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

NOAA FISHERIES

Alaska Fisheries Science Center

2021 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: **Ellen Yasumiishi, Lauren Rogers, Rob Suryan**

September 20, 2021

Ellen Yasumiishi, PhD (she/her)

1

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

RECA

PMEL FOCI

TEAM EFFORT
Shiptime
Cruise Staffing
Lab Research
Data collection
Data processing
QA/QC
Research Syntheses
Products

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

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

EMA

AFSC FOCI

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

Goal & Objectives

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

Objectives:

1. Provide an update on 2021 ecosystem surveys.

2. Provide an update on efforts to integrate recruitment models and indicators into stock assessments.

3. Encourage discussions of data/indicators most useful for stock assessment authors in Reports, Risk Tables, Ecosystem Socioeconomic Profiles, and next generation stock assessments.

Bering Sea
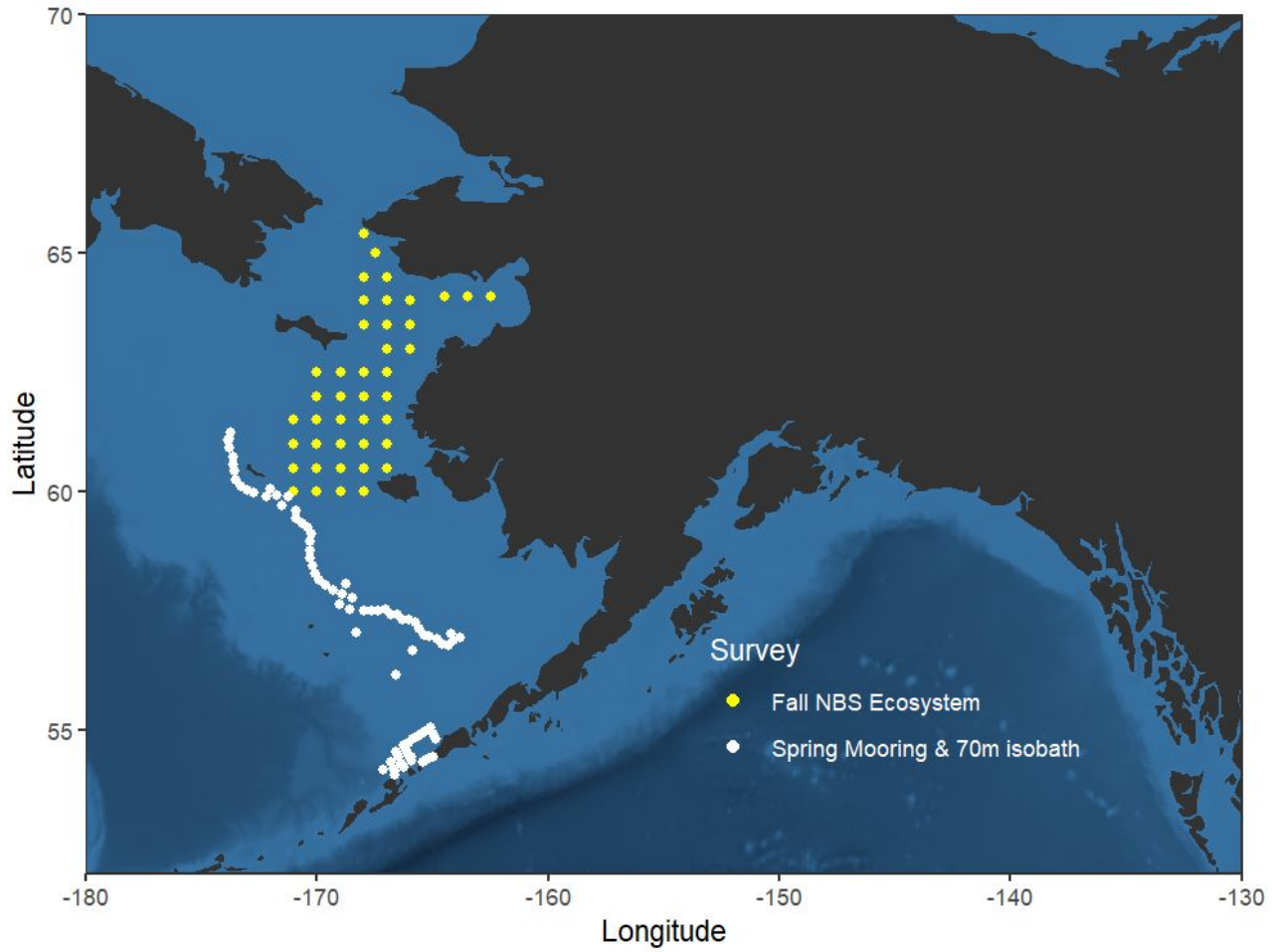
2021 Moorings & 70m Isobath

Focus: Deploy moorings and sample lower trophic levels.

When: Spring and Fall (FALL CANCELLED)

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

Indicators: Integrated chlorophyll; temperature, salinity, oxygen, zooplankton.
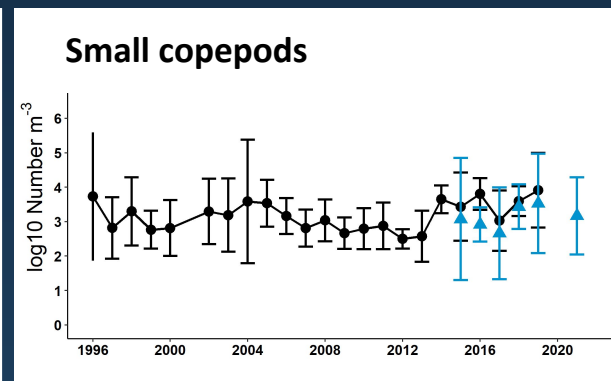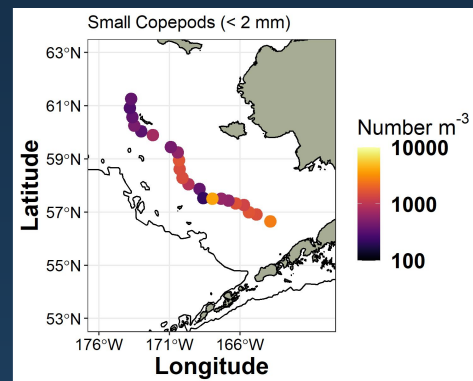
Focus on the Rapid Zooplankton Assessment, zooplankton are important prey for fish and their prey.

Contact : Janet Duffy-Anderson

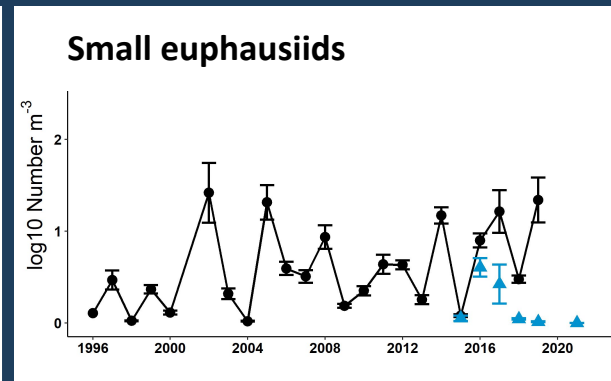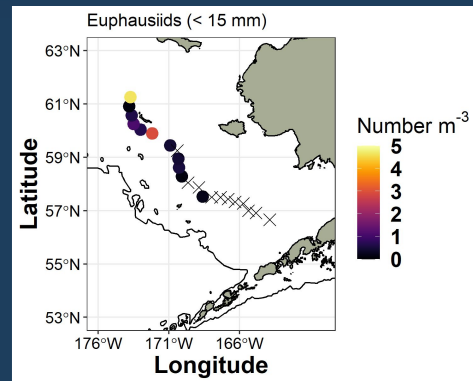# Spring - Rapid Zooplankton Assessment

Large Copepods (> 2 mm)

Large copepods
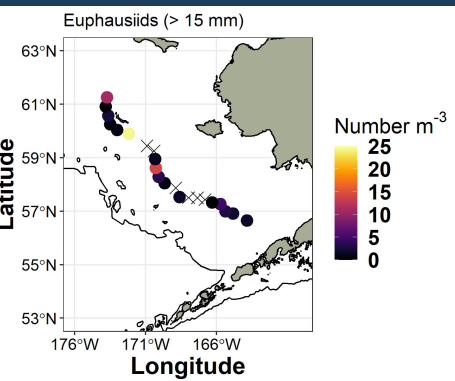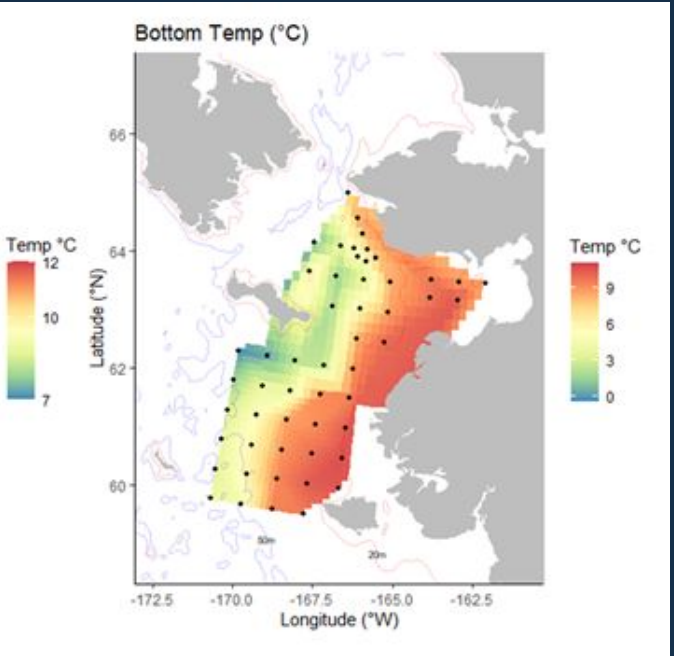
(Blue triangles show rapid assessment)
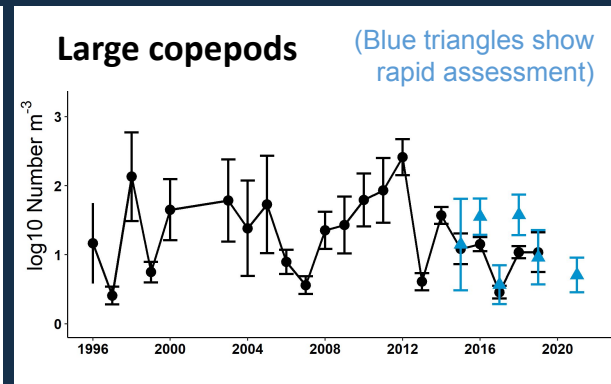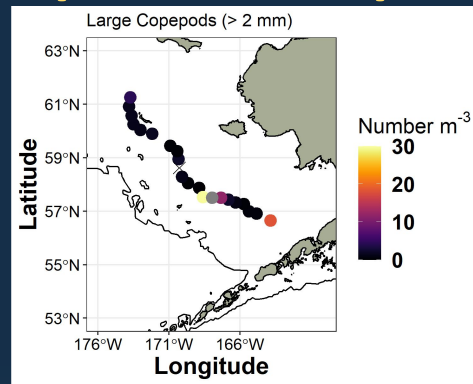
Low abundance of large copepod

High numbers large copepod nauplii (not reported)

Small Copepods (< 2 mm)

Small copepods

Average abundances of small copepods

Euphausiids (> 15 mm)

Euphausiids (< 15 mm)

Small euphausiids

Higher abundance of euphausiids due to large euphausiids (not reported)

6
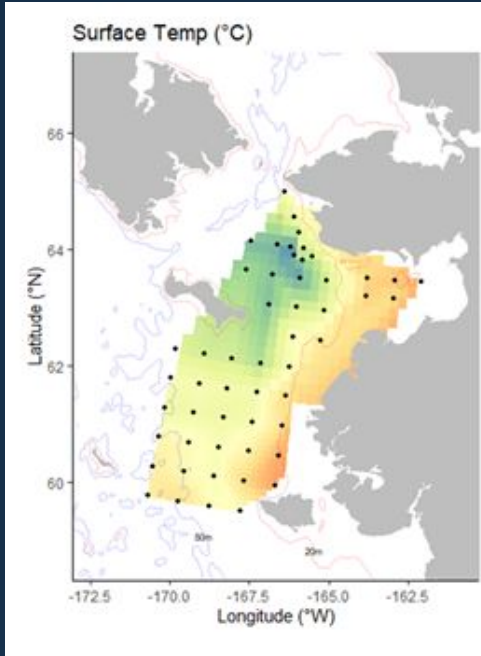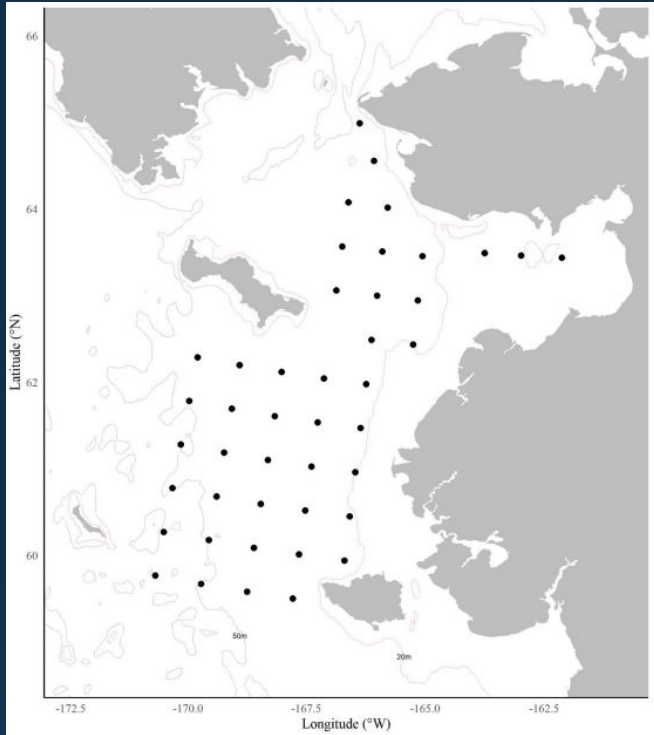
2021 N Bering Sea surface trawl survey

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, 2003-2021, excluding 2008, spans 19 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

Contact : Ed Farley

2021 NBS survey observations

Take home:

- Cold pool south of St Lawrence
- Warm nearshore on the bottom
- Surface temperature 7-11, Bottom temperatures 0-11C
- Beam trawl catches consist of smaller sized snow crab, few large snow crab, and shrimp on the benthos
- Surface trawl catches consist of age-0 and age-1 pollock, age-0 Pacific cod, herring, and juvenile salmon

Fall mooring, 70m isobath, DBO survey

Bering Sea

No fall zooplankton sampling so we lack information of food availability for fish prior to winter.

Potential loss of moorings and data that inform the spring bloom time and sea conditions.

Contact: Janet Duffy-Anderson

CANCELLED

4 Pop-up Floats (PUF) deployed

2021 Summer / Fall PUF planned deployments

- ■ planned for fall NOAA mooring cruise deployment
- ■ planned for fall USCG partner deployment
- ■ planned for summer/fall fishing industry partner deployment
- ■ Deployed on fall mooring cruise
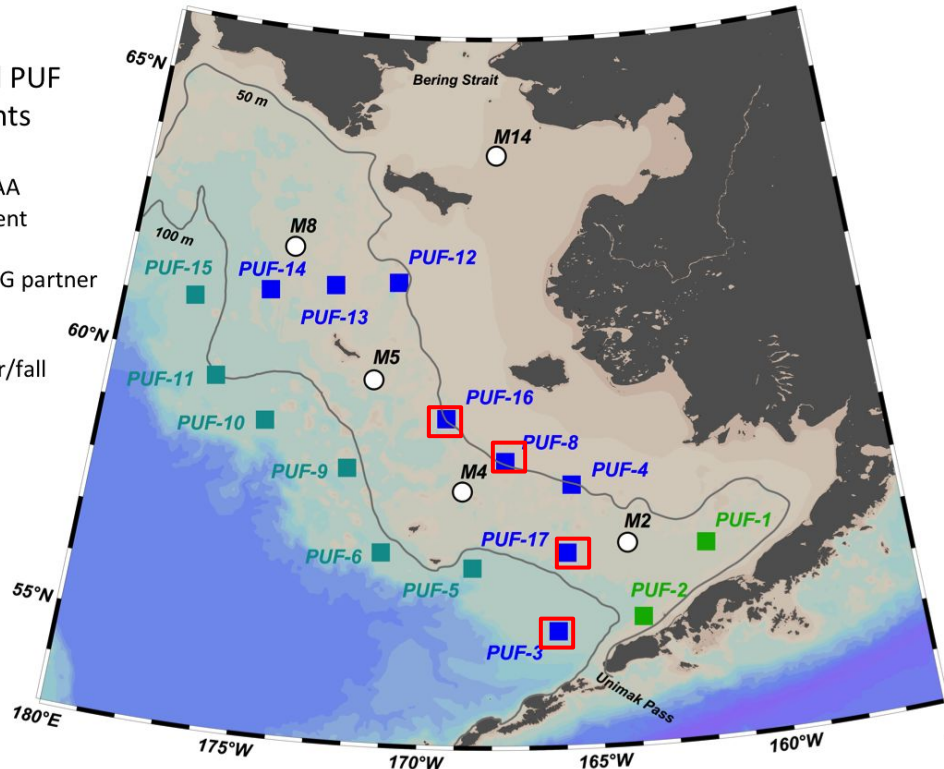
PUFs measure bottom-temperatures year-round

Allow more detailed analysis of cold pool dynamics

Data will be used to validate ROMS bottom temperatures across the shelf, year-round

Working with partners to deploy remaining instruments

Assess habitat suitability for spawning groundfish

Contact: Phyllis Stabeno
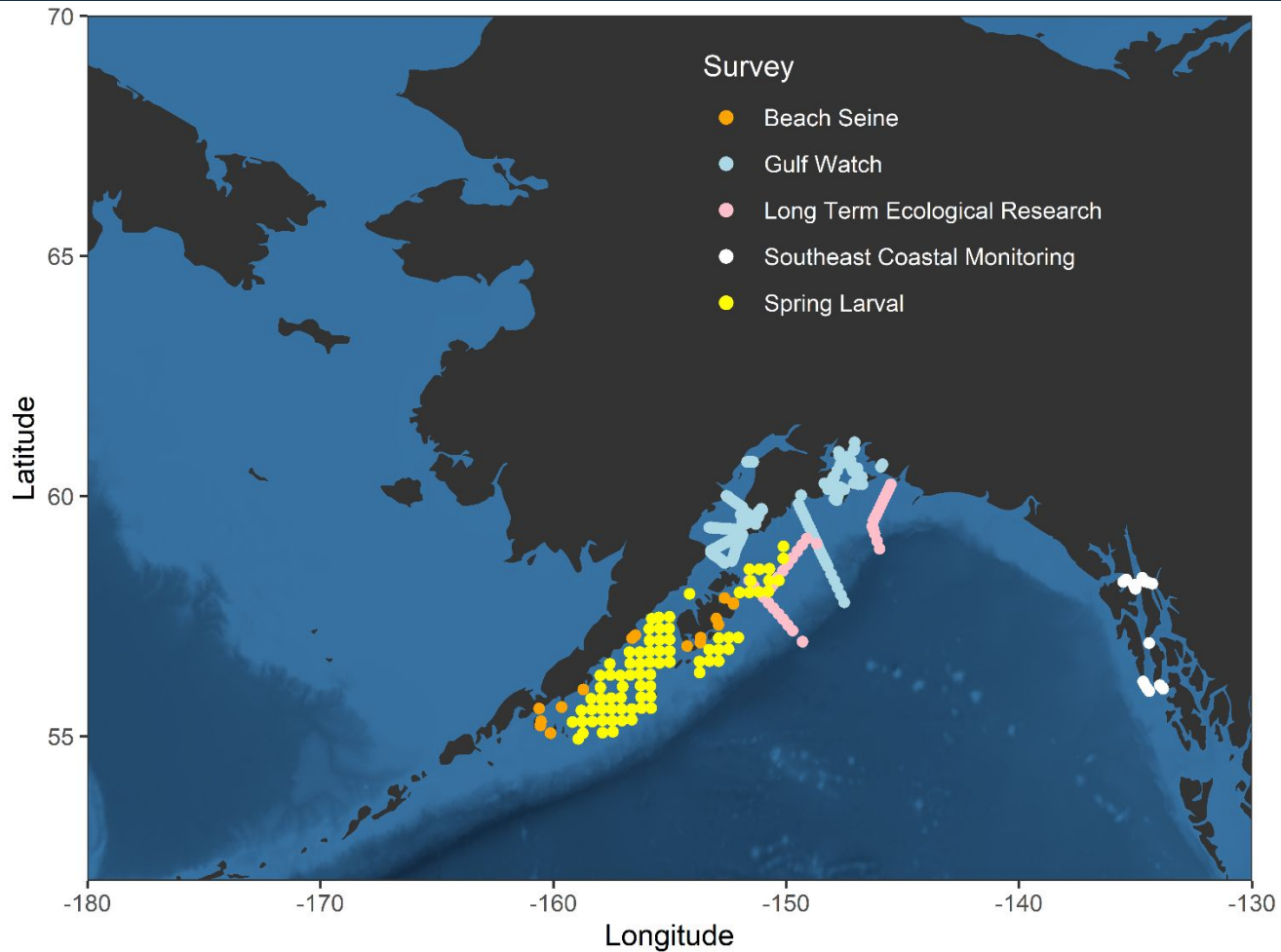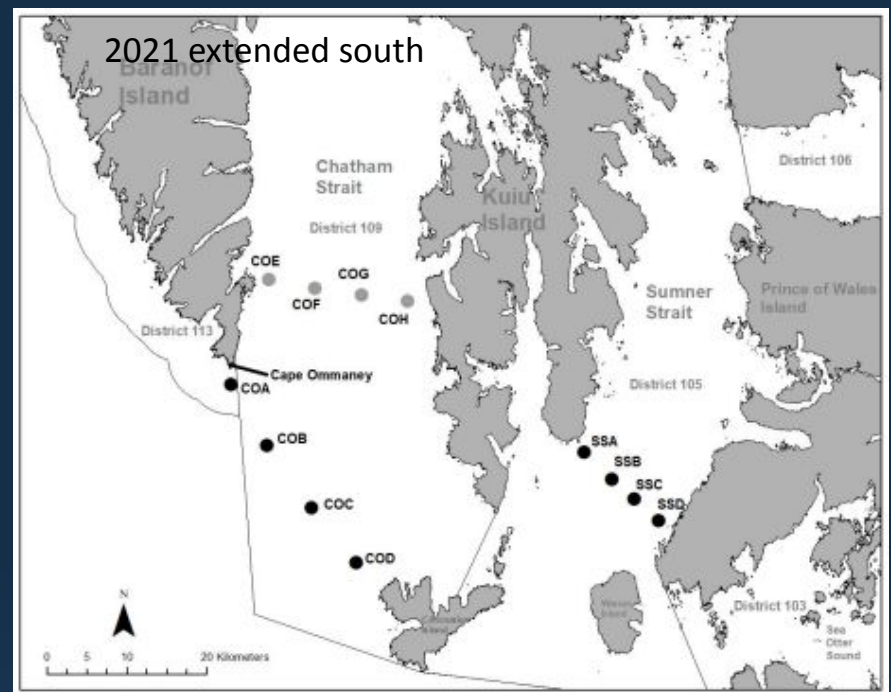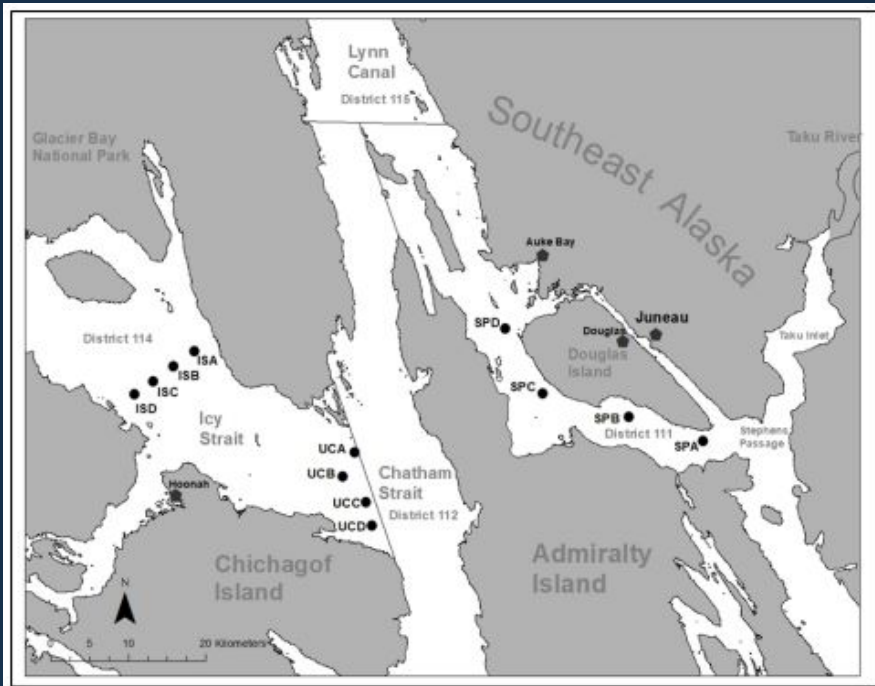
2021 Bering Sea summary

Overall, the zooplankton community appeared in average abundances, similar to that of a year with average ice conditions.

Good indications of large copepod production during summer.

Cancelled fall survey was needed to assess standing stock of zooplankton through the summer, prey base for fish prior to fall.

Gulf of Alaska

EGOA Southeast Coastal Monitoring

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

When: 1997-2021 June/July/August (August cancelled) 25 years
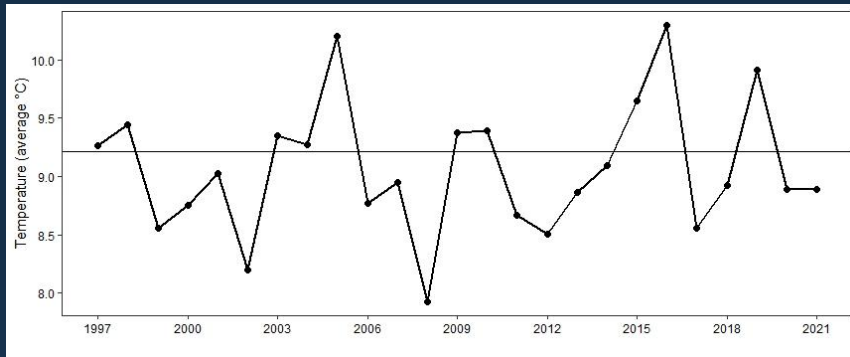
Where: Northern SEAK expanded to southern SEAK

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
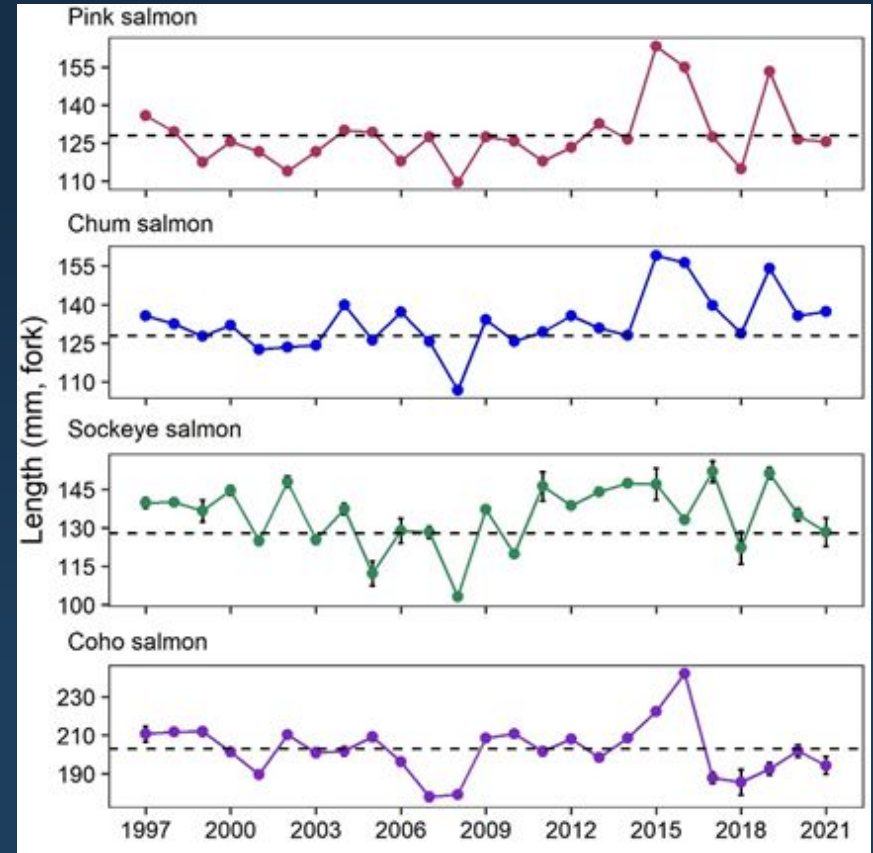
Contact: Andrew Gray
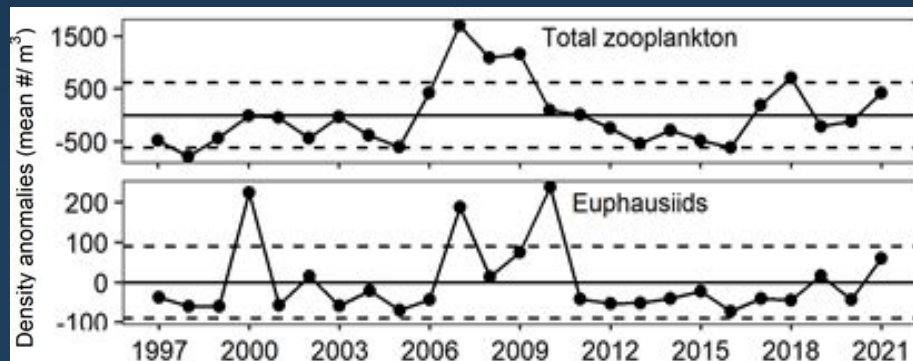
13

SECM 2021 observations
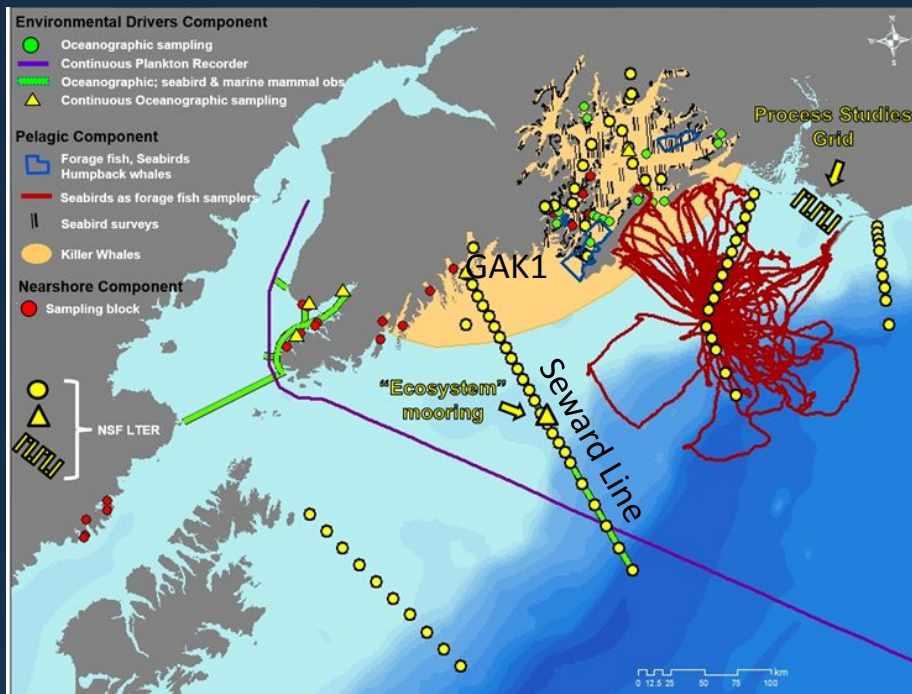
- Icy Strait temperature below average

- Juvenile salmon average size

- Zooplankton density above average

- August survey cancelled: so discontinue sablefish prediction

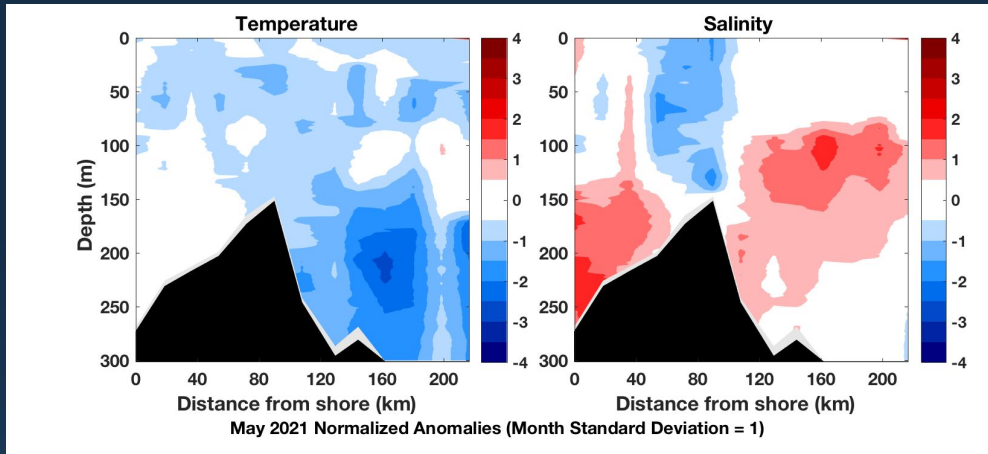**Contacts: Jim Murphy, Emily Fergusson, Jamal Moss**

Gulf Watch & LTER surveys

Gulf Watch Alaska is the long-term ecosystem monitoring program of the *Exxon Valdez* Oil Spill Trustee Council for the marine ecosystem affected by the 1989 oil spill.
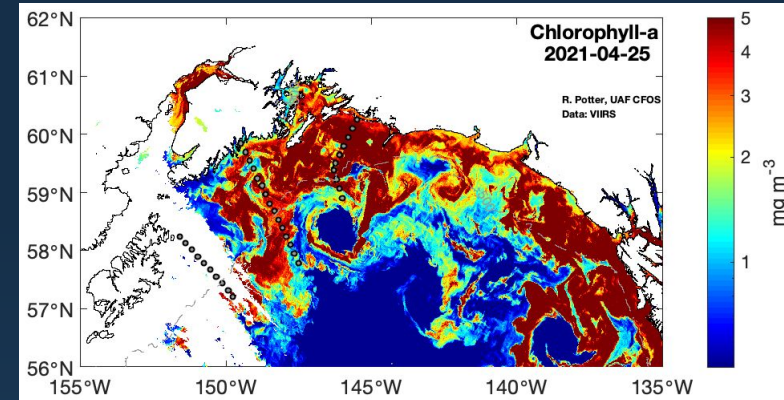
Contact: Rob Suryan

Environmental Drivers

Seward Line 2021 – cross shelf transect

May

May 2021 Normalized Anomalies (Month Standard Deviation = 1)
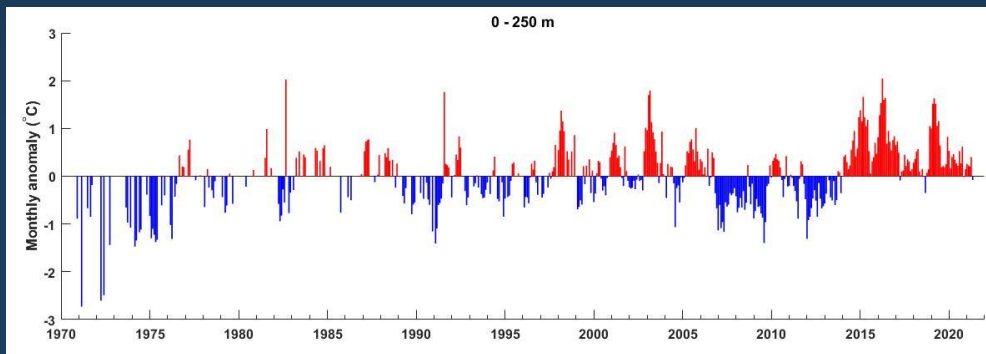
GAK1 – 50 year monthly time series

Massive Bloom - upper 20m
(verified *in situ*, highest chlorophyll concentrations in 24-yr time series of Seward Line, diatoms very abund.)

Take home (Spring):

- Cooler and fresher (deep)
- Large spring bloom with diatoms
- Nearshore GAK1 still warm vs. 50 yr mean
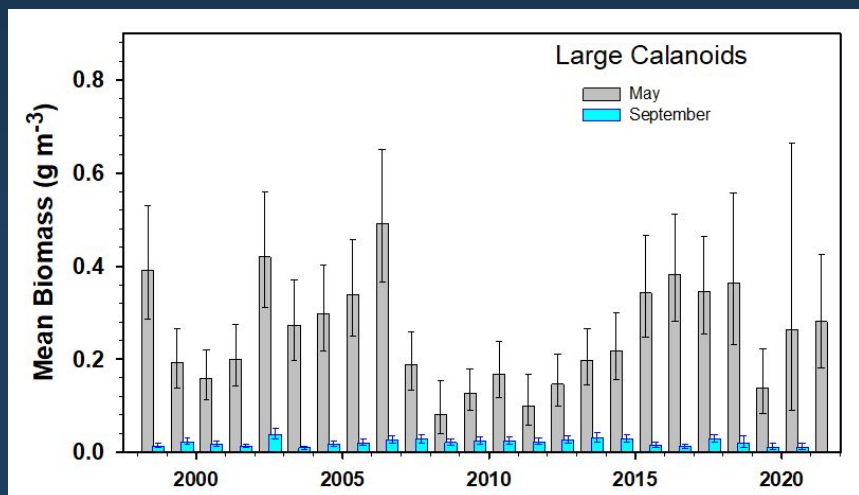- Seabird abundance was among lowest recorded in 20-yr time series

Contact : Rob Suryan   Contributors: S. Danielson, R. Hopcroft

Seward Line: May

1998-2021 0-100-m integrated temperatures
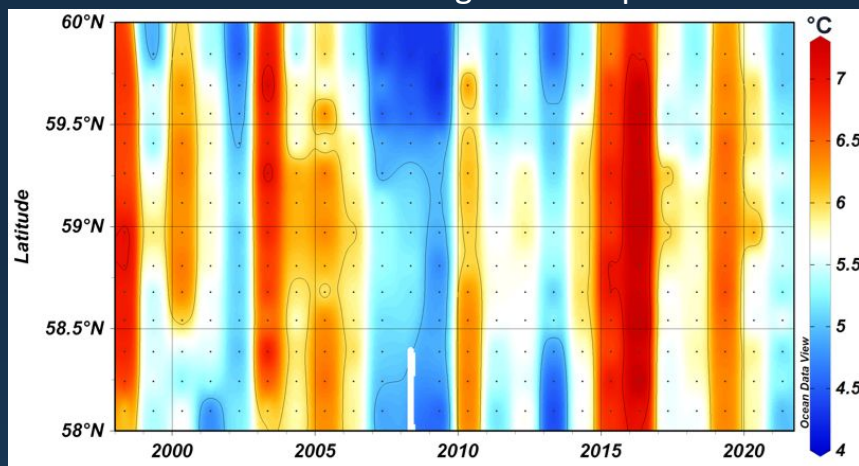
Take home (Spring):
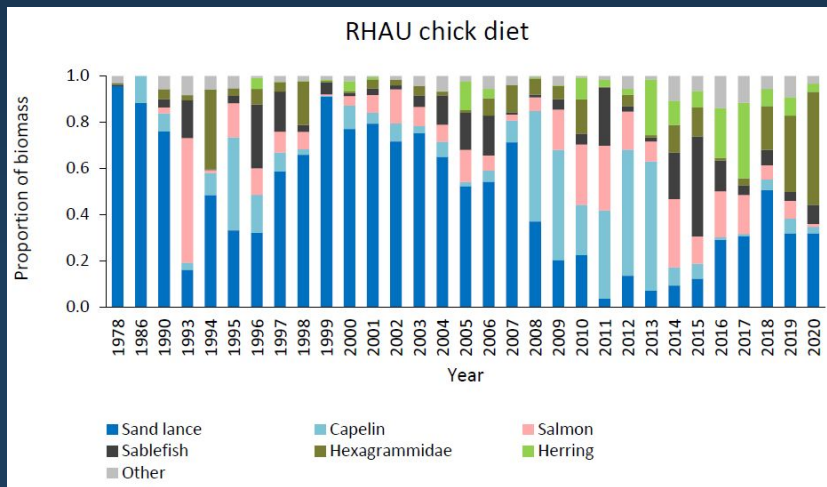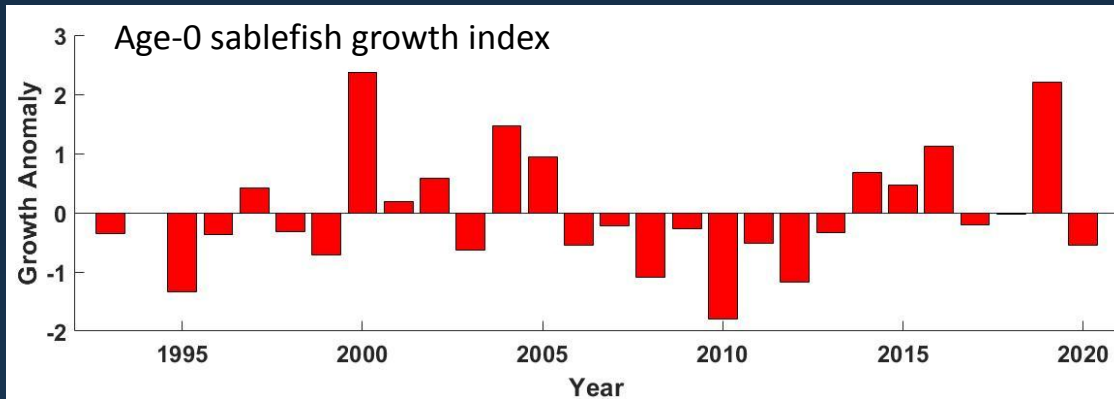
- Cooler 0-100m
- Moderate numbers of large copepods

Contact : Rob Suryan   Contributors: R. Hopcroft, S Dalienson

Prey as indicators

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

Age-0 sablefish growth index

RHAU chick diet

Seabird foraging trips

Seabird Foraging Trips

Take home:

- 2020 age-0 sablefish growth slightly below average
- Auklets not finding age-0 sablefish in 2021 (n=1)
- Positive trend for sand lance, but still very few capelin in 2020

Contact : Rob Suryan   Contributors: Y. Arimitsu, S. Hatch   USGS science for a changing world
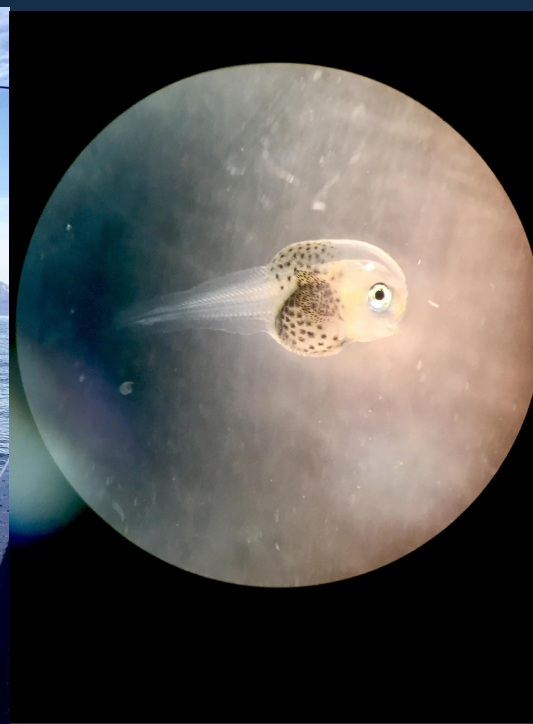
Western GOA Spring Larval Survey

<u>Focus</u>: Larval fishes and lower trophic-level processes (fisheries oceanography)

<u>When</u>: May

<u>Where</u>**:** Western GOA shelf from Kodiak to Shumagins

<u>Operations</u>: CTD, Bongo, CalVET, Neuston
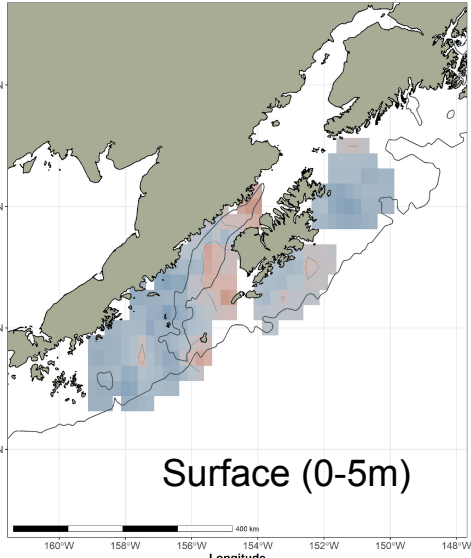
<u>Indicators</u>: Larval abundance, growth, spawn timing, zooplankton, temperature

Note: 2021 survey extent reduced due to limited days at sea
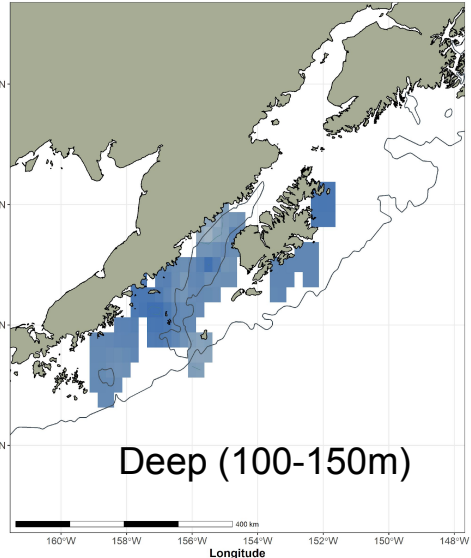
Contact: Janet Duffy-Anderson

Spring Surface (0-5m) and Bottom (100-150m) Temperature

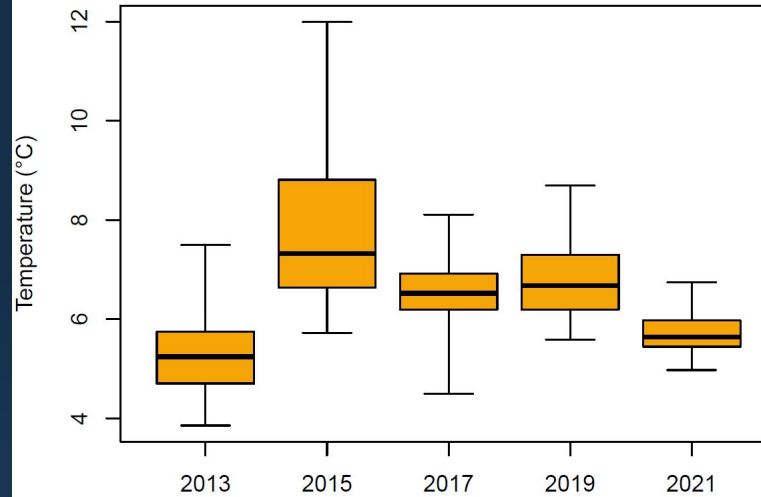Cruise WO21-01: Mean Temperature 1 to 5 meters depth

Surface (0-5m)

Cruise WO21-01: Mean Temperature 100 to 150 meters depth
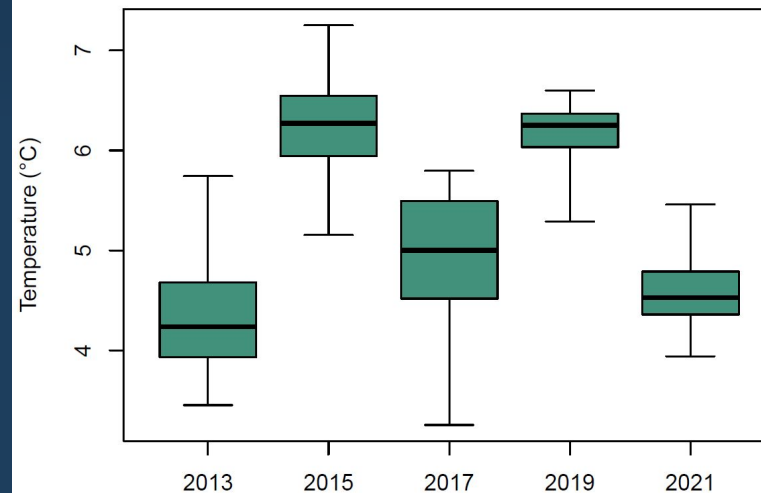
Deep (100-150m)

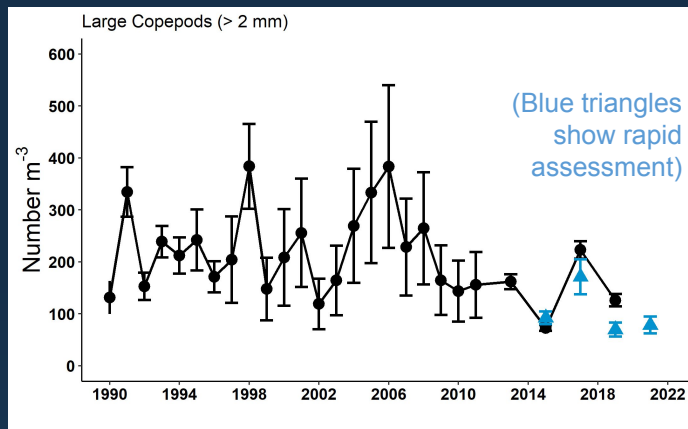

Western GOA Spring
Surface Temperature (1 – 5m)

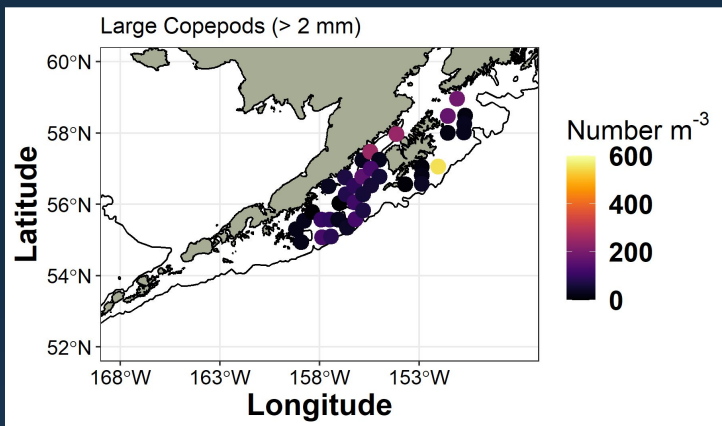
Western GOA Spring
100 – 150m Temperature

Take home:
2021 May temperatures were relatively cool to average at surface and at depth.
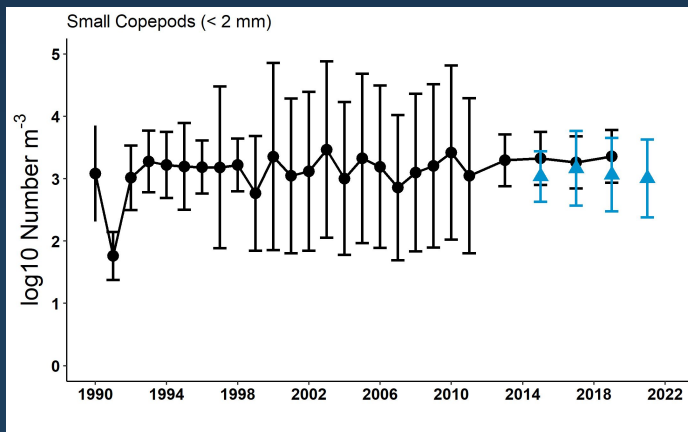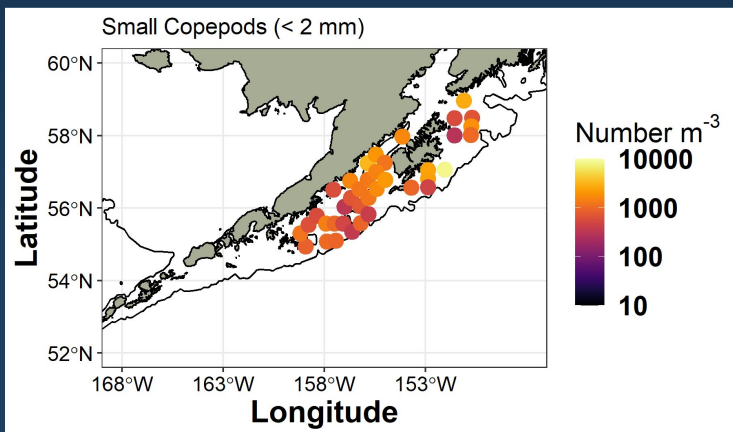
Contact: Lauren Rogers

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Spring - Rapid Zooplankton Assessment

Large copepods (> 2 mm)

Large copepod abundance was very low, similar to 2015 and 2019.

(Blue triangles show rapid assessment)

Small copepods (< 2 mm)

Small copepods were abundant throughout the survey area. Abundance is less variable through time, and 2021 appeared typical.

Contact D. Kimmel

Spring - Rapid Zooplankton Assessment

Euphausiids (< 15 mm)
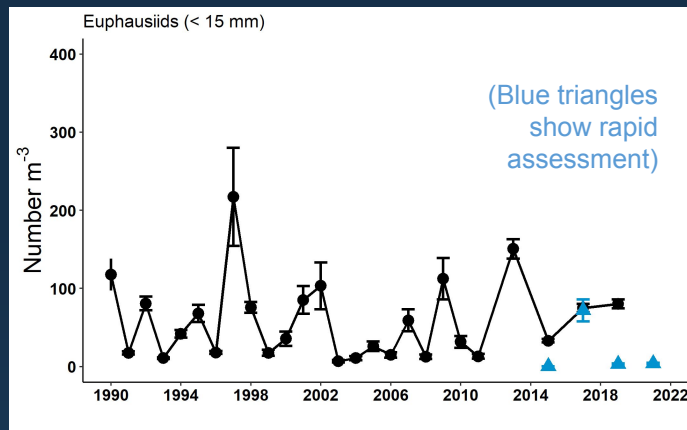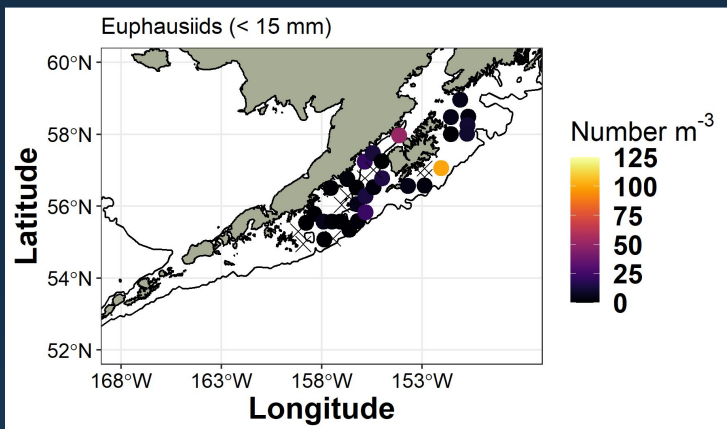
Euphausiids had low abundance overall (note these are juvenile life stages).

(Blue triangles show rapid assessment)
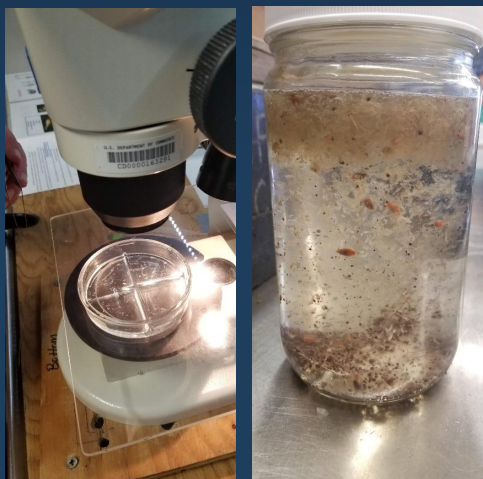
Take home:
Spring zooplankton community resembled recent warm years. Abundant small copepods suggest sufficient forage base for late-stage larval fish.

Contact D. Kimmel

Spring Rapid Larval Assessment: Pacific sand lance

Pacific sand lance — 2019 and 2021 larval distribution maps (Larvae per 10m2: 0, 50, 500, 5000)

Pacific sand lance — Mean abundance (no. per 10m2). (Purple x's show rapid assessment)
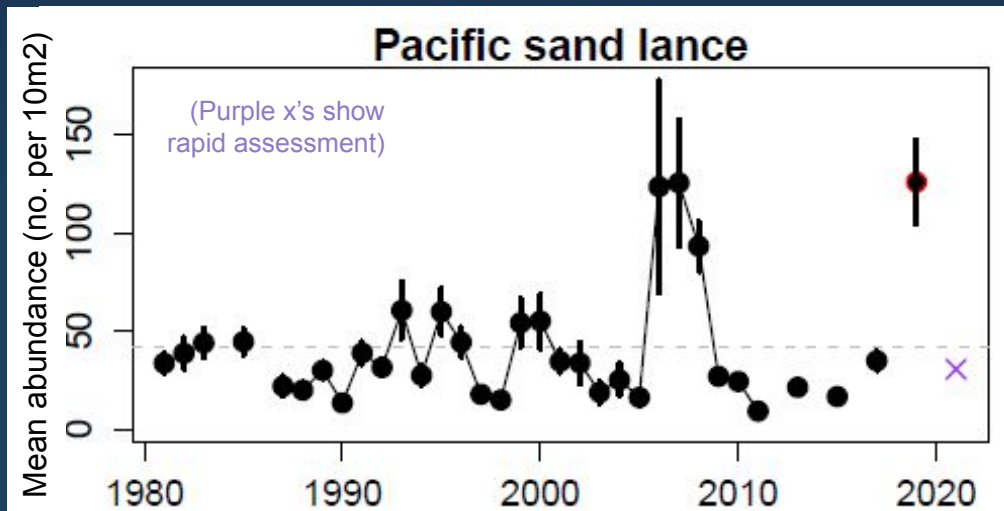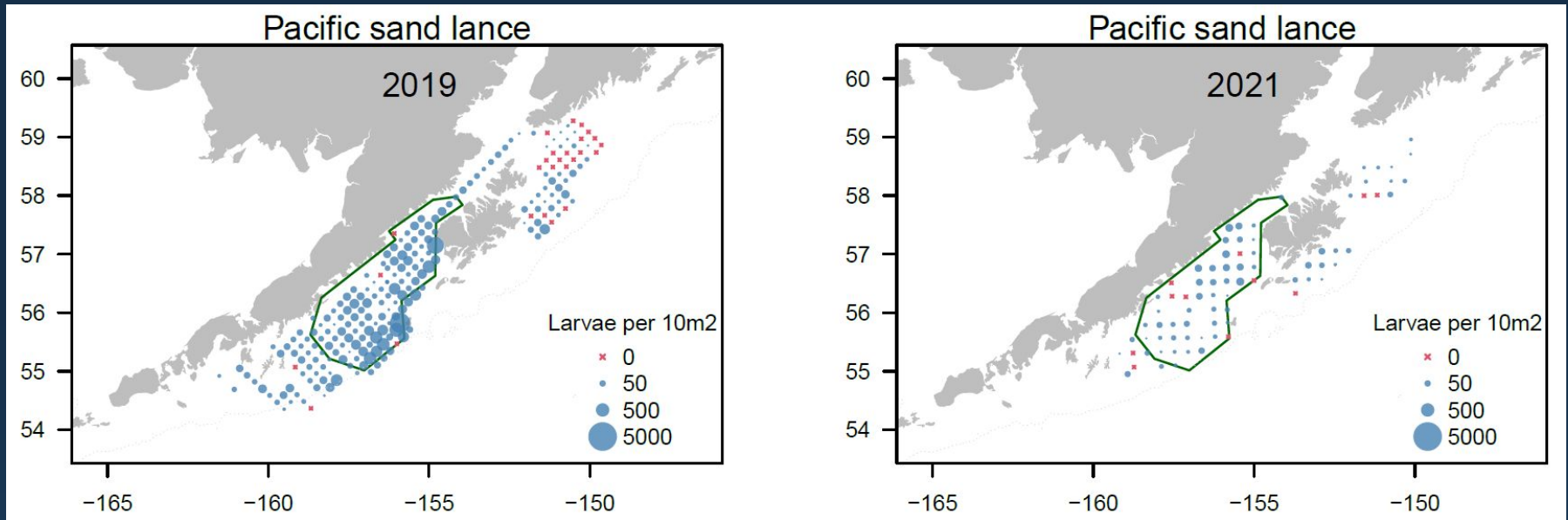
Take home:
This key forage species was caught at most stations in the study area at moderate numbers.

Spring Rapid Larval Assessment: Other species
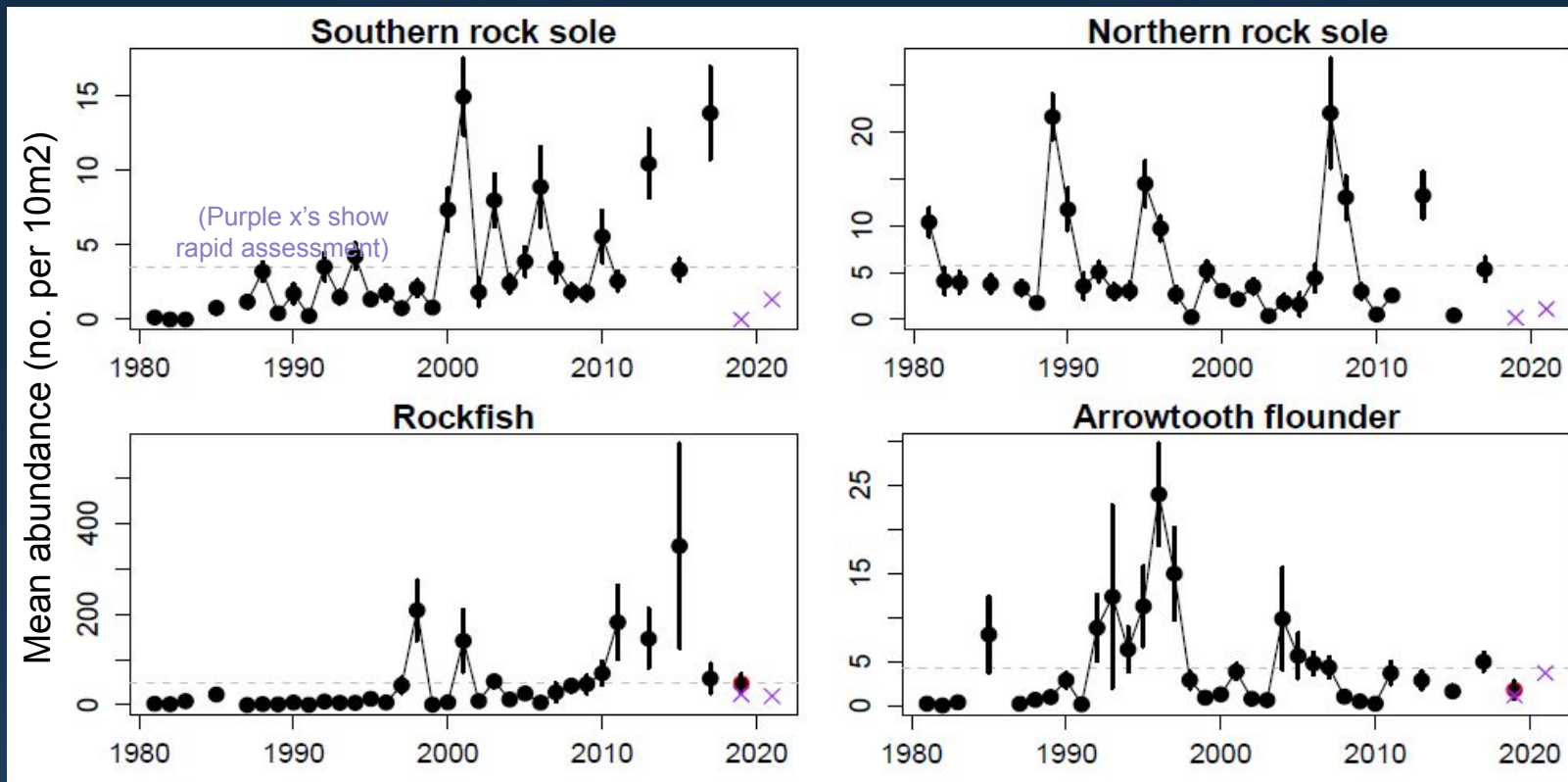
Take home:
All taxa were caught at low to moderate abundance, looking more similar to previous "warm year" catches

Spring Rapid Larval Assessment: Walleye pollock
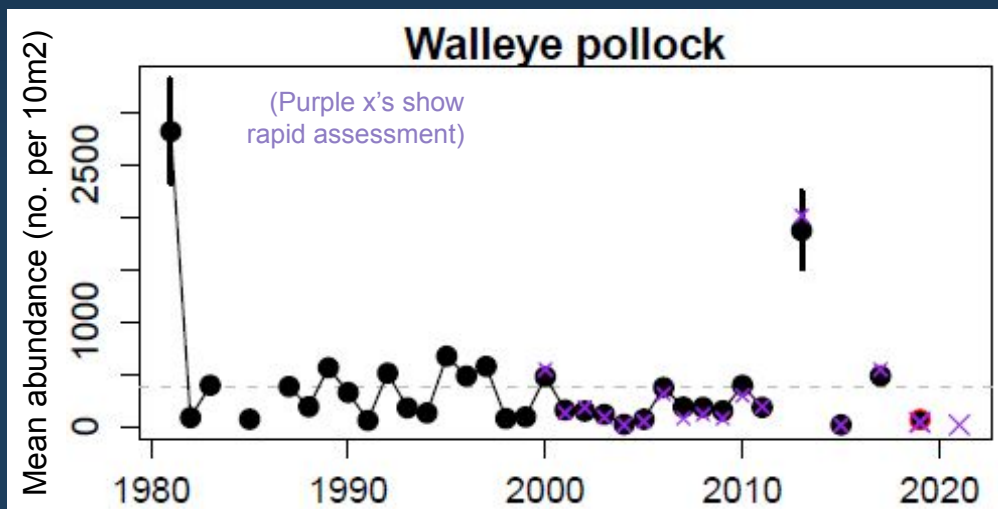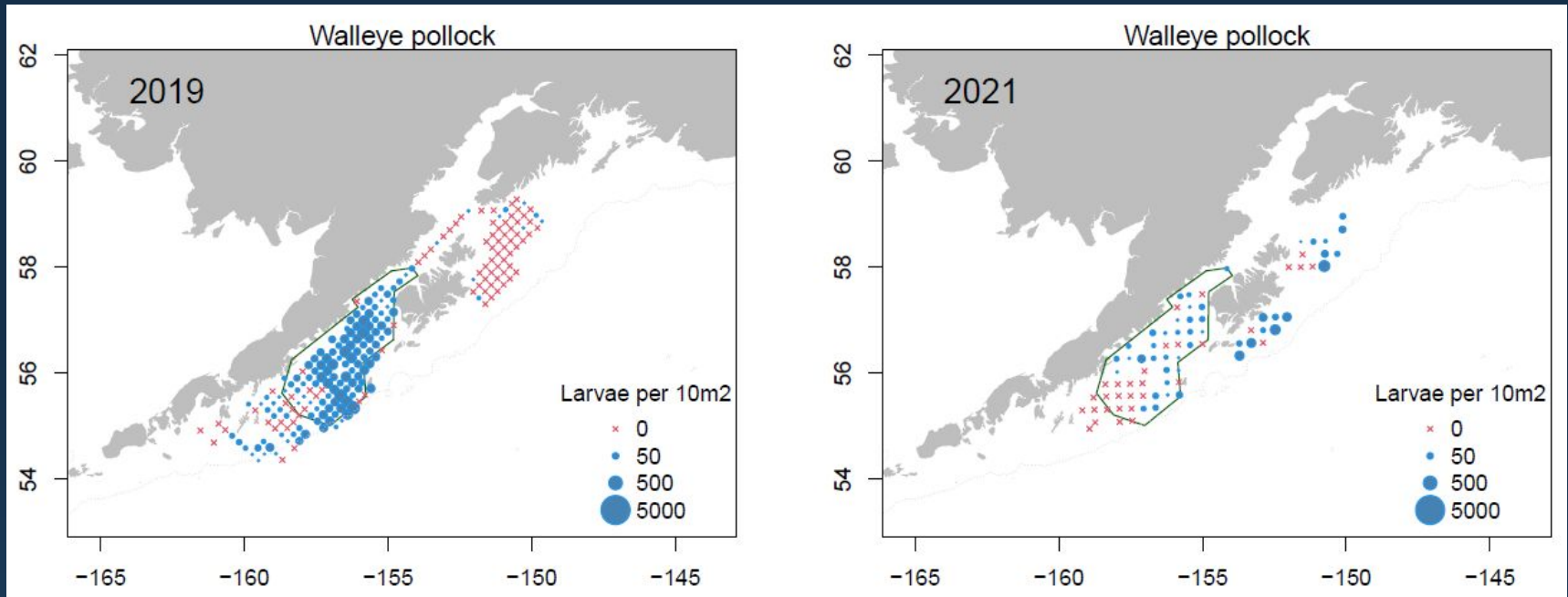
Take home:
Record low abundance of walleye pollock in core area.

Unusual distribution, with highest catches offshore of Kodiak.

Spring Rapid Larval Assessment: Pacific cod

Pacific cod — 2019 / 2021 maps. Larvae per 10m2 legend: × 0, · 10, ● 100, ● 1000.

Pacific cod. Mean abundance (no. per 10m2) vs year. (Purple x's show rapid assessment)
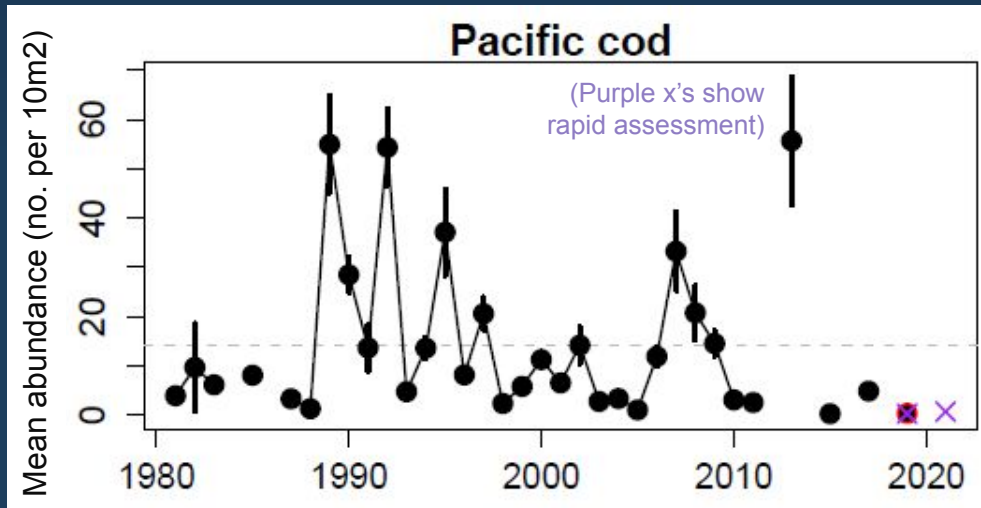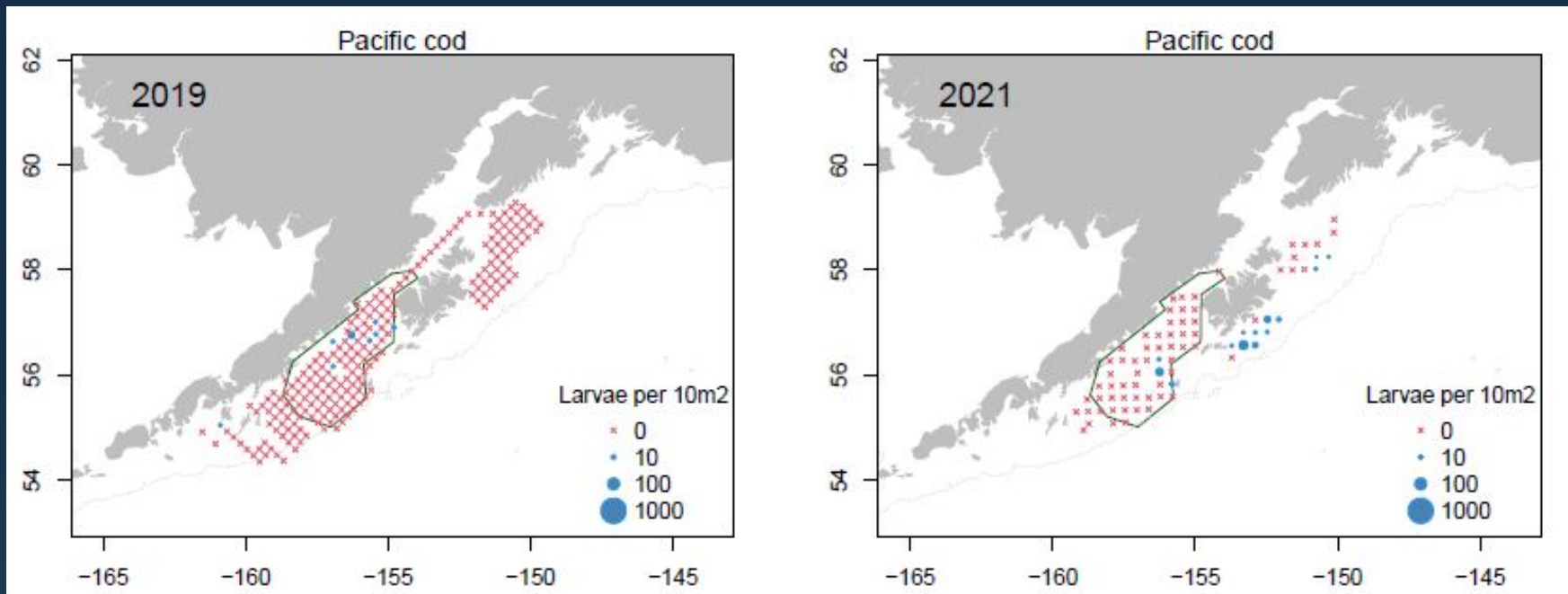
Take home:
Pacific cod nearly absent from core area in 2021, similar to 2015, 2019.

Highest catches offshore of Kodiak

Western Gulf of Alaska

Late summer YOY groundfish and ecosystem survey 2000 - 2019

Implication: No recruitment predictions, seasonal linkage or new

sablefish ecology work

Contact: Janet Duffy-Anderson
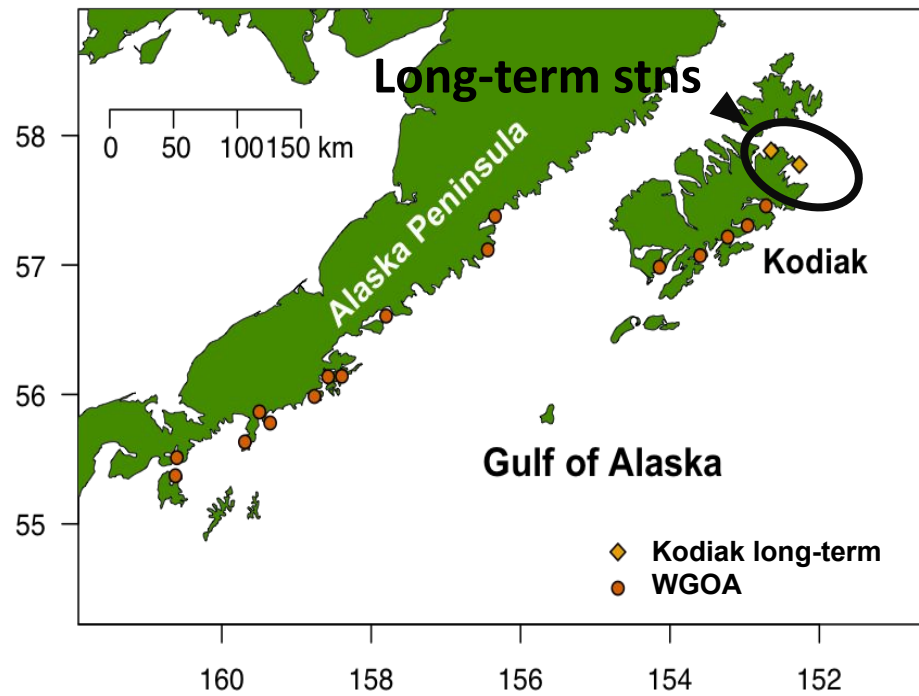
Western GOA Summer Beach Seine

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

When: **Kodiak:** July/Aug (4 surveys, 16 sites across 2 bays) 2006-2021

Expanded WGOA: July/Aug (75 sites across 14 bays) 2018-2021

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
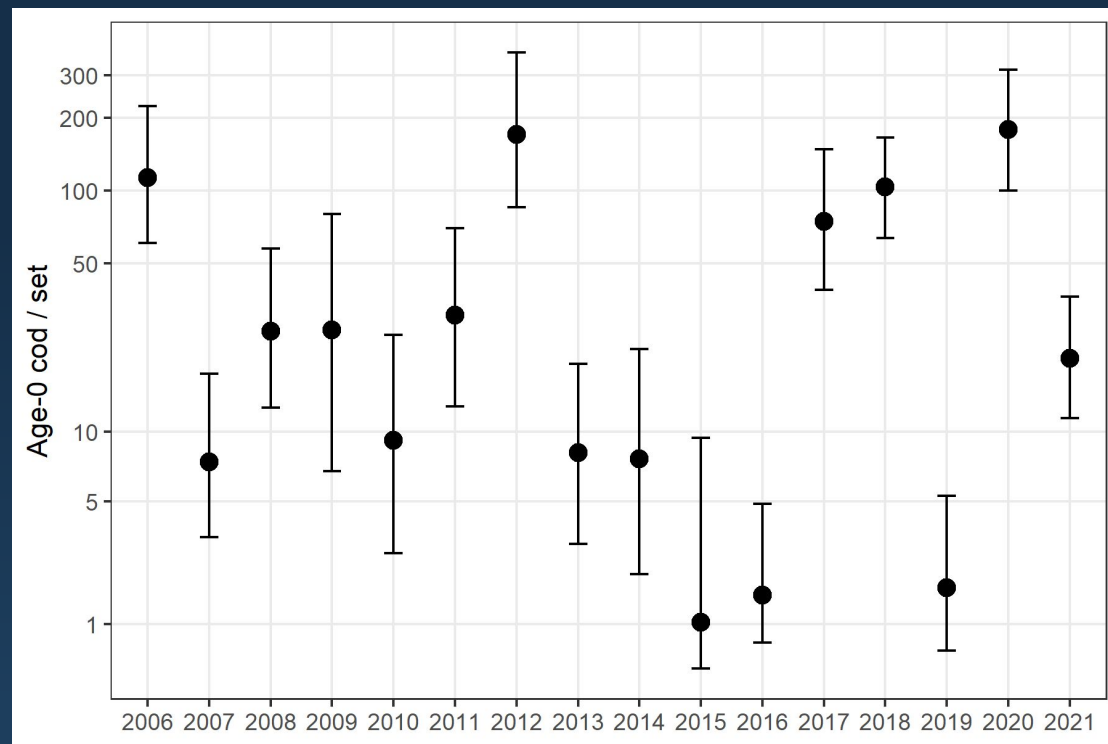
- Combined data from 2 Kodiak bays (2006-2021) and 13 western GOA bays (2018-2021)

- Year-class strength estimated from zero-inflated negative binomial Bayesian regression model

<u>Take home</u>: 2021 Age-0 Pacific cod abundance approximately equal to long-term *log* mean.

Unusual bimodal size distribution - two spawning events?

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. Climate attribution statistics inform judgments about changing fisheries sustainability. Scientific Reports, in revision.

Contact: Ben Laurel, Mike Litzow, Alisa Abookire
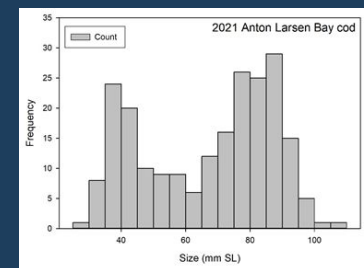
Age-1 Pacific cod abundant in Kodiak survey (2020 yc)

Kodiak juvenile cod CPUE
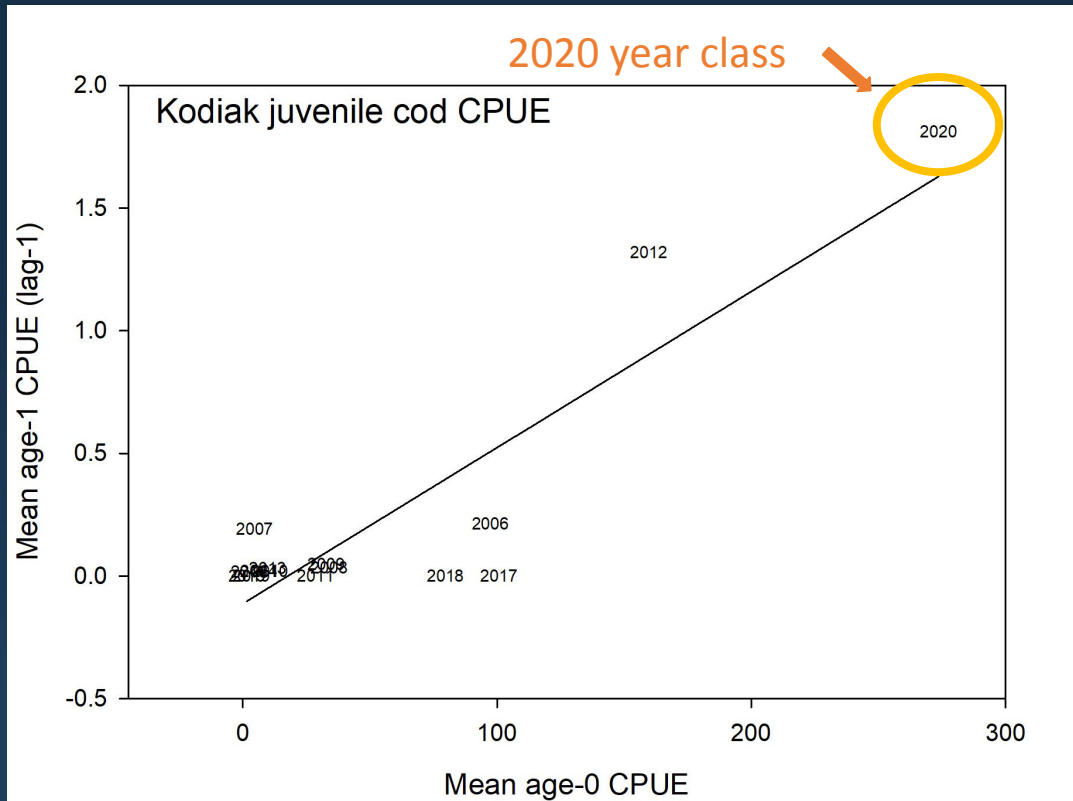
2020 year class

Kodiak seine data and camera survey data (not shown) found abundant age-1s in 2021.

<u>Take home</u>:

Consistent evidence of a large 2020 year class of Pacific cod.

Contact: Ben Laurel, Mike Litzow, Alisa Abookire

Age-0 Pollock (Kodiak and WGOA survey combined)

Estimated beach seine CPUE
Posterior means with 95% CI
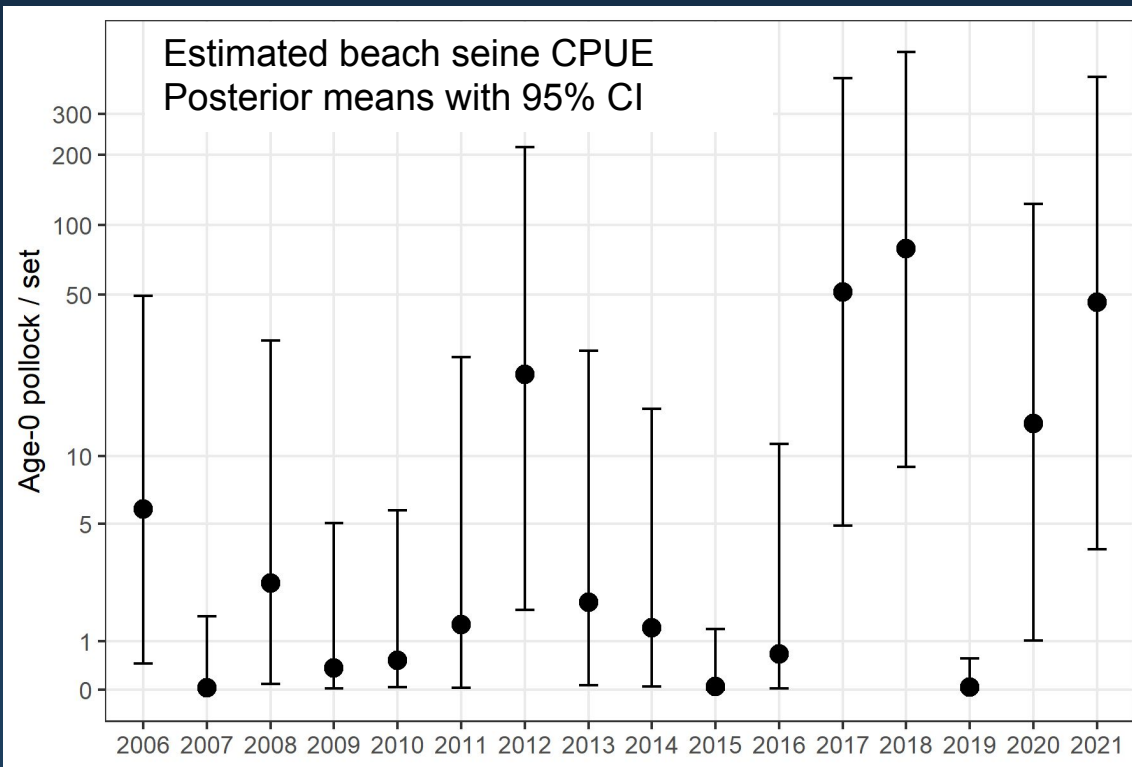
- Combined data from 2 Kodiak bays (2006-2021) and 4 AK Peninsula bays (2018-2021)

- Survey has captured strong year-classes of pollock.

- Greater uncertainty than cod seine results

Take home: 2021 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. Climate attribution statistics inform judgments about changing fisheries sustainability. Scientific Reports, in revision.

Contact: Ben Laurel, Mike Litzow, Alisa Abookire

Gulf of Alaska summary

GOA seems to be returning to pre-blob conditions especially east of Kodiak with cooler conditions, moderate copepods, and moderate fish condition during summer.

In the WGOA during spring, despite seeing cooler temperatures, we are seeing biological conditions of warm years with lower zooplankton and larval catches.

But the good news….. we saw a hot spot of zooplankton and larval pollock and Pacific cod southeast of Kodiak during spring and moderate catches of age-0 P cod and walleye pollock nearshore during summer. Abundance of age-1 Pacific cod in the beach seine indicating a strong 2020 year class.

Highlighted projects

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

- Climate-driven changes to Pacific cod spawning habitat

Contact : Ed Farley, Janet Duffy-Andersen, Rob Suryan, Tom Hurst

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

Log-transformed data, 2006-2016

Bayes R^2 = 0.68

Posterior mean with 80/90/95% CI
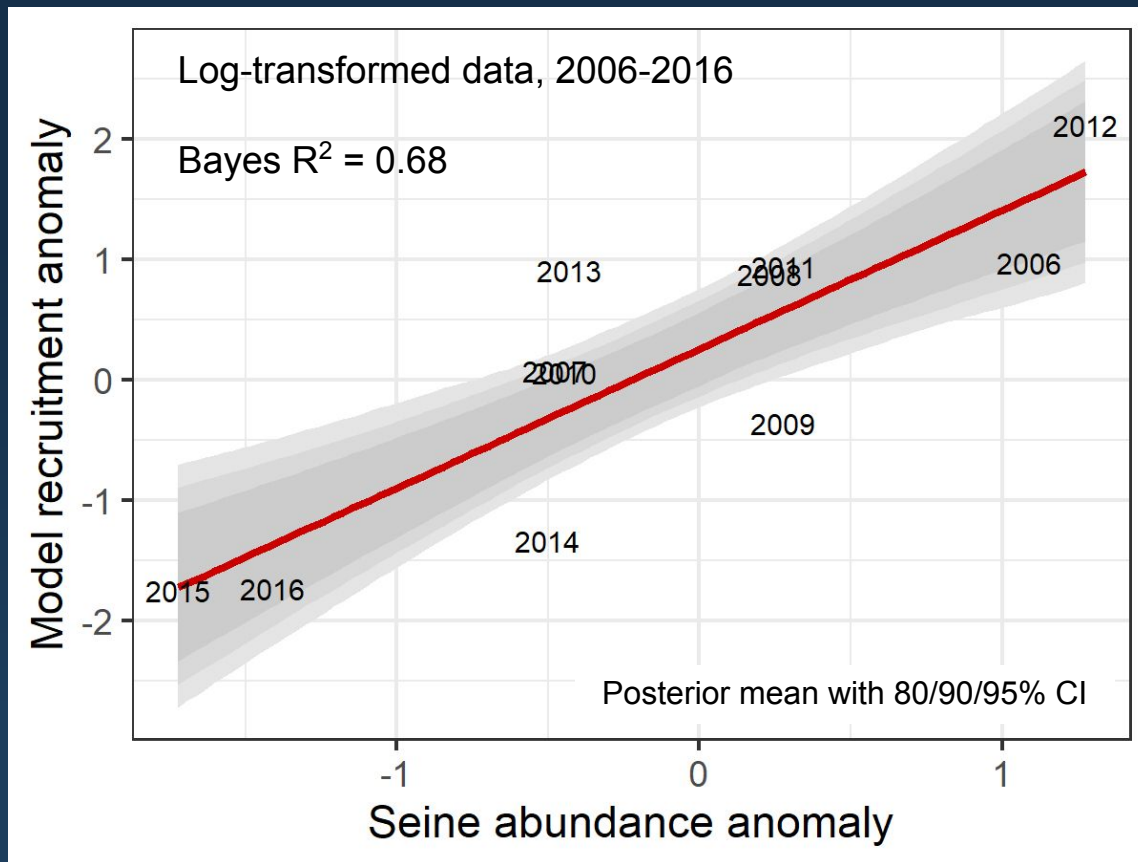
Pacific cod

- 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

Bayes R^2 = 0.40
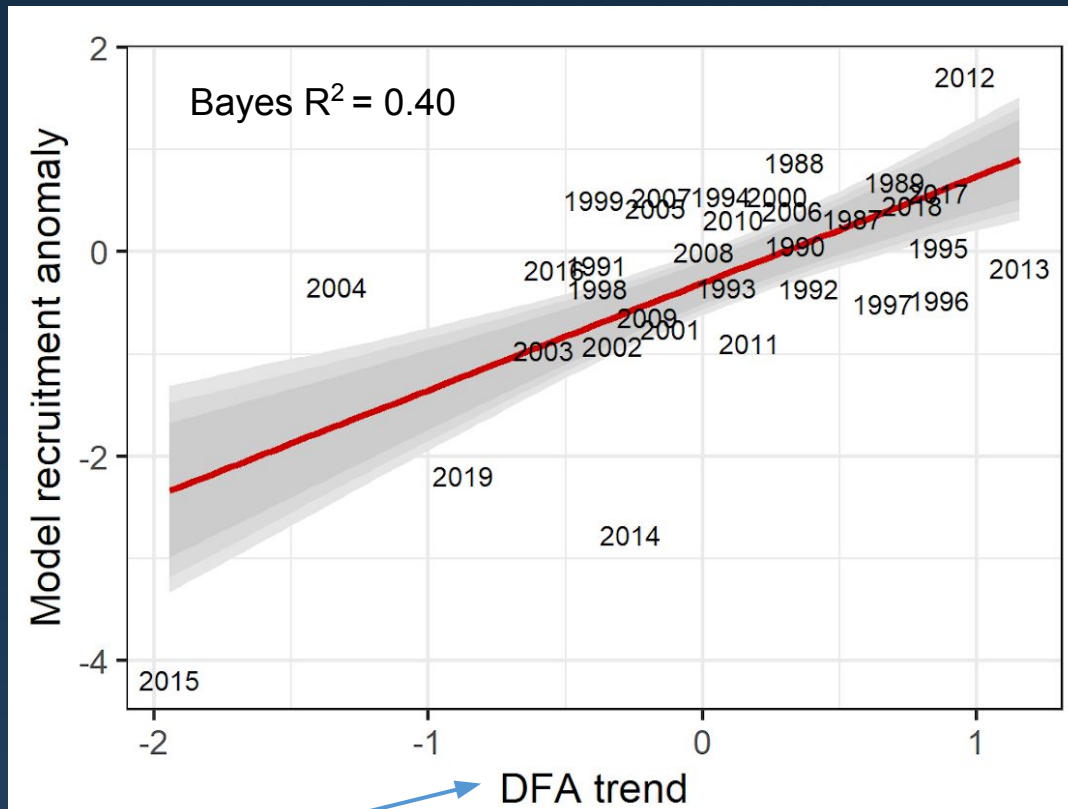
Dynamic Factor Analysis (DFA) trend: reflects shared variability in beach seines, larval survey, juvenile trawl survey

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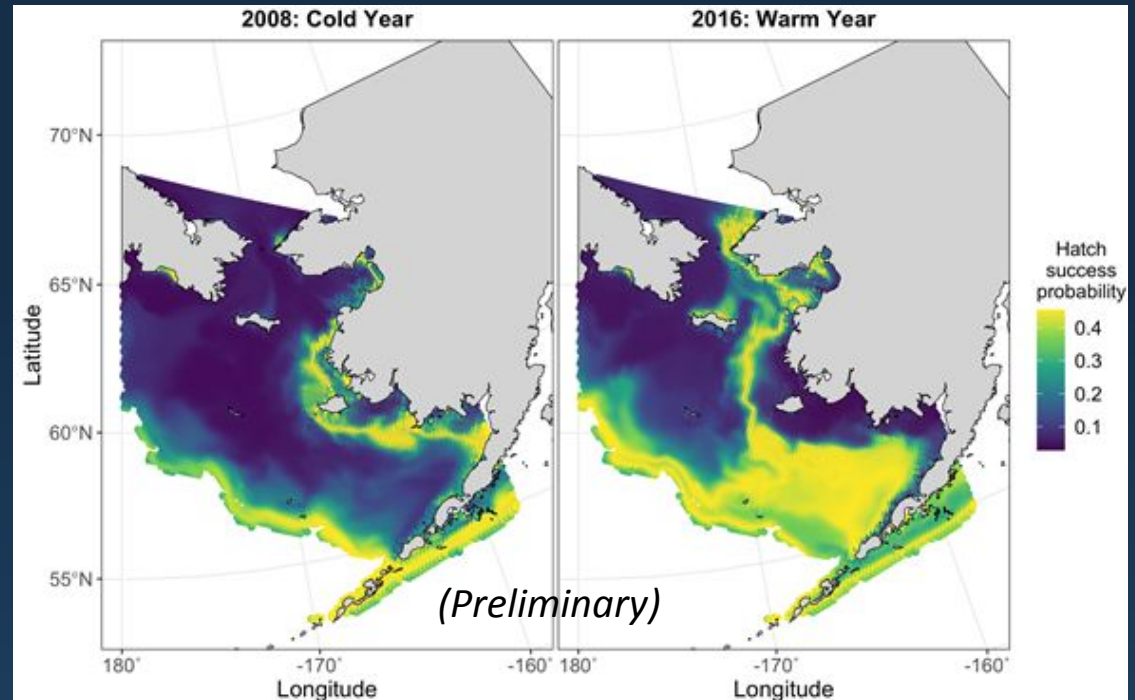
→ Developing indicators for ESPs, inform risk tables
→ Future projections of changes in timing and location of spawning

Jennifer Bigman, Lauren Rogers, Phyllis Stabeno, Ben Laurel, Al Hermann et al.

Acknowledgements

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