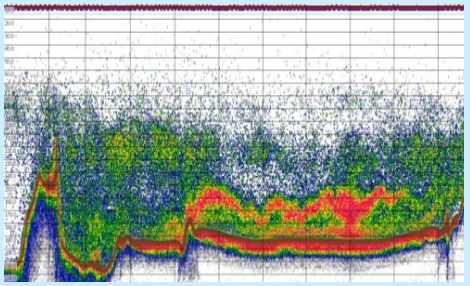
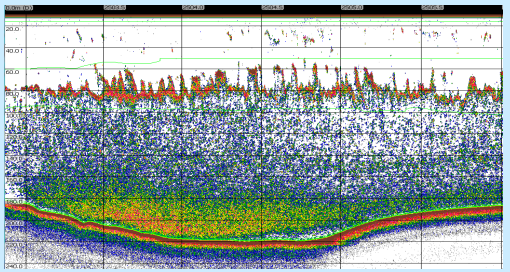
NOAA FISHERIES SERVICE

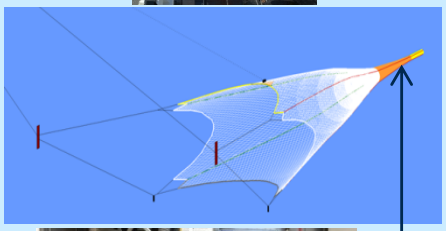
MACE
Midwater Assessment & Conservation Engineering

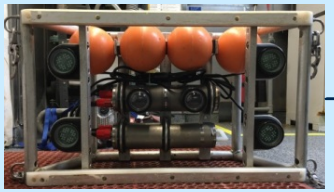
Eastern Bering Sea Acoustic-Trawl Survey Overview

MACE Program









CIE Review May 2016

Fisheries Acoustics part of MACE

Chris Wilson – Program Manager

Patrick Ressler

Fisheries Acoustics

Researchers

Chris Bassett

~~Alex De Robertis~~

Taina Honkalehto

Darin Jones

Nathan Lauffenburger

Abigail McCarthy

Denise McKelvey

Sarah Stienessen

Kresimir Williams

Vacant

Vacant

IT/Hardware Specialists

Scott Furnish

Rick Towler

Contractors/Post-Docs

Robert Levine (MATOC)

Kirsten Simonsen (JISAO)

Academic Collaborators

Tom Weber (UNH)

Peter Dahl (UW)

Gear Technology

CE

vacant

Carwyn Hammond

Scott McEntire

MACE "Fisheries Acoustics" Activities

1. **survey (monitoring)**
2. **survey-related research**
3. **ecological processes research**

OUTLINE - EBS Acoustic-Trawl (AT) Survey

I) MACE Acoustic-Trawl (AT) surveys

II) AT Survey Methods

- EBS - summer AT survey

III) AT Survey Challenges

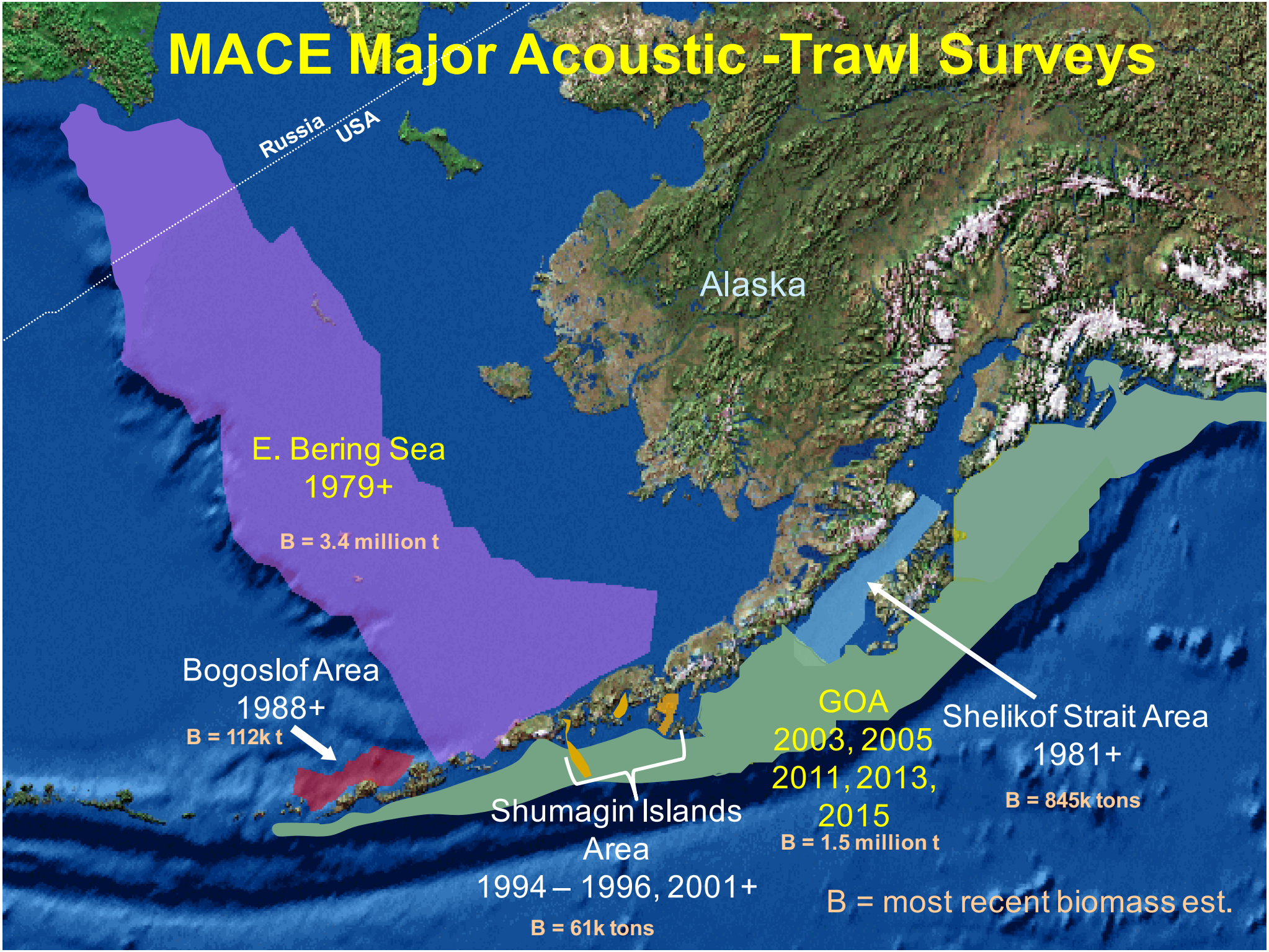
- EBS specific & general

IV) AT Survey-related Research – Examples

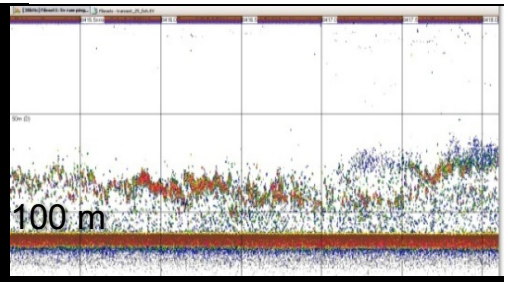
V) AT Survey Results

- General EBS (biomass, dist'n)

VI) BT Survey Acoustics – AVO Project


MACE Major Acoustic -Trawl Surveys
Russia
USA
Alaska
E. Bering Sea
1979+
B = 3.4 million t
Bogoslof Area
1988+
B = 112k t
Shumagin Islands
Area
1994 – 1996, 2001+
B = 61k tons
GOA
2003, 2005
2011, 2013,
2015
B = 1.5 million t
Shelikof Strait Area
1981+
B = 845k tons
B = most recent biomass est.

Acoustic-Trawl Survey Equipment



Vessel: ***Oscar Dyson*** (built 2003, 64 m, 2500 t, 3100 hp) - EBS 2007+
Miller Freeman - pre 2007

Personnel: ~7 Scientists (Chief Scientist, lead scientist (night), computer specialist, 4 support staff (e.g., catch processing)

Acoustic System: **Simrad EK60** echosounder (18, 38, 70,120, 200 kHz), **Echoview** software to analyze acoustic data

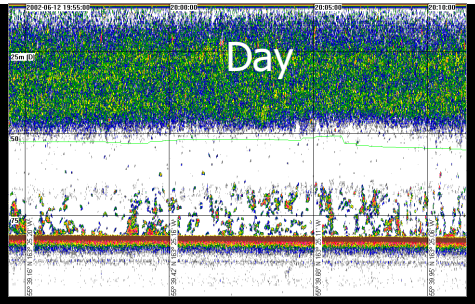
Nets: Midwater = **Aleutian wing trawl** (82 m head/ft rope, ~24 m vert.open, 3.25 m to 1.3 cm mesh sizes)

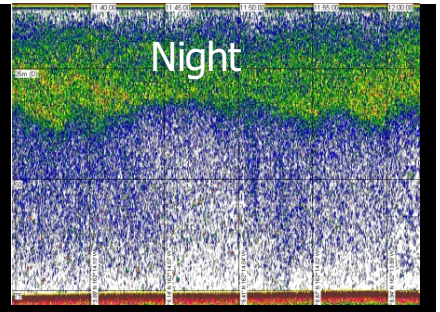
Bottom = 83-112 Eastern **bottom trawl** (26/34 m head/foot rope, ~3 m vert. open, 10 cm to 1.3 cm mesh sizes)

Misc. small midwater nets = mod2-**Marinovich** (12 m head rope, ~6 m vert. open, 6 to 0.3 cm mesh sizes), **Methot** (2.3 m square frame, 2x3 mm to 1 mm mesh sizes)

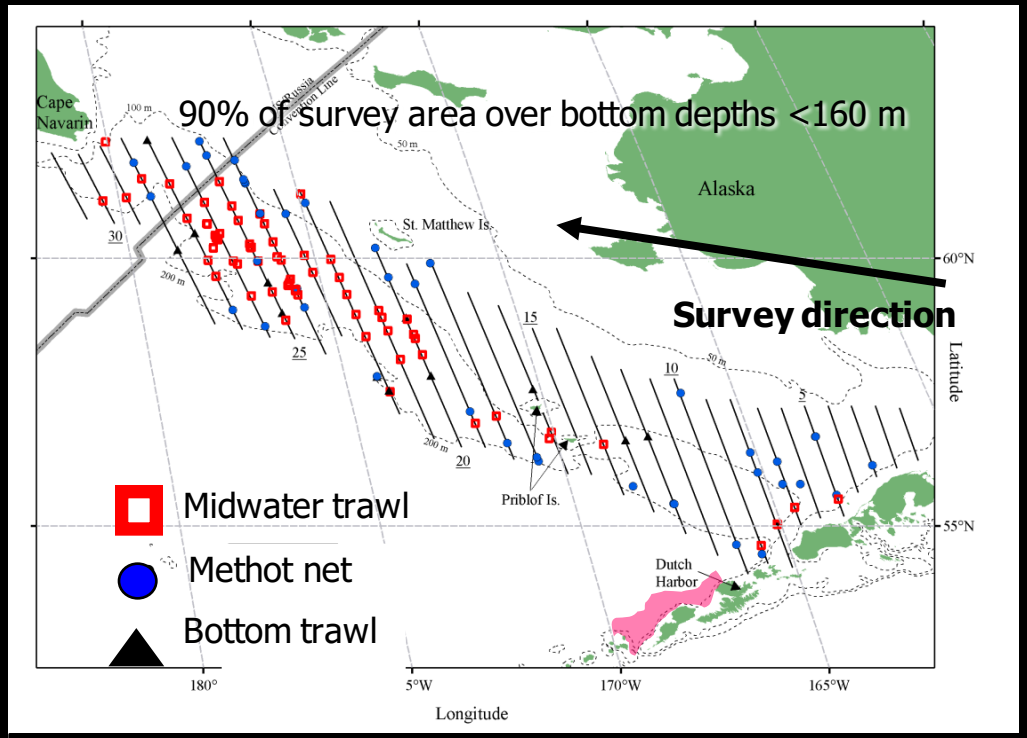
Acoustic-Trawl Survey Methods

- Transects: 4850 nmi (USA) + 750 nmi (Russia), 20 nmi spacing, random start
- Survey during daylight only
- 18, 38, 70,120, 200 kHz
- 75-120 large-trawl "targeted" hauls
- Abundance/biomass by size/age based on acoustic data between 16 m to w/in 3.0 m of seafloor or 500 m (euphausiid abundance 2004+)
- Physical oceanographic data collected
- Ancillary projects time permitting

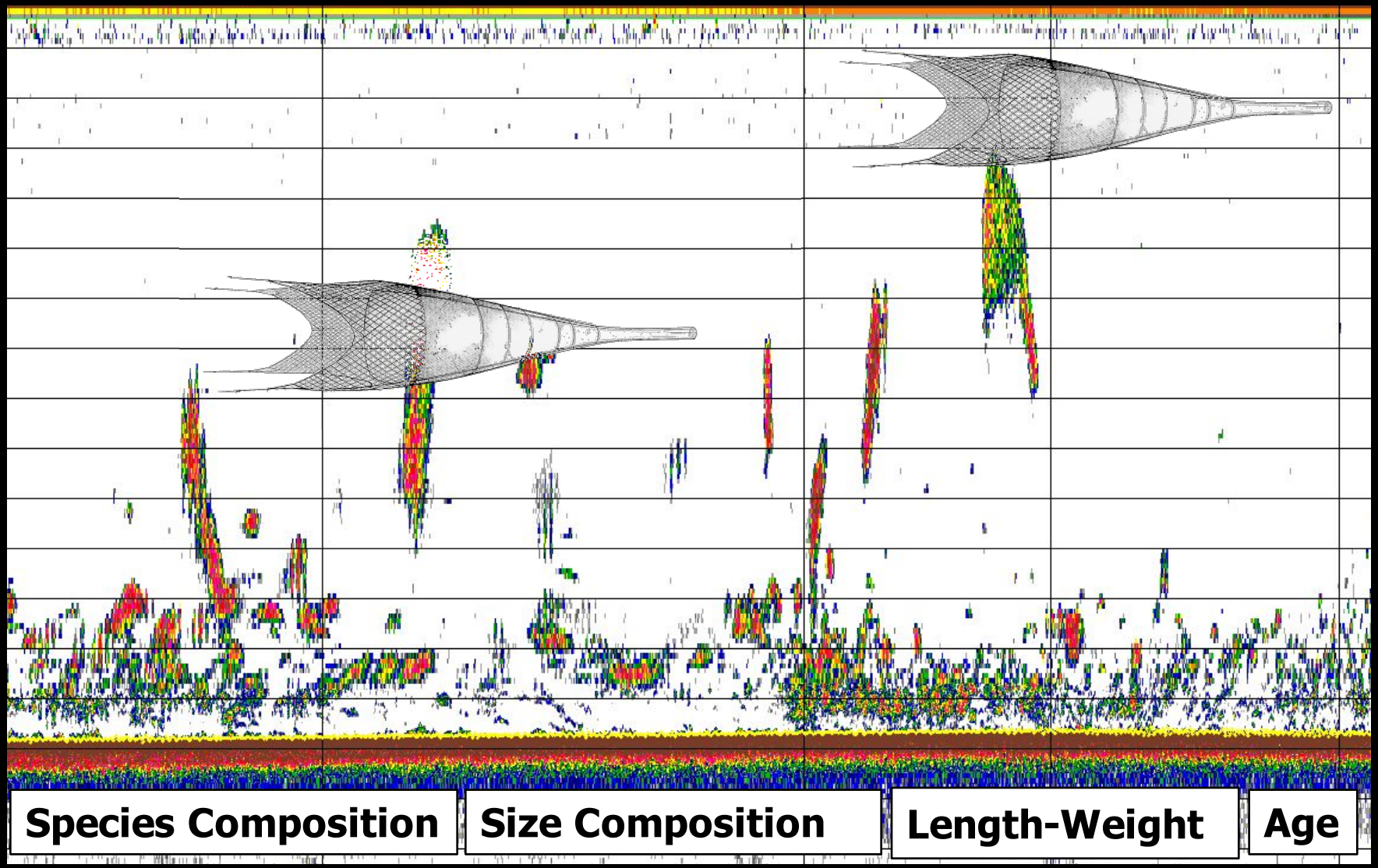




EBS Summer Survey (June-Aug)

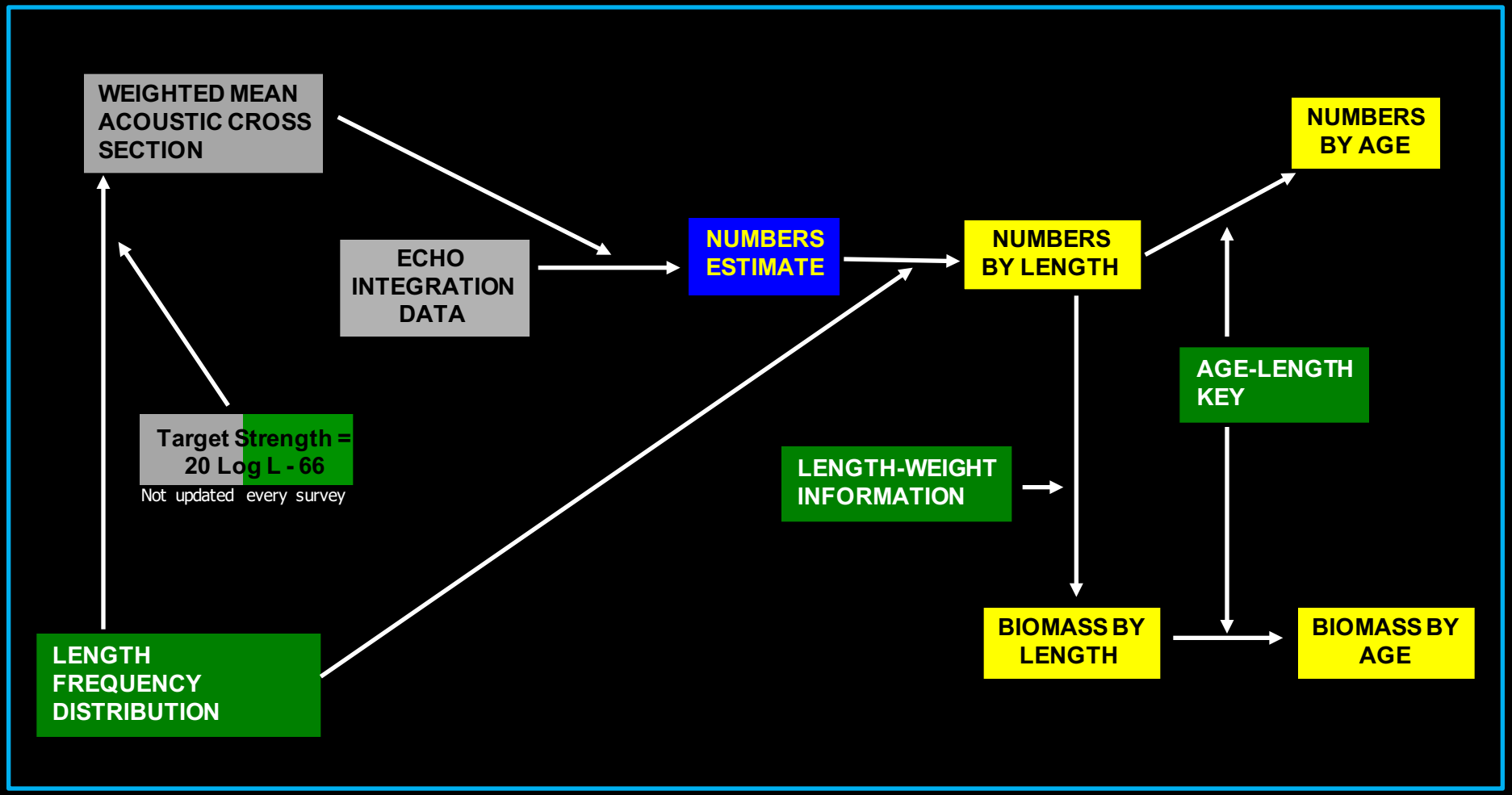


The role of trawling in acoustic-trawl surveys



Slide courtesy Kresimir Williams

Acoustic and Trawl survey data to estimate: Numbers Biomass



Acoustic-trawl survey challenges

SPECIFIC (EBS)

- Survey area (geographic)
- Survey area (water column)

GENERAL (EBS + GOA)

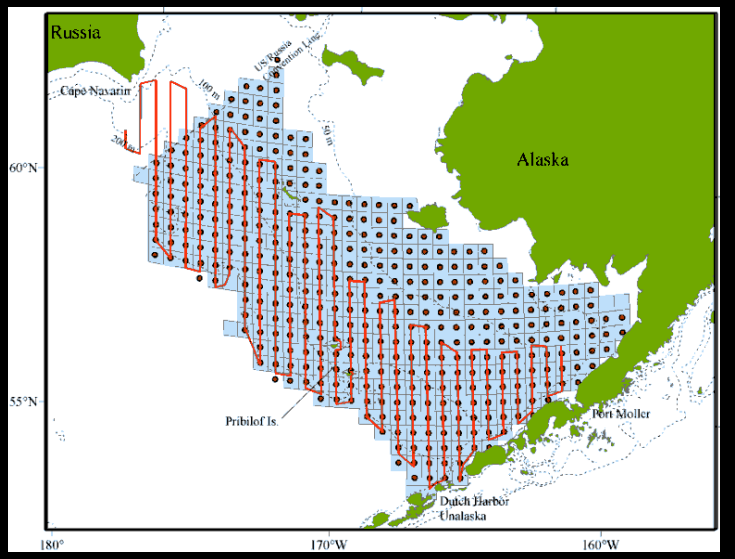
- Length Strata Construction
- Species Classification
- Vessel Avoidance
- Trawl Selectivity
- Target Strength

- TOTAL UNCERTAINTY BUDGET

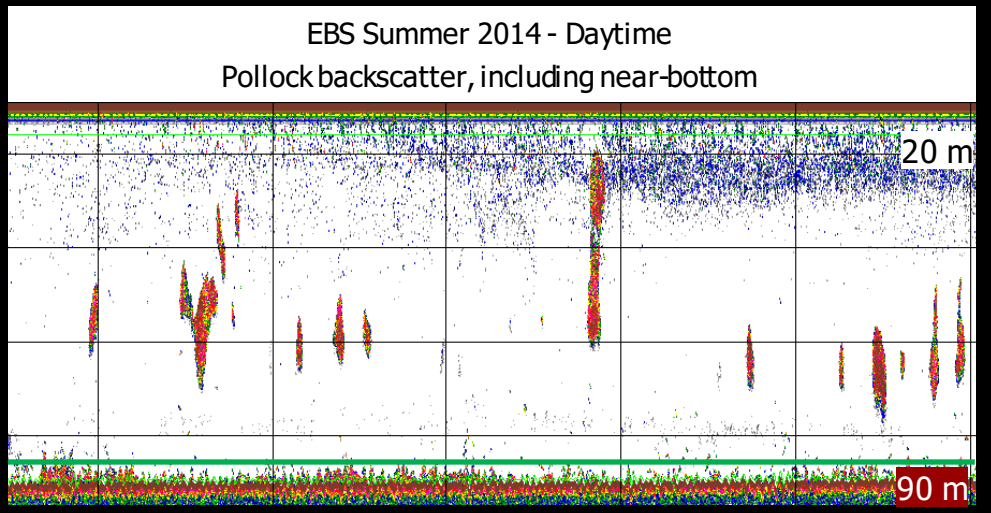
AT survey challenges – EBS specific

Survey area: Geographic

- Transect endpoints determined by absence of detectable pollock
- Russian zone surveyed 9 times since 1994 (requested 1991+, denied 5x)
- Similar area surveyed since 1991 (w/ parallel transects)



- Survey area: water column
- Why 3m? Is it optimal?
- Species composition w/in 3m zone?
- Can BT survey data resolve spp. comp…?



AT survey challenges – EBS water column

Species composition of near-bottom backscatter?

Rationale: Expand analysis region from 3 to ~0.5 m above bottom

Approach:

1) Develop model to estimate proportion of near-bottom backscatter attributed to pollock using BT survey data (haul & near-bottom acoustics).

2) Fit model using simultaneously collected BT catch (791 hauls) & near-bottom acoustics data from recent BT surveys (2006-2011).

   Pollock accounts for ~85% of near-bottom backscatter on average

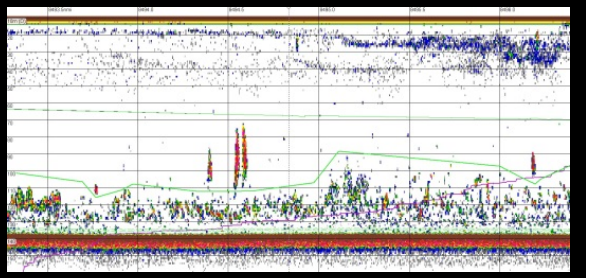
3) Use model to apply corrections to earlier surveys (1994-2014)

   Near-bottom backscatter increased pollock abundance by 20-60%

4) Summer 2016 EBS: use fitted model coefficients with BT survey hauls to estimate pollock backscatter (abundance) in near-bottom zone as an additional index

Lauffenburger et al. CJFAS (*accepted*)

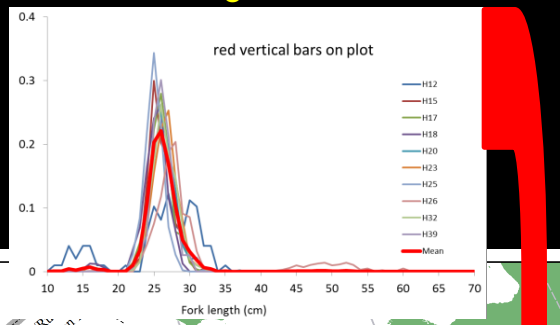
AT survey challenges – EBS specific/general

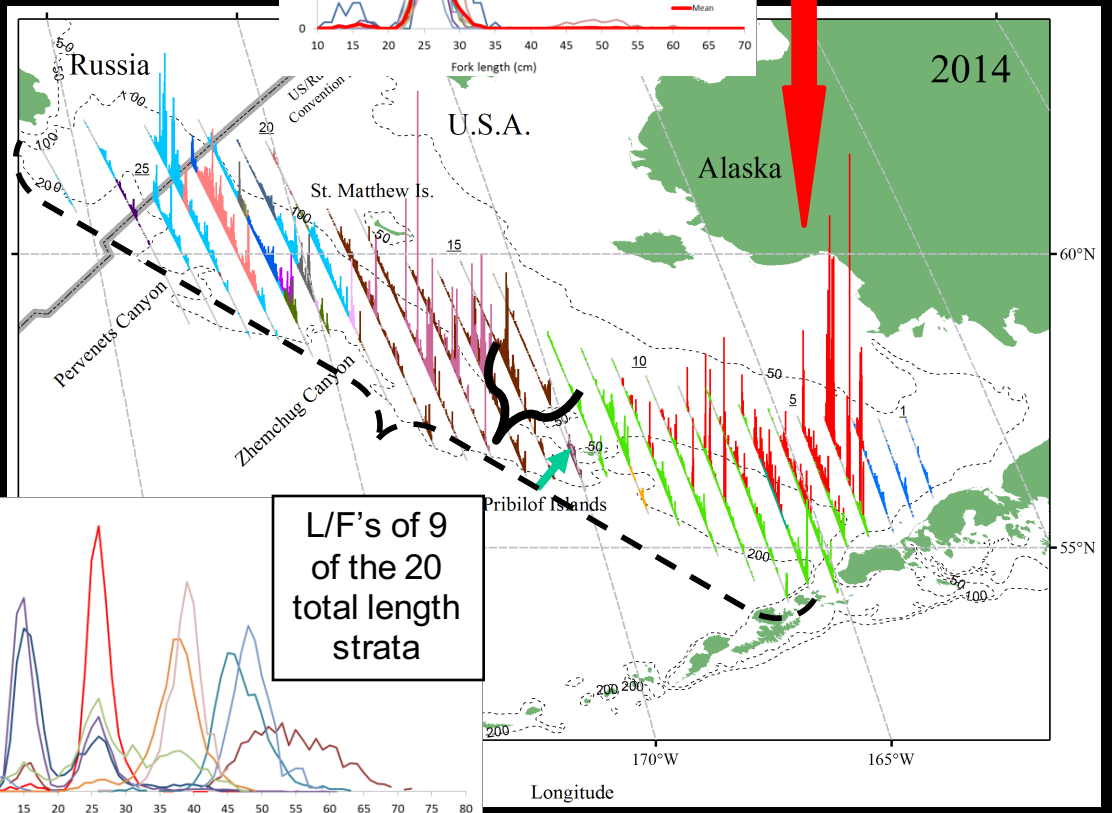


Length Strata Construction

- Hauls with similar L/F, echosign type, location grouped into strata
- Grouping done by-eye
- Stratum L/F applied to acoustic data to estimate pollock abundance/biomass in each stratum
- Develop more objective clustering procedure….

Hauls in length stratum “2”



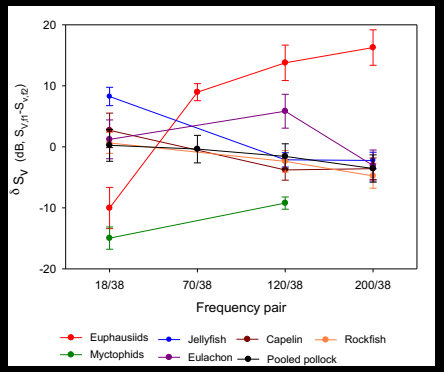


L/F’s of 9 of the 20 total length strata

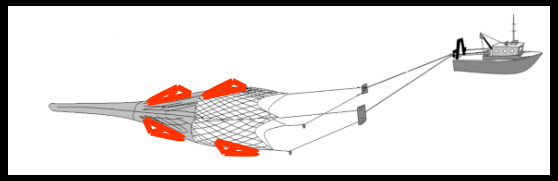
Survey-related Research:

Quantify and Reduce Sources of Bias and Uncertainty

1) Provides methodological and technological advances to acoustic survey efforts



2) Tests assumptions inherent in acoustic survey methodologies



Survey-related Research

Selected examples:
Acoustic
Trawl

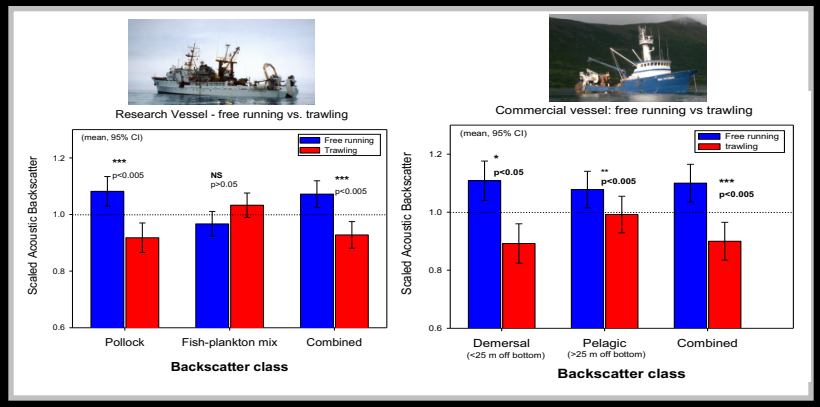
MACE Survey-related research - acoustics

Fish avoidance to underwater-radiated vessel noise

- **Retrospective Work** De Robertis & Wilson 2006

  Acoustic backscatter less for trawling vs free-running (NOAA ship, fishing vessel)

  EBS '96-'02 GOA '03



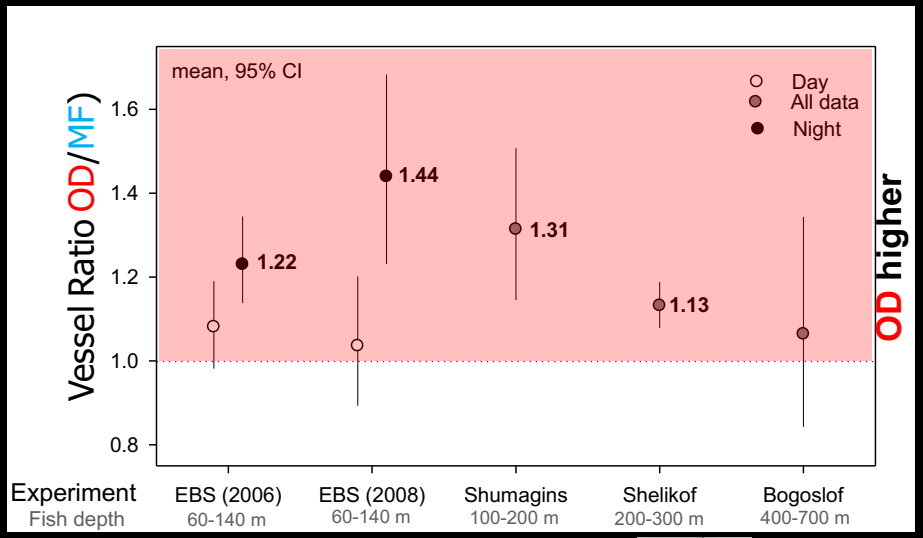
- **Vessel Comparison Work (NOAA ships)** De Robertis et al. 2010a,b; 2011; 2012

  noise-reduced ship may see more pollock than conventional ship

Oscar Dyson

versus

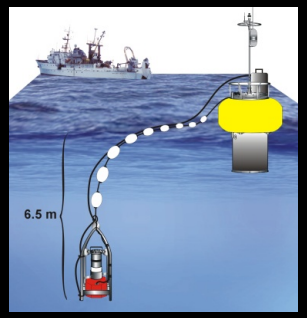
Miller Freeman



- **Acoustic-buoy work**

  Confirms noise-reduced vessel may see more fish than conventional ship, in absolute sense

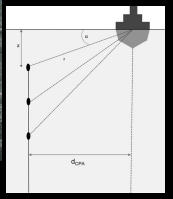
  De Robertis & Wilson 2010b



- MACE Hydrophone Mooring

  Novel, inexpensive approach to obtain high quality underwater vessel noise measurements

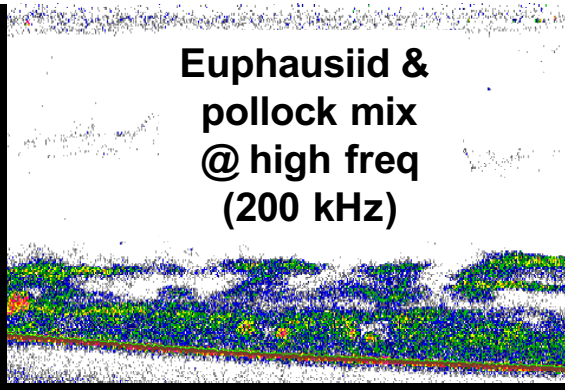
  De Robertis et al. 2012

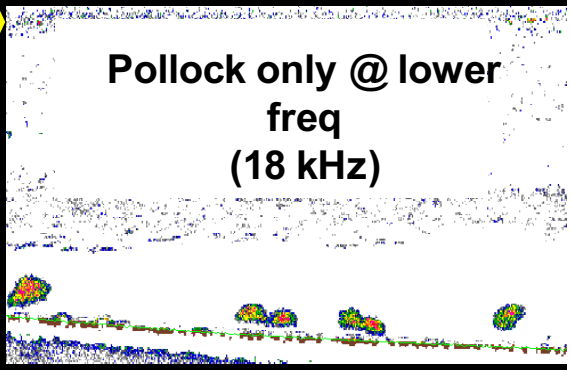


MACE Survey-related research - acoustics

Multi-frequency Z-score method to improve species classification

Differences in frequency-dependent backscattering can be species-specific





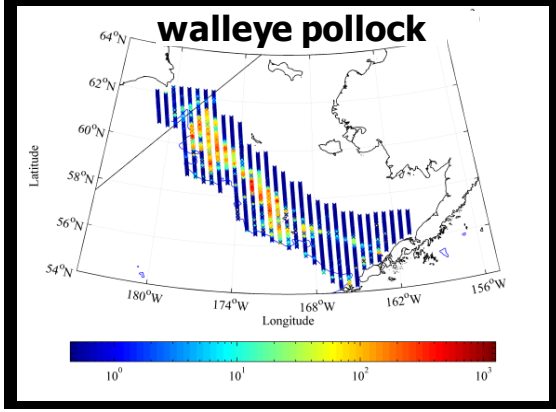
1) Objective procedure developed using

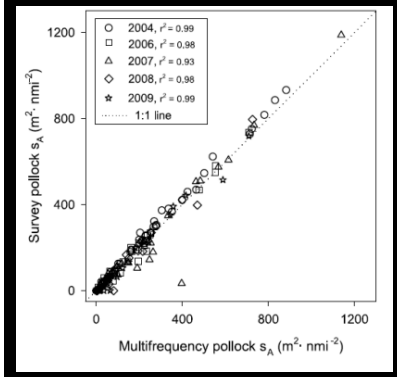
Frequency-dependent differences

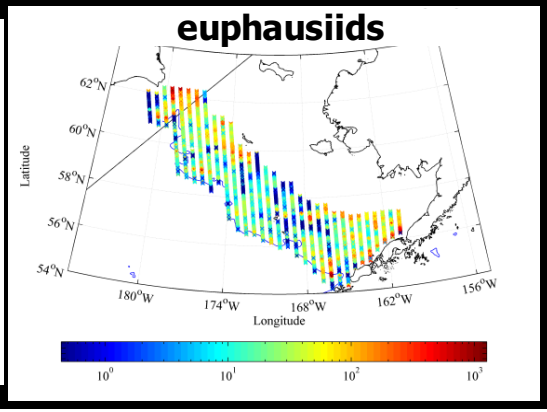
+

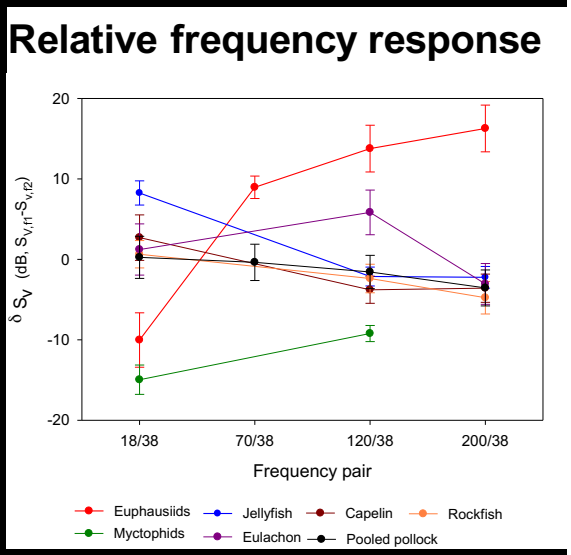
Statistical classification approach

2) Procedure validated thru testing, routinely used in EBS





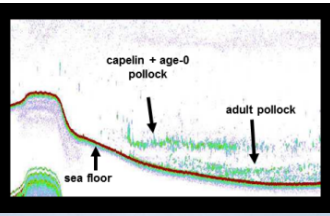




De Robertis et al. 2010

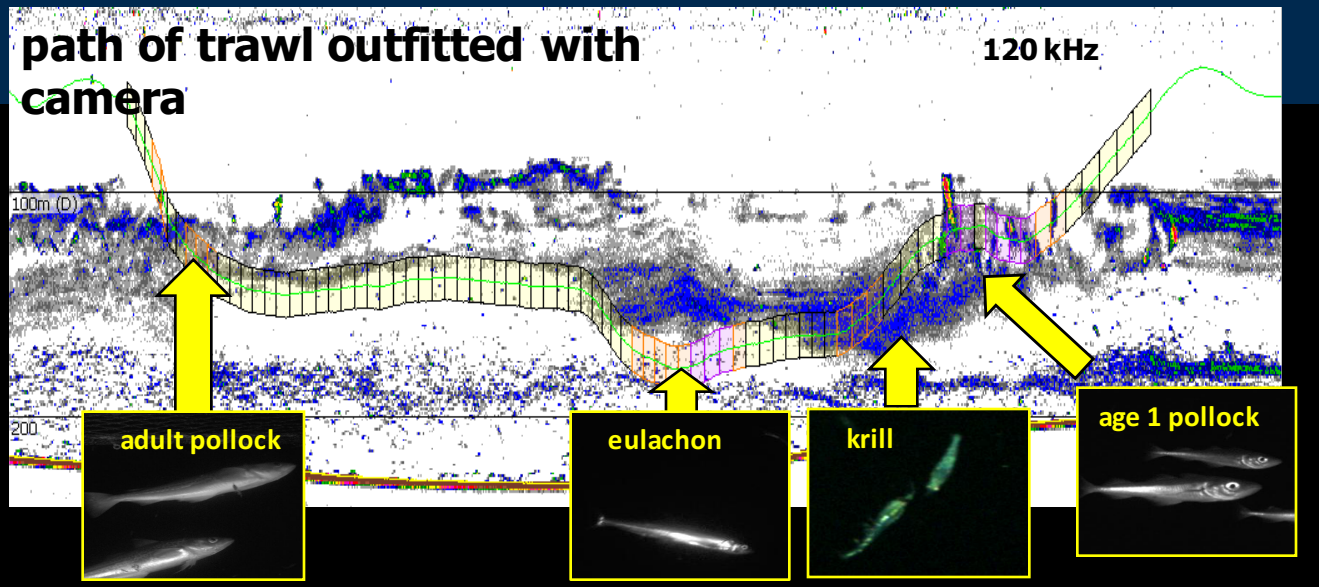
MACE Survey-related research - acoustics

CamTrawl - to improve species classification



- Species ID and pollock size structure from multiple acoustic layers
- Reduce/eliminate catch processing effort
- Longer tows in high density fish sign (i.e., open codend)
- Non-retention = non-lethal

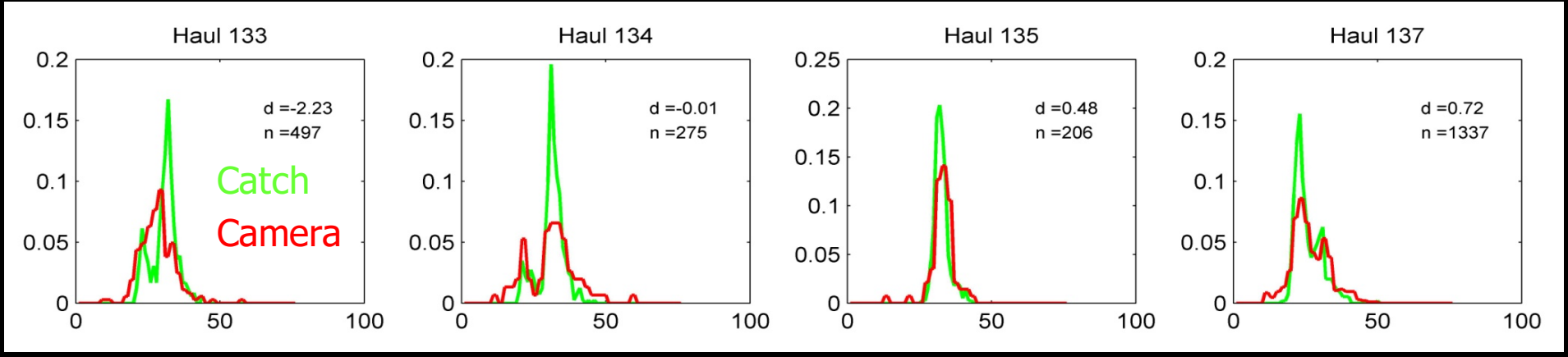
CamTrawl view



Williams et al. 2010a, b

CamTrawl (cont.) Automated stereo-based length measurements

- Implemented on all MACE AT surveys
- Minimal QC required
- Negligible difference in L/F from auto processed vs physically measured
- Next steps: codend open/close protocol, Auto spp. ID

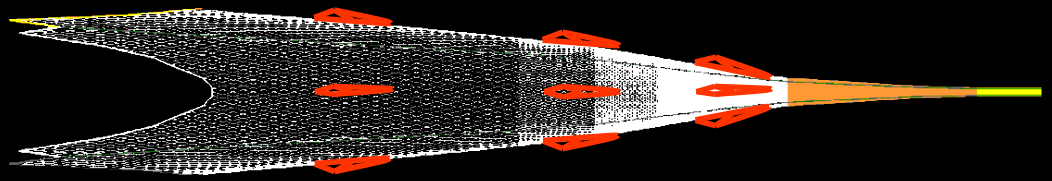


MACE Survey-related research - trawls

Is MACE trawl an unbiased sampler?

Trawl selectivity project

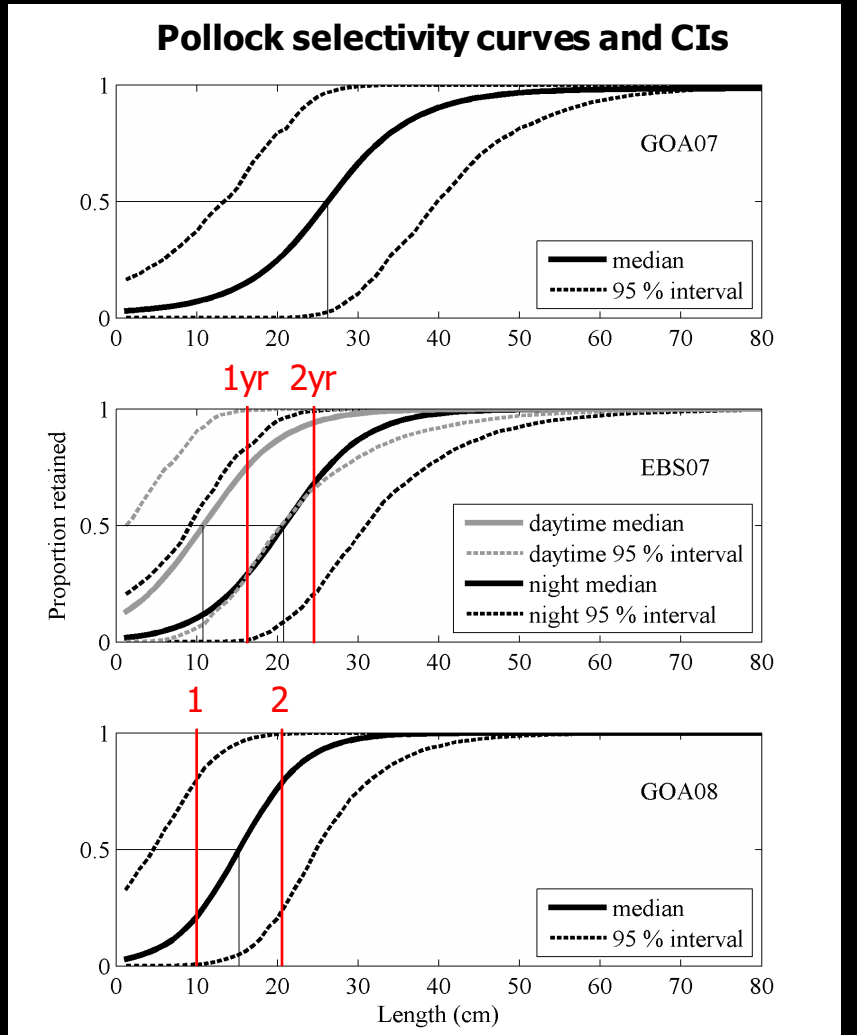
Recapture nets



- **Hierarchical Bayesian model to estimate pollock selectivity as function of fish length**

- **Age-1 pollock under-sampled**

Williams et al. 2011, 2013, 2015



MACE Survey-related research: acoustics + trawl

Goal: Total uncertainty model

1) Confidence intervals for estimates of total biomass currently based on geostatistical methods (sampling variability only)
(Pettigas 1993 ICES J.Mar. Sci)

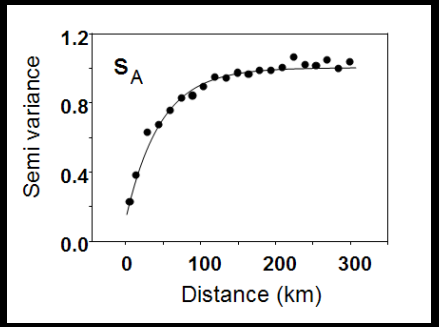
2) Method using bootstrapping and geostatistical sequential simulation under development to provide CI biomass and numbers by age-class

3) Confidence intervals by age-class include uncertainty in:
- spatial distribution of backscatter
- age-length key
- length-weight relation
- length-frequency spatial distribution

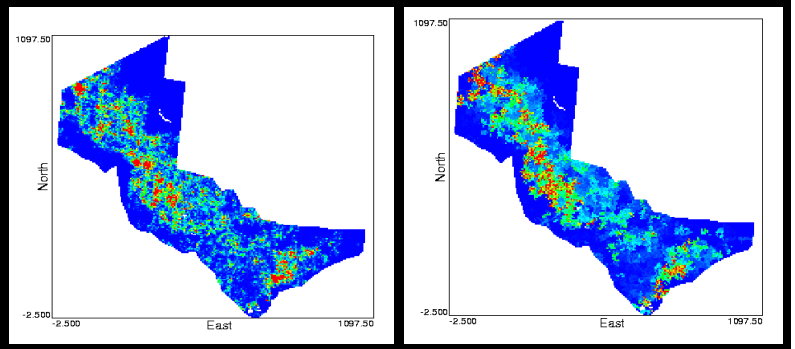
4) Potential sources of bias, e.g.,
- trawl selectivity
- fish avoidance
- species classification errors
- TS-length relation

not yet included in model

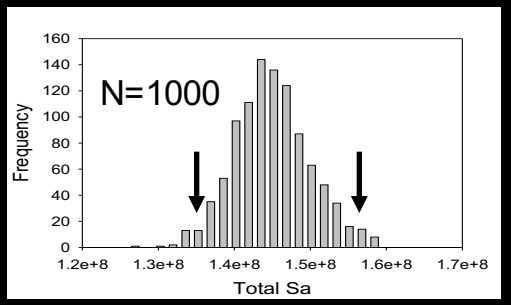
Model



Simulations



PDF



Total Biomass

Walline 2007; Woillez et al. 2016 IJMS

MaceBase 2: AT Survey database

- Relational database for AT survey data storage (acoustic, trawl, camera) & abundance estimation

- First used for summer 2015 AT survey

- Facilitates sensitivity analyses to explore influence of different factors on survey abundance estimates, e.g.,

  - haul assignments (nearest-neighbor vs one length stratum/entire survey area)
  - Proportional allocation of backscatter for mixed species aggregations
  - trawl selectivity corrections
  - alternative TS relationships

- Analysis of non-systematic/opportunistic acoustic data (e.g., BASIS survey grid, bottom-mounted echosounders)

Acoustic-Trawl Survey Results – General Trends

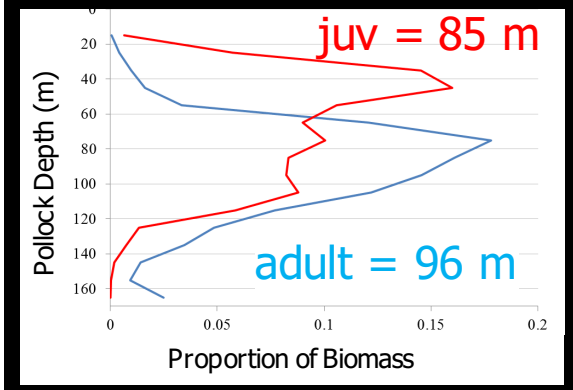
Pollock biomass, distribution

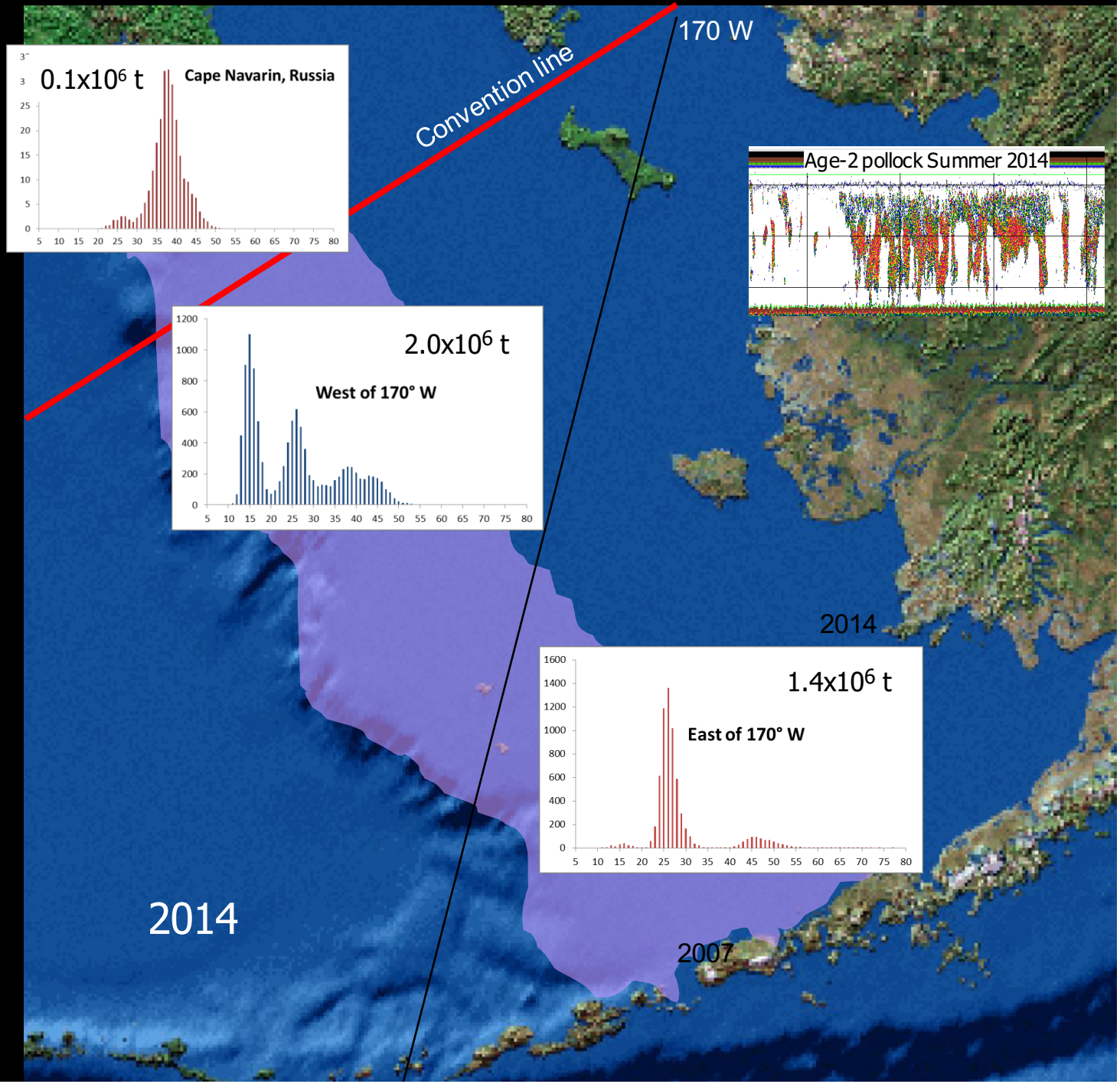
Results – Size Composition

- **Russia w/o juveniles as in US zone**
- **Age-1s relatively abundant in US_NW**
- **Age-2s extend east of 170W**

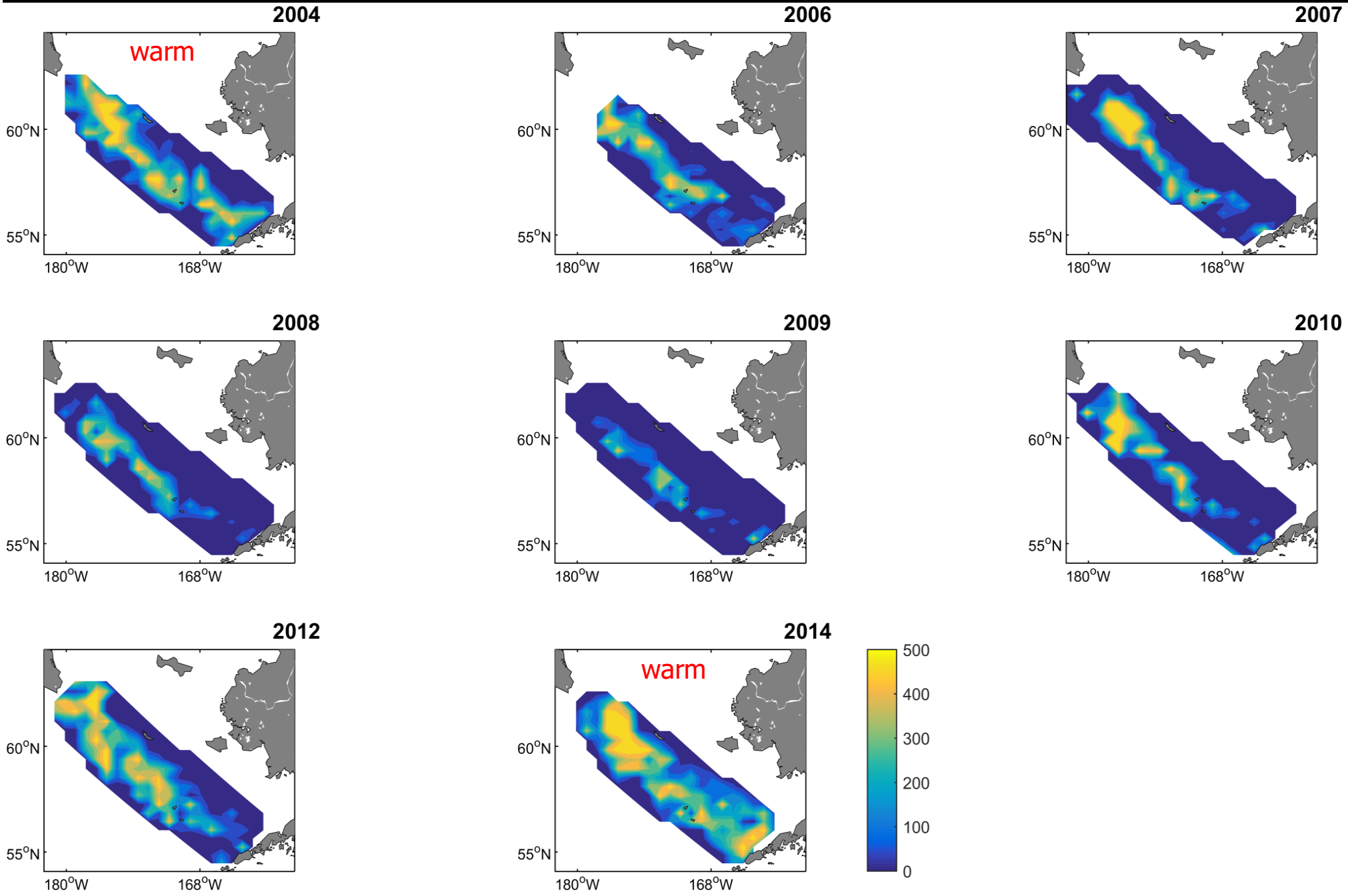
Pollock Vertical Distribution

Juveniles typically shallower than adults



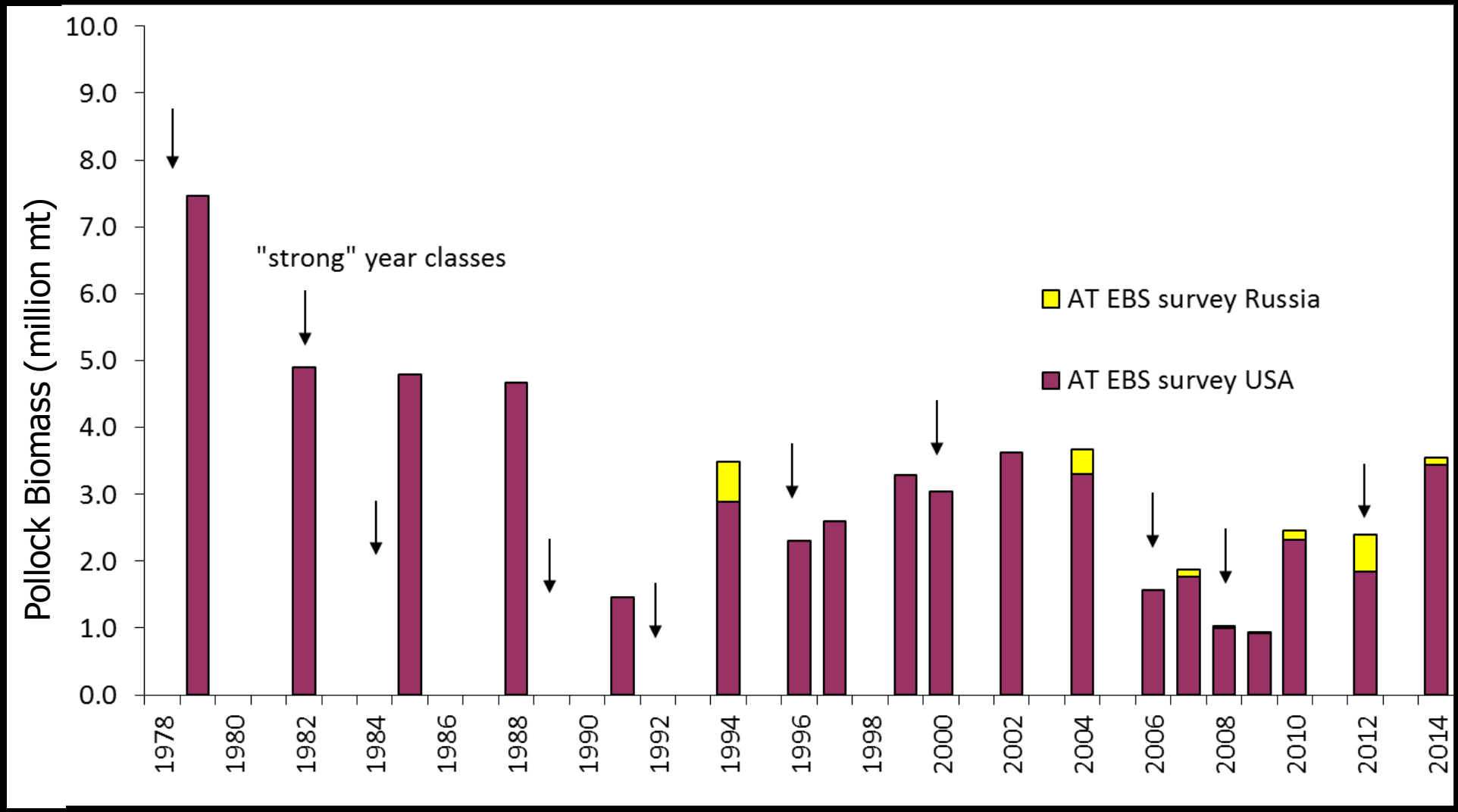


Results – EBS Summer Pollock Distribution 2004-2014



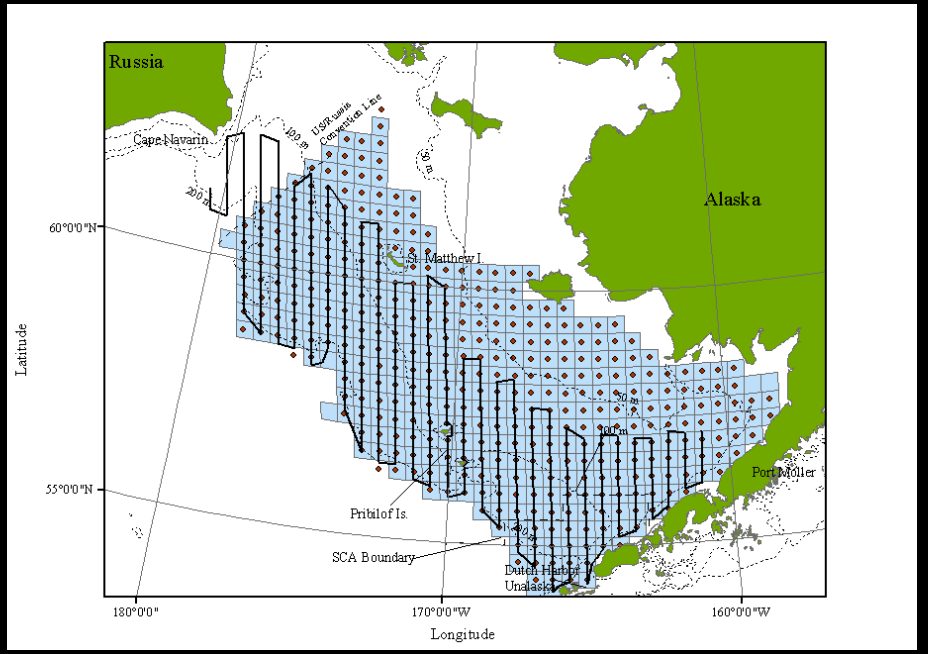
Results – EBS Summer Biomass

- **Rebuilding trend ?**
- **Strong YC @ 2-6 yr frequency**
- **Proportion of Biomass in Russia ≤ 22%**



AVO Project

- Acoustic data collected aboard charter vessels during "annual" EBS Bottom Trawl (BT) Survey (Acoustics from Vessels of Opportunity = AVO)
- Acoustic data estimate "index" of *midwater* pollock abundance.
- AVO abundance index fills data gaps in "biennial" MACE EBS acoustic-trawl (AT) survey.



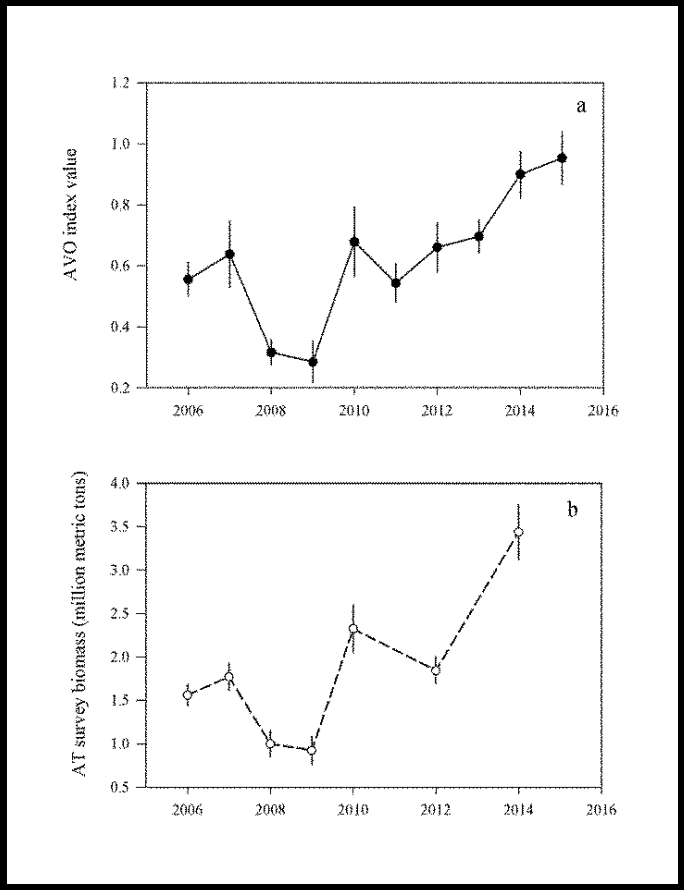
Methods

- Scientific sounders (Simrad ES60) collect data annually (BT surveys)
- Sounders are calibrated before/after summer BT survey
- Data analysis involves combination of manual and automatic post-processing of data from an index area.
- Quality of AVO index is evaluated against biennial AT survey biomass estimate.

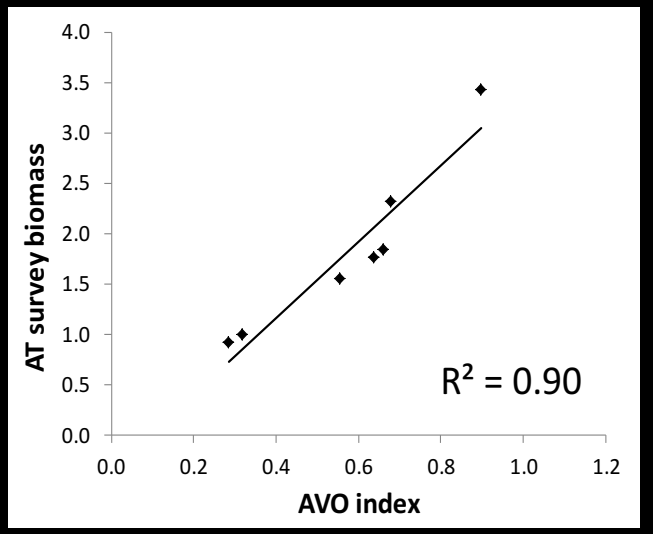
Honkalehto et al. 2011 CJFAS

AVO Project - Results

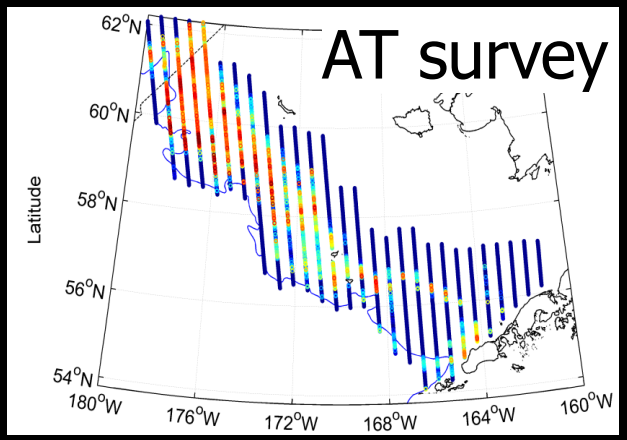
AVO index and AT survey pollock biomass time series show good agreement

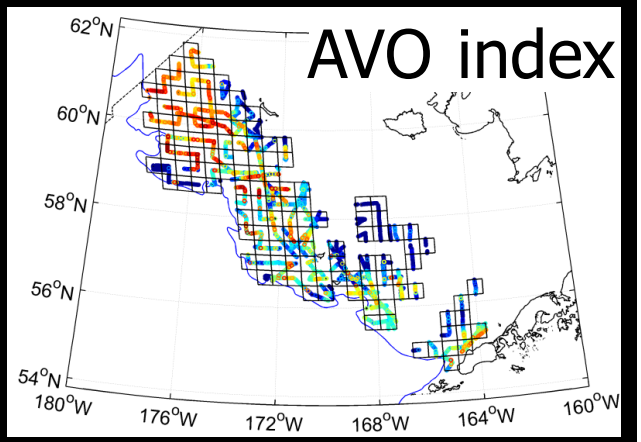


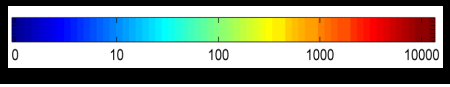
AVO index agrees well with AT survey pollock biomass



Distributional patterns for AT survey & AVO are typically similar as shown here with densest pollock in NW survey area (summer 2010)







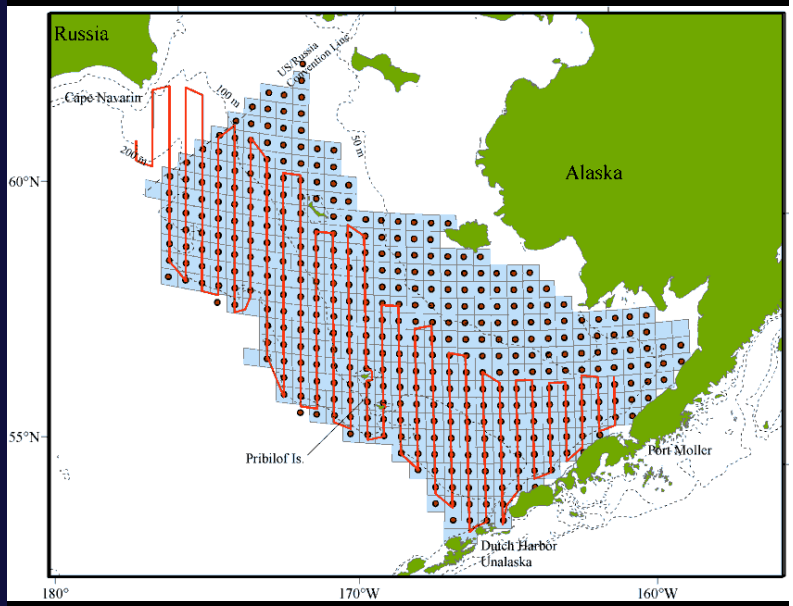
s_A, 38 kHz

Questions?

RACE Eastern Bering Sea Surveys – Summary Statistics

	Bottom Trawl (BT) Survey	Acoustic-Trawl (AT) Survey	
	EBS	EBS	Bogoslof
Frequency	annual	triennial⇒biennial	annual⇒biennial
Date	May - July	June - Aug	March
T-Series	1982	1979	1988
Geog. Area (km^2)	496k	326k	12k ⇒ 3k
Avg Bot Depth (m) (range)	81 (20 – 200)	129 (50 – 1500)	1200 (90 – 2000)
Sampled depths	seafloor to 3m above	3m above to sea surface	sea surface to 1000 m
No. Trawl hauls	~375	75-120	10-15
Acoustic data	opportunistic	4700 nmi (+600 Russia)	1000 ⇒ 600 nmi
Assessed Spp.	demersal spp. pollock, fishes crabs, inverts	semi-demersal pollock euphausiids	semi-demersal spawning pollock

Summer BT versus AT survey areas



Species composition of near-bottom backscatter?

Expanding analysis region to 0.5 m above bottom will increase survey accuracy once acoustic contribution of other fishes known

Method

1) From BT survey, use simultaneously collected bottom trawl catch (791 hauls) & acoustic data (0.5 to 3 m off-bottom) from 2006-2011 to fit species specific coefficients:

$$\sum_{h=0.5}^{3} s_A = A_{pk} \cdot CPUE_{pk} + A_{p_{cod}} \cdot CPUE_{p_{cod}} + A_{flatfishes} \cdot CPUE_{flatfishes} + \cdots$$

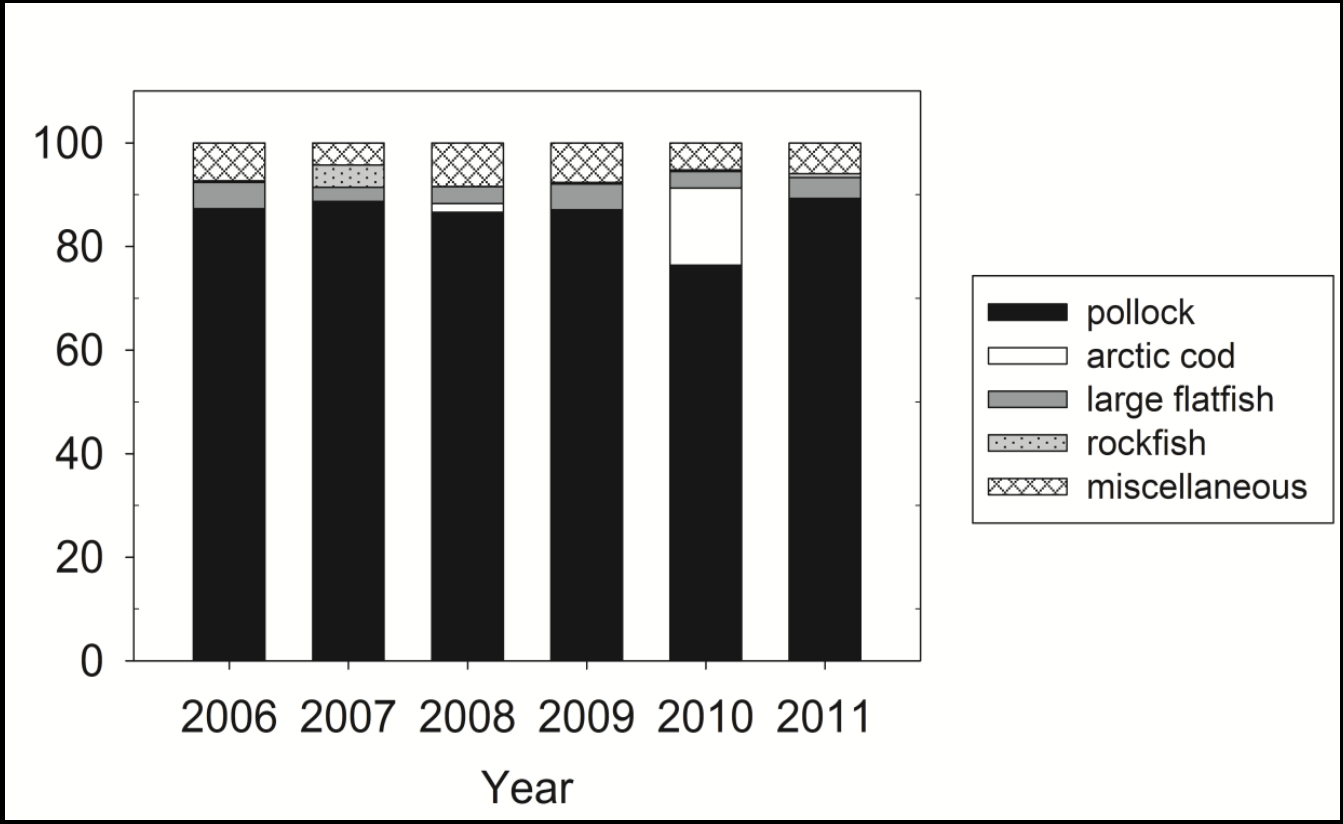
2) Use these coefficients to find proportion of backscatter attributable to pollock (and other species):

$$Prop_{pk} = \frac{s_{A,pk}}{\sum_{sp} s_{A,sp}} = \frac{A_{pk} \cdot CPUE_{pk}}{\sum_{sp}(A_{sp} \cdot CPUE_{sp})}$$

Lauffenburger et al. CJFAS (*accepted*)

Species composition of near-bottom backscatter? (cont.)

Proportion of backscatter attributable to pollock (and other species) between 0.5 and 3 m off-bottom from 2006 – 2011



Pollock is around 85% of the 0.5-3 m backscatter on average

Lauffenburger et al. CJFAS (*accepted*)

Species composition of near-bottom backscatter? (cont.)

Method for applying correction back in time and for future use (starting in 2016):

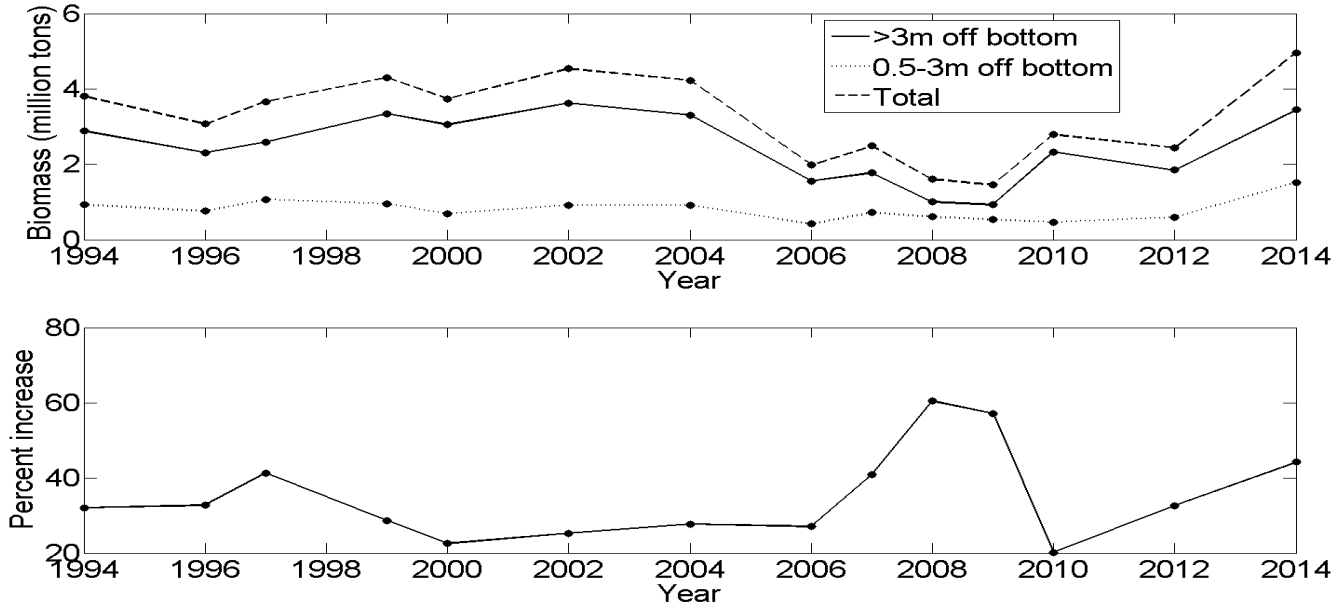
1) Find BT catch from closest BT survey trawl stations

   (w/in 25 nmi max range, weight by 1/R distance)

2) Estimate proportion of backscatter from pollock

   a) Use fitted coefficient values from the earlier species-catch/backscatter model

   b) Use proportion to scale backscatter between 0.5 and 3 meters



Near bottom backscatter increased pollock abundance by 20-60%

Lauffenburger et al. CJFAS (*accepted*)