- Analyses ongoing; Point of no return ~16 days after first feeding



fed larvae higher wet weight than **starved larvae** 14 days after first feeding

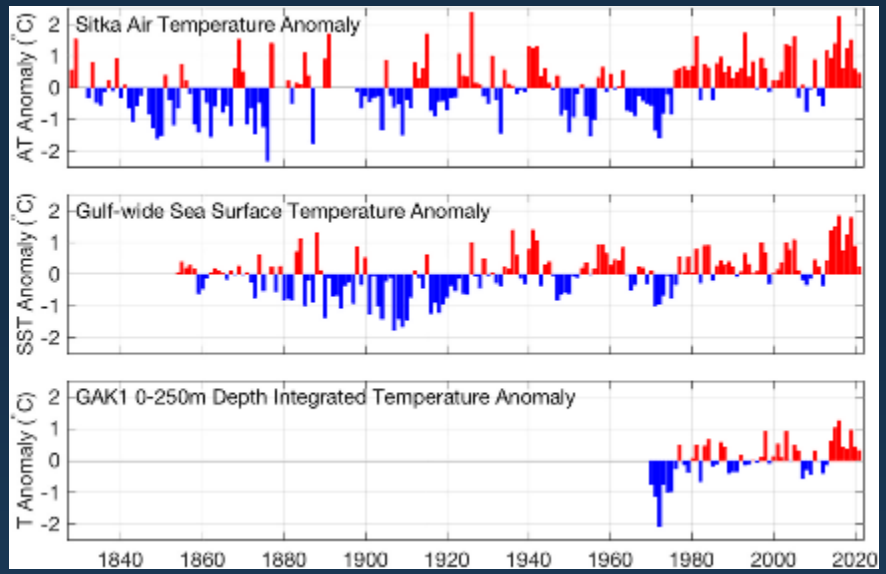
Ali Deary, Tom Hurst, Steve Porter, Kelia Axler, Jenna Barrett

Temperature Variation in the GOA - synoptic to century-long time scales

Warming Pattern

GOA-wide annual average SST since the start of the recent Pacific Marine Heatwave (2014–2021) has been:

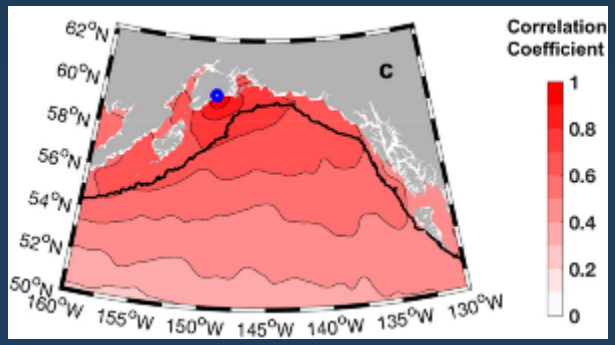
- *1.20℃ above the long-term mean*
- *2.03℃ warmer than the first decade of the 1900s*
- *2.19℃ warmer than the mean of 1970–1976*



*****Predictive Potential*****

GAK1 water column mean temperature anomalies are related to:

- *Prior year Sitka air temperature (r = 0.49, p < 0.05)*
- *Prior year Gulf-wide SST anomalies (r = 0.41, p < 0.05)*



Danielson et al. 2022 Deep-Sea Research II, doi.org/10.1016/j.dsr2.2022.105155

Acknowledgements

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NOAA Contacts:
Ed Farley
Rob Suryan
Libby Logerwell
Mike Litzow
Tom Hurst

rob.suryan@noaa.gov

Recruitment Processes Alliance

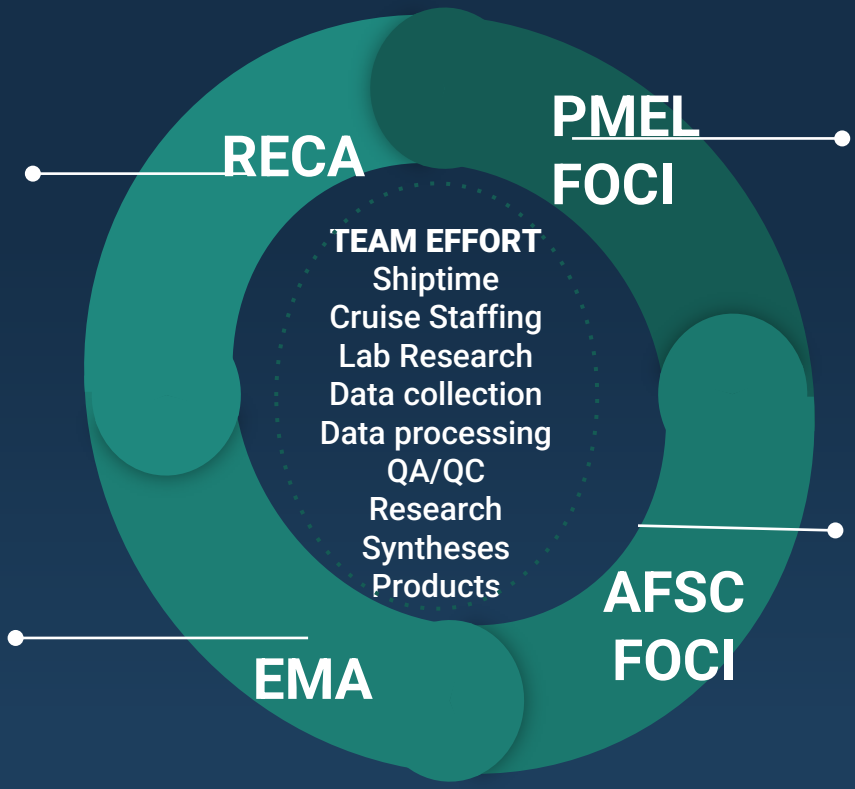
Conduct long-term monitoring and use a holistic ecosystem approach to address emerging questions and provide critical baseline information to stakeholders

NOAA FISHERIES
AFSC Juneau, AK

CONTRIBUTIONS//SKILLS: Bioenergetics, diets, nutritional and trophic ecology, nearshore studies, Gulf Watch Alaska

NOAA FISHERIES
AFSC Juneau, AK

CONTRIBUTIONS//SKILLS: Bering Sea young of the year gadids & forage fish, jellies, phytoplankton, salmon, surface trawl, Arctic, ESR's, GOA/BS/Arctic RAPs



NOAA RESEARCH
Pacific Marine Environmental Lab
Seattle, WA

CONTRIBUTIONS//SKILLS: Physical oceanography, nutrients, models, advanced technologies, atmospheric, and phytoplankton.

NOAA FISHERIES
AFSC Seattle, WA

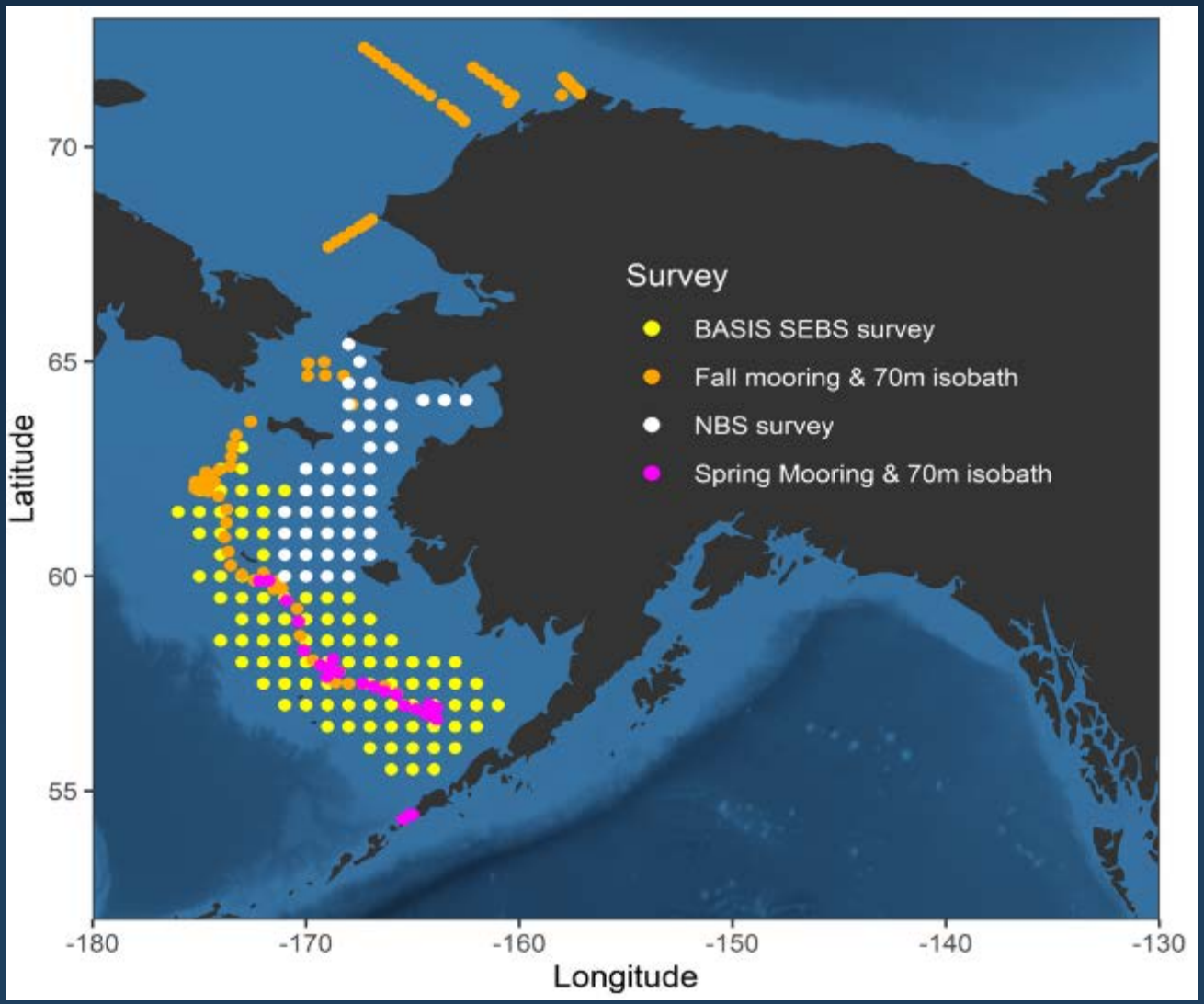
CONTRIBUTIONS//SKILLS: Zooplankton, eggs & larvae, GOA young of the year gadids & forage fish, beam trawl, diets, Arctic

Scientific Research Collaborations & Partnerships

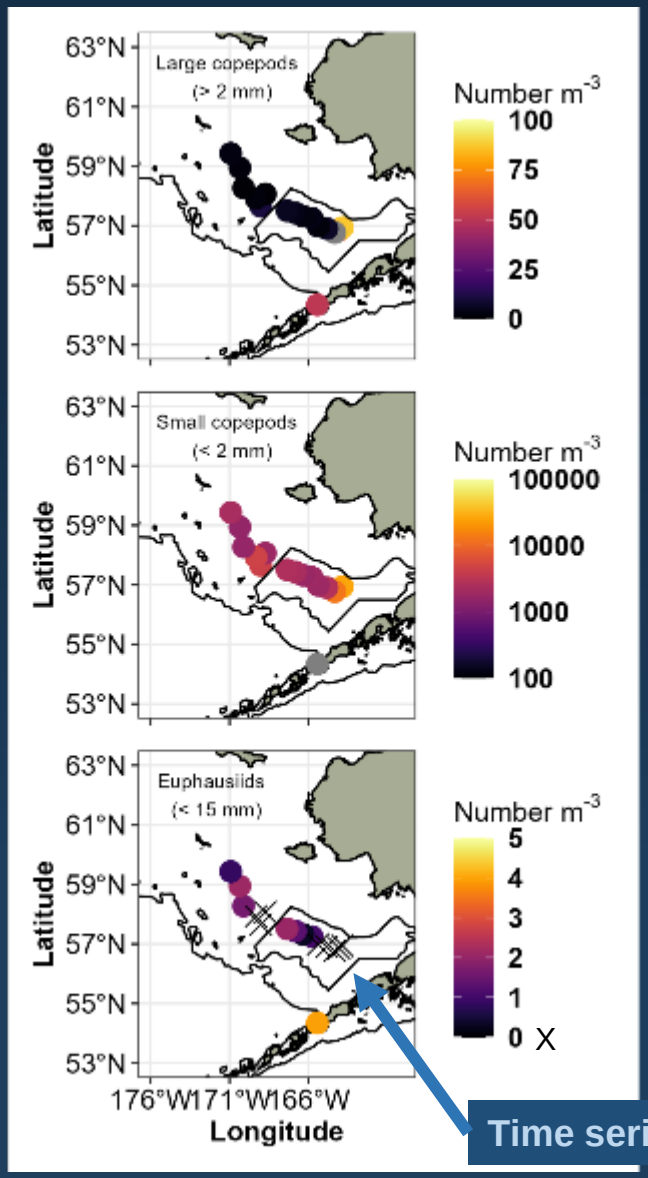
NOAA MML, WHOI & NWFSC HABs, UAF & NOAA OA, NOAA eDNA, EFH, USFW seabird, ADFG salmon

Non-base funds to the RPA include North Pacific Research Board IERP's, NPRB single projects, NOAA NOPP, NOAA RAP, ADFG, NOAA Arctic Research Program

Bering Sea


Survey
BASIS SEBS survey
Fall mooring & 70m isobath
NBS survey
Spring Mooring & 70m isobath
Latitude
70
65
60
55
-180
-170
-160
-150
-140
-130
Longitude

Spring - Rapid Zooplankton Assessment



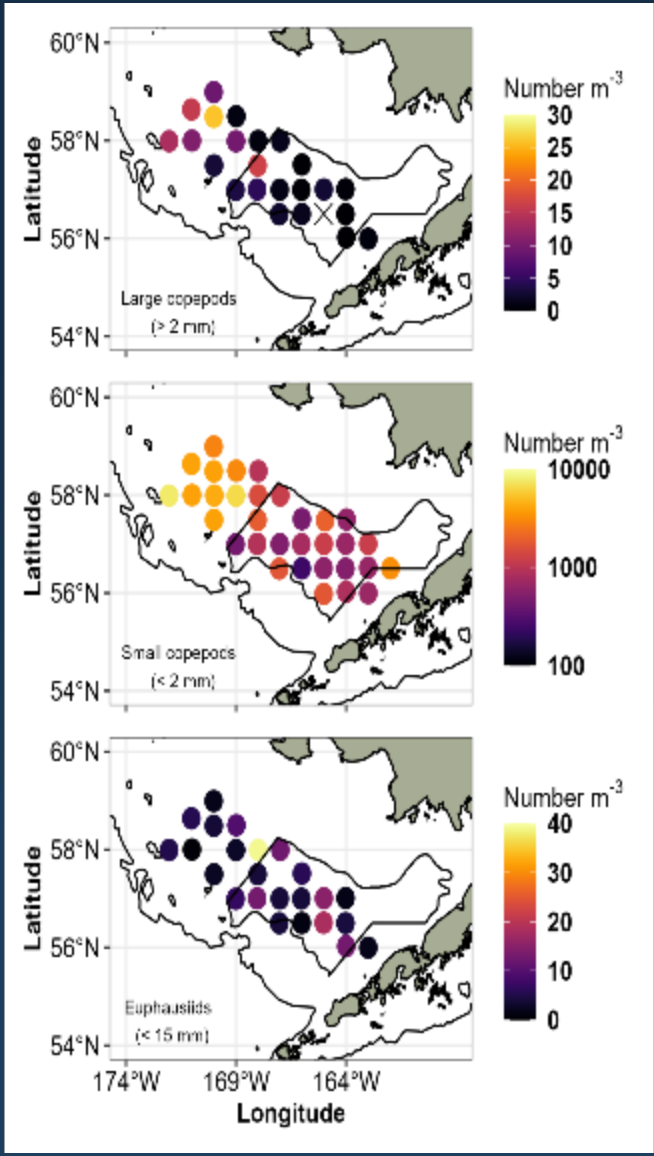
Spatial Patterns

Take home (Spring 2022):

Copepods
- Highest in south

Euphausiids
- High value in Unimak Pass
- Absent or low at other stations

Fall BASIS - Rapid Zooplankton Assessment



Spatial Patterns

Take home (Fall 2022):

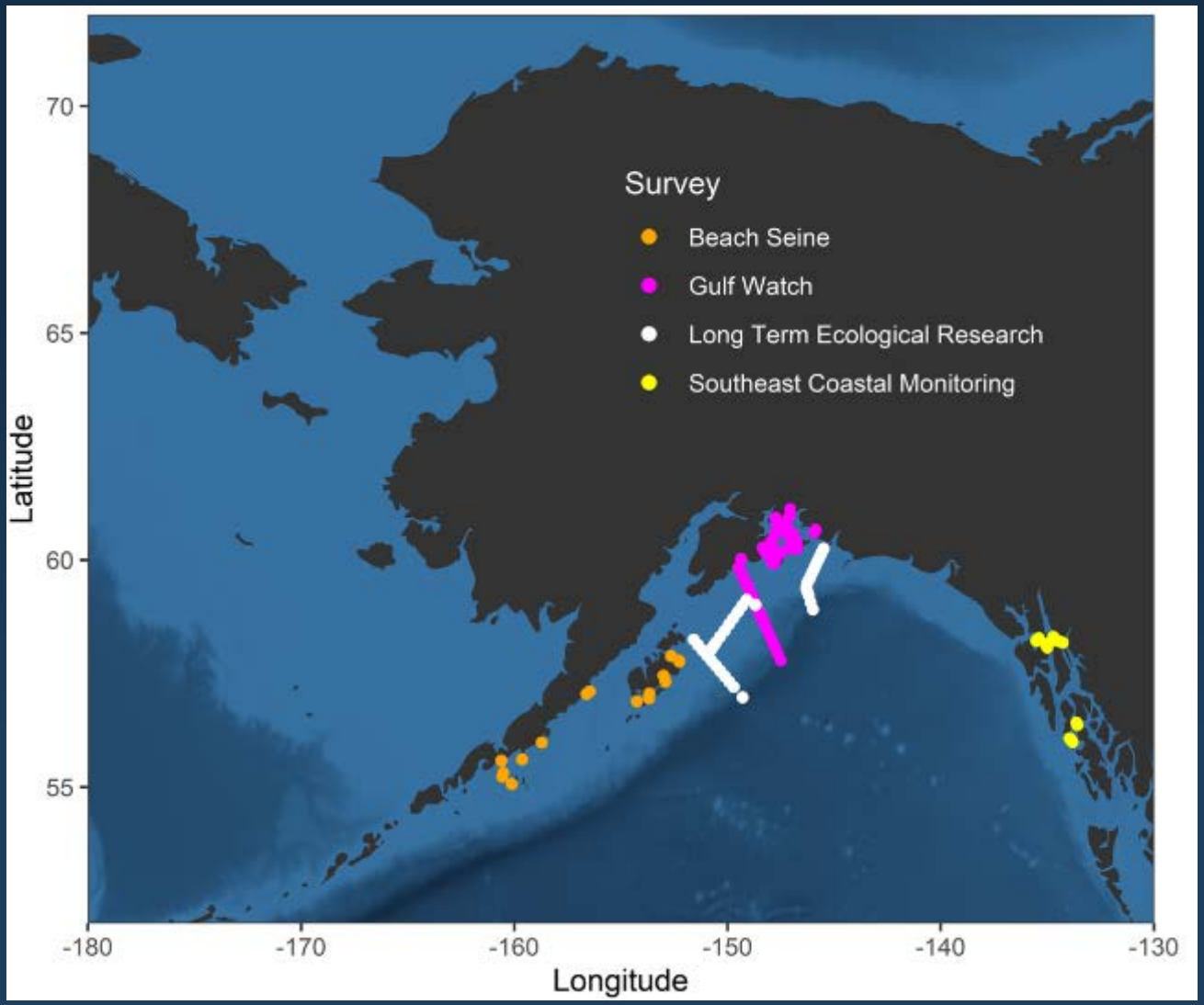
Copepods

- Highest in North

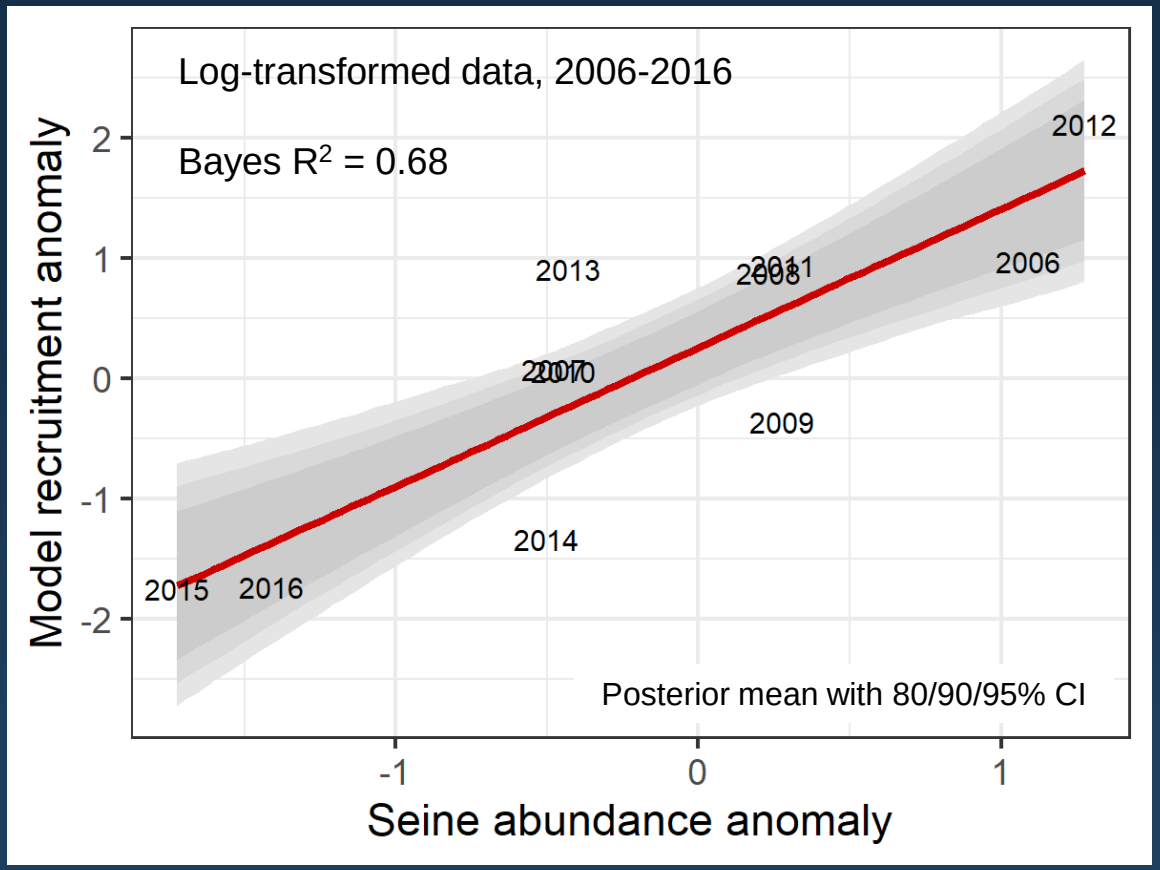
Euphausiids

- Low throughout with large patch along 58th parallel

Gulf of Alaska



Predicting gadid year-class strength from larval and age-0 surveys



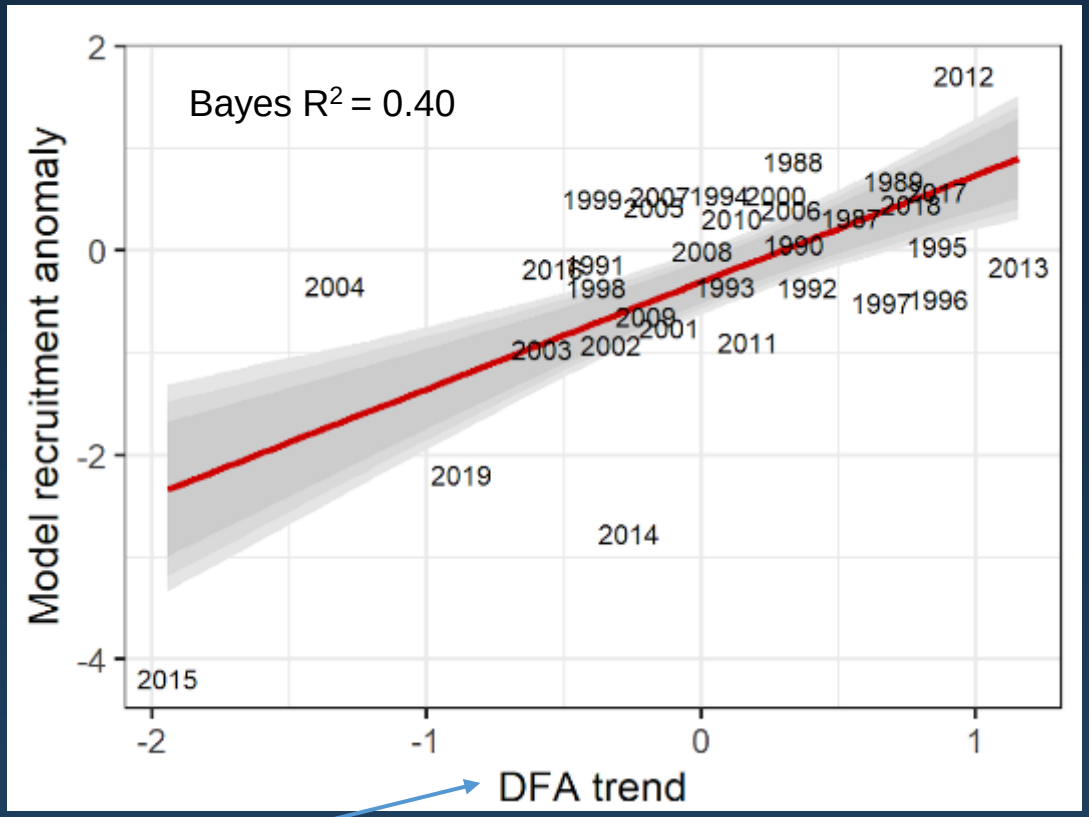
Pacific cod

- Age-0 abundance in seines predicts model-estimated age-3 recruitment

github.com/mikelitzow/predict-R

Litzow, M.A., Abookire, A.A., Duffy-Anderson, J., Laurel, B.J., Malick, M.J.,, Rogers, L.A. Predicting year-class strength for climate-stressed gadids in the Gulf of Alaska. Fisheries Research, submitted.

Predicting gadid year-class strength from larval and age-0 surveys



Dynamic Factor Analysis (DFA) trend: reflects shared variability in beach seines, larval survey, juvenile trawl survey

Walleye pollock

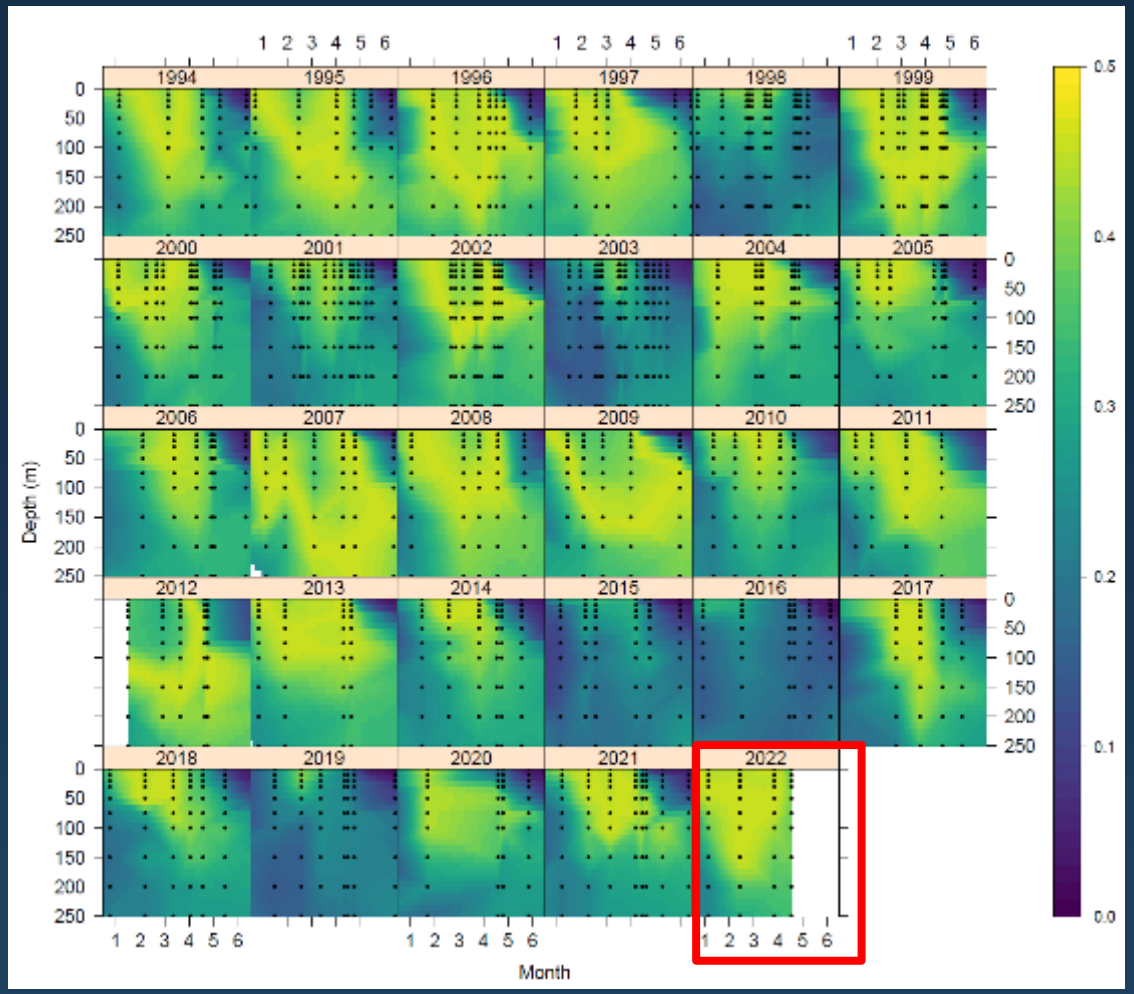
- A combined index of larval, age-0 seine and age-0 trawl abundance predicts model-estimated age-1 recruitment
- Seines allow prediction in even years (no larval/trawl data)

Take home: Early life history surveys give us early indications of year-class strength, especially important as we experience novel climate conditions.

Litzow, M.A., Abookire, A.A., Duffy-Anderson, J., Laurel, B.J., Malick, M.J.,, Rogers, L.A. Predicting year-class strength for climate-stressed gadids in the Gulf of Alaska. Fisheries Research, submitted.

Climate-driven changes to Pacific cod spawning habitat in the Gulf of Alaska

Use GAK1 data coupled with an experimentally-derived relationship between temperature and hatch success to understand how suitable spawning habitat varies across space and time



Take home: Increase in suitable spawning habitat for Pacific Cod in 2022

[Optimal bottom temperatures: 3 - 6 °C]

→ Developing indicators for ESPs, inform risk tables

→ Future projections of changes in timing and location of spawning

Lauren Rogers & Ben Laurel