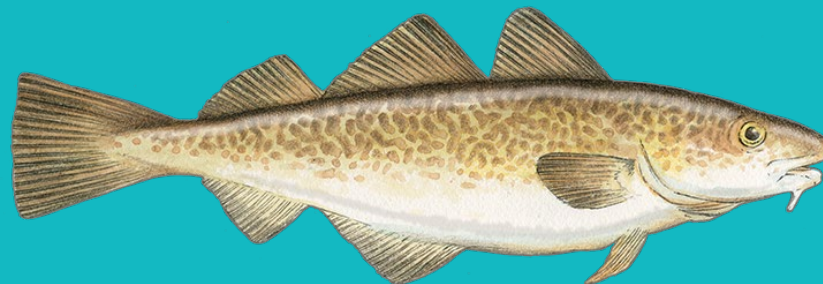




**NOAA**  
**FISHERIES**

# Aleutian Islands Pacific cod Research Updates

Ingrid Spies, Maia Kapur, Steve Barbeaux, Pete  
Hulson, Ivonne Ortiz, Sara Schaal, Laura Spencer



# Aleutian Islands Pacific cod

- Survey
- Environment
- Fishery
- Assessment
- Genetic update



Photo credit: Sandi Neidetcher

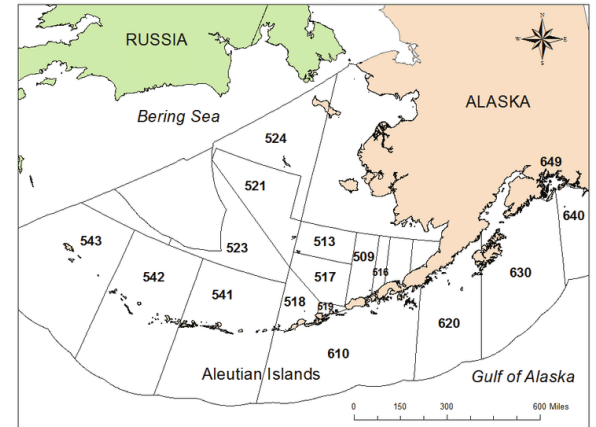
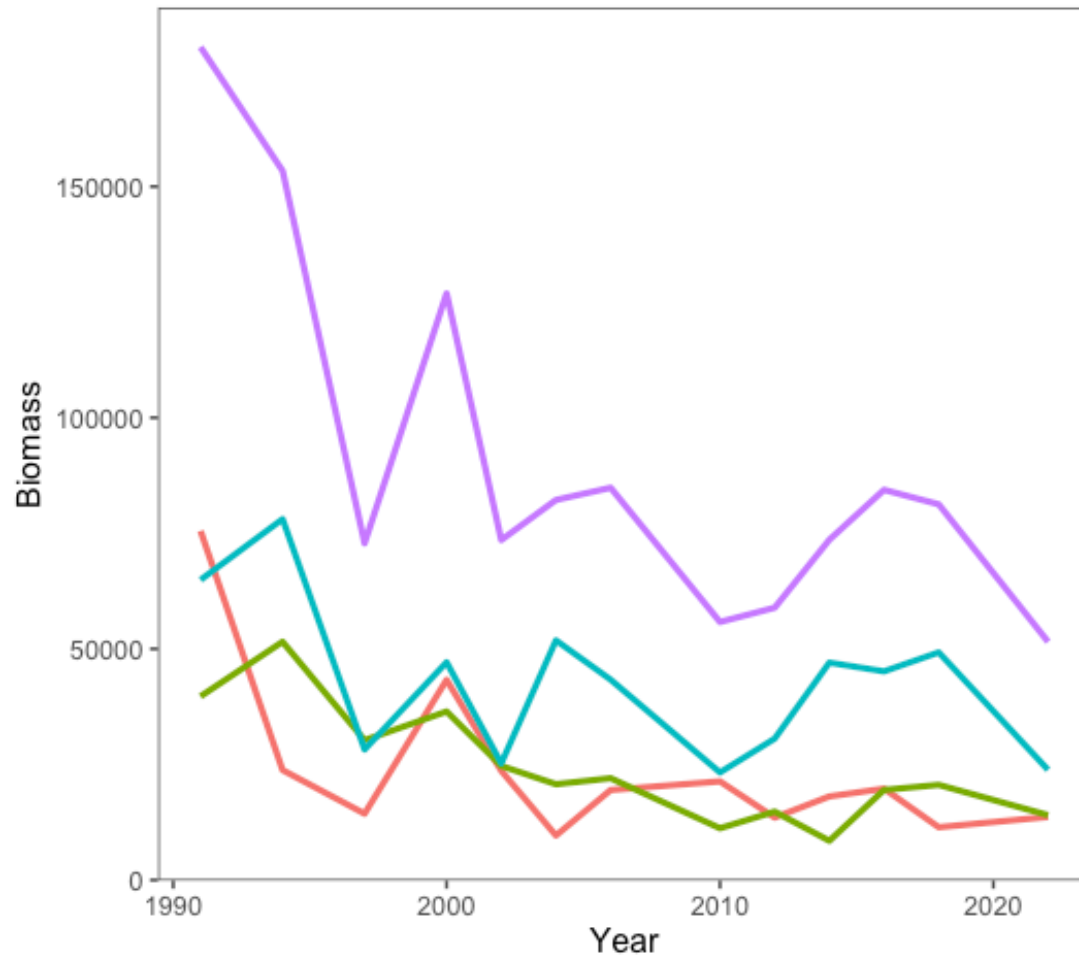
# Survey



**NOAA**  
**FISHERIES**



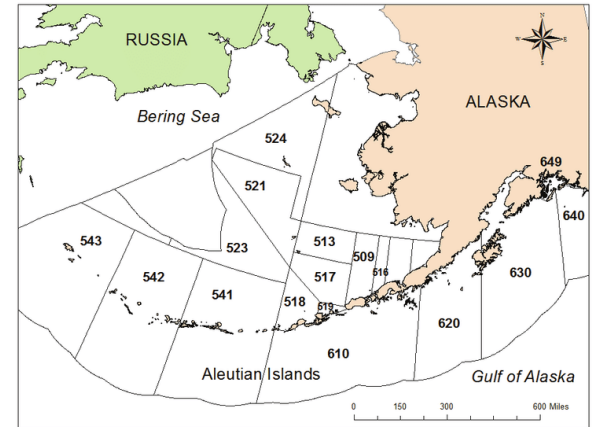
# Aleutian Islands Pacific cod trawl survey estimates by NMFS area



- Region
- Western
  - Central
  - Eastern
  - Total

# Aleutian Islands Pacific cod trawl survey estimates by NMFS area

Biomass (t)				
Year	Western	Central	Eastern	Total
1991	75,514	39,729	64,926	180,170
1994	23,797	51,538	78,081	153,416
1997	14,357	30,252	28,239	72,848
2000	43,298	36,456	47,117	126,870
2002	23,623	24,687	25,241	73,551
2004	9,637	20,731	51,851	82,219
2006	19,480	22,033	43,348	84,861
2010	21,341	11,207	23,277	55,826
2012	13,514	14,804	30,592	58,911
2014	18,088	8,488	47,032	73,608
2016	19,775	19,496	45,138	84,409
2018	11,425	20,596	49,251	81,272
2022	13,661	14,041	23,837	51,539



\*\*There is a survey planned for summer 2024.

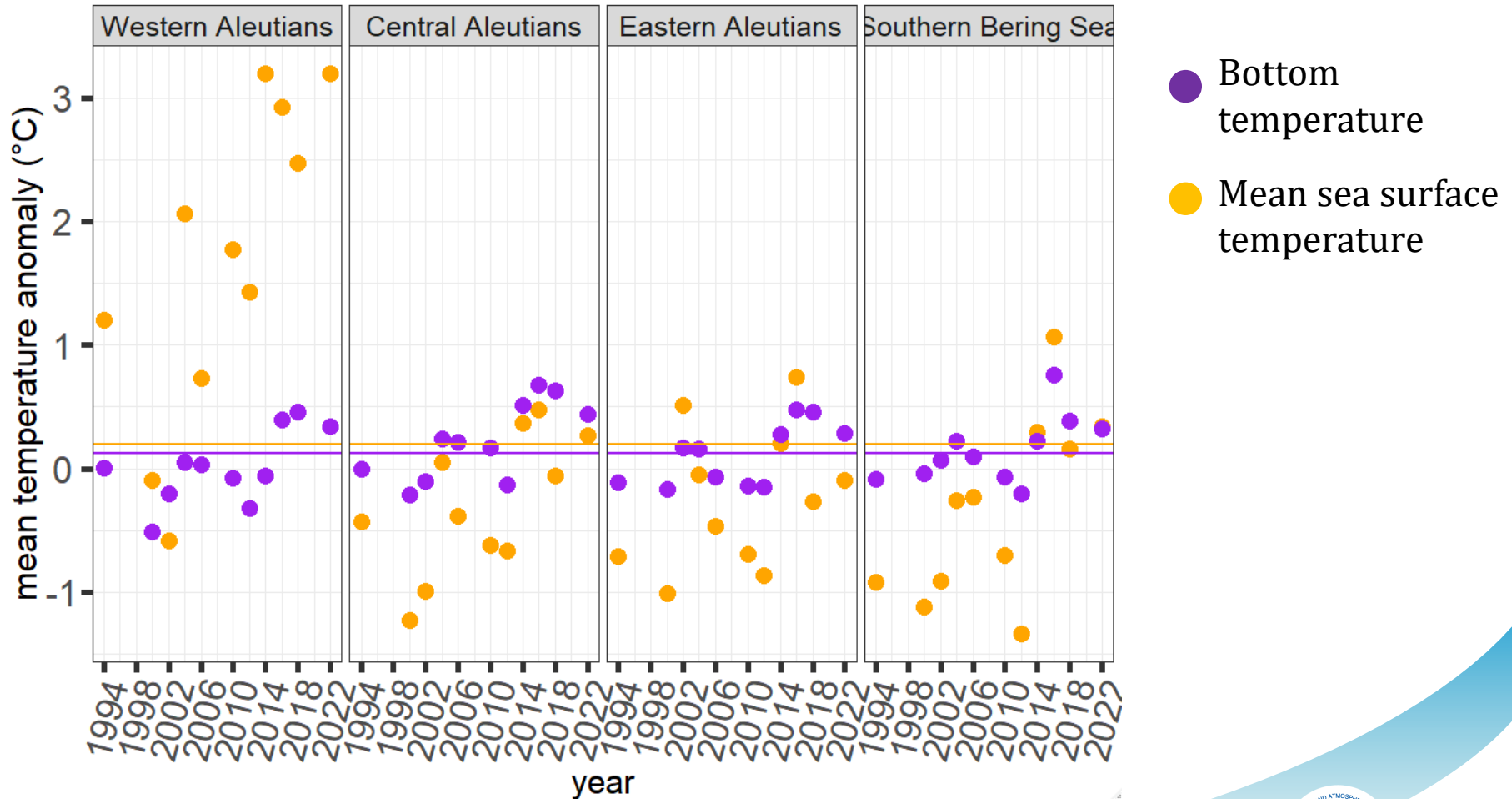
# Environment



**NOAA**  
**FISHERIES**

# Water temperatures in the Aleutian Islands have been above the long term mean since at least 2014

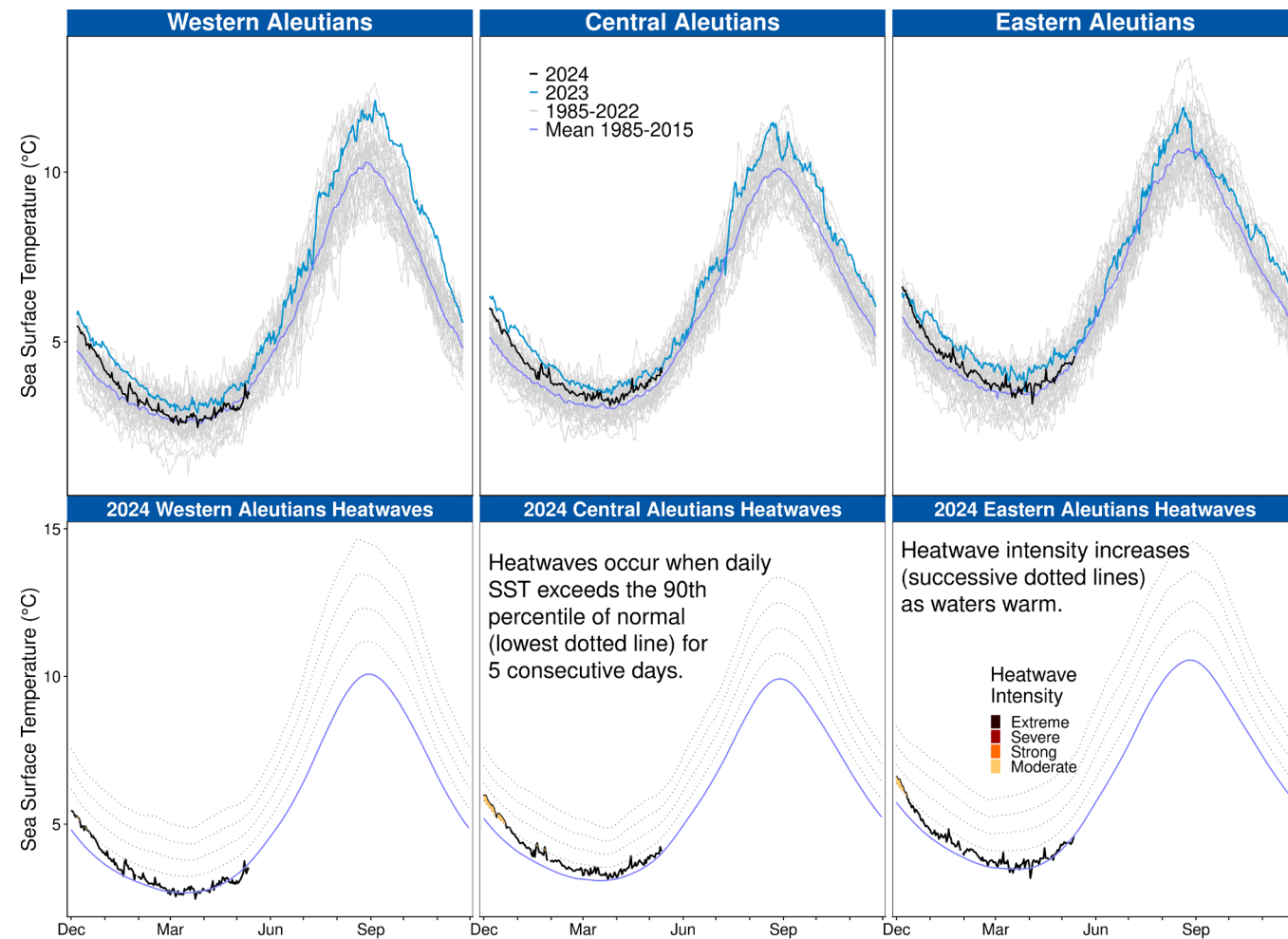
## Mean SST and Bottom Temp Anomalies



- Bottom temperature
- Mean sea surface temperature



# 2024 has not been as warm as 2023 and appears to be approaching the 1985-2015 mean.



NOAA Coral Reef Watch data, courtesy National Environmental Satellite, Data, and Information Service (Updated: 05-12-2024)  
 Data are modeled satellite products and periodic discrepancies or gaps may exist across sensors and products.  
 Contact: matt.callahan@noaa.gov

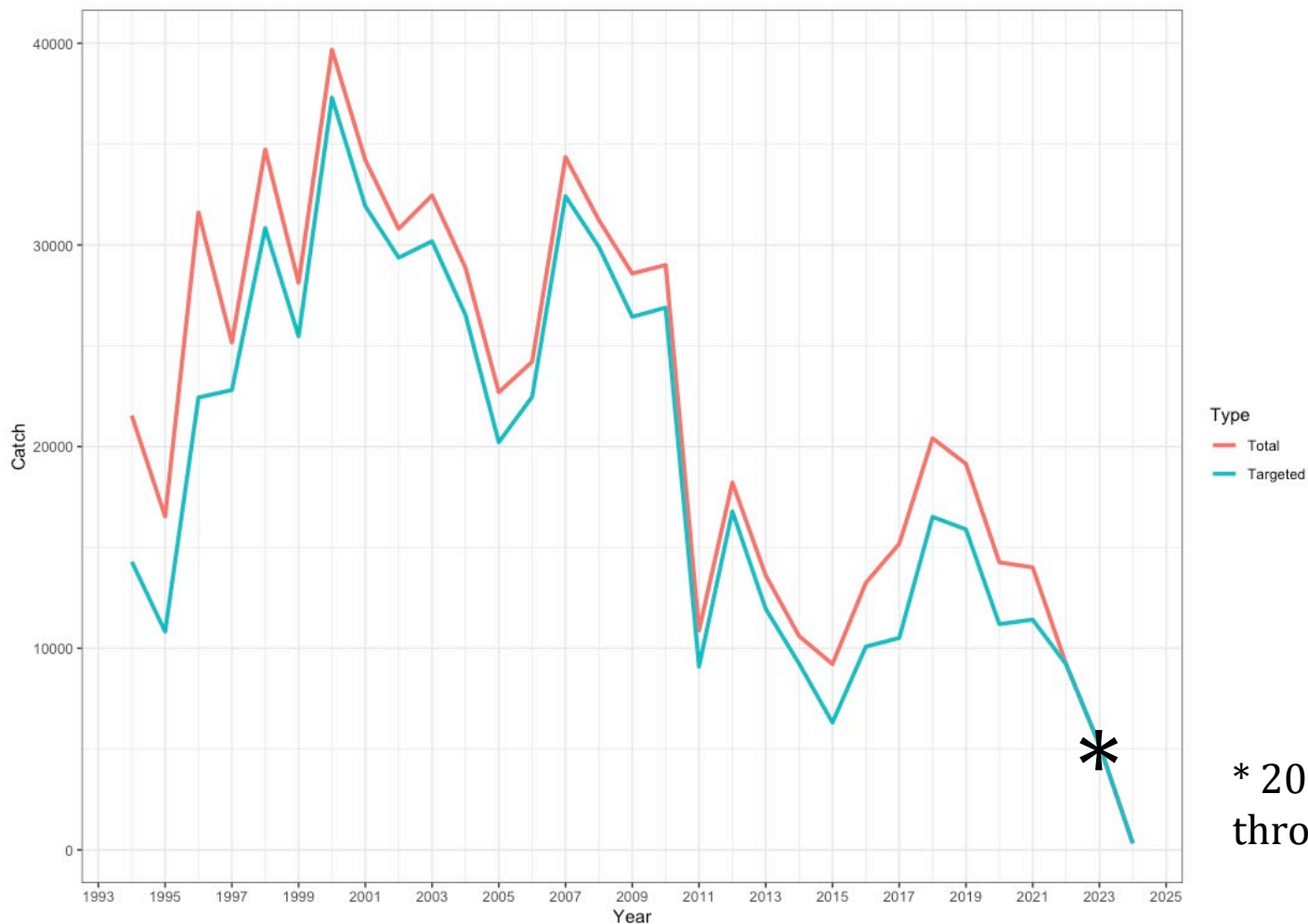


# Fishery



**NOAA**  
**FISHERIES**

# Aleutian Islands catch has declined



\* 2024 data complete through May 1, 2024.

# Aleutian Islands catch has declined

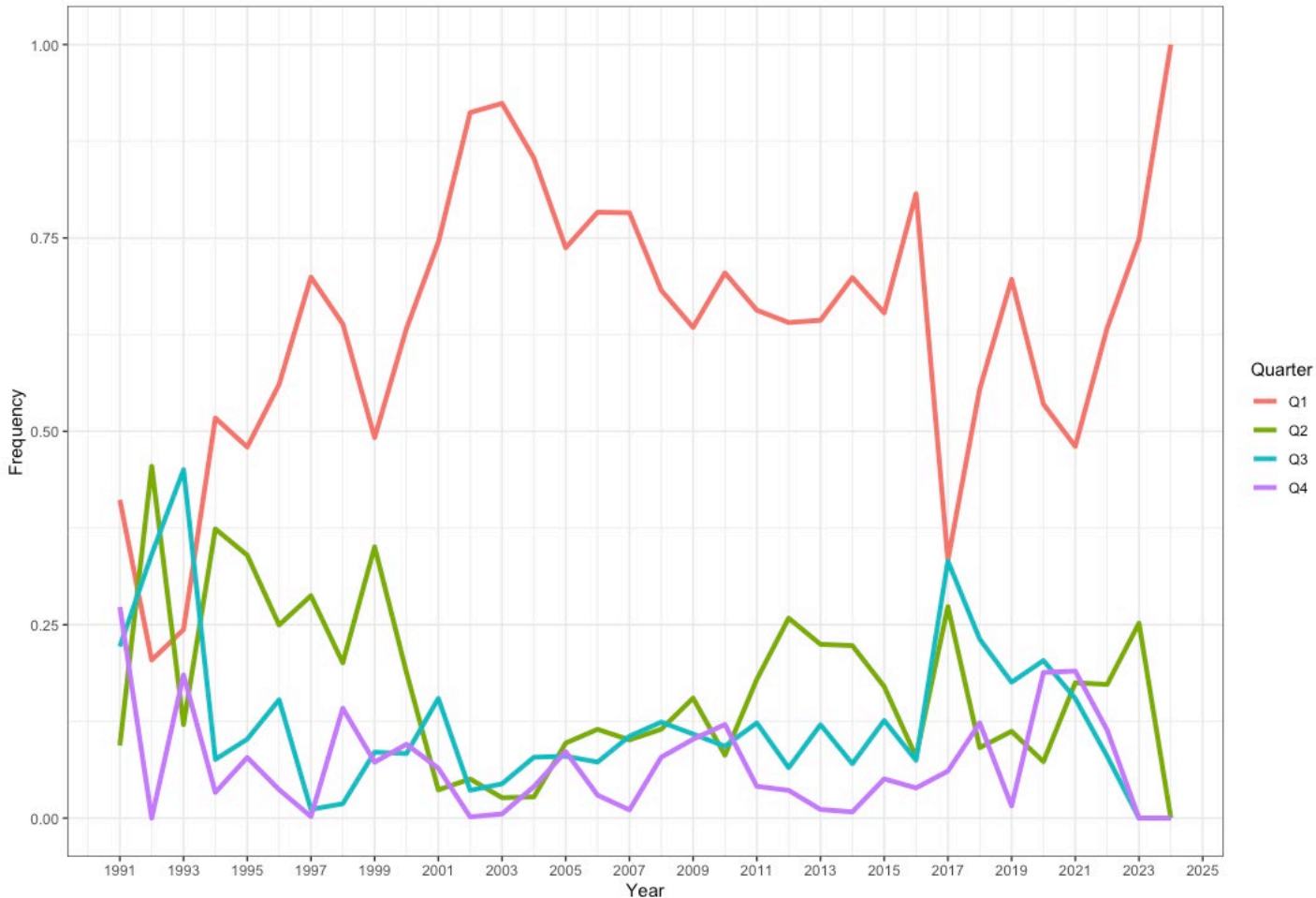
Pacific cod fishery length frequency by gear and year



**NOAA**  
FISHERIES

# Catch primarily occurs in the first quarter (winter) when cod are aggregating to spawn.

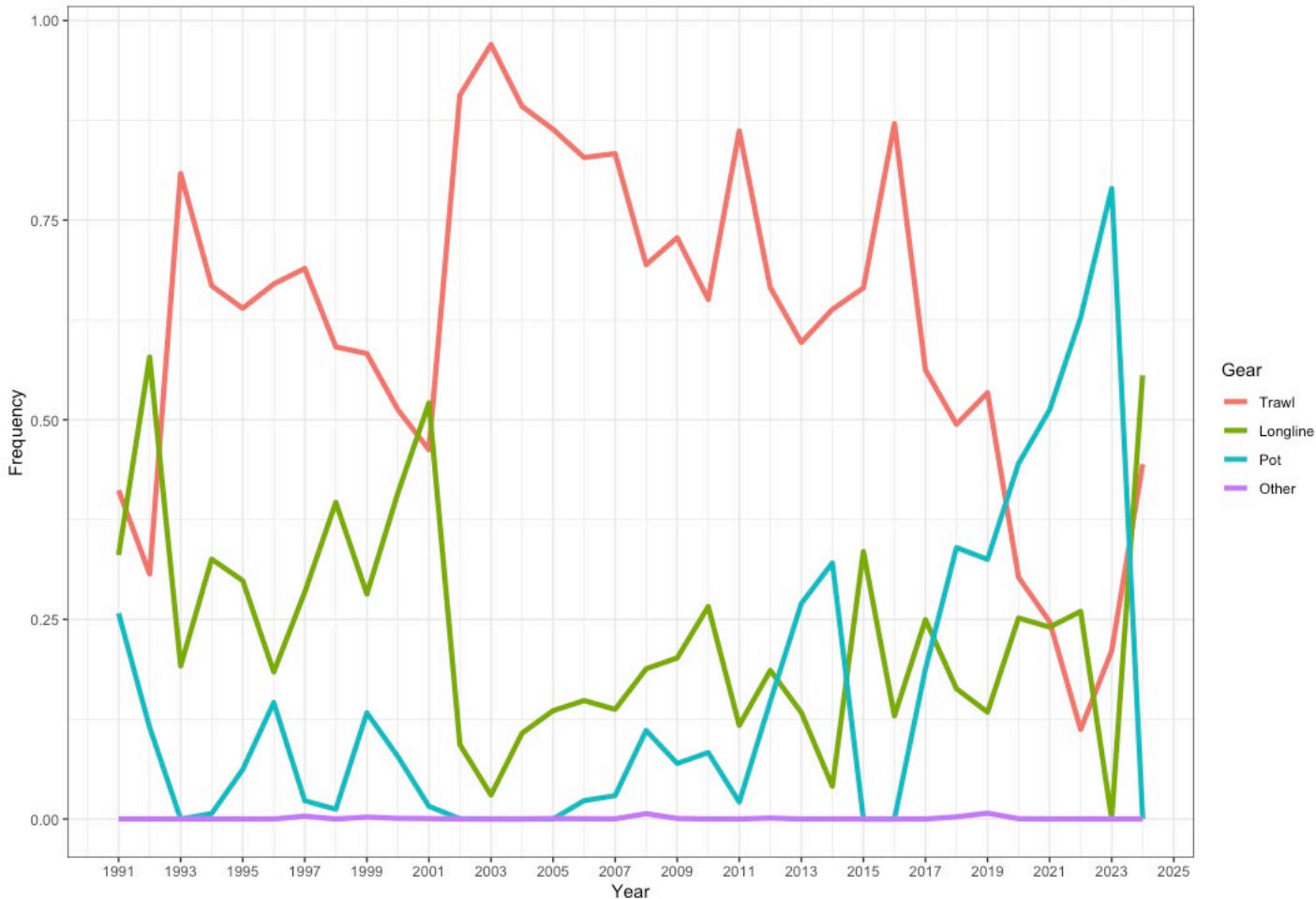
Catch by quarter, Aleutian Islands Pacific cod fishery



**NOAA**  
FISHERIES

# Gear is predominantly trawl, although pot has become more predominant.

Proportion of Aleutian Islands Pacific cod catch by year and gear

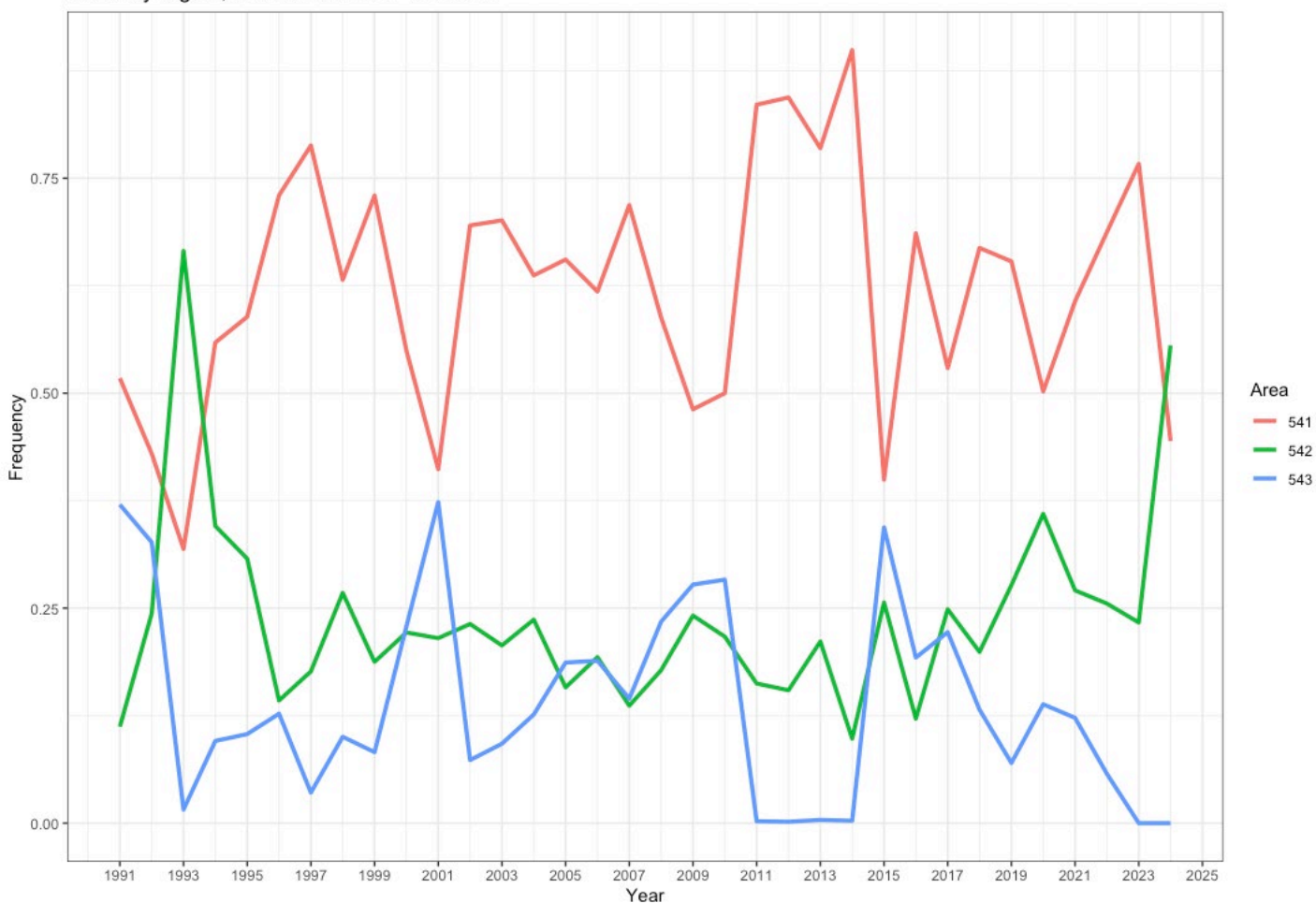


**NOAA**  
FISHERIES



# Most catch takes place in the eastern Aleutians, area 541.

Catch by region, Aleutian Islands Pacific cod



**NOAA**  
FISHERIES

# Assessment



**NOAA**  
**FISHERIES**

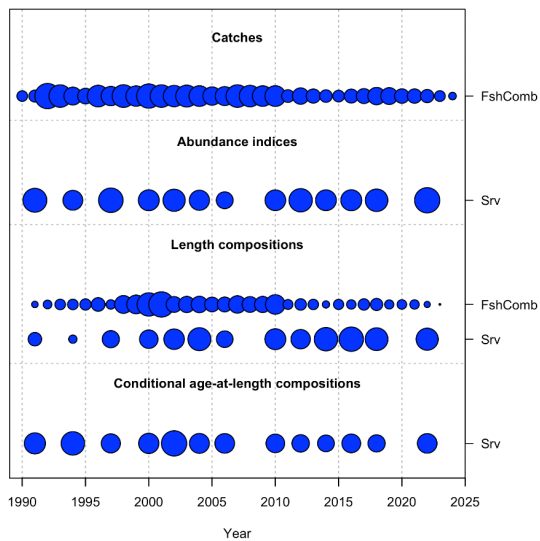
# Assessment methodology

1. The Tier 5 methodology has not changed (Model 13.4).  $ABC = 75\% * M * \text{Biomass}$
2. Age structured models take into account more information



# Data used in age structured models

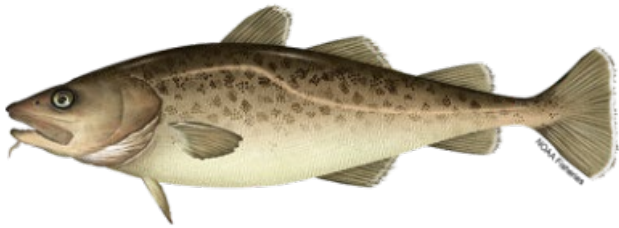
Source	Type	Years
Fishery (Trawl, Pot, LL)	Catch biomass	1991-2024*
Fishery (Trawl, Pot, LL)	Length composition	1991-2024
AI bottom trawl survey	Biomass estimate + Length composition	1991, 1994, 1997, 2000, 2002, 2004, 2006, 2010, 2012, 2014, 2016, 2018, 2022
AI bottom trawl survey	Age composition	1991, 1994, 1997, 2000, 2002, 2004, 2006, 2010, 2012, 2014, 2016, 2018, 2022



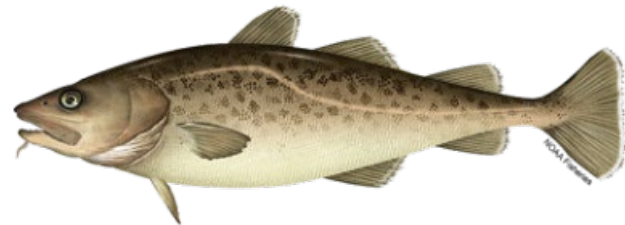
There were 10,134 records of aged and lengthed Pacific cod taken from NMFS research surveys between 1991 and 2022.

# Specifying natural mortality

- *Then\_lm* used to estimate a base value of M through growth patterns and maximum ages  
([http://barefootecologist.com.au/shiny\\_m.html](http://barefootecologist.com.au/shiny_m.html))



EBS cod  
Max age = 14  
Then\_lm M = 0.387



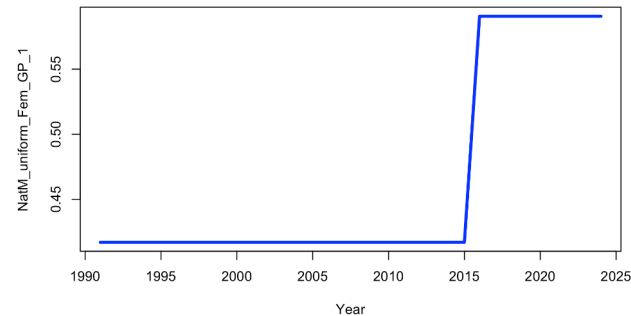
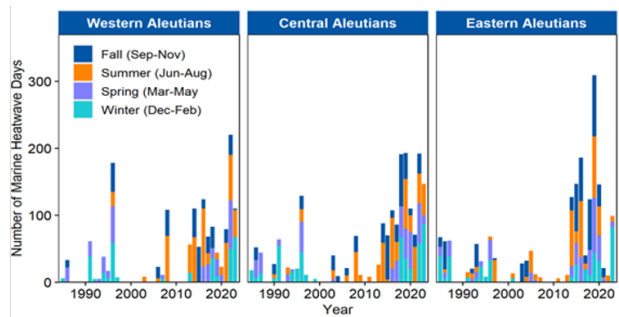
AI cod  
Max age = 13  
Then\_lm M = 0.417



# Incorporating an increase in natural mortality in response to heatwave can improve the fit to the data.

Time block on natural mortality was incorporated to explain the shift in the 2010s.

Pacific cod are sensitive temperature, which can result in increased mortality.



Time varying M has been implemented for GOA Pacific cod as a result of heatwave conditions.

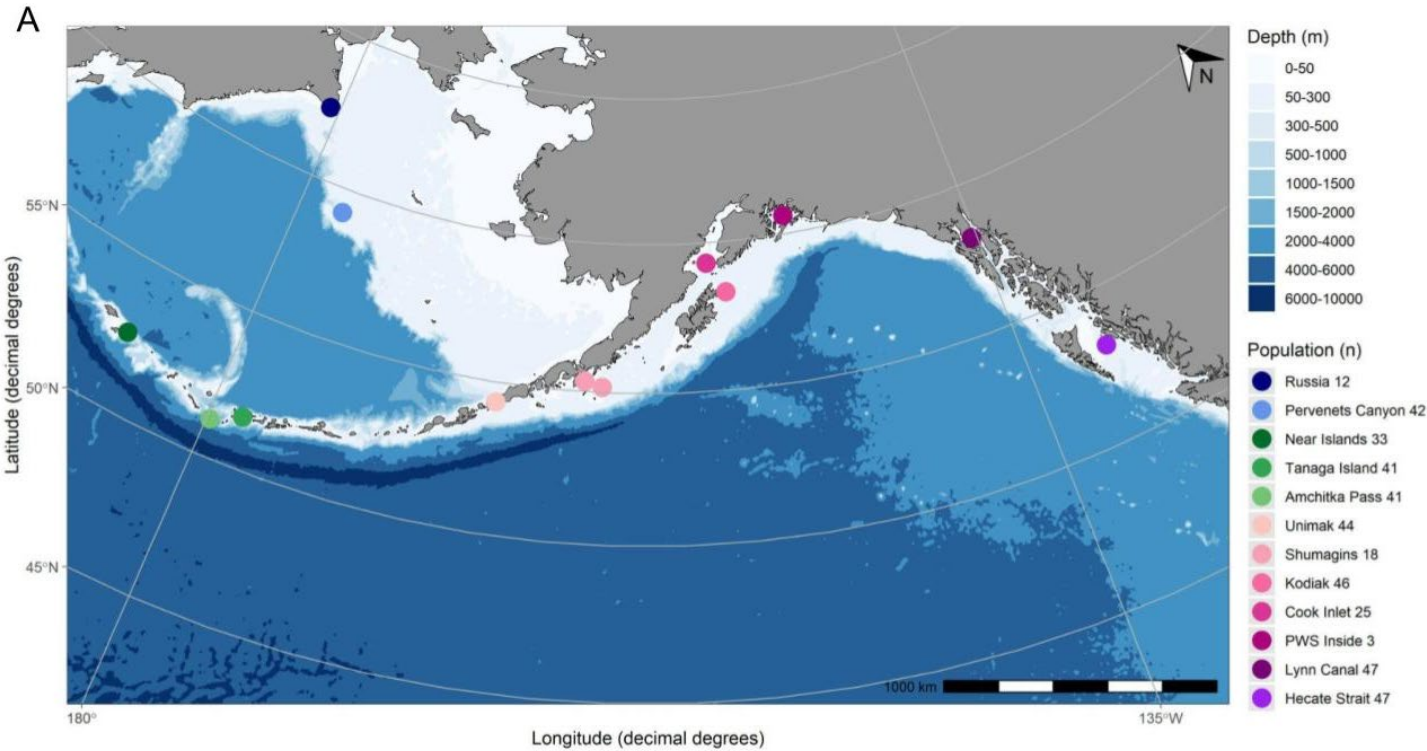
# Genetics update



**NOAA**  
**FISHERIES**

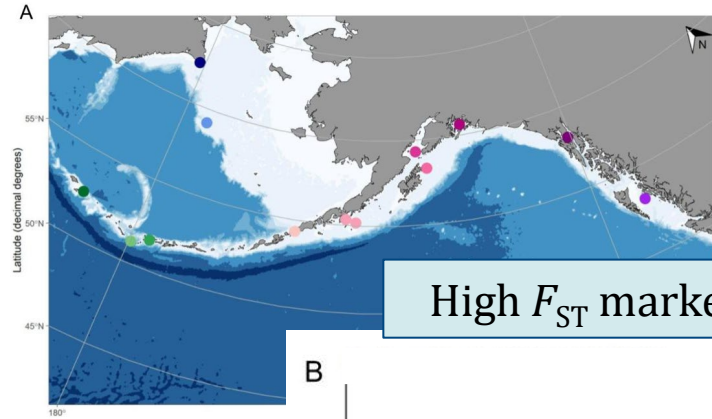
# To what extent is there seasonal variation in stock-specific adult habitat use in Pacific cod? (Dr. Sara Schaal)

*Hypothesis:* Genetic stock proportions of summer caught Pacific cod adults will show mixing of multiple stocks at each location due to summer movement to feeding grounds



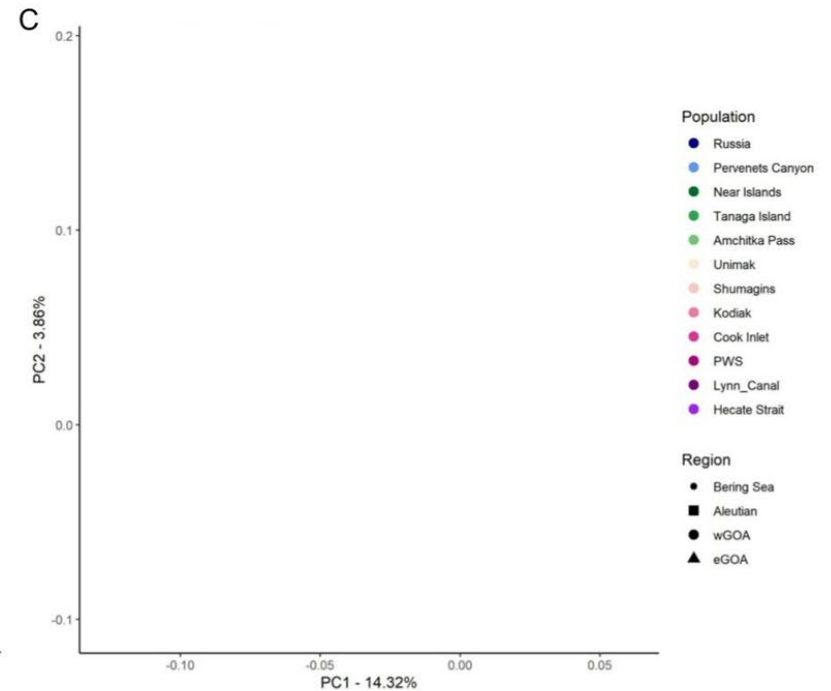
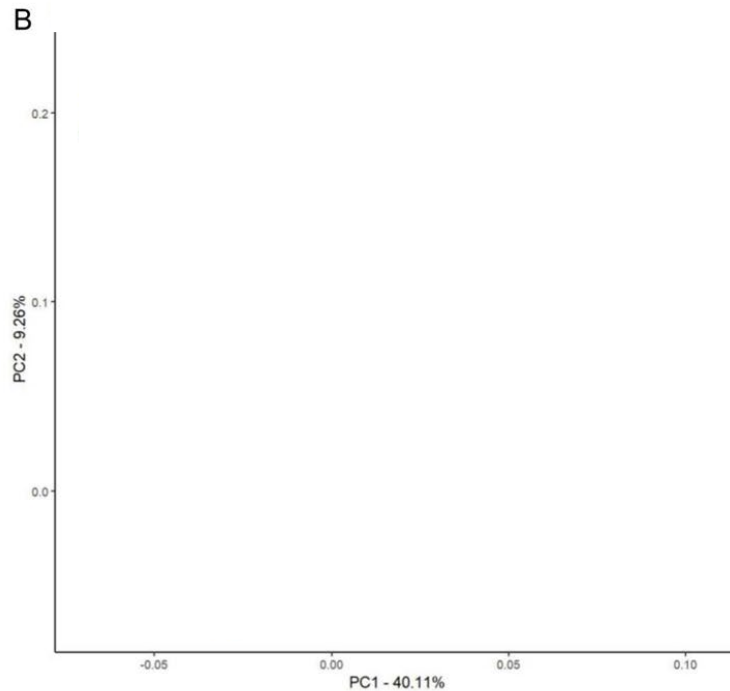
Low-coverage whole genome sequencing (lcWGS) of 429 individuals to assess population genetic structure across the Gulf of Alaska and Bering Sea

# Genotyping-in-Thousands by Sequencing (GT-seq) - captures the population genetic structure using a subset panel of markers

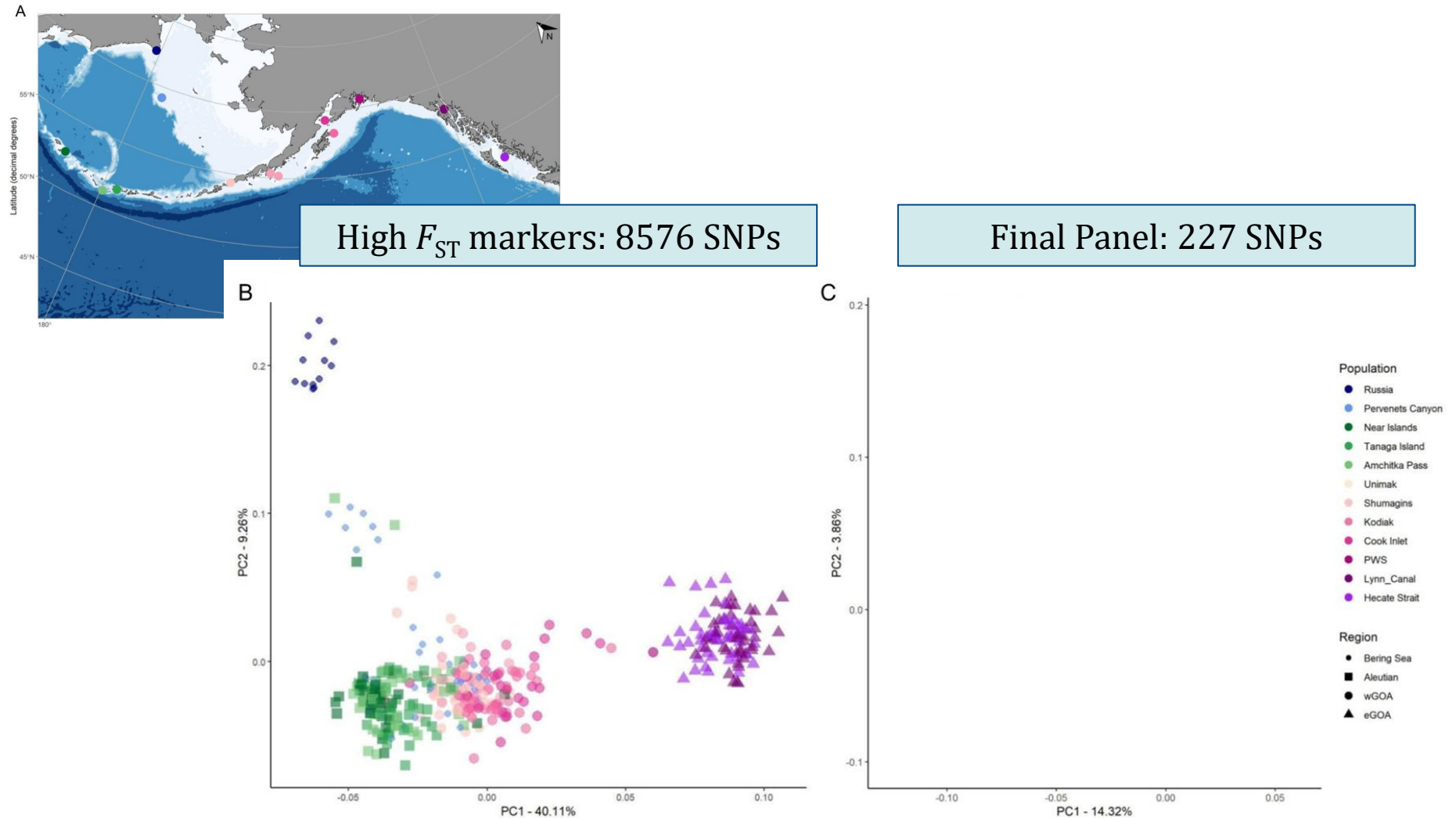


High  $F_{ST}$  markers: 8576 SNPs

Final Panel: 227 SNPs

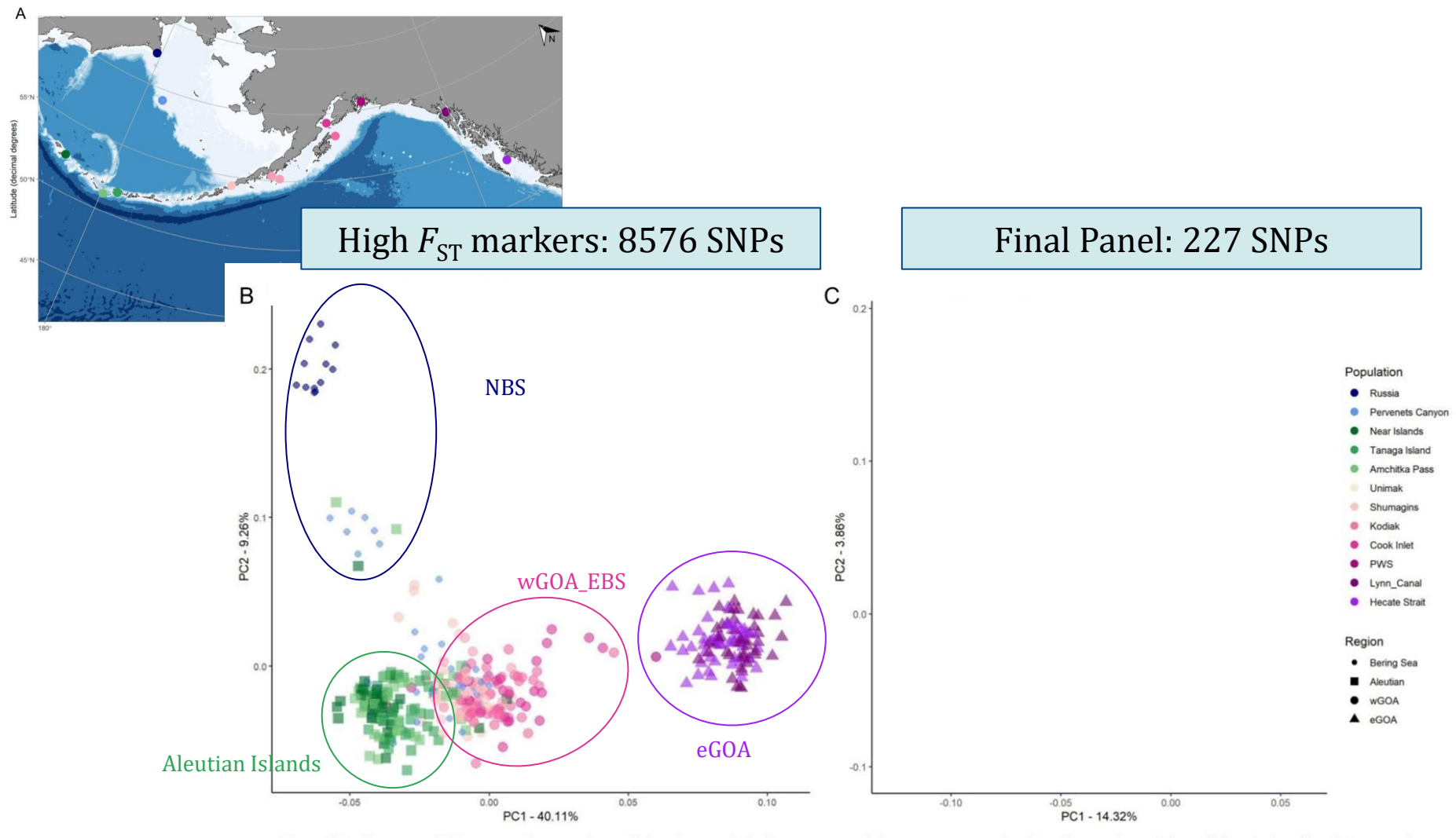


# Genotyping-in-Thousands by Sequencing (GT-seq) - captures the population genetic structure using a subset panel of markers

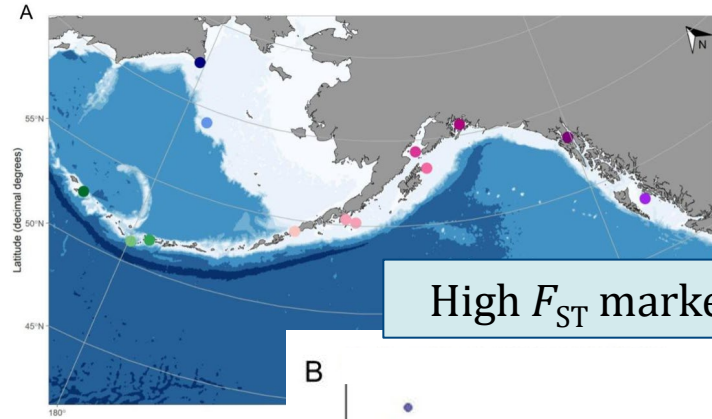




# Genotyping-in-Thousands by Sequencing (GT-seq) - captures the population genetic structure using a subset panel of markers

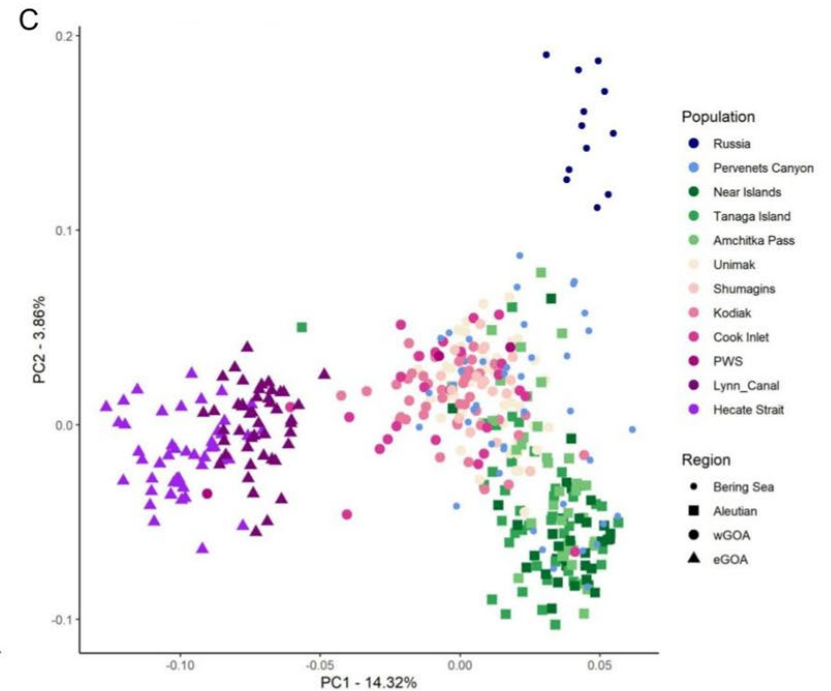
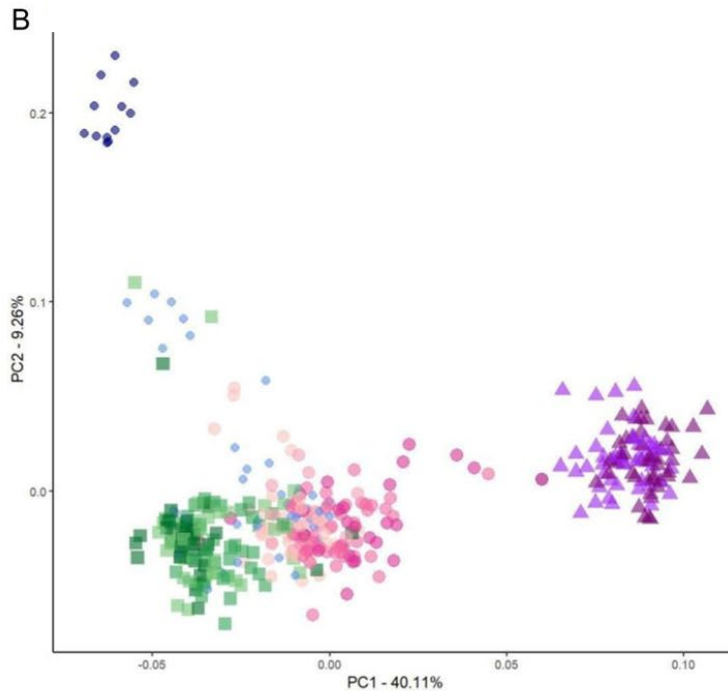


# Genotyping-in-Thousands by Sequencing (GT-seq) - captures the population genetic structure using a subset panel of markers

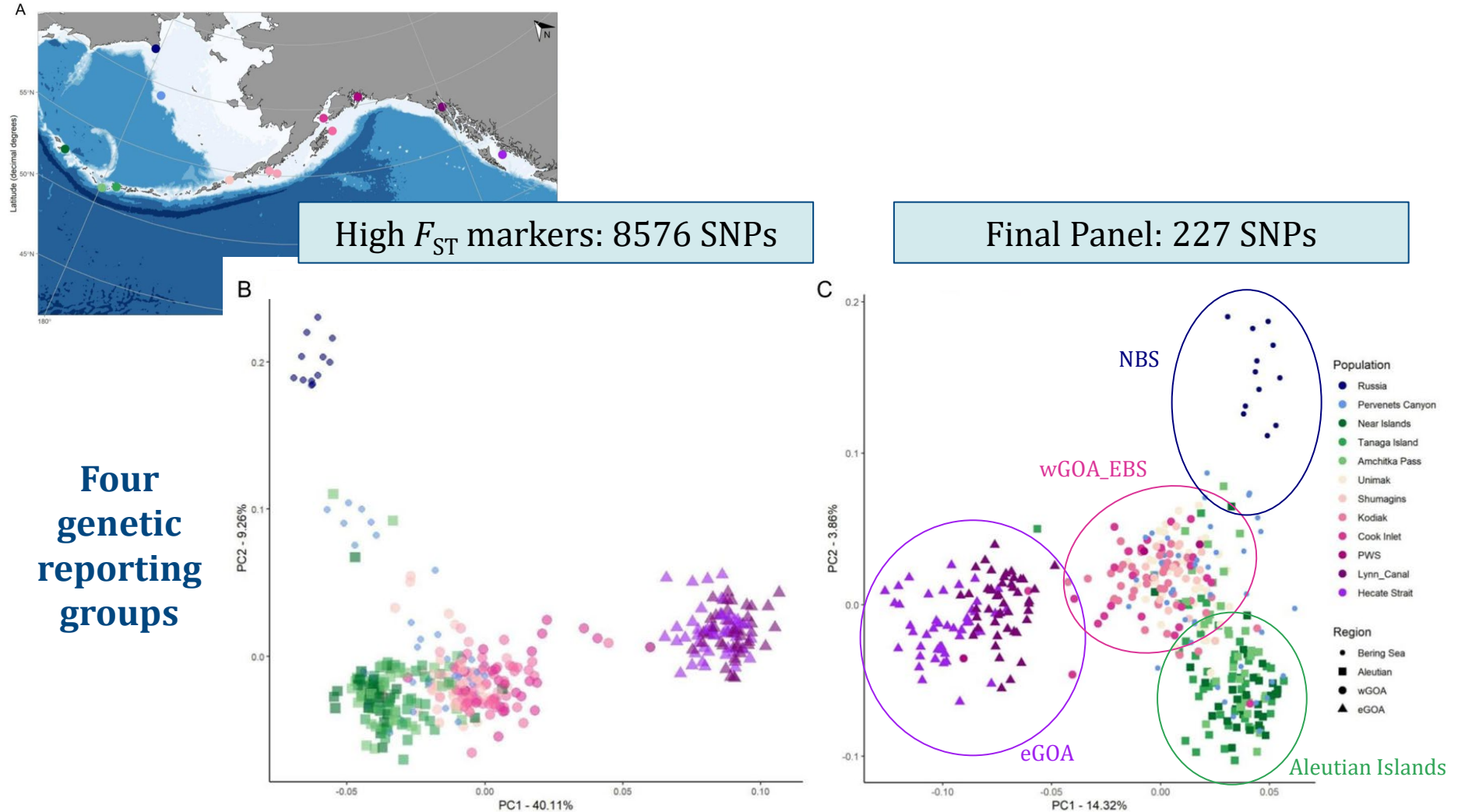


High  $F_{ST}$  markers: 8576 SNPs

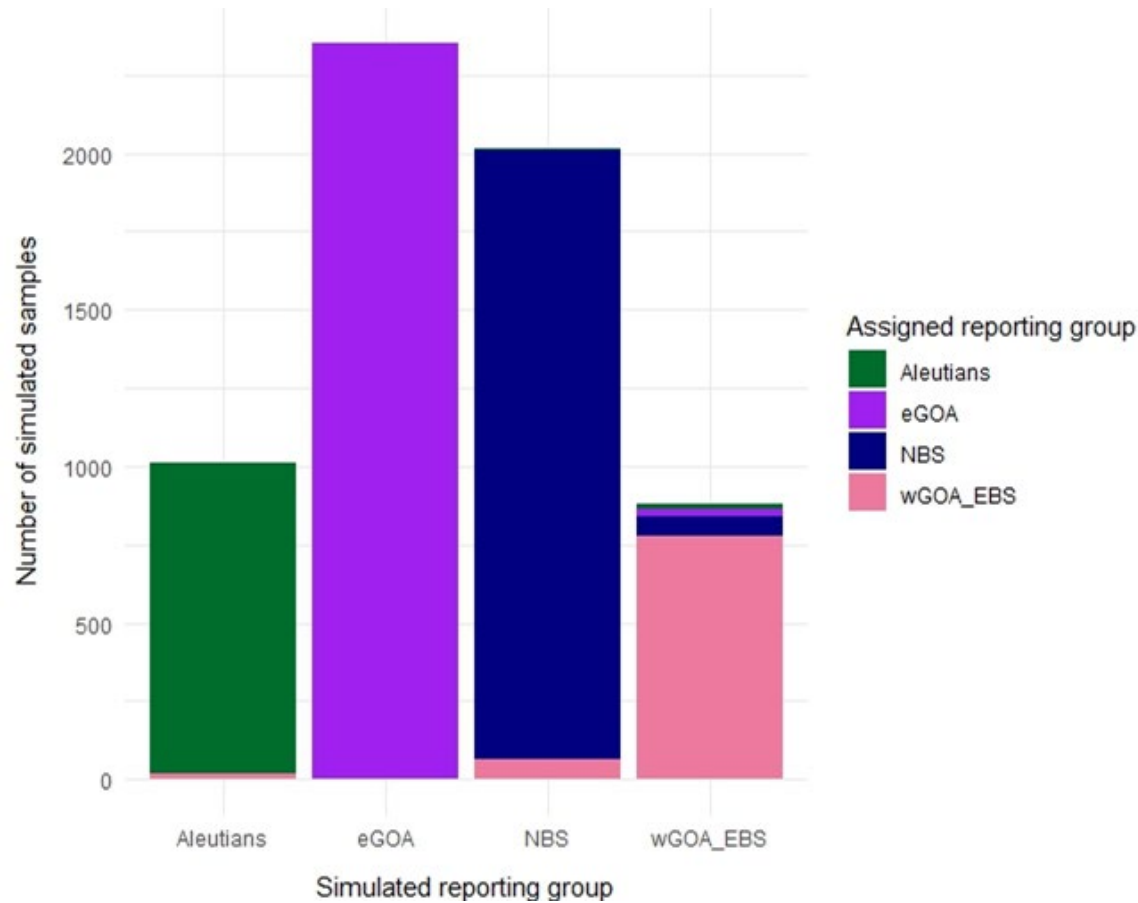
Final Panel: 227 SNPs



# Genotyping-in-Thousands by Sequencing (GT-seq) - captures the population genetic structure using a subset panel of markers



## Panel Performance - Rubias leave-one-out mixture simulations



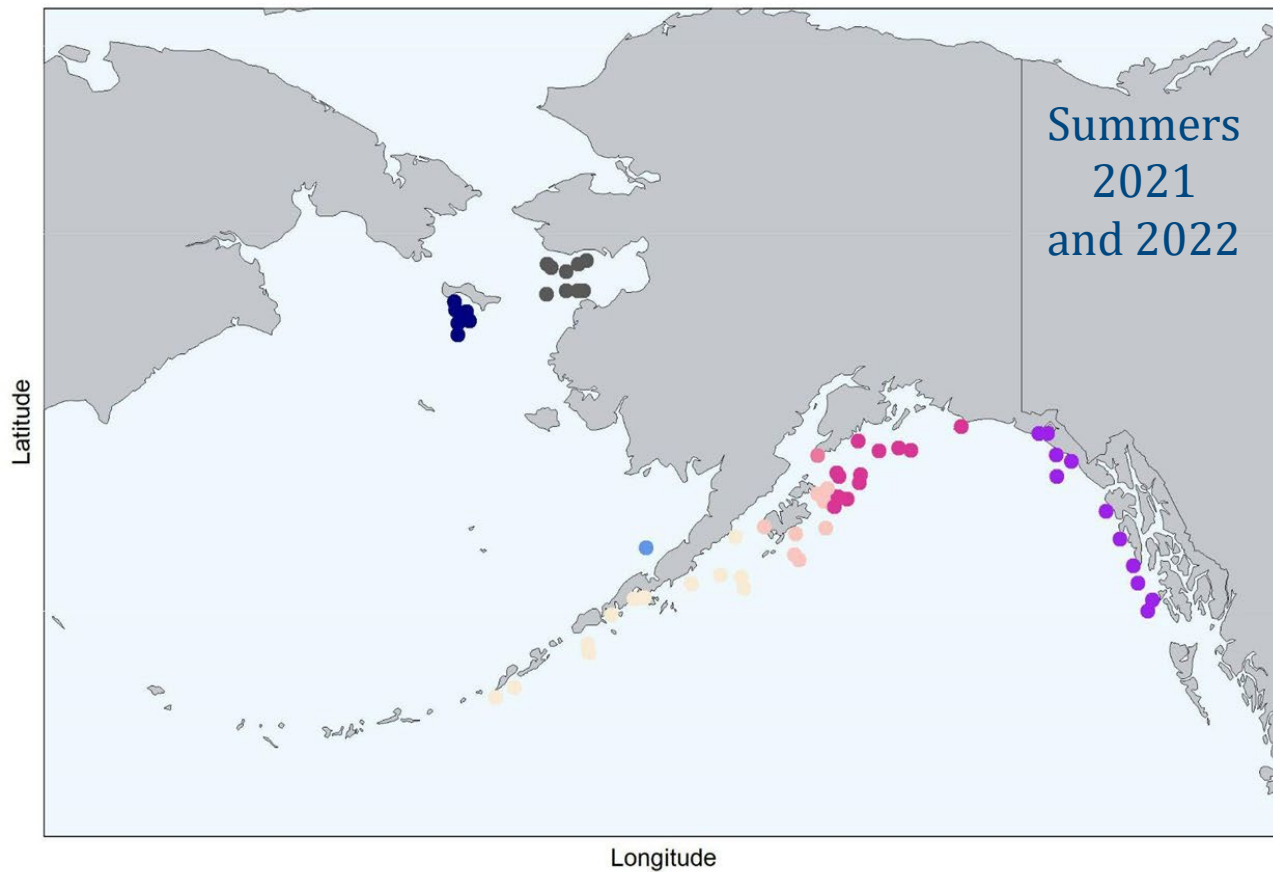
Samples assigned with > 90% confidence

Reporting Group	Assignment Accuracy
Aleutians	97.6%
eGOA	98.9%
NBS	97.1%
wGOA_EBS	90.7%
<b>Overall</b>	<b>97.0%</b>



# Summer caught Pacific cod adults

## Map of Sampling Locations



- Norton Sound - 28
- Northern Bering Sea - 24
- Eastern Bering Sea - 25
- Western GOA - 24
- Kodiak - 21
- Outside Cook Inlet - 23
- Central GOA - 54
- Eastern GOA - 25

**Total sample size: 224**

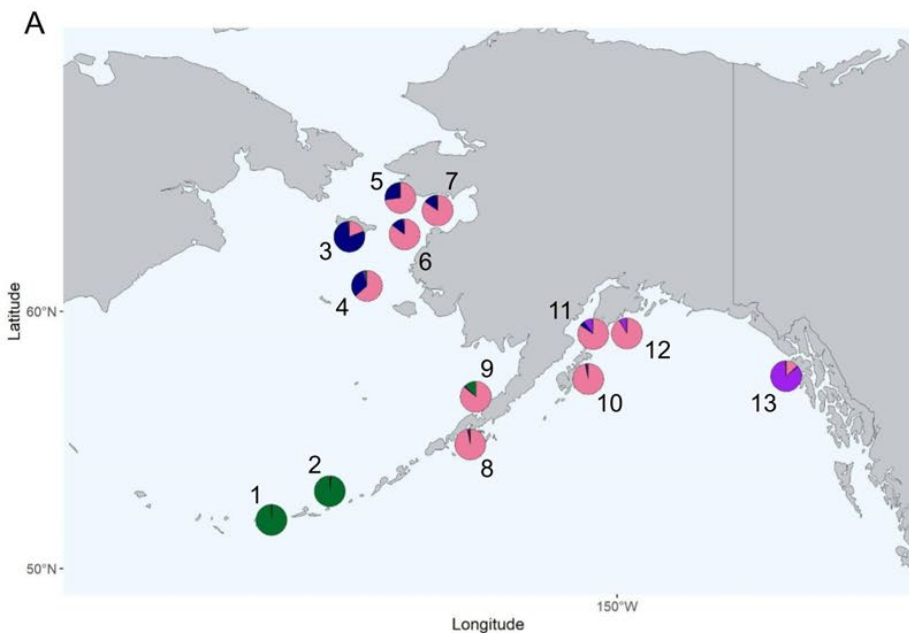


**NOAA**  
FISHERIES

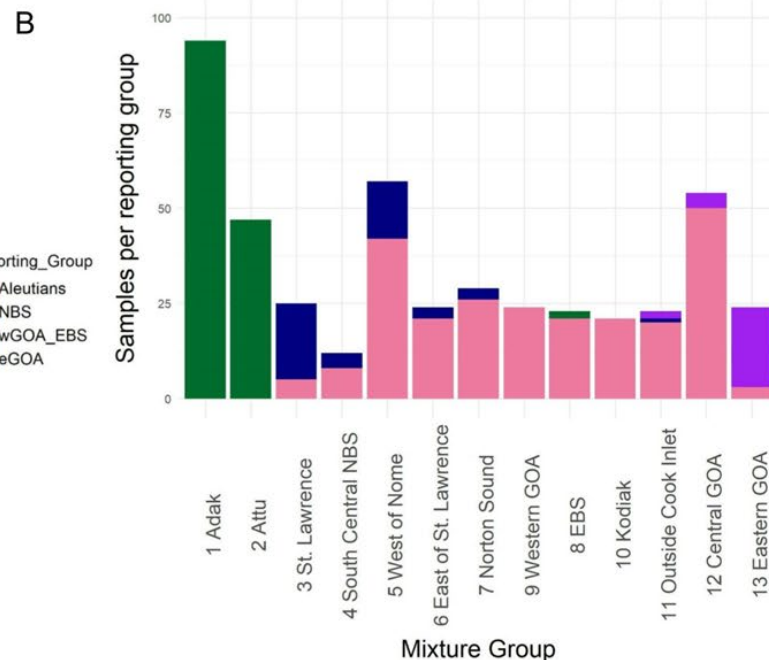


# Individual assignment based on mixture analysis for samples > 90 probability of assignment

## Mixture Proportions Per Collection Site



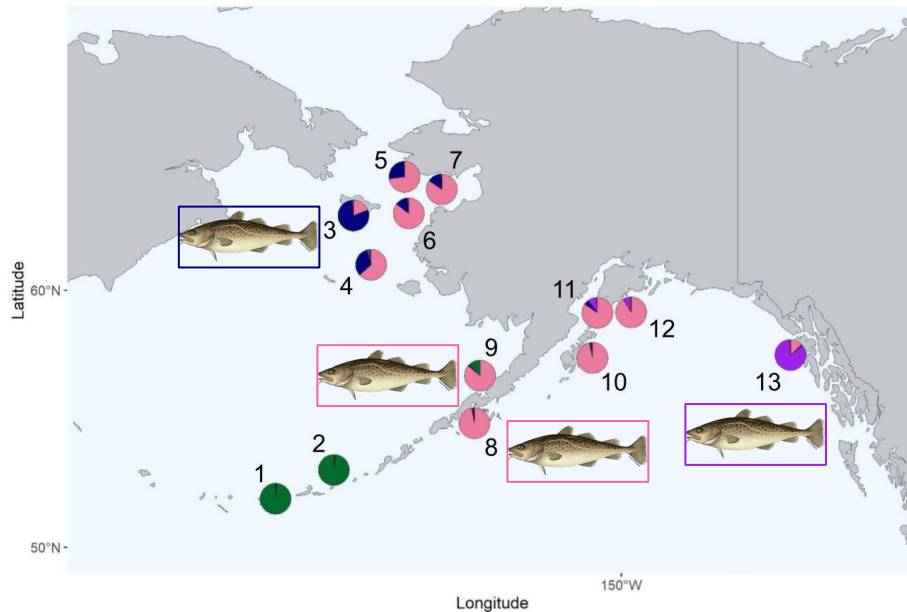
## Individual Assignments Per Collection Site



## Summer Caught Adult Pacific cod Conclusions

### To what extent is there seasonal variation in stock-specific adult habitat use in Pacific cod?

*Hypothesis:* Genetic stock proportions of summer caught Pacific cod adults will show mixing of multiple stocks at each location due to summer movement to feeding grounds.

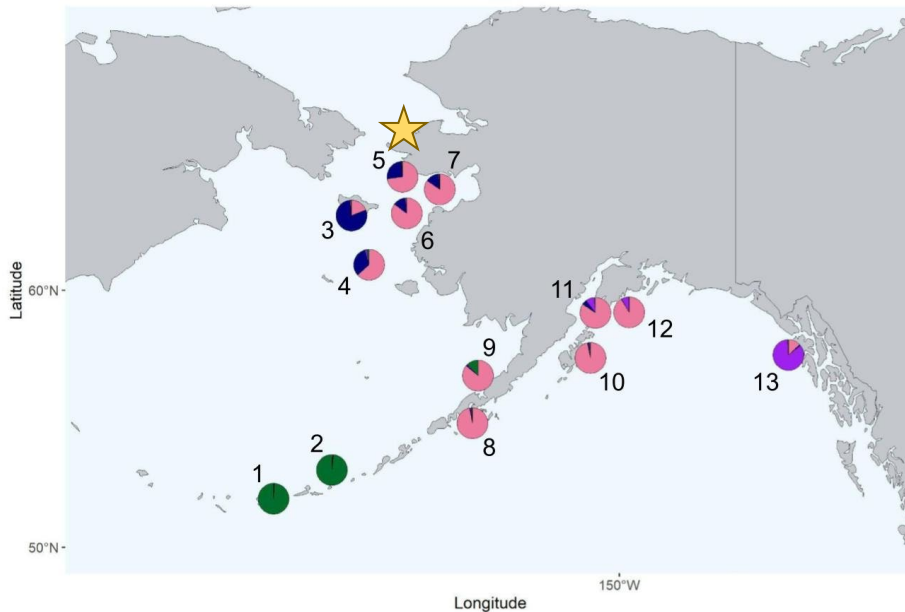


Overall *some* seasonal movement between spawning groups

## Summer Caught Adult Pacific cod Conclusions

### To what extent is there seasonal variation in stock-specific adult habitat use in Pacific cod?

*Hypothesis:* Genetic stock proportions of summer caught Pacific cod adults will show mixing of multiple stocks at each location due to summer movement to feeding grounds.

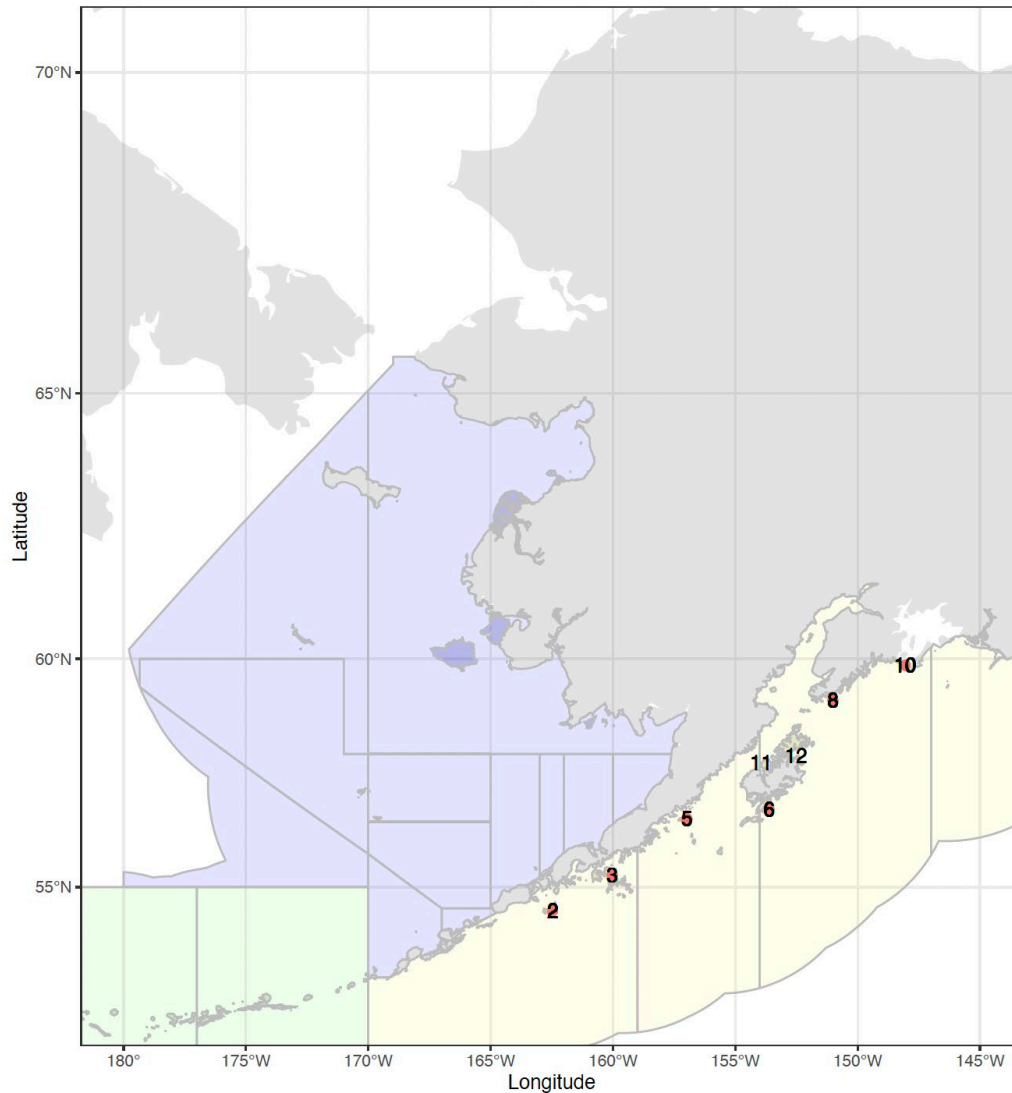


Overall *some* seasonal movement  
between spawning groups

\*With the exception of the EBS/NBS

\* Evidence for natal homing

# Sequencing is planned to examine whether subtle differences exist between EBS and western GOA cod

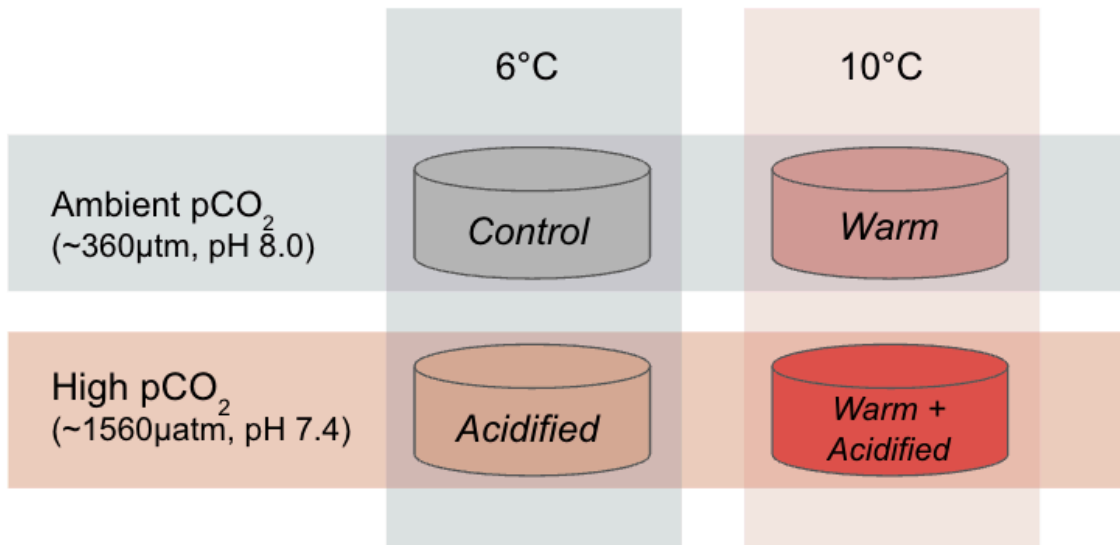


# Genetics update (Gene expression)



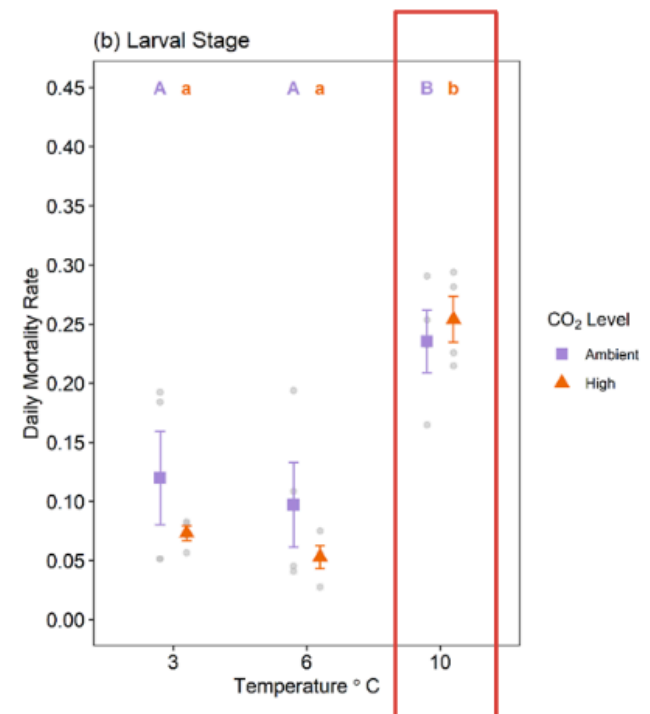
**NOAA**  
**FISHERIES**

# We looked at gene expression in larval Pacific cod reared in different temperatures and pH treatments (Dr. Laura Spencer)



~9 week exposure, fertilized eggs → post-flexion stage (~6-8mm)

High larval mortality in Warm, Warm+Acidified



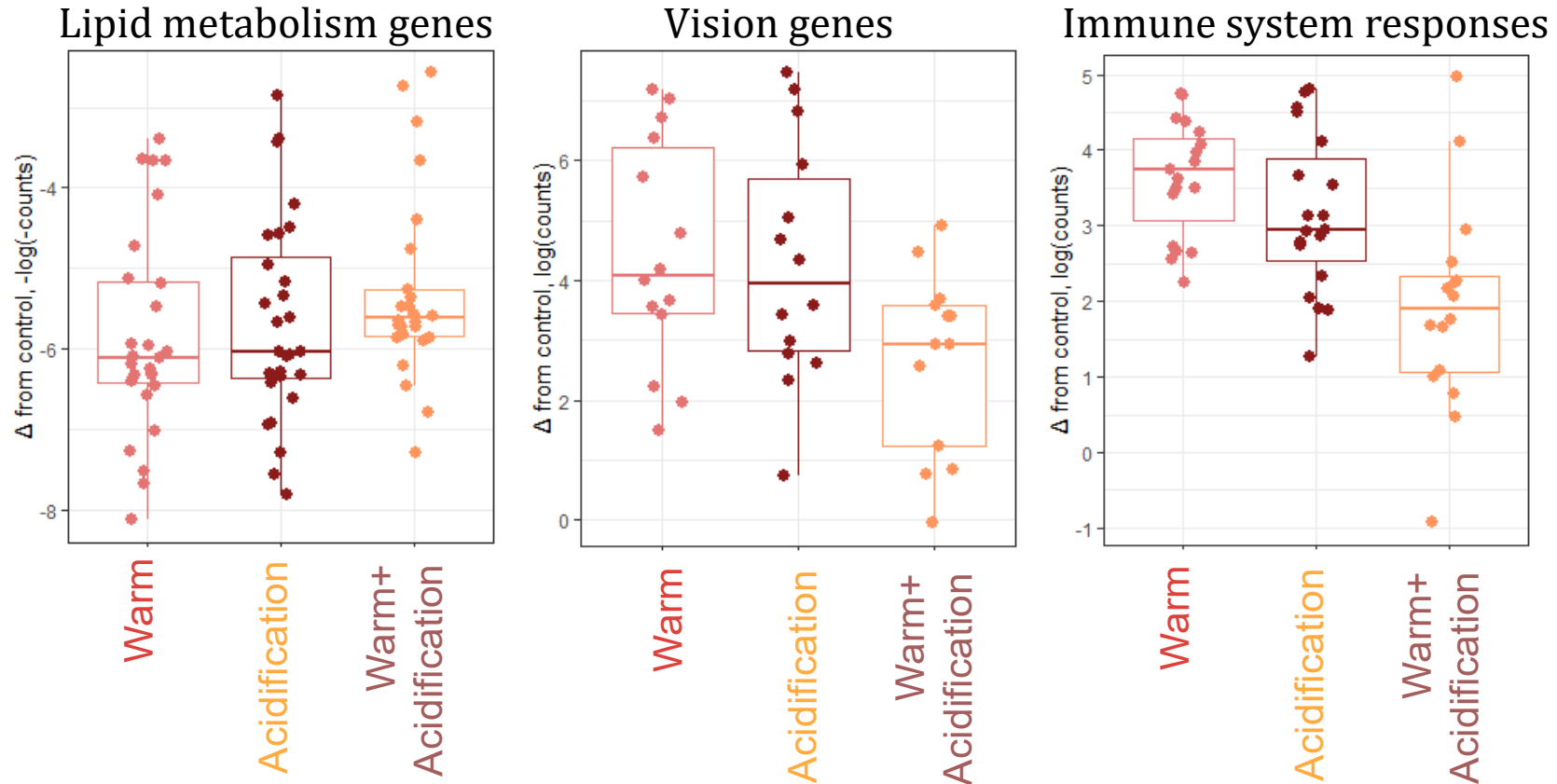
Slesinger et al. *in revision*



**NOAA**  
FISHERIES



# Differential gene expression in larval cod exposed to heat and ocean acidification



Mortality at the larval stage may be a key to understanding higher population mortality under heat stress in Pacific cod.

# Questions



**NOAA**  
**FISHERIES**