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# Eastern Bering Sea Shelf Bottom Trawl Survey: Pacific Cod CIE Review

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# Pacific cod CIE review

## Presentation outline

- Eastern Bering Sea (EBS) shelf bottom trawl survey
  - Purpose
  - Logistics, methods, design, sampling
  - Environment
- Products
- Availability of Pacific cod to survey trawl
  - “No-vertical-response” behavior (Nichol et al. 2007)
  - Investigations using trawls and acoustics
  - Spatial availability

# EBS shelf bottom trawl survey

## Multi-purpose and multi-species survey

- Assessment and management
  - Targeted and non-targeted  
(14 species & 9 taxonomic groups)
  - Commercial crab stocks  
( 7 commercial crab stocks)
- Biological & oceanographic data  
(e.g., age, growth, food habits, spatial distribution, maturity, acoustic backscatter, genetics, systematics, pathology, EFH, CTD, light intensity, etc.)
- Ecosystem assessment & modeling

# Logistics

Base of operations – Dutch Harbor



# Survey charter vessels

## Past and present

University of Washington  
RV *Alaska* 1983 – 1992  
10 years



NOAA Ship *Chapman*  
1982 – 1984  
3 years



FV *Aldebaran*  
1993 – 2005  
2007-2012  
**19 years**



FV *Arcturus*  
1993 – 2009  
**17 years**



FV *Alaska Knight*  
2010 -present  
6 years



FV *Vesteraalen*  
2014 -present  
2 years



Contracted through 2018

# Survey personnel

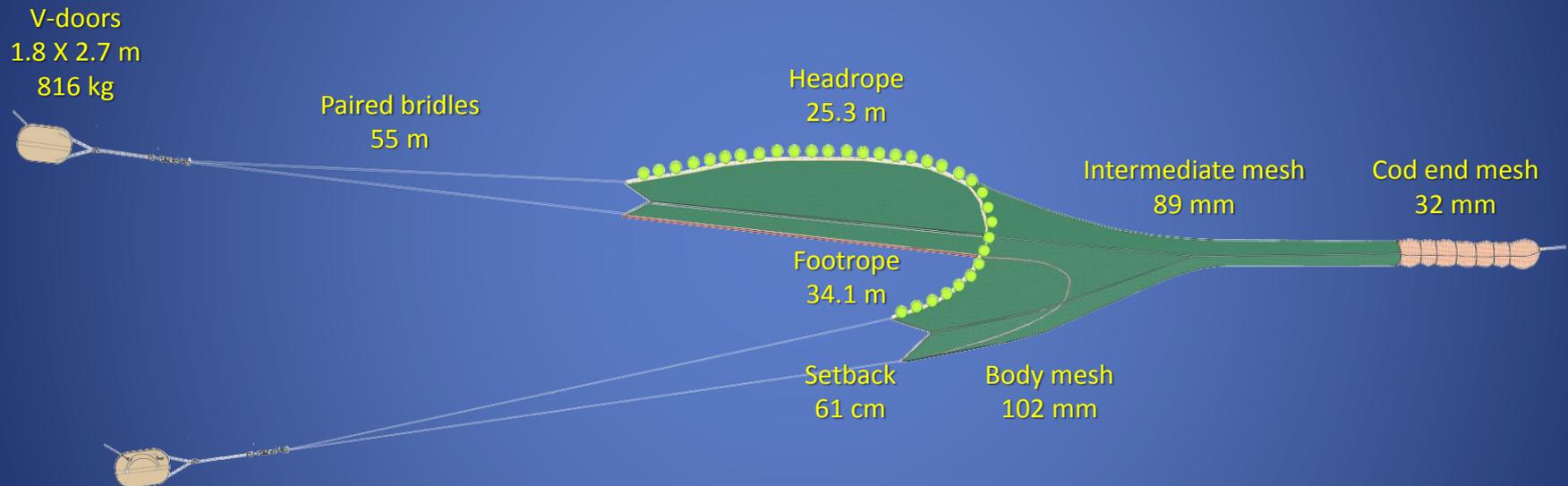
\*Lead positions

- Six scientists
  - Field Party Chief\*
  - Deck Lead\*
  - Crab Lead\*
  - IPHC, ADF&G, Stomachs
- Six vessel crew
  - Captain
  - Engineer
  - Lead Fisher
  - Fishers
  - Cook



# Research bottom trawl

83-112 Eastern

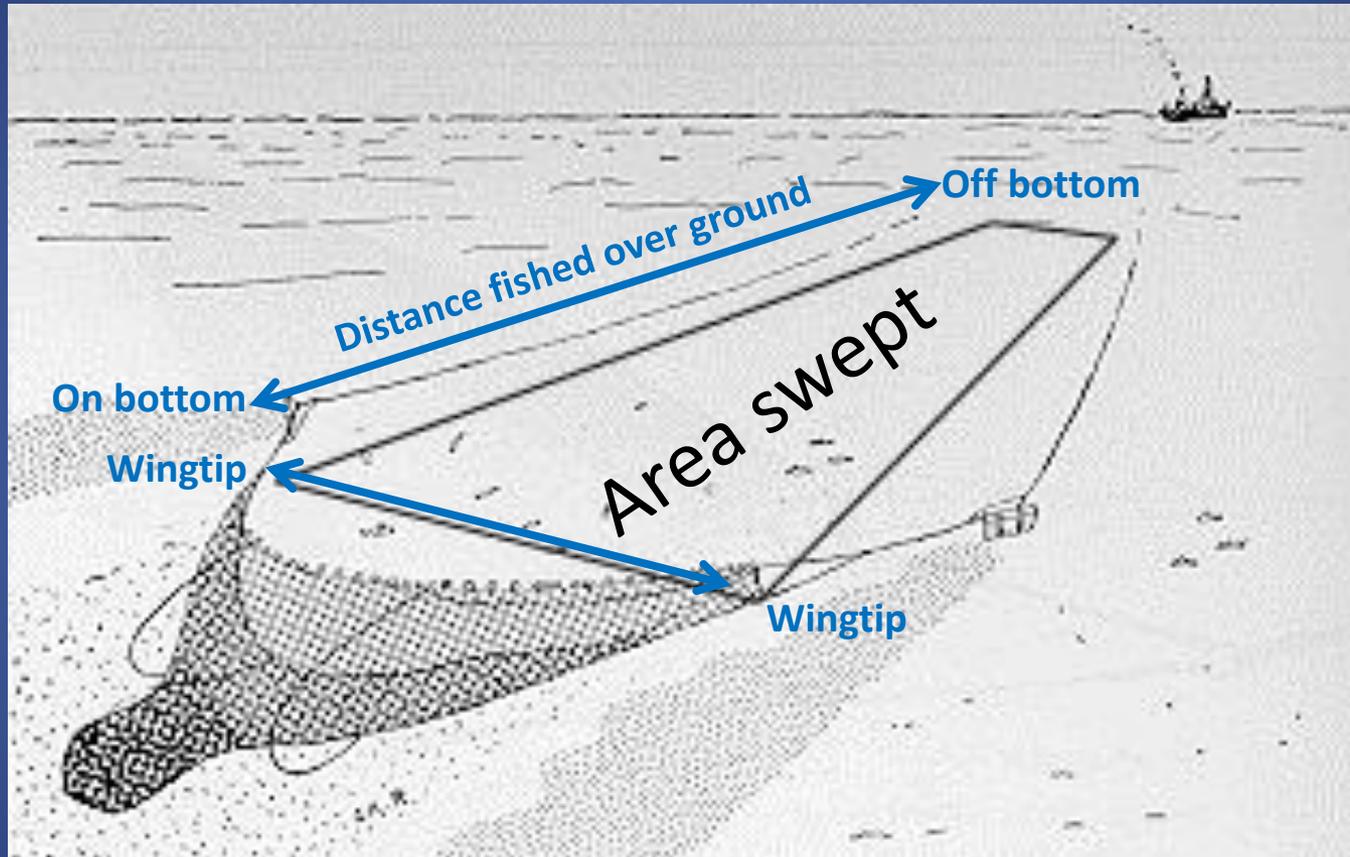


- Specifications for standardized survey trawl construction:

Stauffer, G. (compiler). 2004. NOAA protocols for groundfish bottom trawl surveys of the Nation's fishery resources. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/SPO-65, 205 p.

# Catch sample standardization

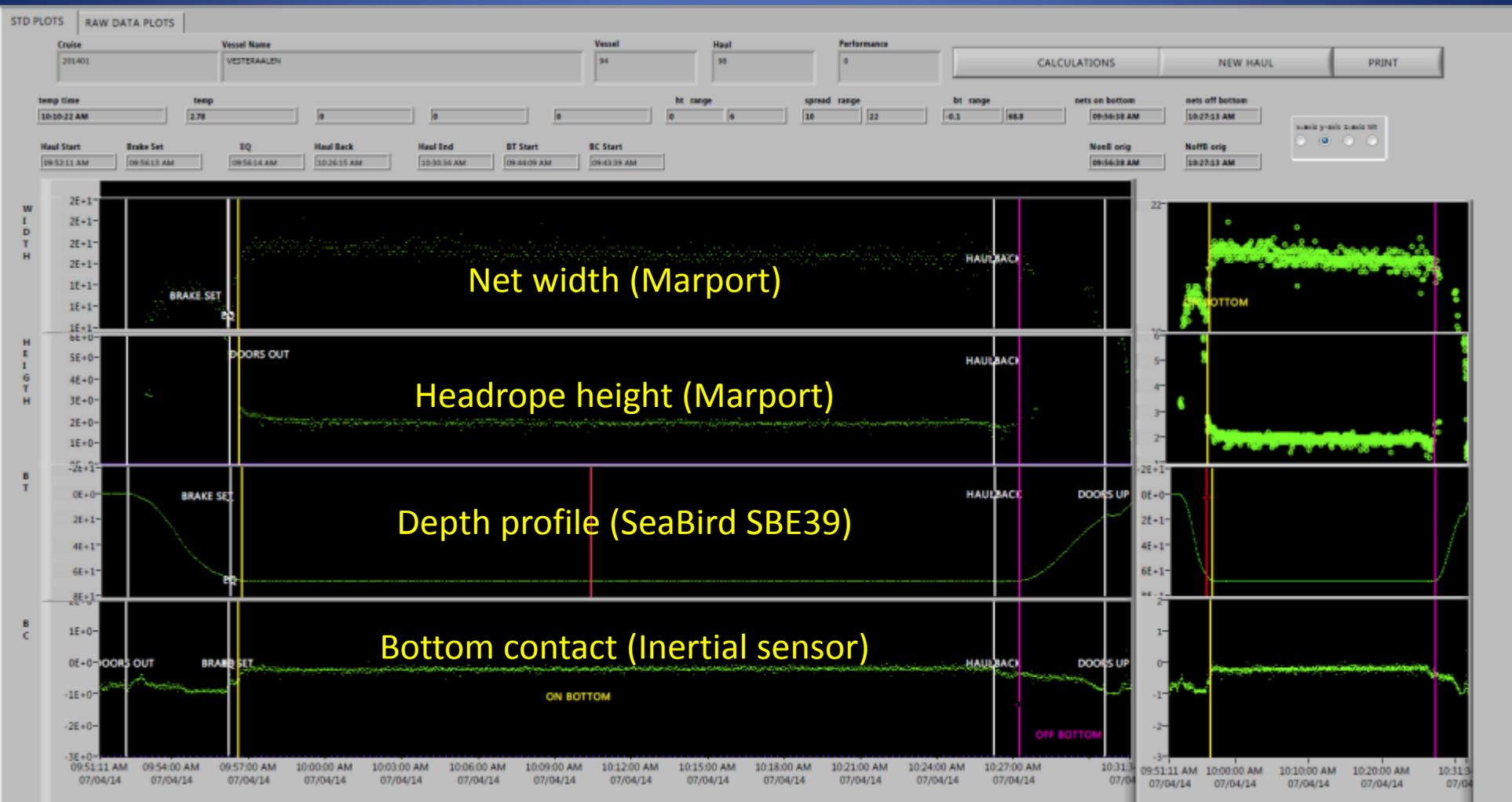
## Area swept



- Standard tow is 30 minutes (brakeset to haulback) at towing speed 3 knots over ground
- Protocols for standardized towing procedures: Stauffer 2004

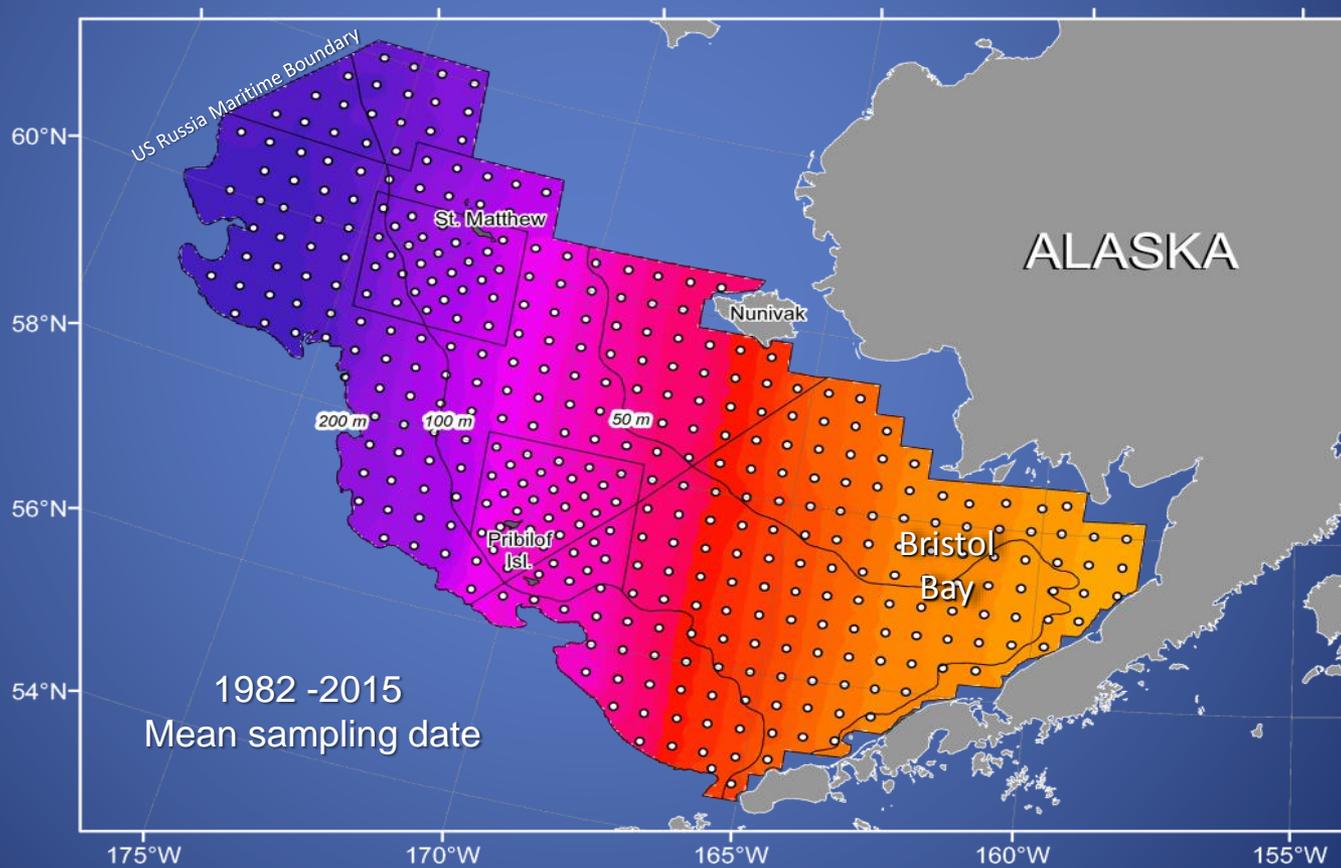
# Catch sample standardization

## Gear mensuration for area swept



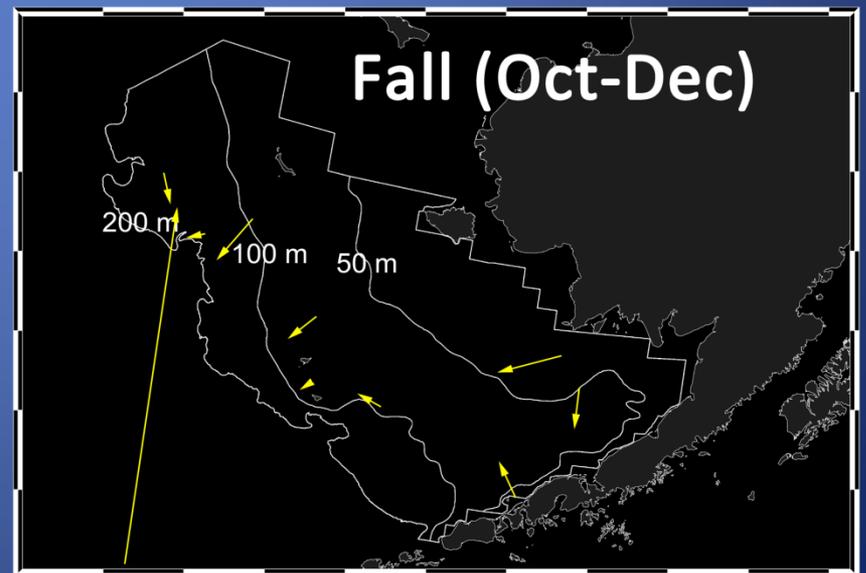
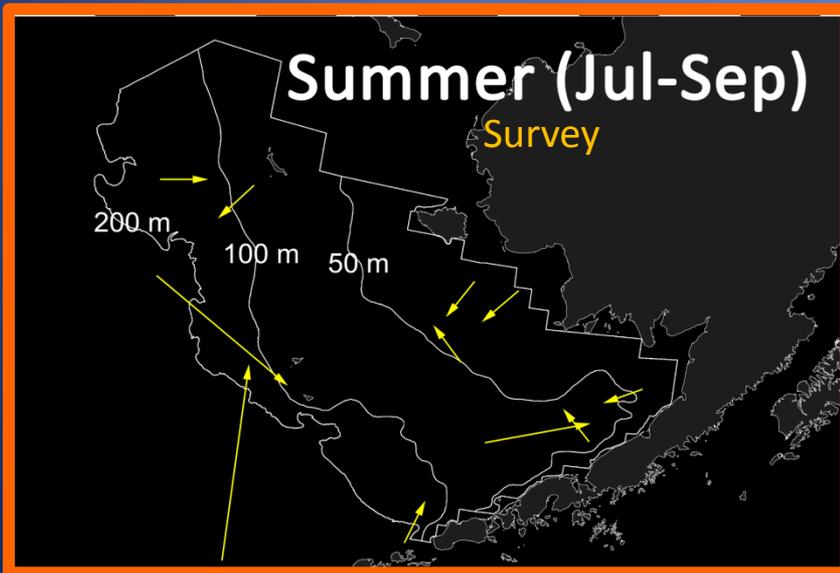
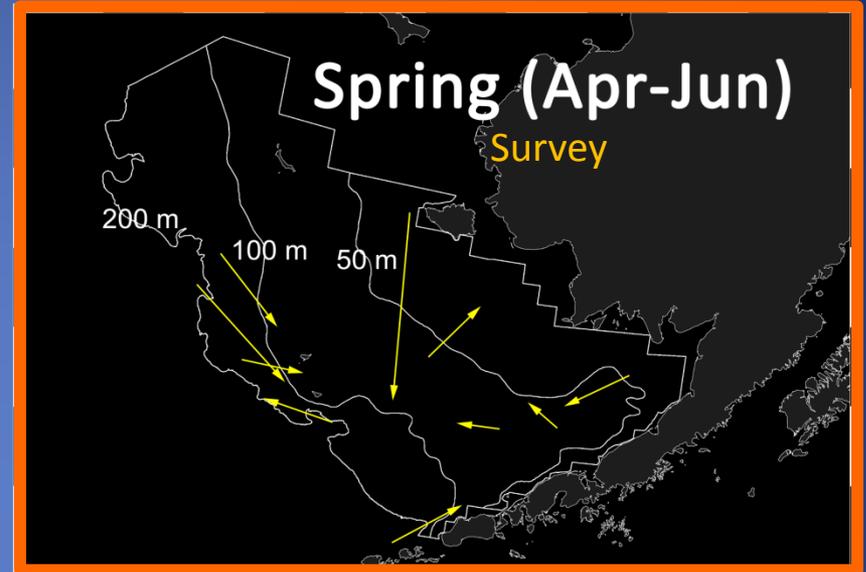
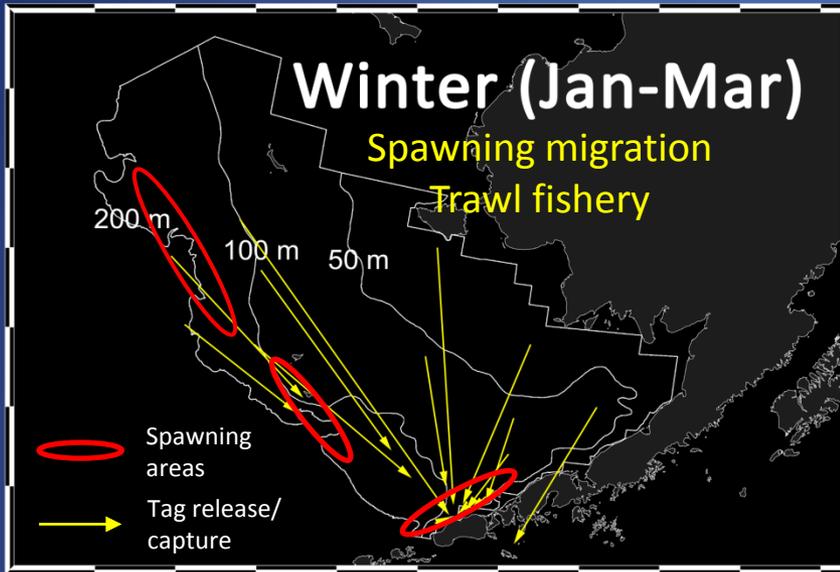
# Survey timing

“Xerox scan snapshot”

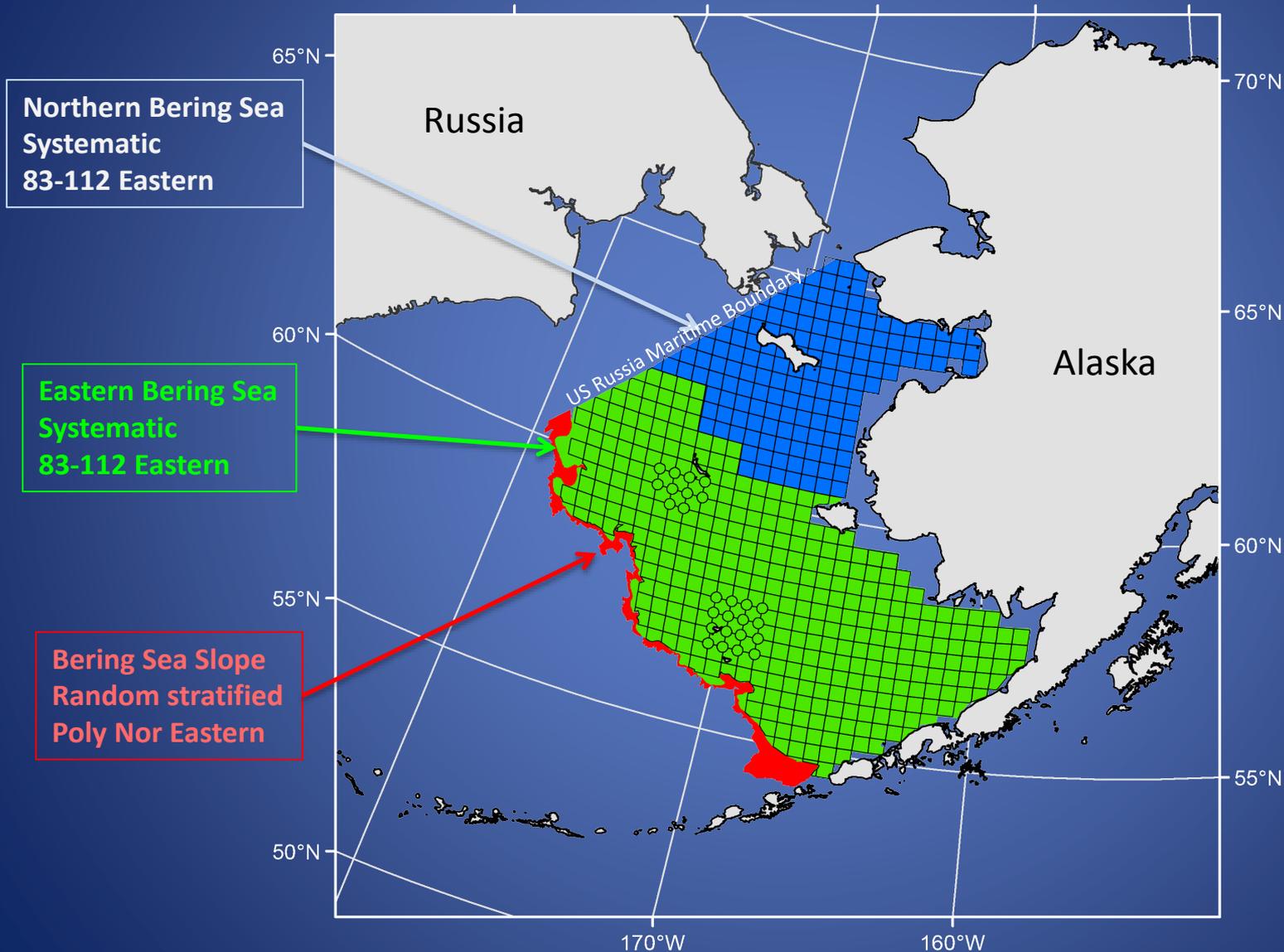


# Pacific cod seasonal migrations

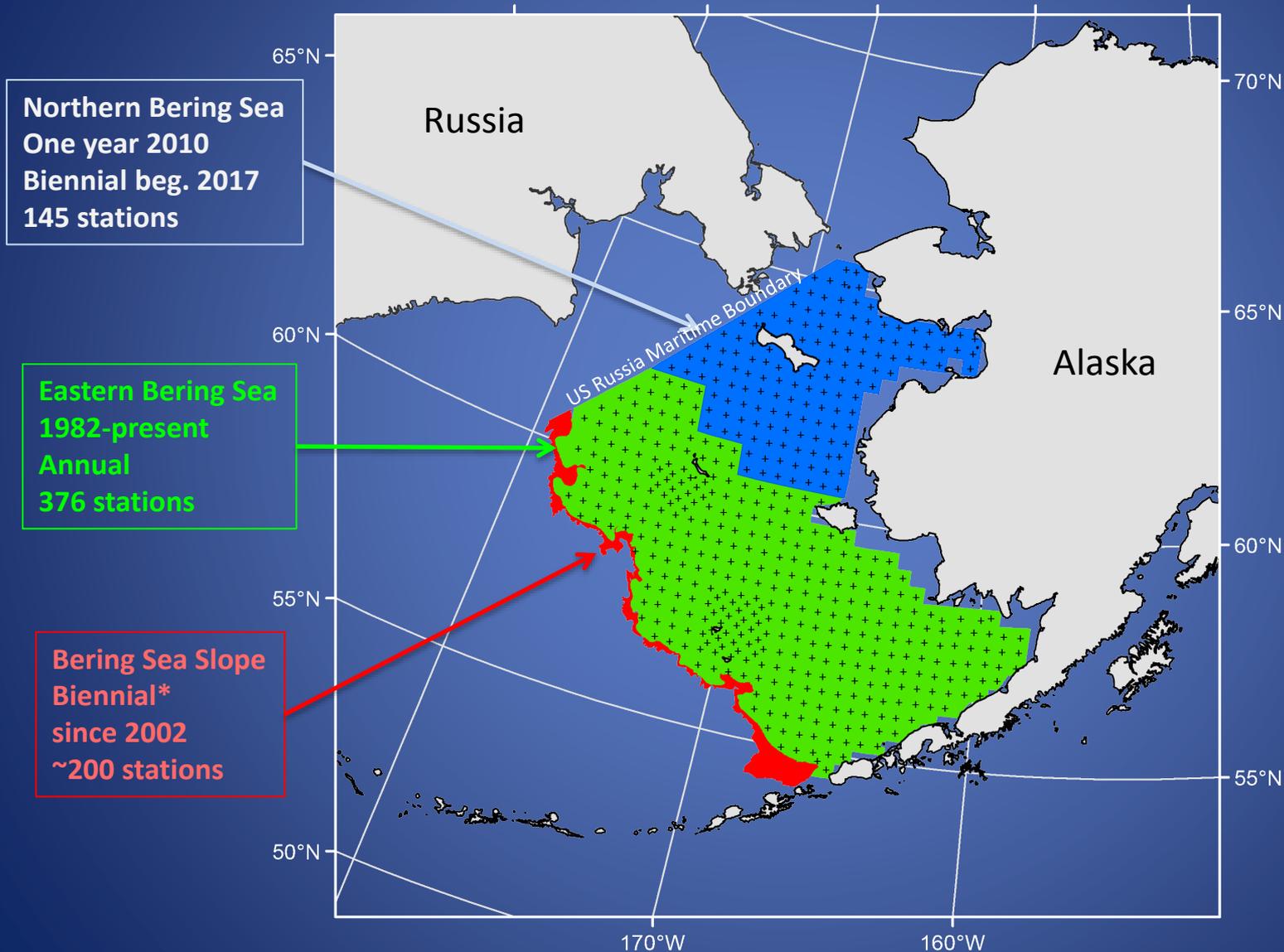
(adapted from Shimada and Kimura 1994 & Neidetcher et al. 2014)



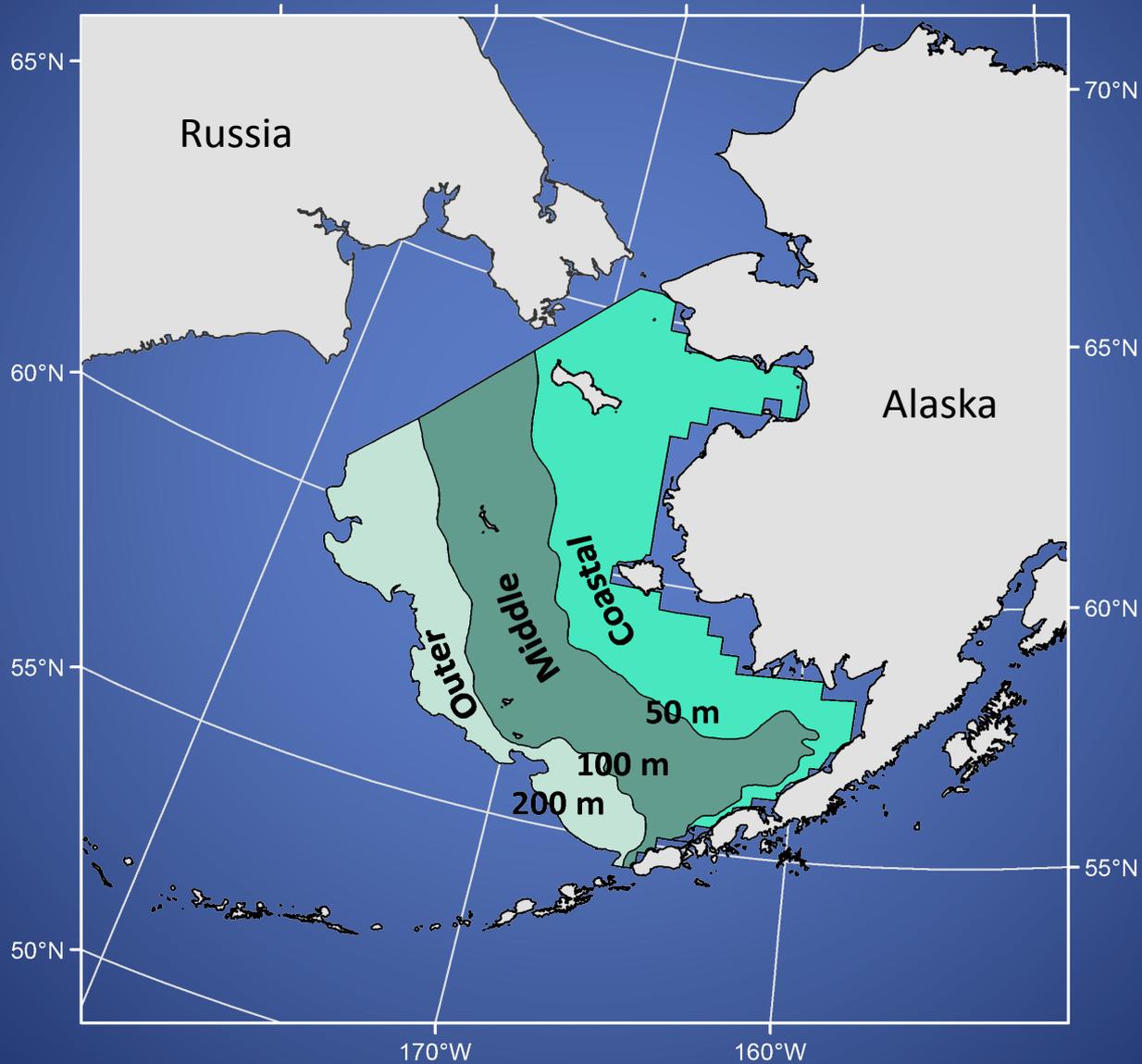
# Survey design and trawl gear



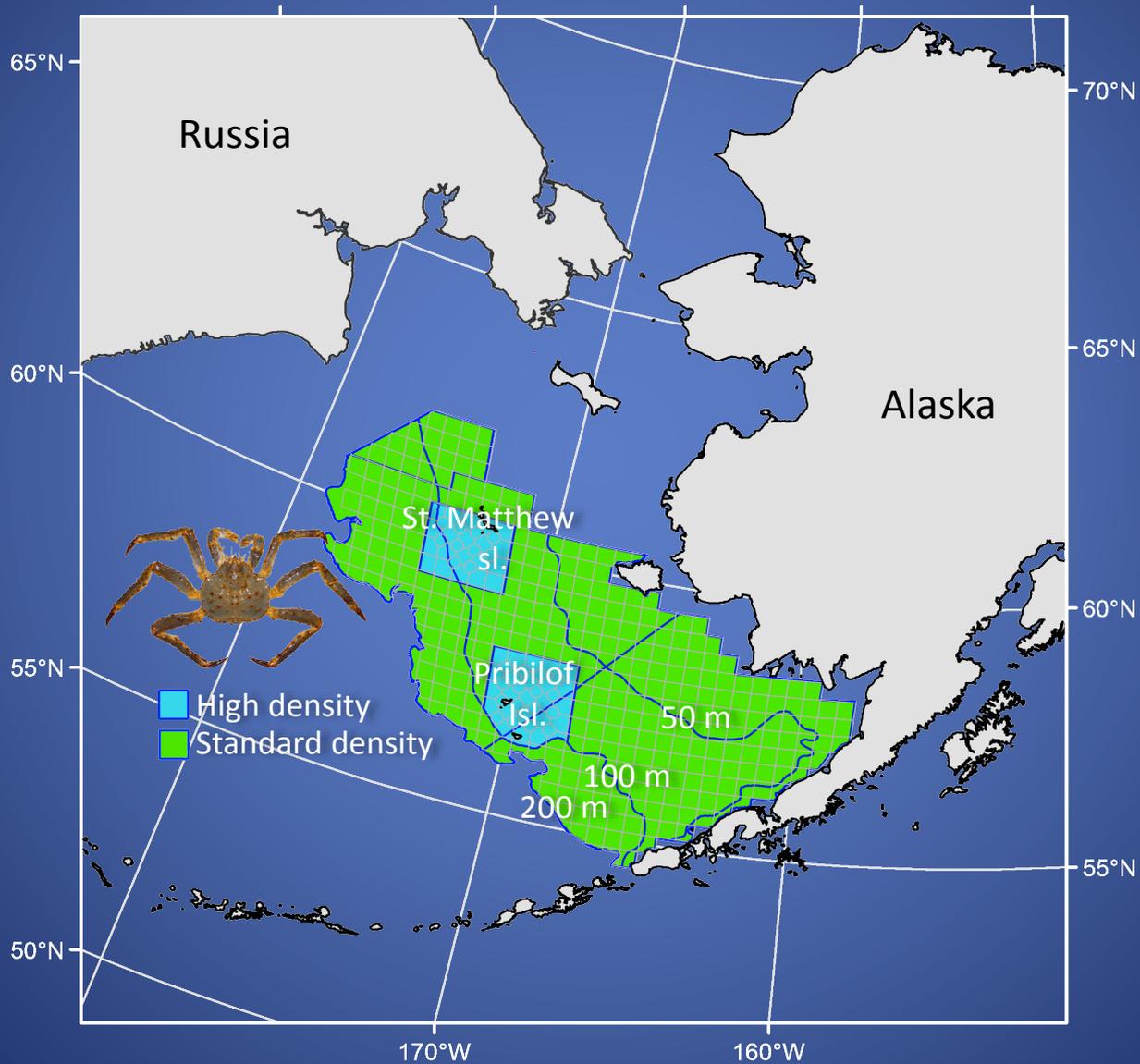
# Survey continuity and stations



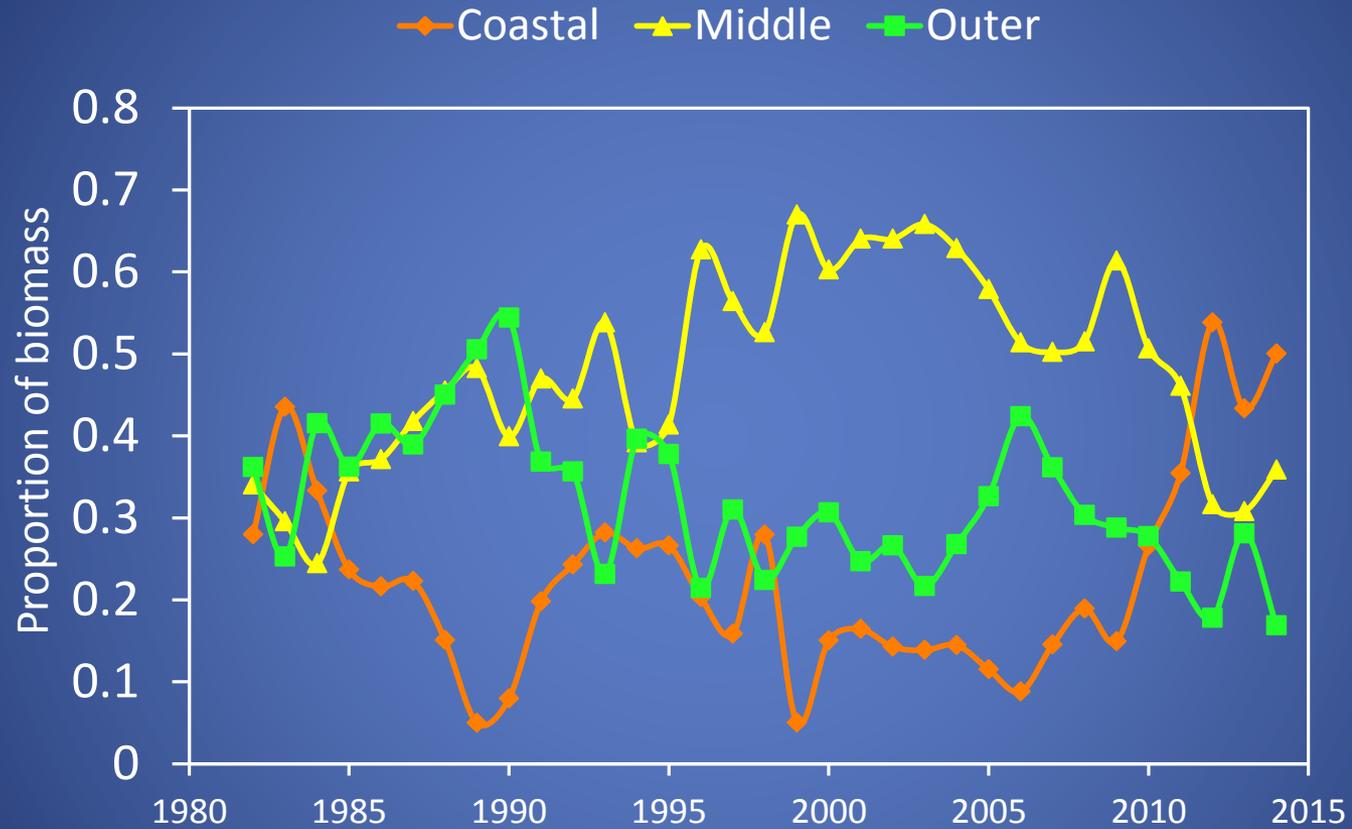
# EBS shelf domains



# Strata & sampling density

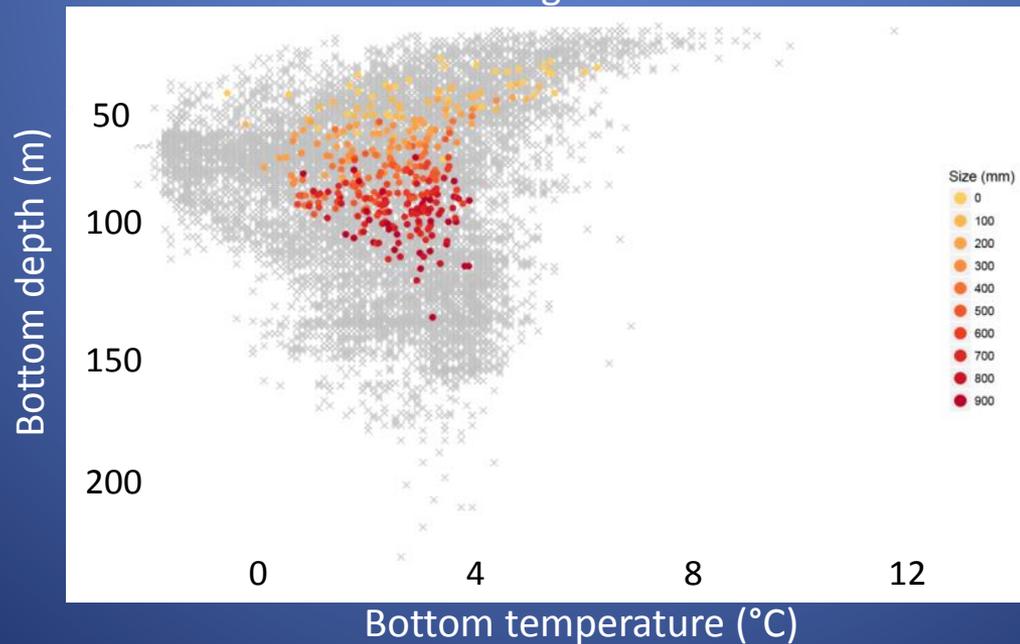
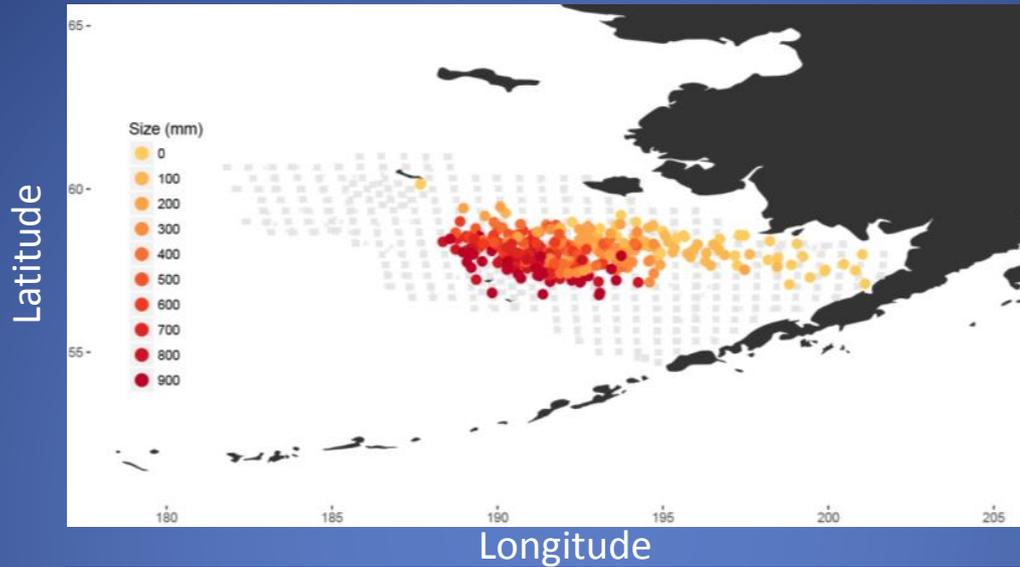


# Spatial shifts in biomass by domain



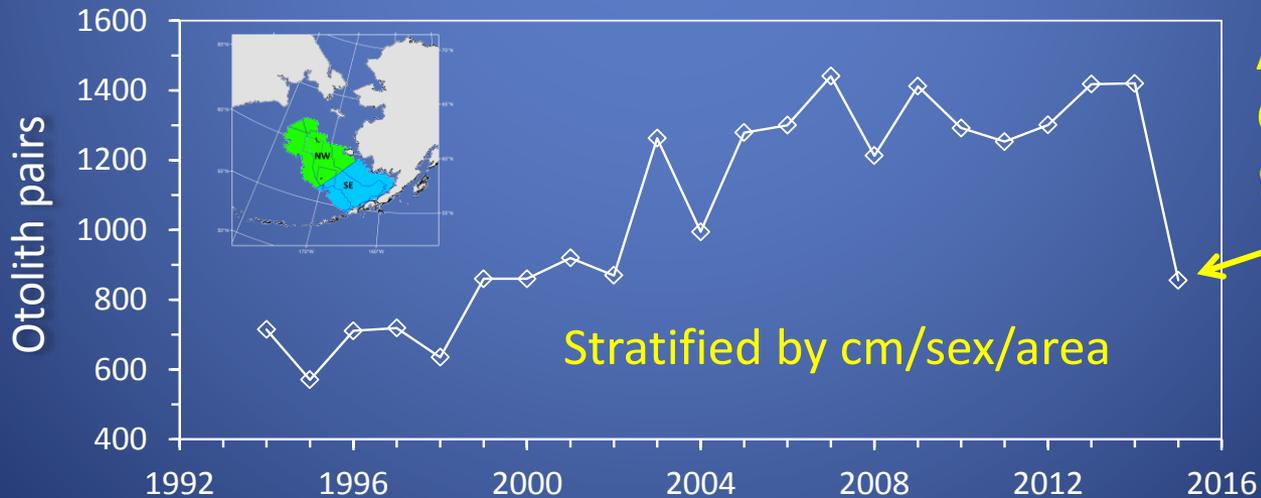
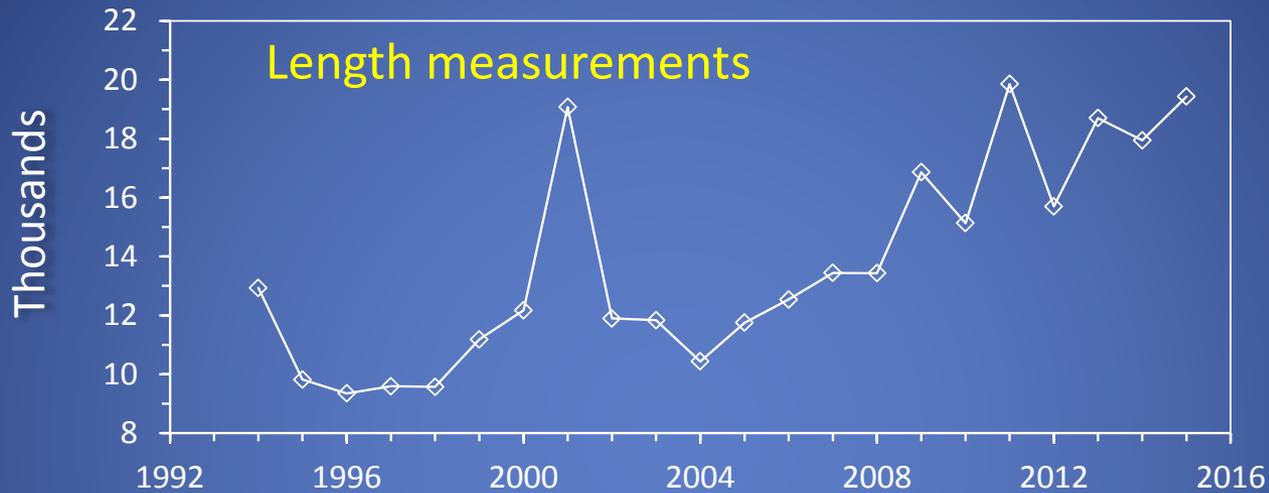
# Ontogenetic and spatial shifts

Barbeaux and Lauth (in review)



# Catch sampling

## Lengths and otolith pairs



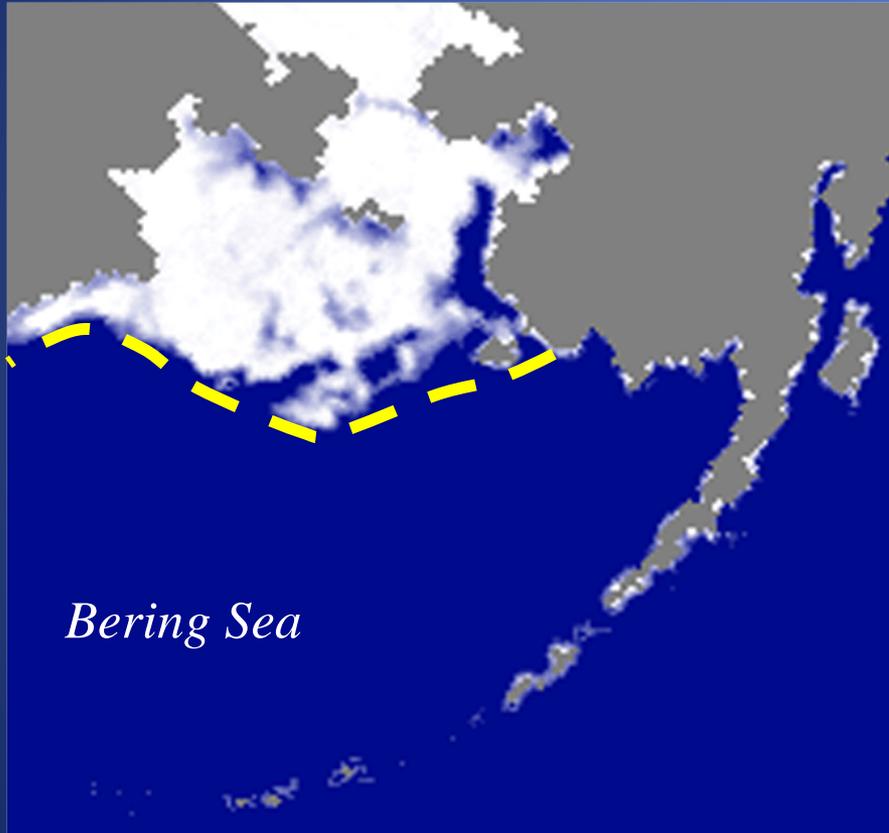
# Analysis

- Systematic design with fixed starting point
- Analytical procedures follow those of a StrRan design although we use StrSys design
- Variance does not take into account spatial autocorrelation
- Alternative variance estimator investigated to (D'Orazio 2003)
  - resulted in lower variance estimate for most years
  - ignores other process errors (e.g., environment, sampling process, density dependence, etc.)

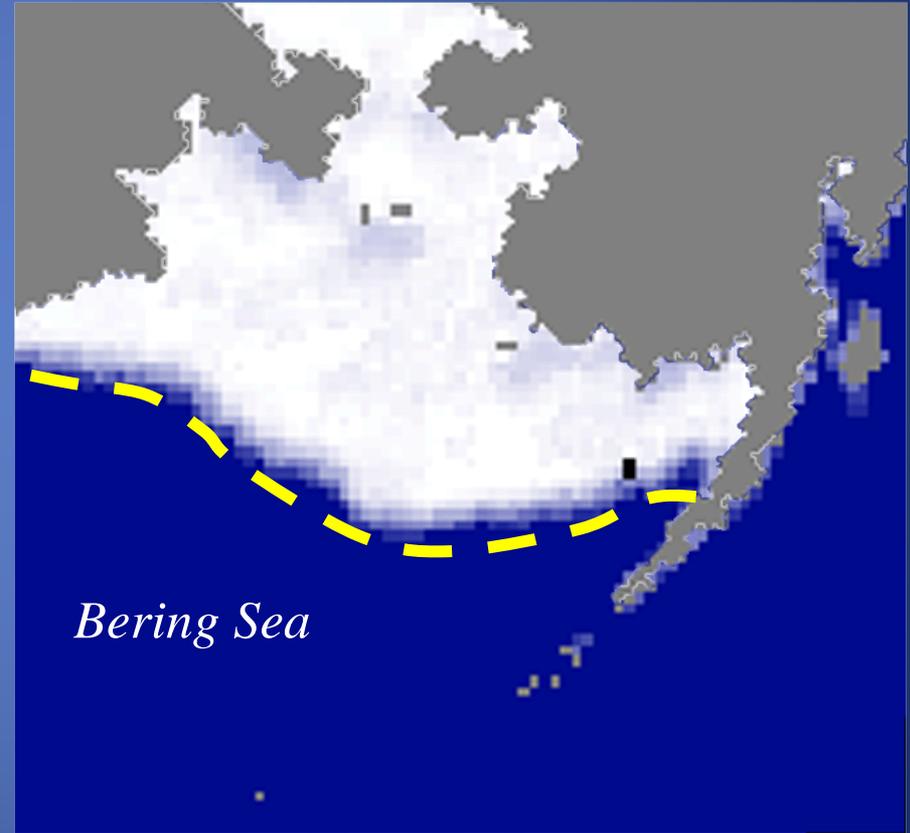
# Survey environment

## Variable seasonal ice cover

- March sea ice minimum

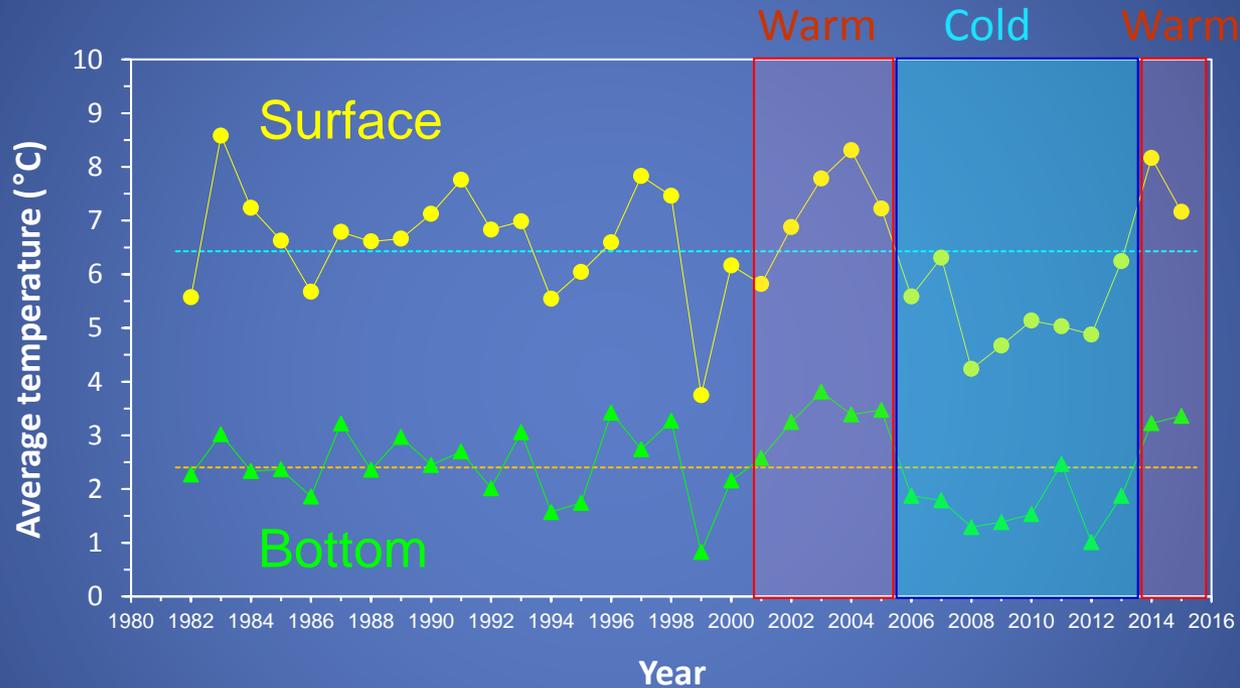


- March sea ice maximum



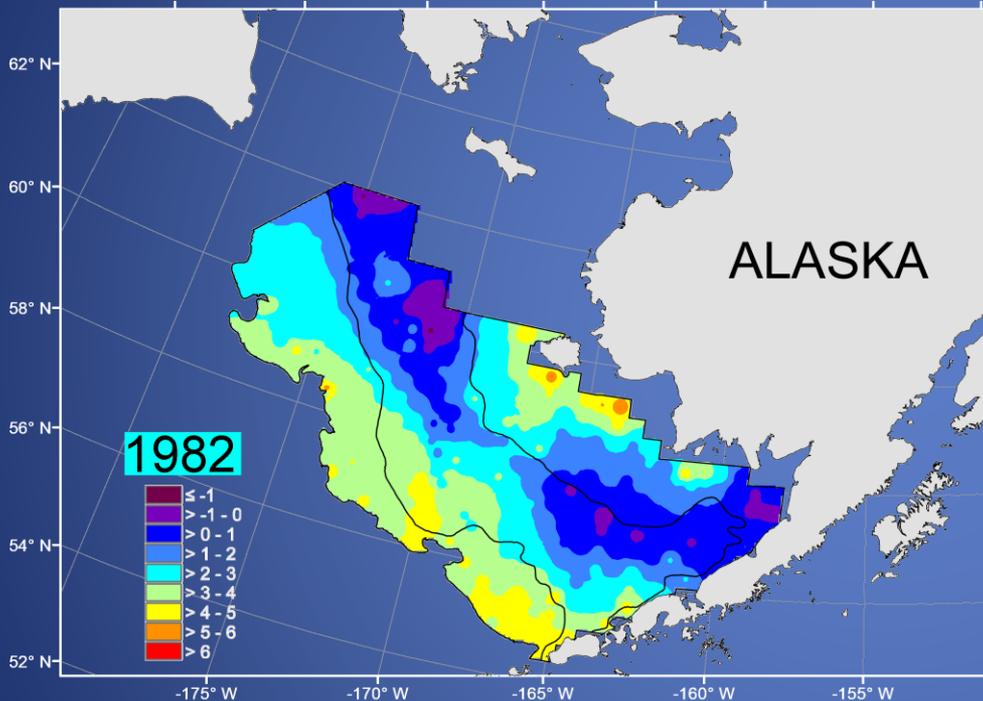
# Survey environment

## Average surface and near bottom temperatures



# Survey environment

Cold pool (<2°C)

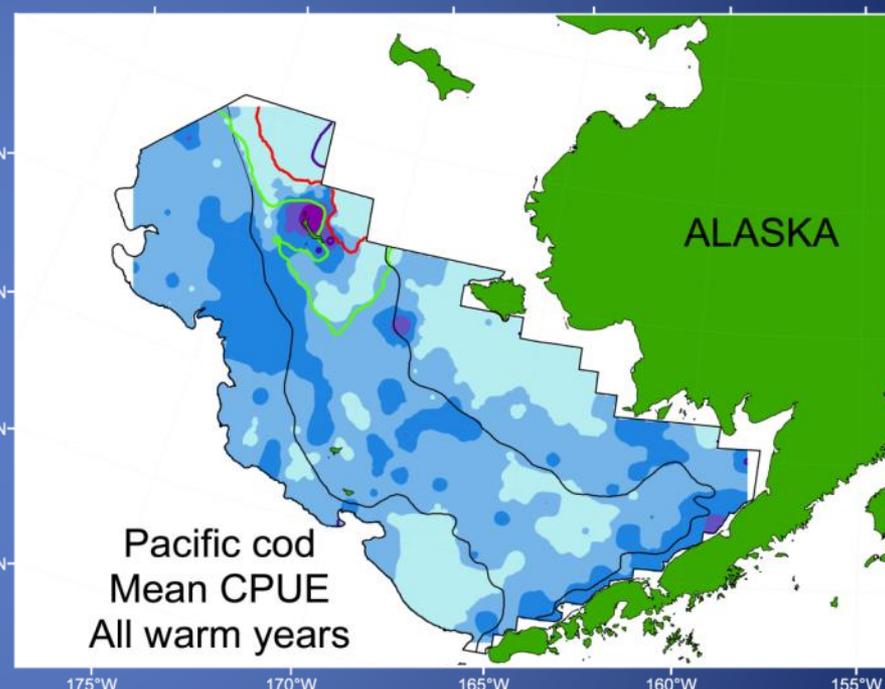
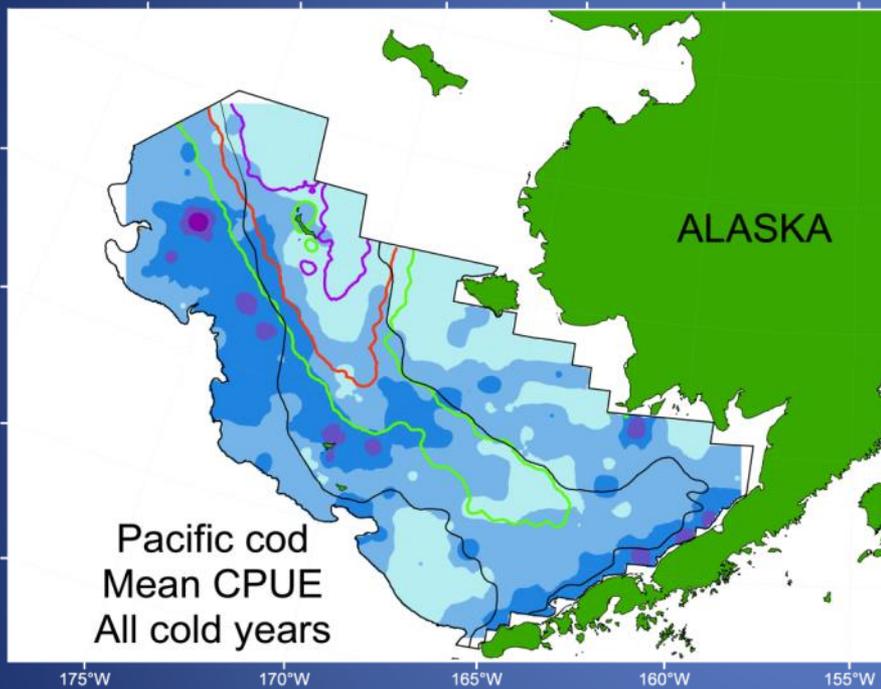


## Potential temperature effects:

- Survey trawl sampling efficiency
- Pacific cod spatial distribution
- Migration patterns
- Recruitment success
- Growth patterns (size-at-age)
- Reproductive maturity

# Pacific cod distribution

## Environmental effects



CPUE (kg/ha)

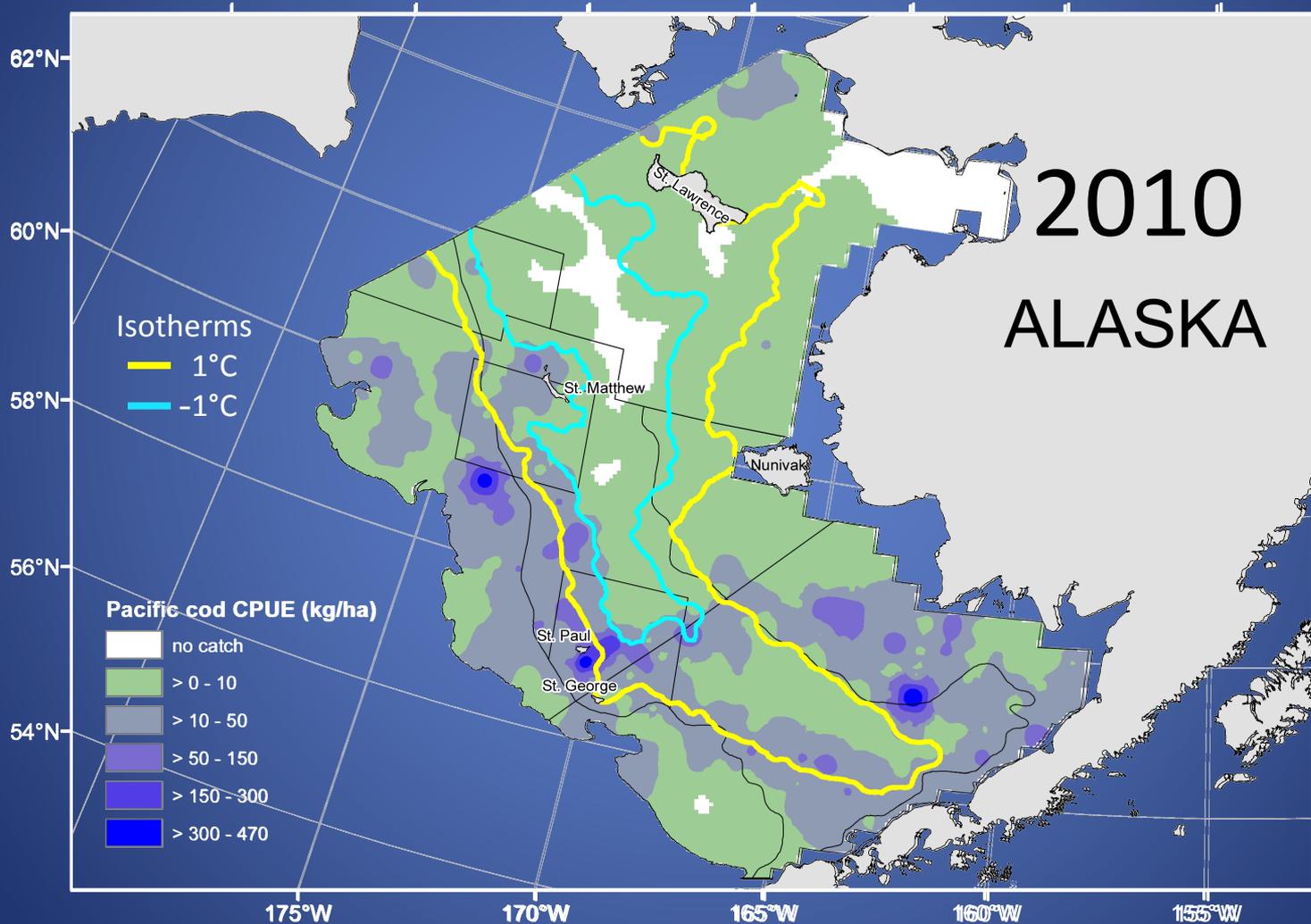


Bottom temp. contour



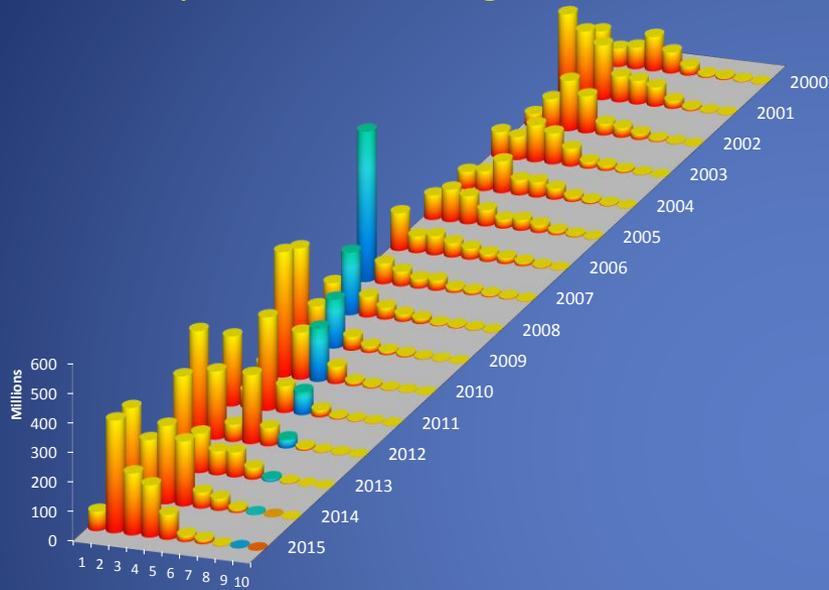
# Pacific cod distribution

## Environmental effects

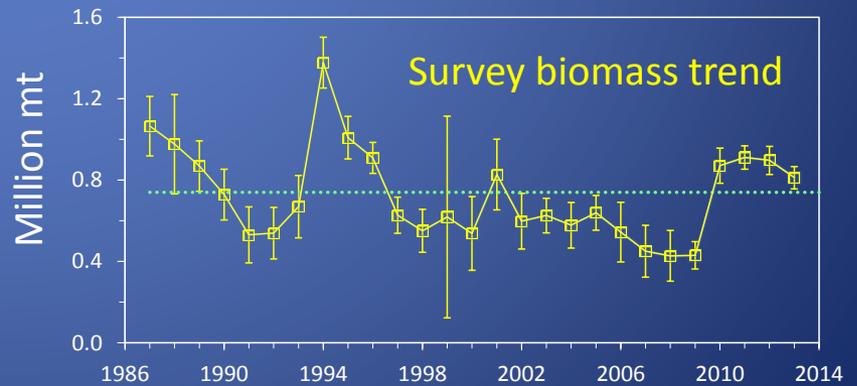
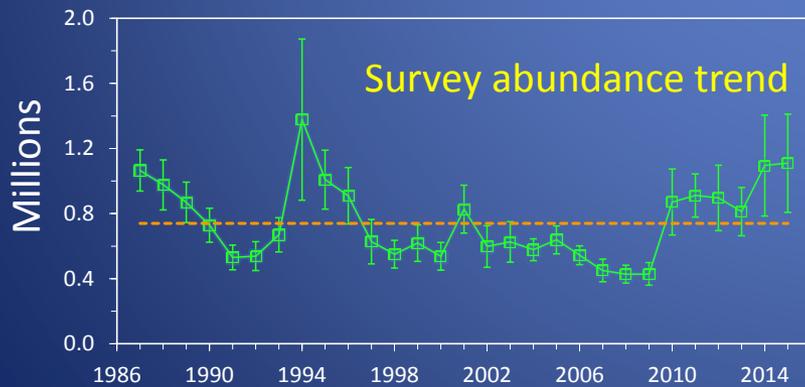
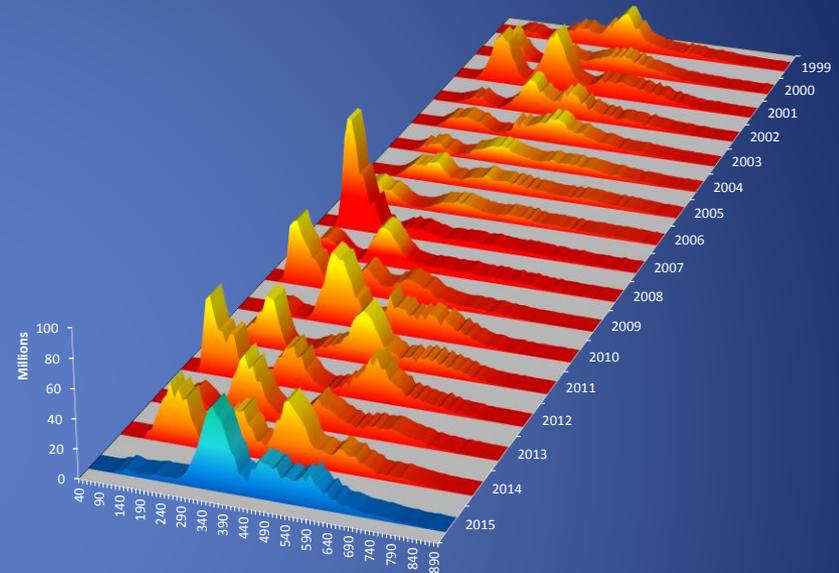


# Products

## Total survey abundance-at-age



## Total survey abundance-at-length



# Availability of Pacific cod to survey trawl

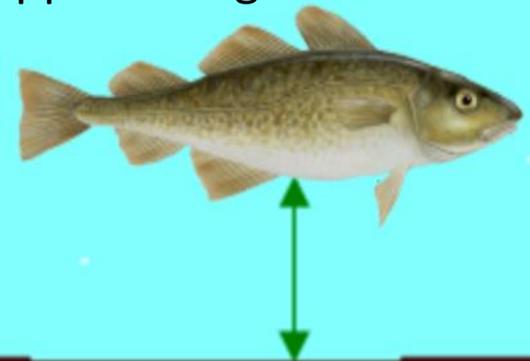
(Nichol et al. 2007)

## Approach:

- Based on 11 archival tags - released & re-captured in 2002
- **Size range 60 – 81 cm**, captured over flat bathymetry
- $N = 29,462$  depth recordings during survey time period
- 95% daytime recordings within 10 m of bottom
- **47.3% available to EBS research trawl (2.5 m)**
- **91.6% available to AI/GOA research trawl (7.0 m)**

## Assumptions:

- “No-vertical-response” behavior to an approaching vessel or trawl
- Environmental conditions in 2002 were representative of average conditions over all years in time-series



# Availability of Pacific cod to survey trawl

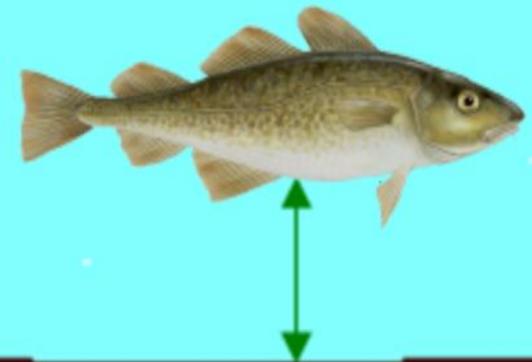
(Nichol et al. 2007)

**Question:** No-vertical-response behavior valid?

**Importance:** Incomplete knowledge about sampling processes can lead to assumptions that impact modelled results & subsequent management advice

(Maunder and Piner 2014)

**Approach:** Review investigations using **EBS trawl & acoustic backscatter data** collected during EBS shelf bottom trawl surveys



# EBS trawl and acoustic backscatter data

2005 to present

- EBS survey charter vessels have been collecting acoustic backscatter data from 38 kHz echosounders (Simrad ES60)
- Relatively sophisticated and capable of collecting backscatter data of scientific quality
- Charter vessel depth sounders are calibrated pre- and post-cruise
- Review of **four** investigations involving use of trawl/acoustic data

1) VonSzalay, P.G., D.A. Somerton, S. Kotwicki. 2007. Correlating trawl and acoustic data in the eastern Bering Sea: a first step toward improving biomass estimates of walleye pollock (*Theragra chalcogramma*) and Pacific cod (*Gadus macrocephalus*)? Fish. Res. 86:77-83.

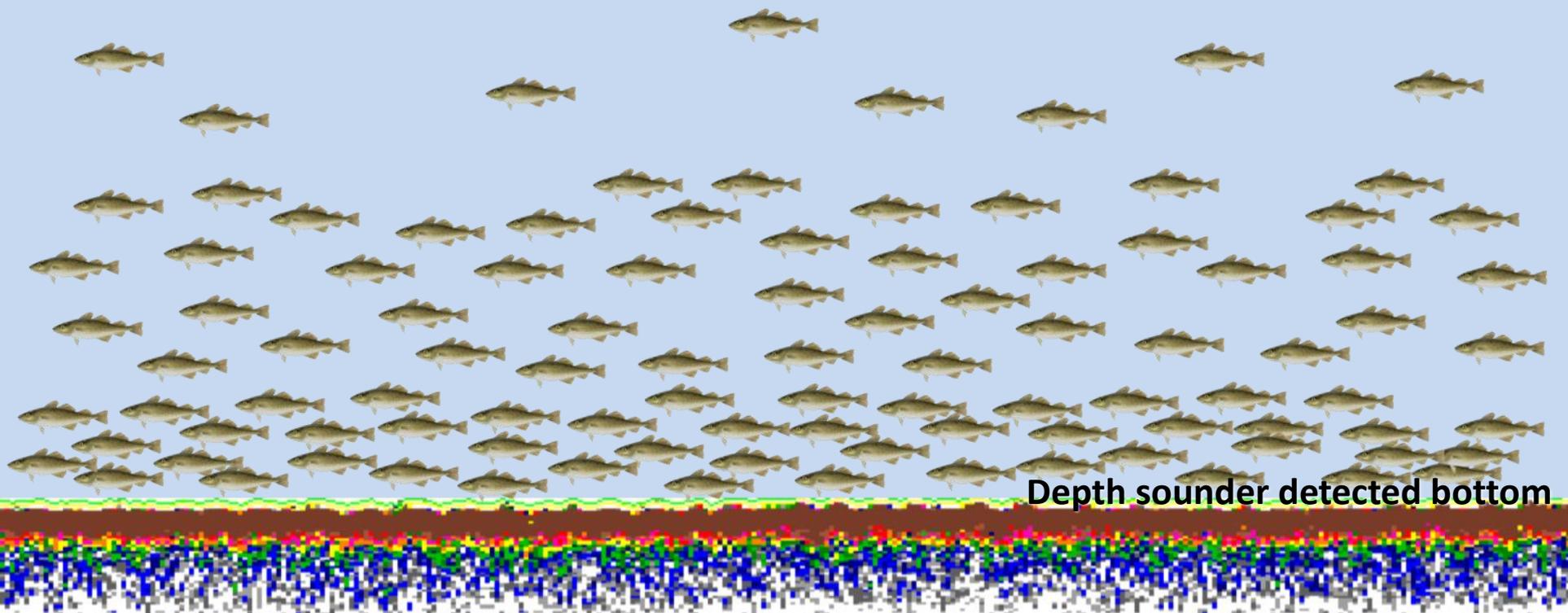
2) Weinberg, K., C. Yeung, D.A. Somerton, G.G. Thompson, P. Ressler. (accepted by U.S. Fish. Bull.). Is Pacific cod (*Gadus macrocephalus*) survey selectivity dome shaped? Direct evidence from trawl studies.

3) Lauffenburger, N., A. De Robertis, S. Kotwicki. (submitted to CANJFAS). Combining bottom trawls and acoustics in a diverse semipelagic environment: What is the contribution of walleye pollock (*Gadus chalcogrammus*) to near-bottom acoustic backscatter?

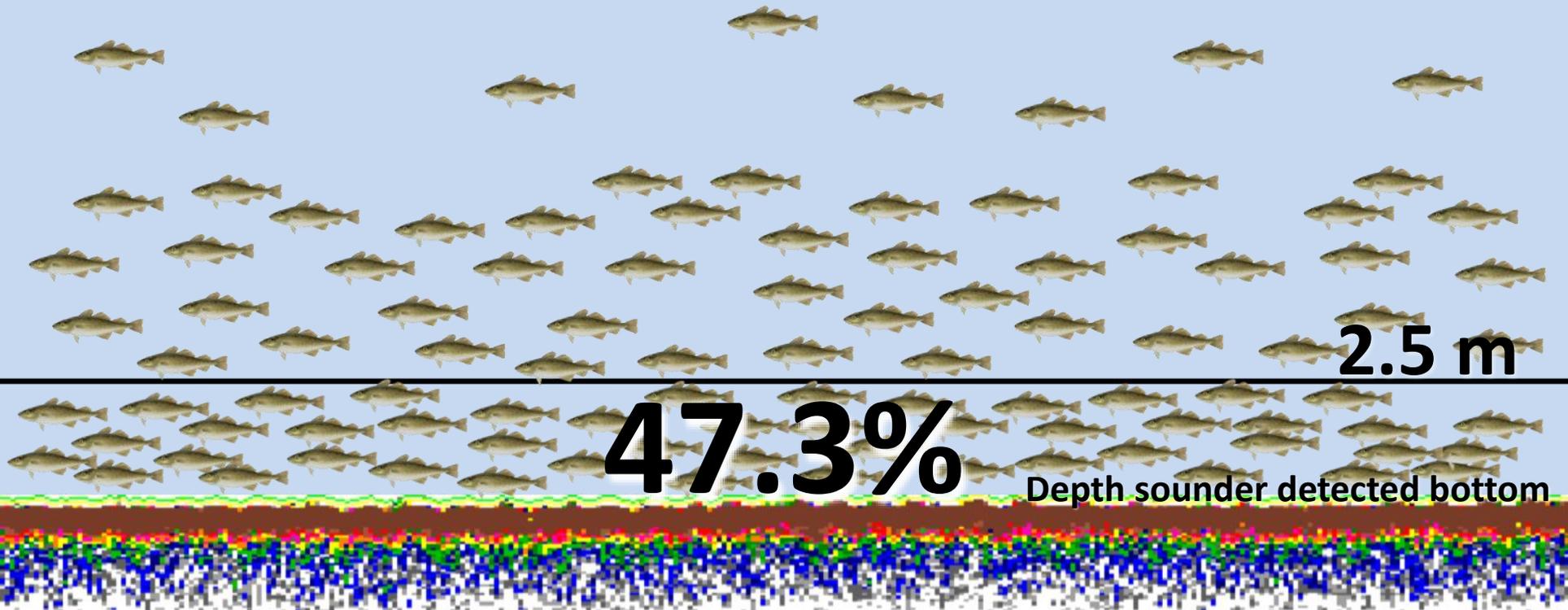
4) Lauth, R.R., E. Jorgenson, C. Yeung. (in prep). Examining the no-vertical response assumption of Pacific cod (*Gadus macrocephalus*) to survey bottom trawls.

# No-vertical-response behavior cartoon

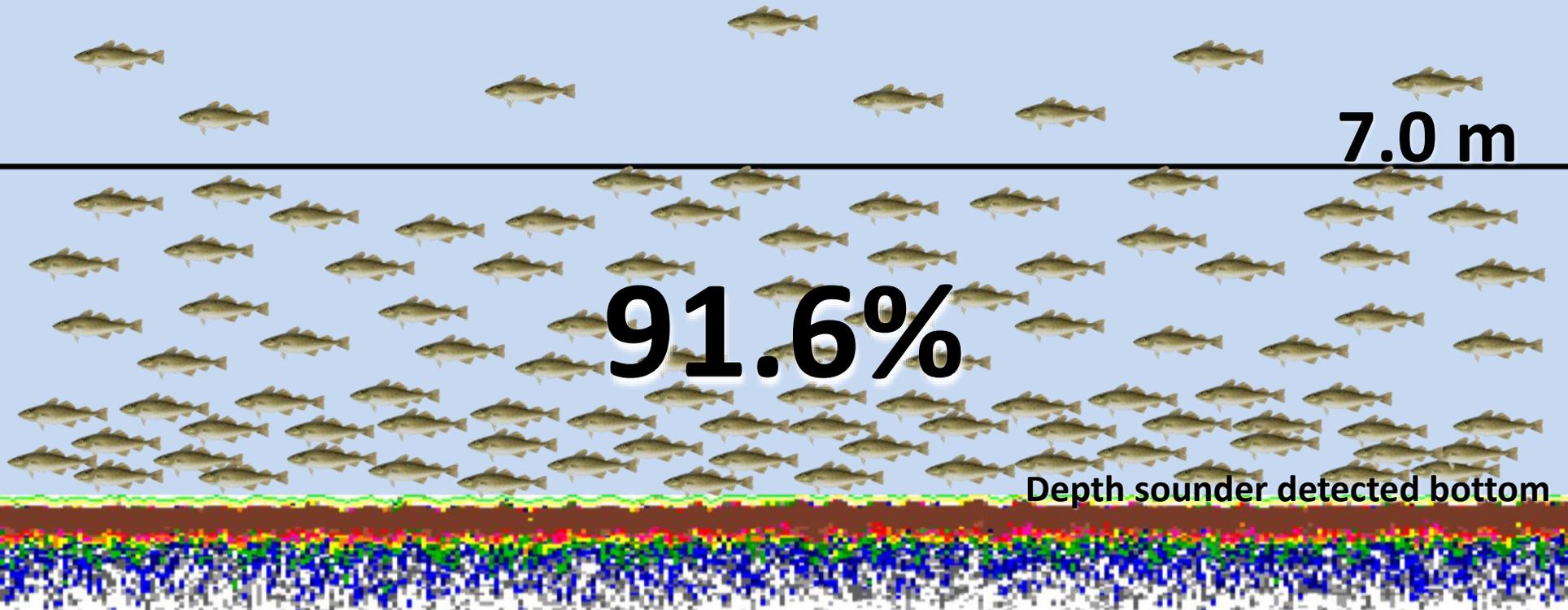
100 Pacific cod in 60 to 81 cm size range



# Bering Sea shelf research trawl (2.5 m)

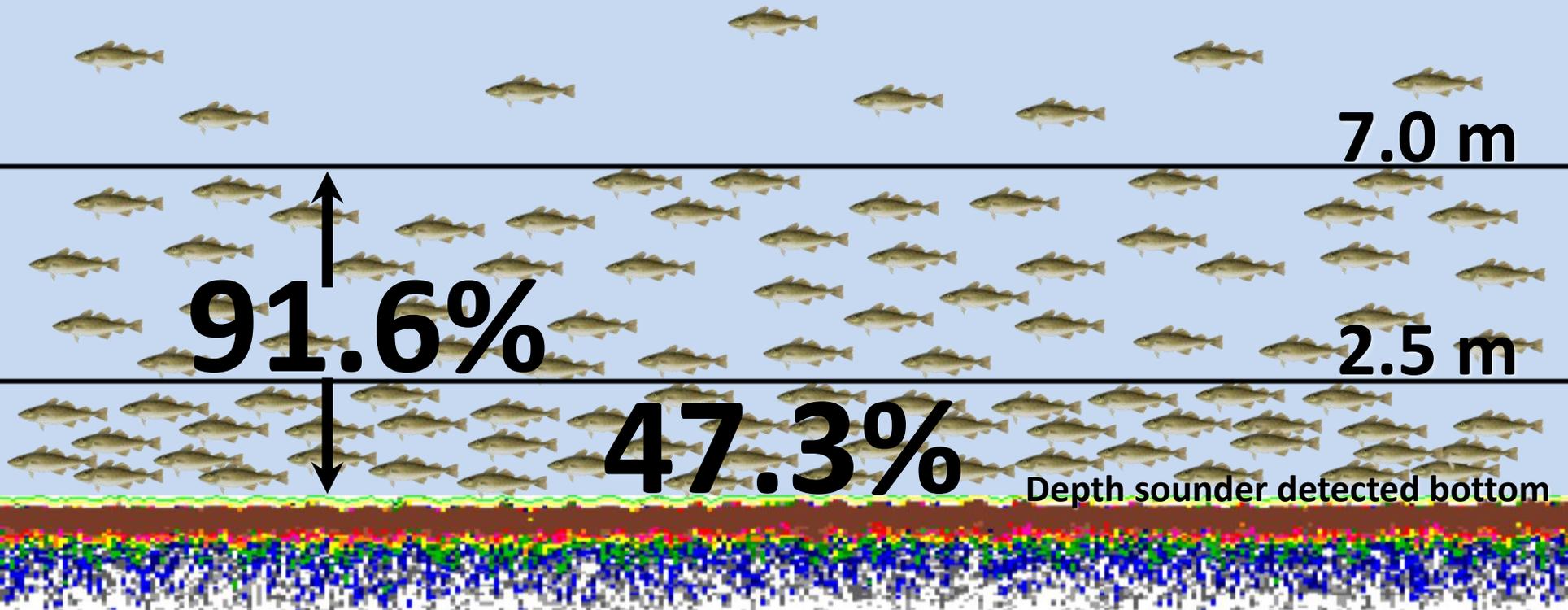


# Gulf of Alaska research trawl (7.0 m)

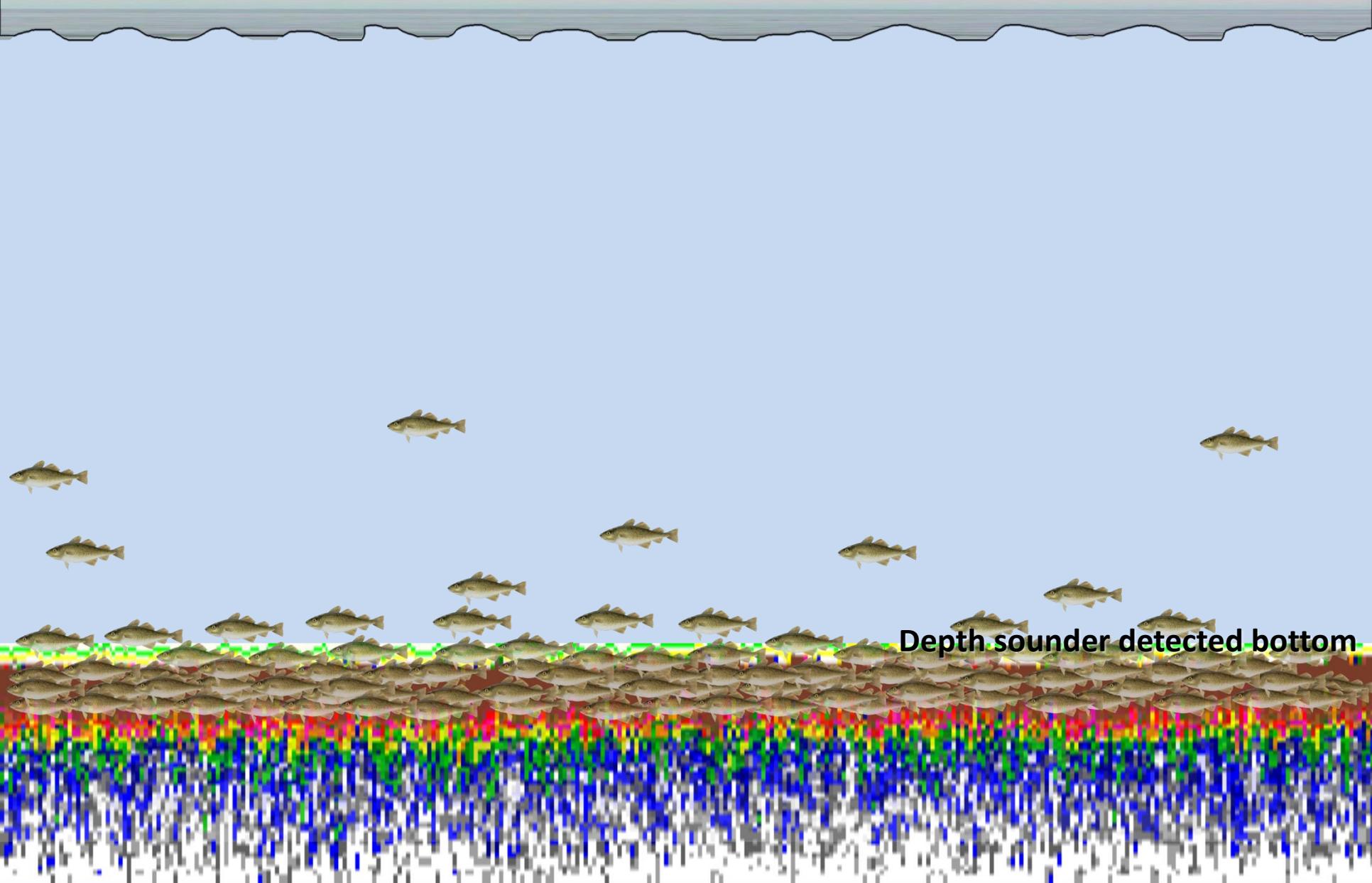


# Expected if NVR behavior is mechanism

$$\text{True EBS:GOA catch ratio} = \frac{47.3}{91.6} \approx 0.5$$

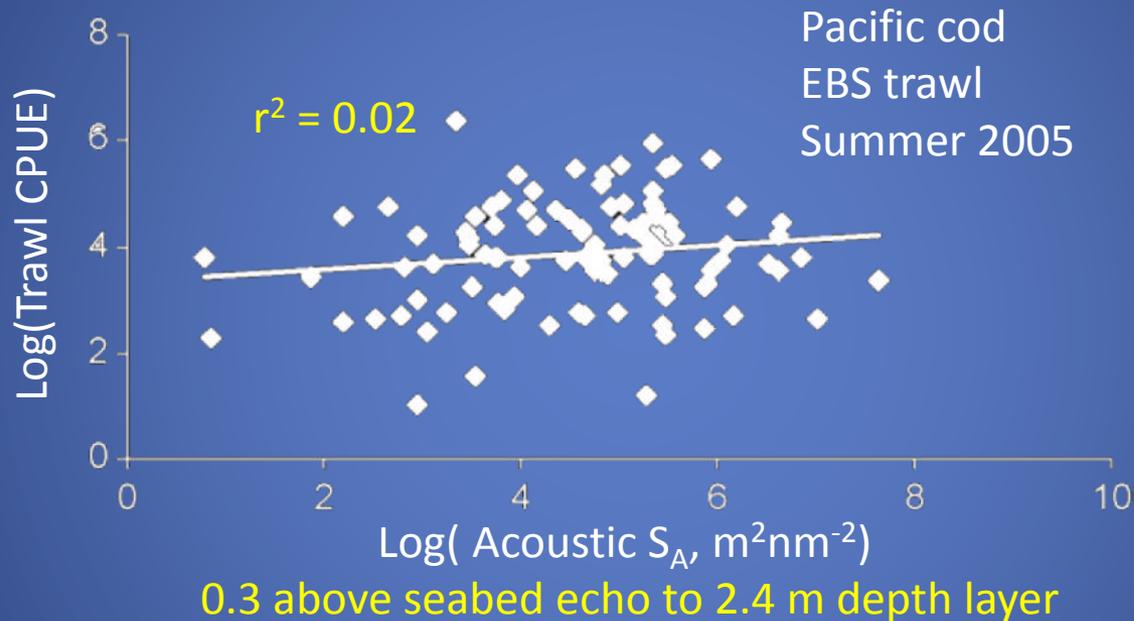


# Most likely explanation



# 1) EBS trawl and acoustic backscatter data

VonSzalay et al. 2007

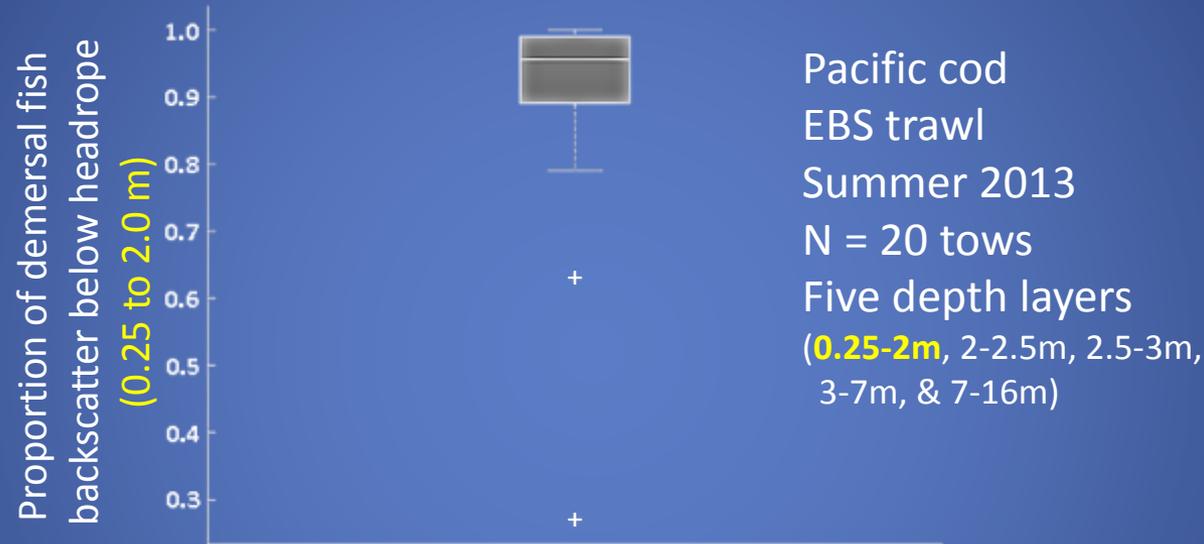


## Results and conclusions:

- Correlation for Pacific cod was not significant ( $r^2 = 0.02$ )
- Pollock backscatter overwhelms Pacific cod backscatter
- Pacific cod more benthic and tend to be in Acoustic Dead Zone (ADZ)

## 2) EBS trawl and acoustic backscatter data

Weinberg et al. (U.S. Fish. Bull)



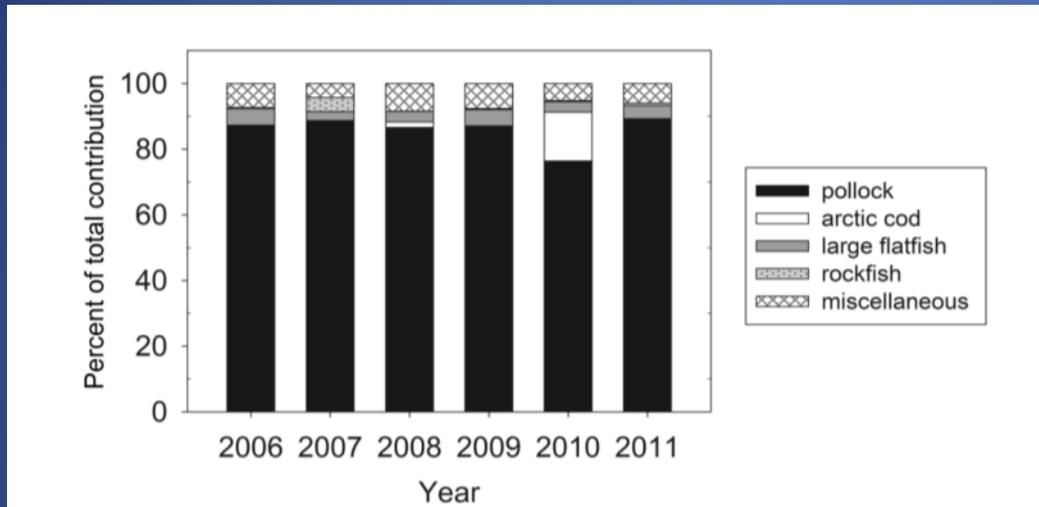
Both vessels

### Results and conclusions:

- Highest demersal backscatter values observed within 0.25 to 2.0 m depth layer (14X greater than in any other depth layer)
- Subsequent upward movement after vessel passes cannot be discounted, but unlikely given what is known about other gadids
- Study also shows that 61-80 cm Pacific cod not out-swimming net

# 3) EBS trawl and acoustic backscatter data

Lauffenburger et al. (submitted to CANJFAS)



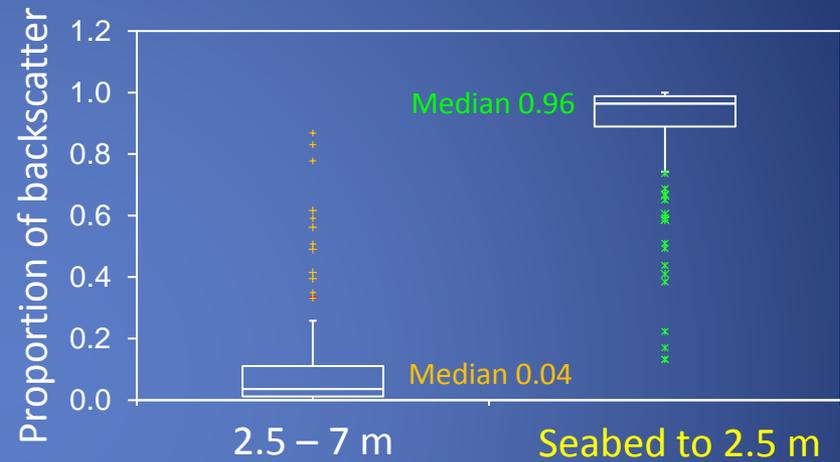
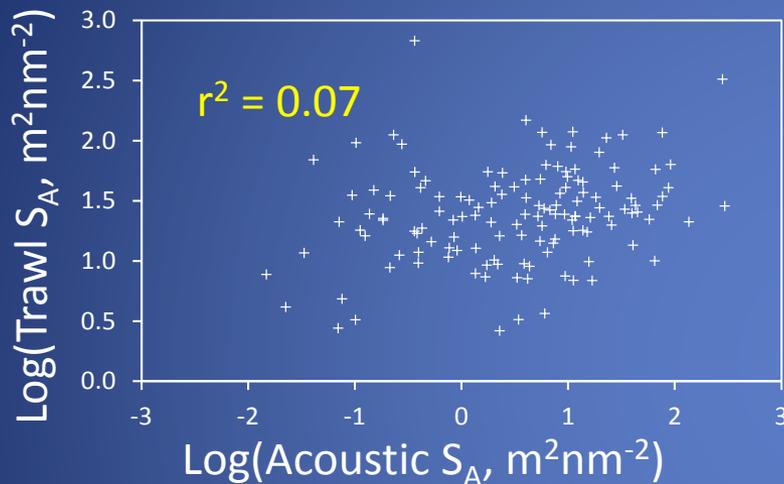
16 taxa modeled  
0.5 to 3.0 m depth layer  
6 years of data

## Results and conclusions:

- Pollock dominant source of backscatter
- Pacific cod not significant source of backscatter in 0.5 to 3.0 m depth layer
- Pacific cod likely in the ADZ where not distinguishable from seabed detected bottom (< 0.5 m)

# 4) EBS trawl and acoustic backscatter data

Lauth et al. (in prep)



## Approach:

- >100 kg Pacific cod, <15% by weight other
- N = 139 samples, 2006 – 2014\*, depth range 21 – 152 m\* (good representation)
- Total trawl backscatter estimated from Pacific cod  $\geq 60$  cm

## Results and conclusions:

- No significant correlation between trawl  $S_A$  and acoustic  $S_A$
- Pacific cod likely in the ADZ where not distinguishable from seabed detected bottom (< 0.25 m)

# 4b) Side-by-side gear comparison experiment

Lauth et al. (in prep).

## Approach:

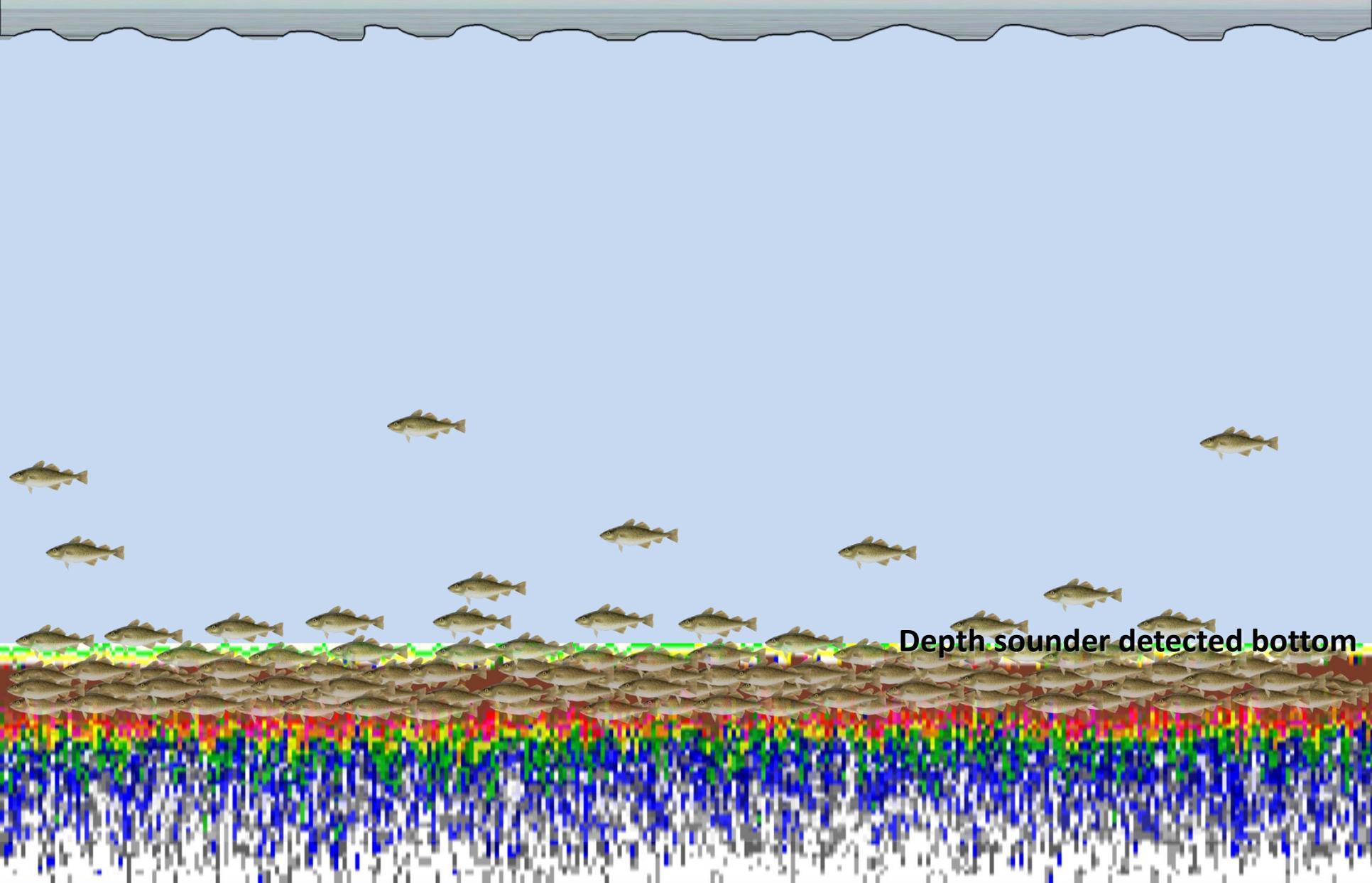
- Two vessels, 17 paired tows with EBS (2.5 m) and GOA (7 m)
- Compare mean and median CPUEs for 60-81 cm cod
- Compare EBS:GOA CPUE ratio for 60-81 cm cod



## Results and conclusions:

- No significant difference between mean or median CPUE's
- Cannot reject  $H_0$  that true EBS:GOA catch ratio is equal to mean catch ratio = 1.25
- Close to zero probability that the EBS trawl CPUE was less than GOA trawl CPUE for Pacific cod in the 60-81 cm size range
- Results do not support a no-vertical-response behavior to an approaching vessel or trawl but investigation has temporal, spatial & environmental limitations

# Most likely explanation



Depth sounder detected bottom

# Spatial availability

Large Pacific cod outside survey box?



“Leaky”



No sampling or  
low density sampling