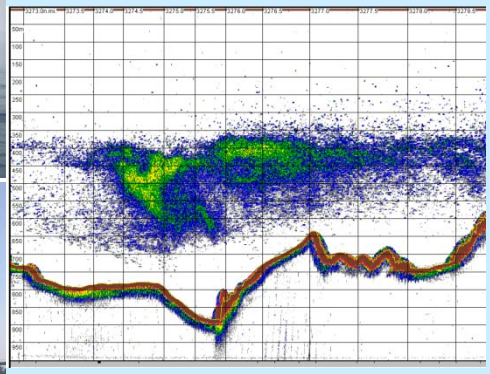
NOAA
FISHERIES
SERVICE

Acoustic-Trawl Survey Overview

MACE
Midwater Assessment & Conservation Engineering

MACE Program



OUTLINE - Acoustic-Trawl Surveys

I) MACE Program Staff, Program Activities

II) Acoustic-Trawl (AT) Survey Methods Overview

III) AT Survey-Related Research - examples

IV) AT Survey Challenges

V) MACE Interactions w/Stock Assessment Scientists

VI) “Special” Projects for Stock Assessment needs

VII) Data/Results Dissemination and Documentation

Fisheries Acoustics part of MACE

Chris Wilson – Program Manager

Neal Williamson

Fisheries Acoustics

Biologists

Alex De Robertis

~~Mike Guttormsen~~

Taina Honkalehto

Darin Jones

Abby McCarthy

Denise McKelvey

Patrick Ressler

Sarah Stienessen

Paul Walline

Kresimir Williams

IT/Hardware Specialists

Scott Furnish

Rick Towler

Zach Berkowitz (2 yrs)

Kevin Taylor (3 yrs)

Academic Collaborators

Tom Weber (UNH)

Kirsten Simonsen (NRC)

Gear Technology

CE

Craig Rose

Carwyn Hammond

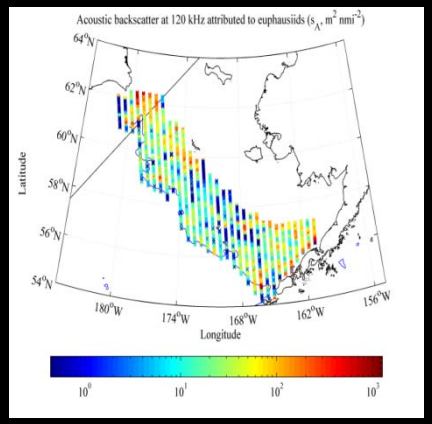
Scott McEntire

MACE “Fisheries Acoustics” Activities

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

3. Ecological Processes Research:

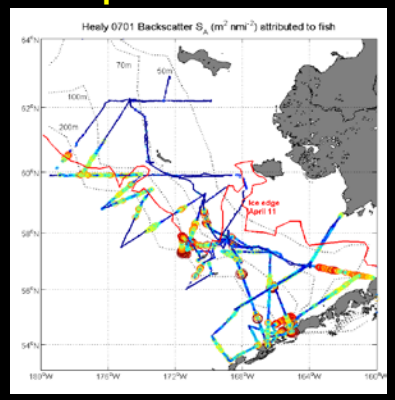
Summer Euphausiid Distribution



Patrick Ressler

1) **Bering Sea Integrated Ecosystem Research Program (BSIERP)**
(2006+)

Winter "pollock" Distribution

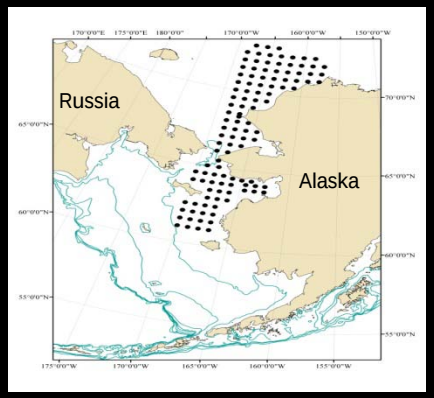


Alex De Robertis

2) **Loss of Sea Ice Program (LOSI)**
(2007, 2008)

3) **Arctic EIS (Chukchi Sea survey)**
(summers 2012, 2013)

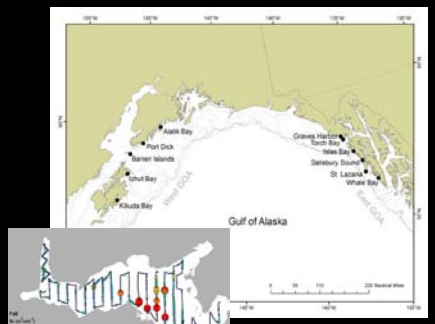
Multi- species Assessment

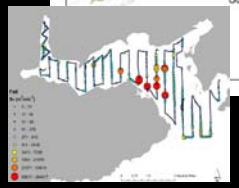


Alex De Robertis, Kevin Taylor

4) **GOA-IERP (NearShore Component)**
(spr, summer, fall 2012, 2013)

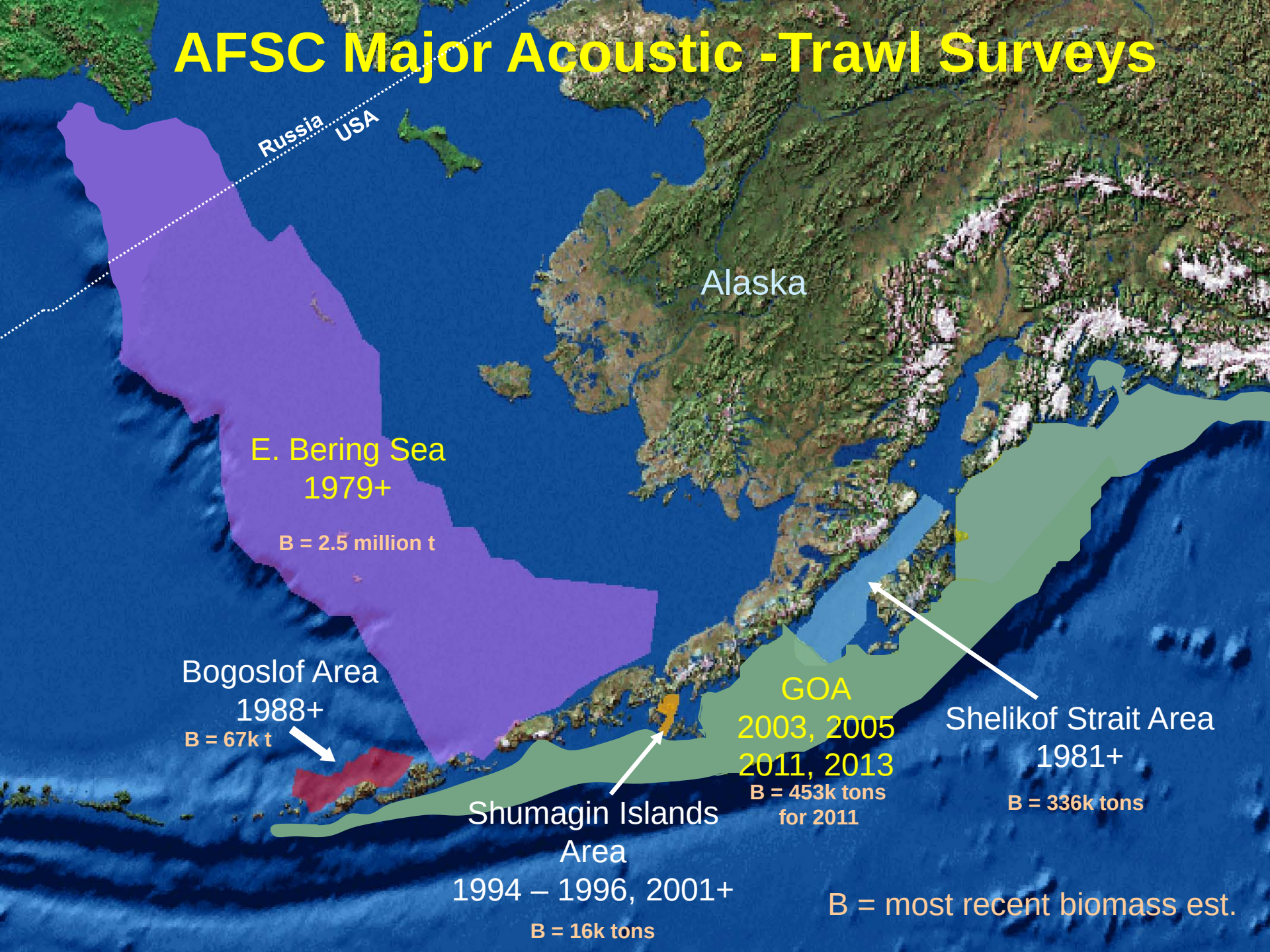
Multi-species Assessment





Alex De Robertis

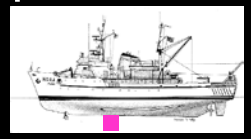
AFSC Major Acoustic -Trawl Surveys



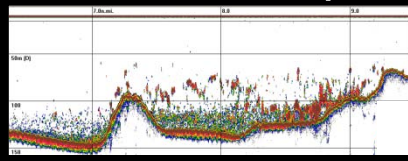
Acoustic-Trawl Survey Equipment

Vessel: ***Oscar Dyson*** (built 2003, 64 m, 2500 t, 3100 hp) - Shelikof 2008+
Miller Freeman (built 1967, 66 m, 1900 t, 2200 hp) - EBS 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), **Myriax Echoview** software to analyse acoustic data



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

Bottom = poly Nor'eastern **bottom trawl** (head/foot rope = 27/25 m, vert. open ~ 6 m, net mesh 13 cm to 1.3 cm codend liner)

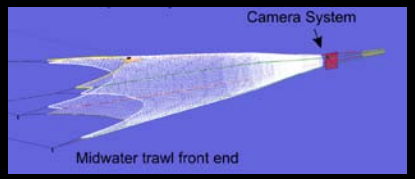
Misc. small midwater nets = mod-**Marinovich** (head rope 14 m, mesh 6 cm to 3 mm codend liner), **Methot** (2.3 m square frame, net mesh 2x3 mm to 1 mm codend)

Acoustic-Trawl Survey Equipment (cont.)

Miscellaneous:

- Multiple open-closing codend device

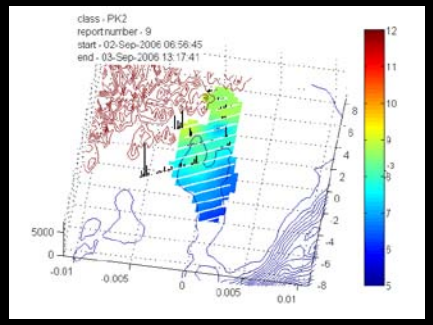
- Lowered acoustic system



- Camera-trawl system

Physical oceanography instruments:

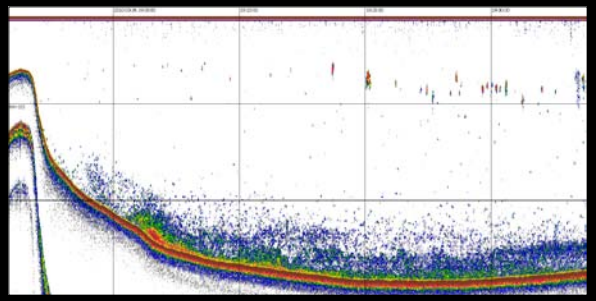
- CTD, XBT, thermo-salinograph, ADCP (153 kHz)

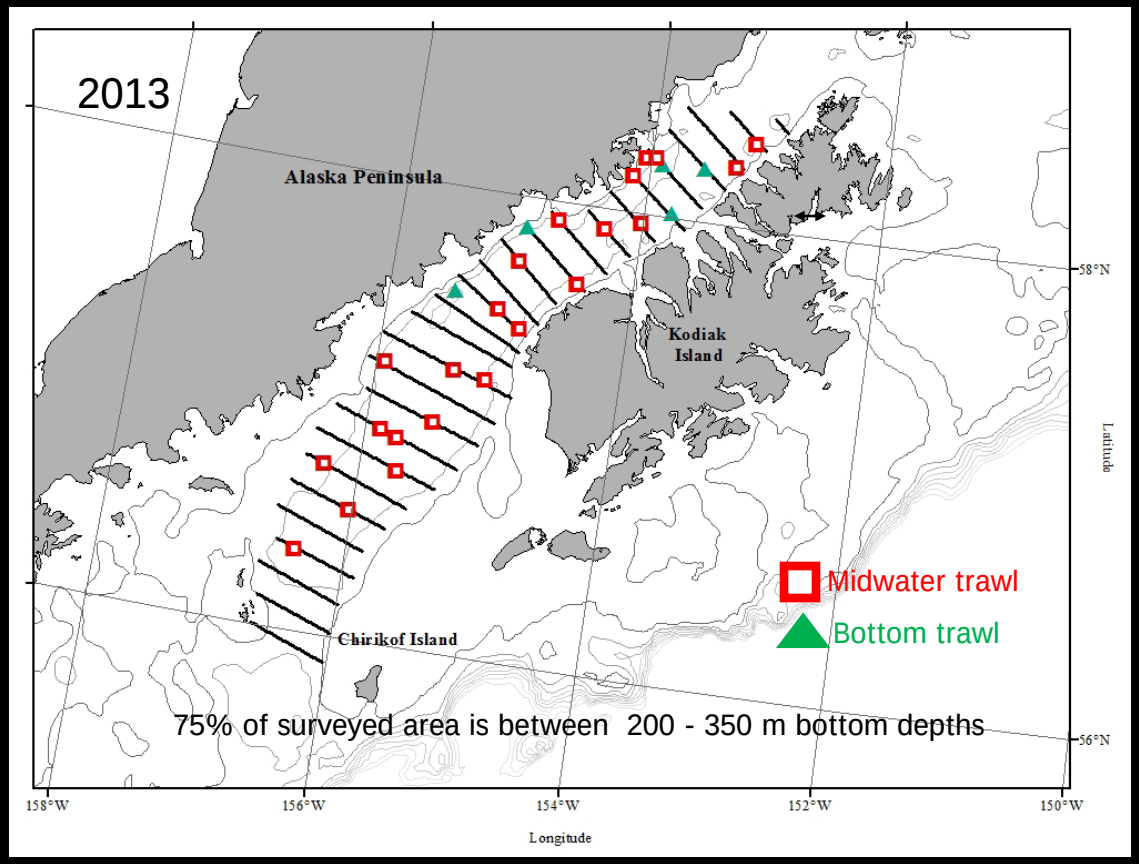


Acoustic-Trawl Survey Methods

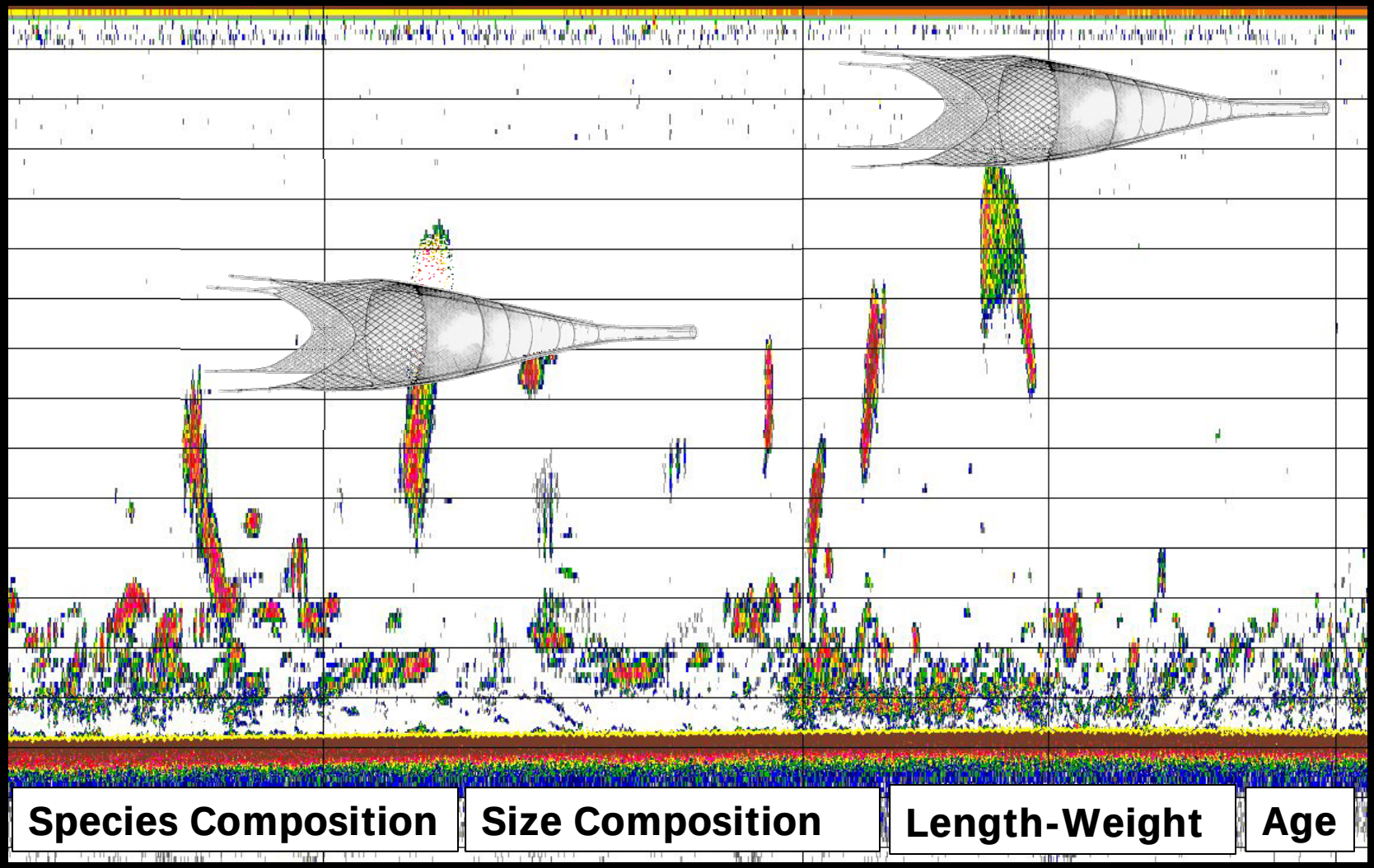
- Transects: 700 nmi, 7.5 nmi spacing, random start
- Survey 24 hrs/day
- 18, 38, 70,120, 200 kHz
- 11-30 large-trawl “targeted” hauls
- Abundance/biomass by size/age based on acoustic data between 16 m to w/in 0.5 m above seafloor or 500 m
- Physical oceanographic data often collected
- Few ancillary projects

Shelikof Pre-Spawning Survey March (~ 1.5 weeks)



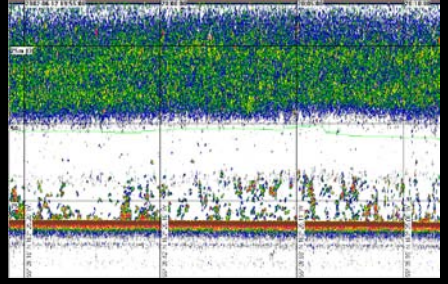


The role of trawling in acoustic-trawl surveys



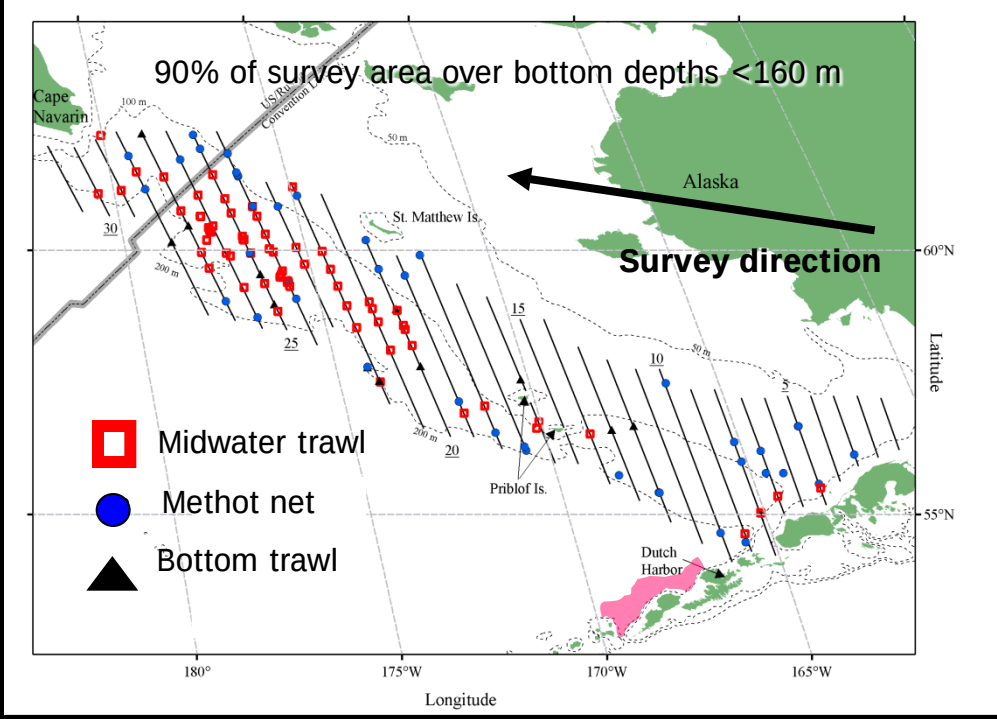
Slide courtesy Kresimir Williams

Acoustic-Trawl Survey Methods

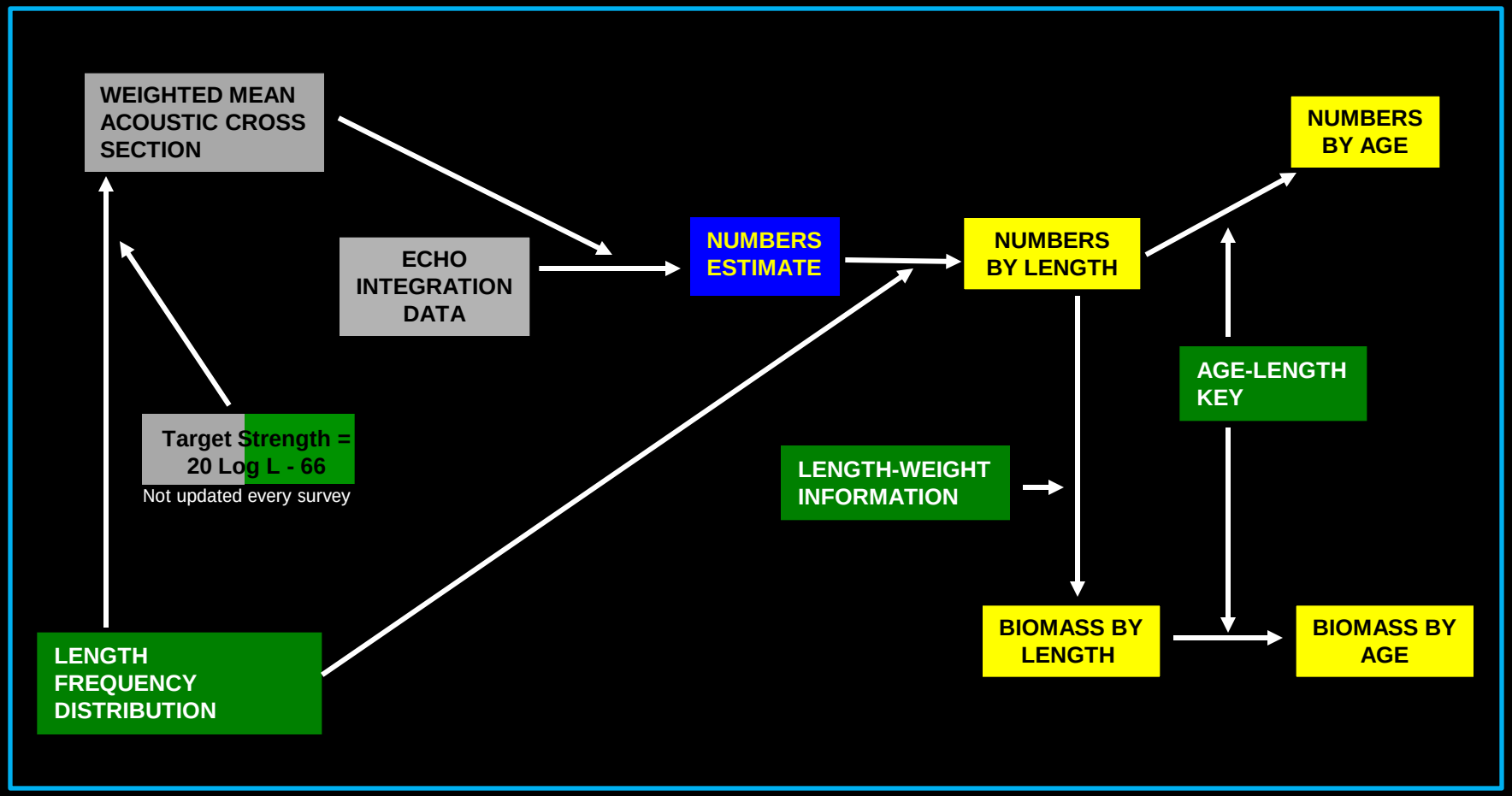


- Transects: 4850 nmi (USA) + 750 nmi (Russia), 20 nmi spacing, random start
- Survey during daylight only
- 18, 38, 70,120, 200 kHz
- 75-100 large-trawl "targeted" hauls
- Abundance/biomass by size/age based on acoustic data between 16 m to w/in 3.0 m above seafloor or 500 m (euphausiid abundance 2004+)
- Physical oceanographic data often collected
- Few ancillary projects

EBS Summer Survey (June-July)



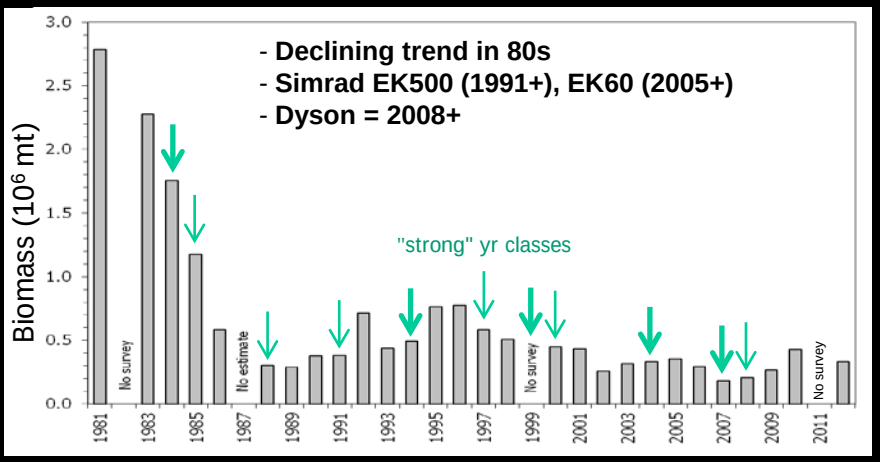
Acoustic and Trawl survey data to estimate: Numbers Biomass



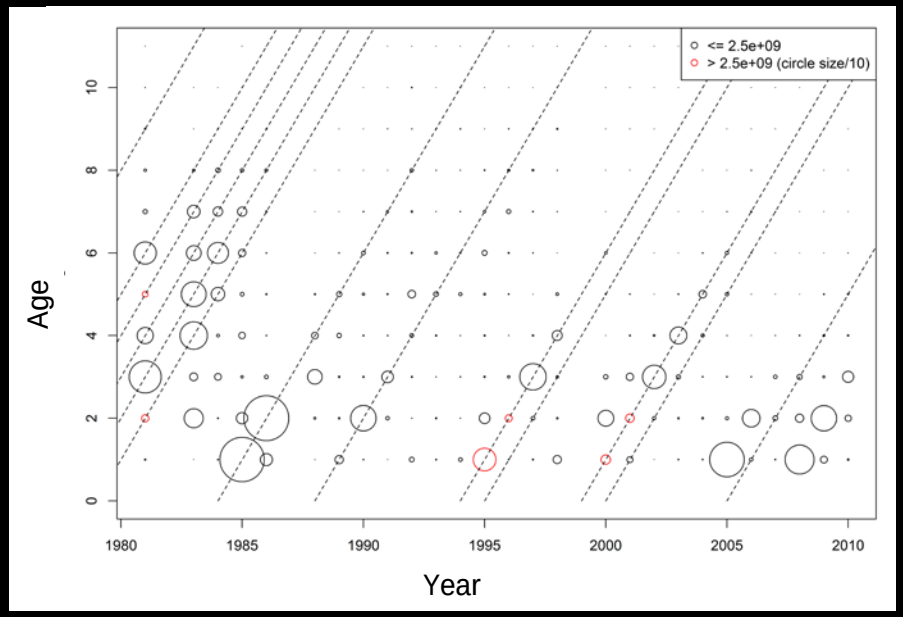
MACE AT Survey Time Series Results – 2 Examples

Shelikof Pre-spawning Pollock

Biomass

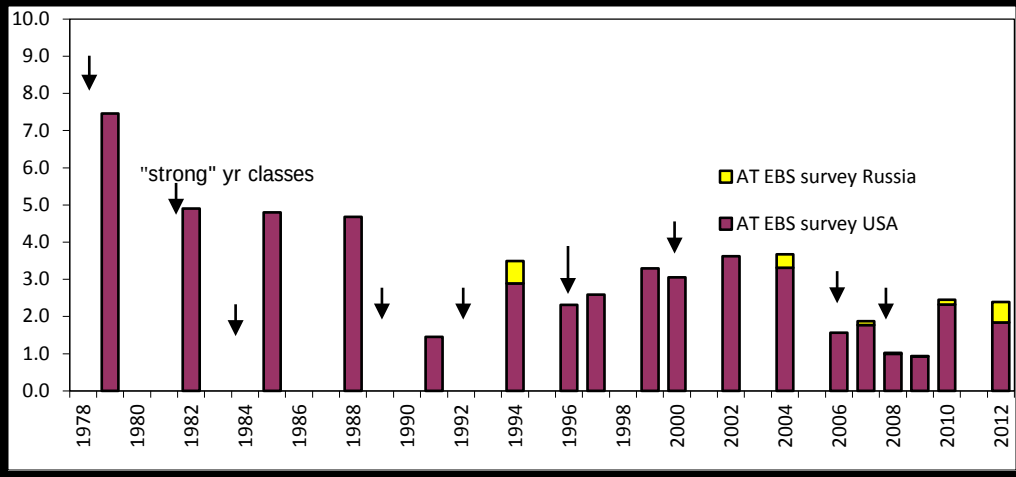


Age Composition

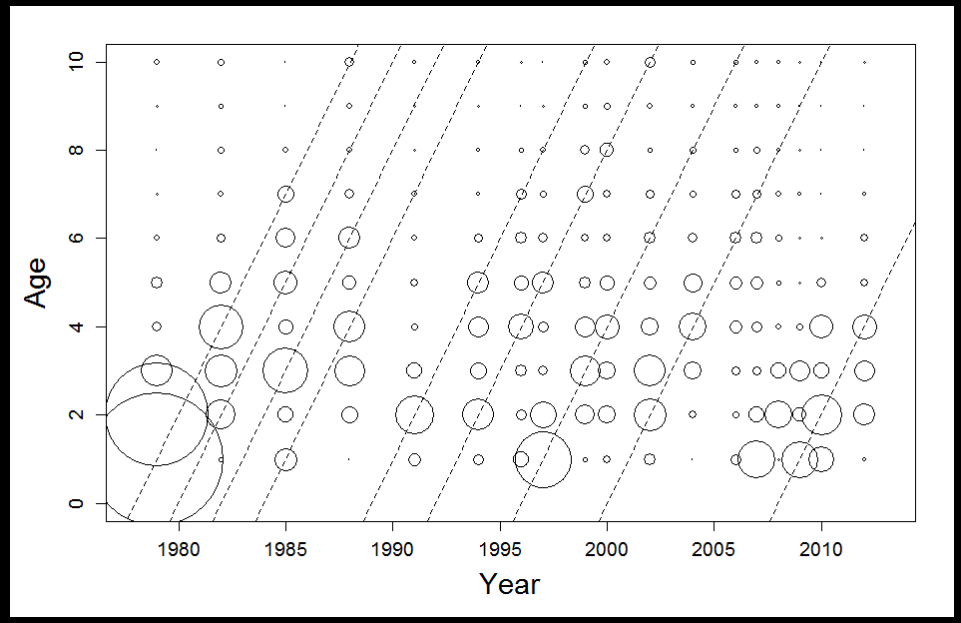


Summer EBS Pollock

Biomass



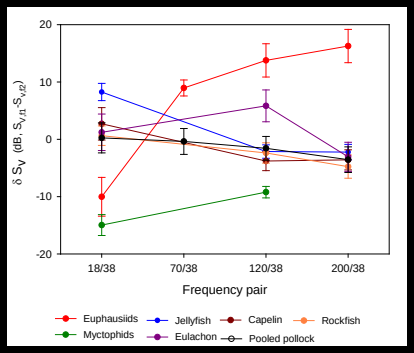
Age Composition



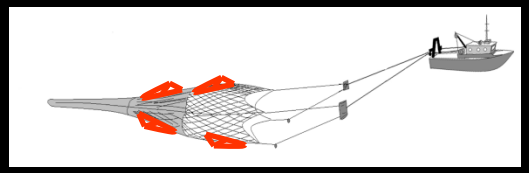
Survey-related Research:

Quantify and Reduce Sources of Bias and Uncertainty

1) Provides methodological and technological advances to acoustic survey efforts



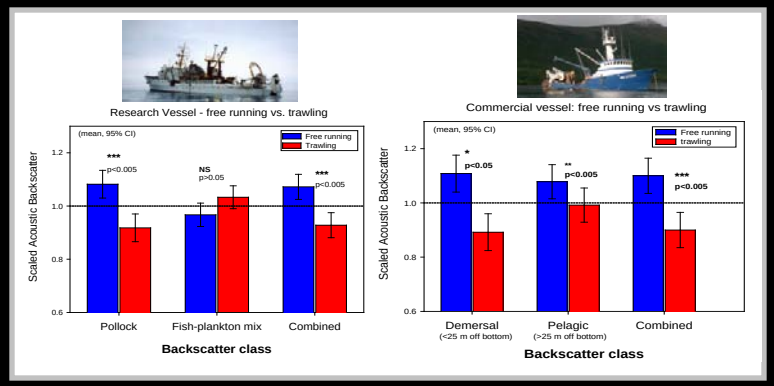
2) Tests assumptions inherent in acoustic survey methodologies



Survey-related Research

Selected examples:
Acoustic
Trawl

Fish avoidance to underwater-radiated vessel noise



- **Retrospective Work**

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

  EBS '96-'02 GOA '03

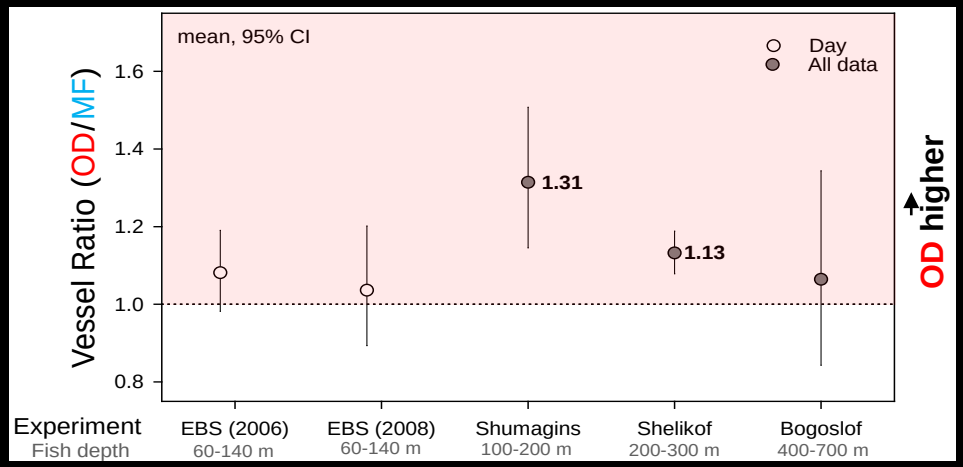
- **Vessel Comparison Work (NOAA ships)**

  noise-reduced ship may see more pollock than conventional ship

Oscar Dyson

versus

Miller Freeman



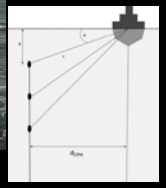
- **Acoustic-buoy work**

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

- MACE Hydrophone Mooring

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

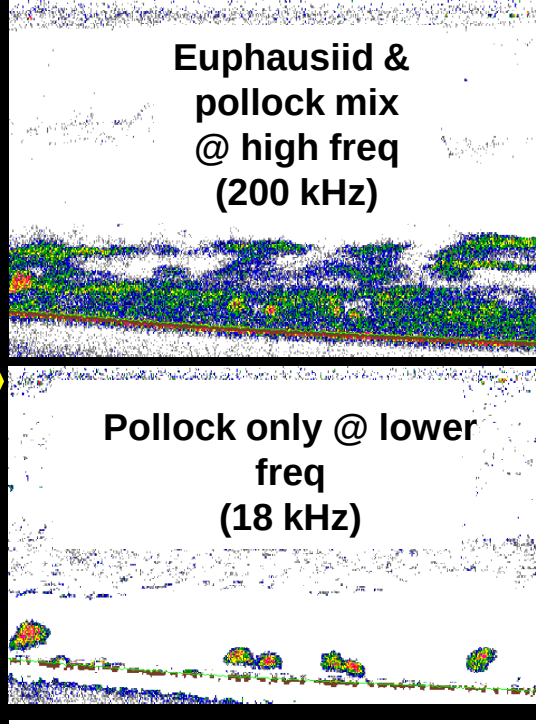
De Robertis et al. 2012



MACE Survey-related research - acoustics

Multi-frequency Z-score method to improve species classification

Differences in frequency-dependent backscattering can be species-specific



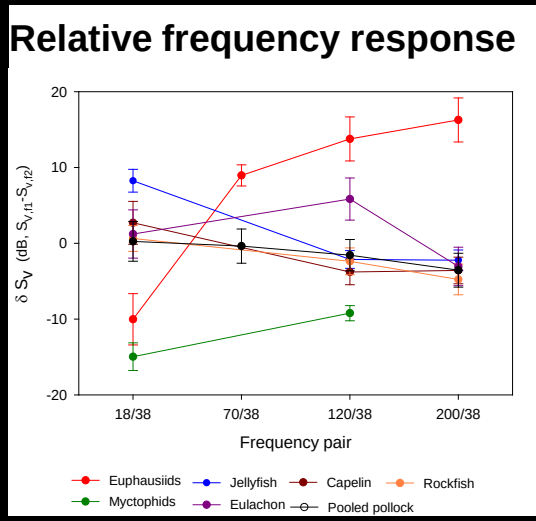
1) Objective procedure developed using

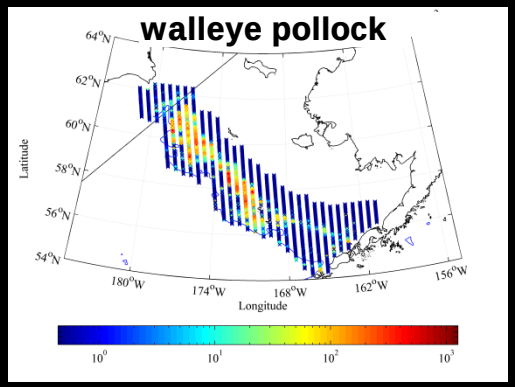
Frequency-dependent differences

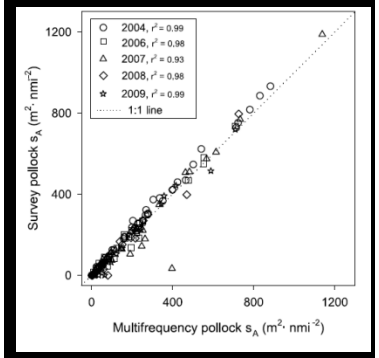
+

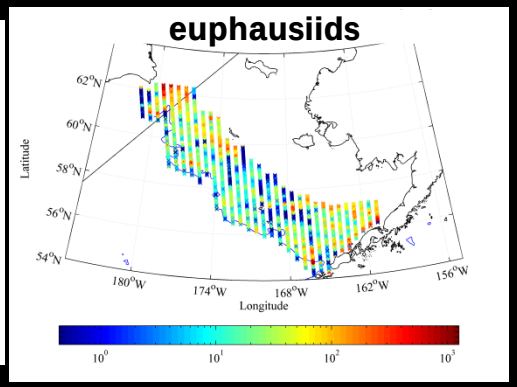
Statistical classification approach

2) Procedure validated thru testing, routinely used in EBS

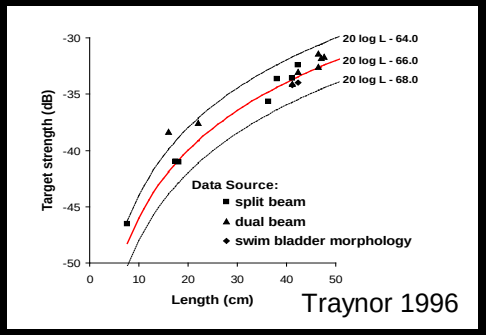






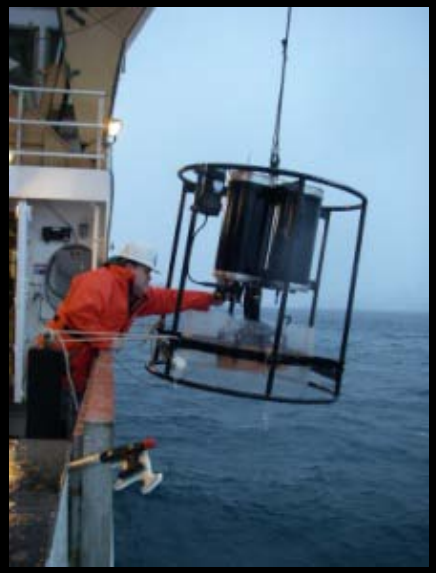


Refinements to *in situ* target strength (TS) measurements



Traynor 1996

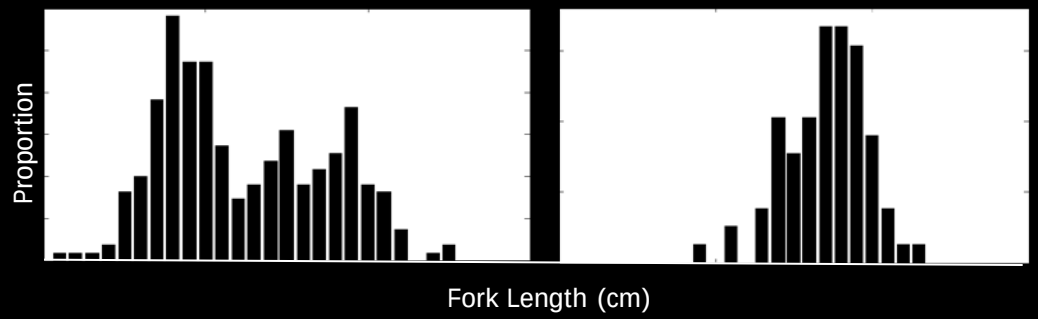
Target strength is needed to convert acoustic data to numbers/biomass



1) Lowered acoustic system (SWFSC/AFSC) improves *in situ* TS measurements

2) Analytical procedure soon under development to better utilize *in situ* measurements for TS estimation

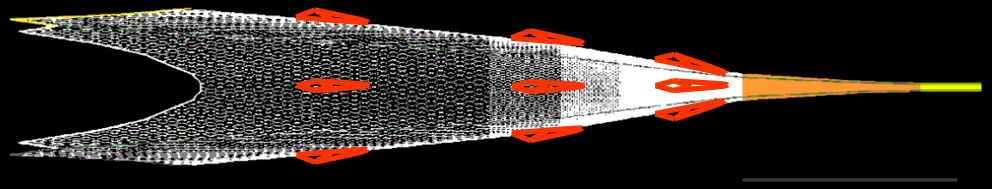
...measurements may no longer be restricted to unimodal size distribution conditions

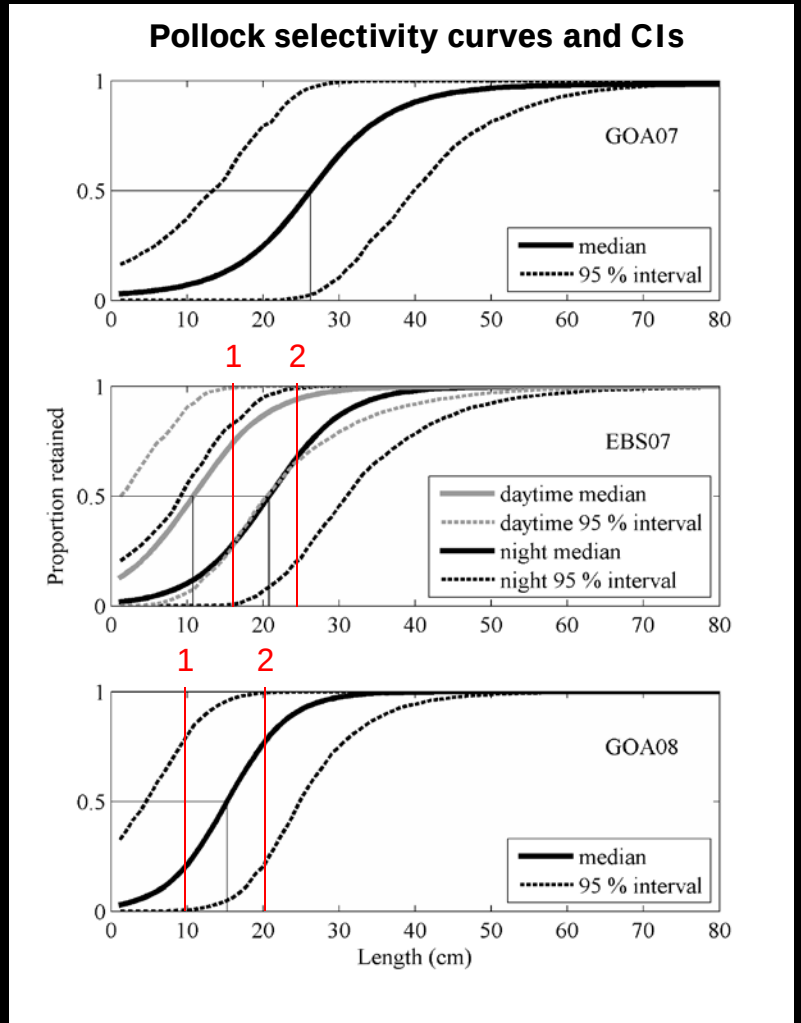


Is MACE trawl an unbiased sampler?

Trawl selectivity project

Recapture nets

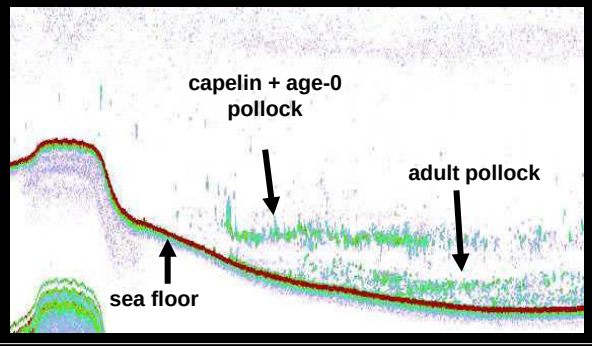




- **Hierarchical Bayesian model to estimate pollock selectivity as function of fish length**

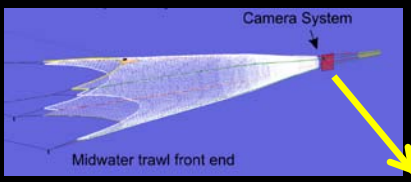
- **Age-1 pollock under-sampled**

Trawl innovations for higher resolution sampling

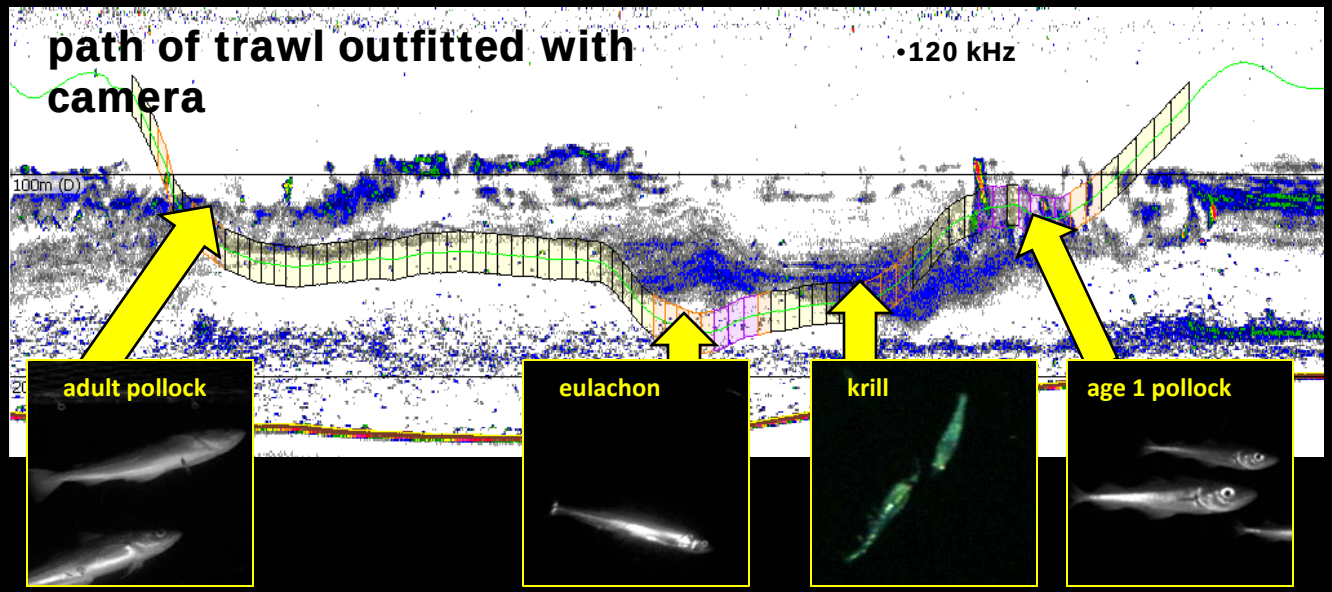


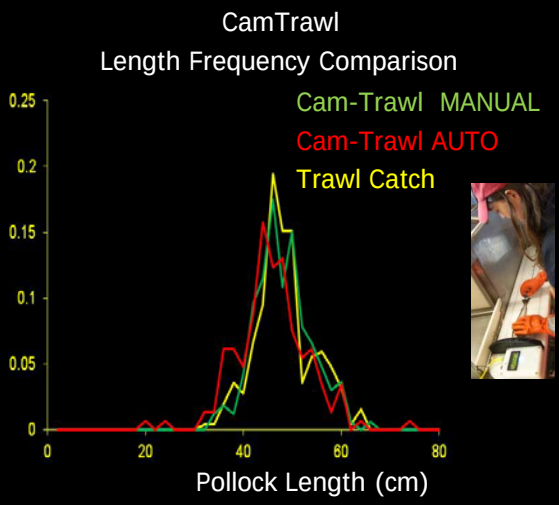
Improve interpretation of acoustic data

1) Camera-Trawl device



2) Multiple Opening/Closing Codend device





MACE Survey-related research: acoustics + trawl

Goal: Total uncertainty model

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

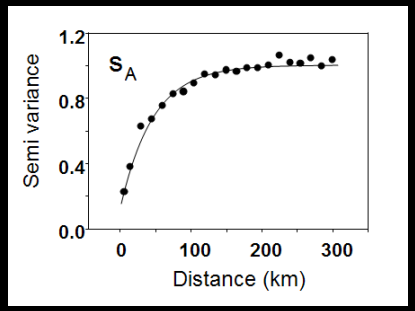
2) Method using bootstrapping and geostatistical sequential simulation under development to provide CI biomass and numbers by age-class

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

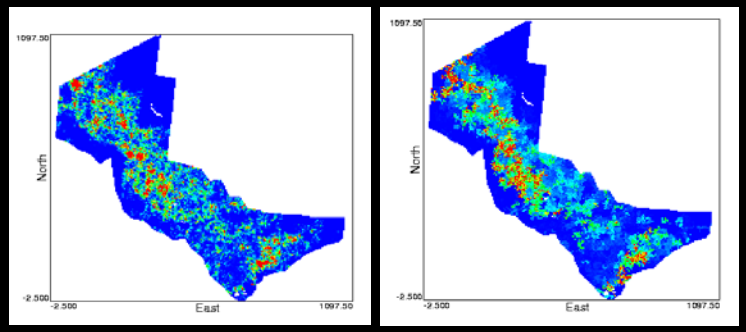
4) Potential sources of bias, e.g.,
   - trawl selectivity
   - fish avoidance
   - species classification errors
   - incorrect TS-length relation

   not yet included in model

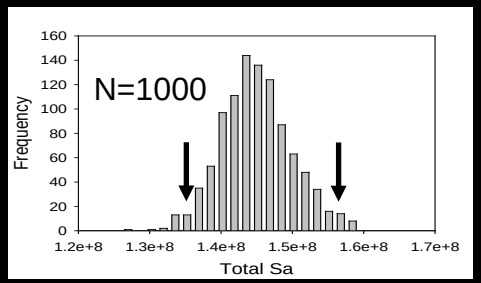
Model



Simulations



PDF



Total Biomass

Walline 2007 ICES J. Mar. Sci.

Acoustic-trawl survey challenges
(GOA + EBS)

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

- TOTAL UNCERTAINTY BUDGET

MACE Interactions w/Stock Assessment Scientists

- Regularly scheduled:

  Annual MACE-REFM Survey Needs meeting – 2004+

- Ad hoc:

  Collaborative Research Projects w/AFSC Stock Assess.

MACE-REFM Survey Needs meeting Agenda

Date: 22 Jan 2013. 13:00-15:00
Location: rm 2134

I) EBS Needs
   i. Winter Surveys
      1. Bogoslof – triennial?
   ii. Summer Survey
      1. 0.25 m vs 3 m index (spp. comp, ADZ) – status
      2. AVO - status

II) GOA Needs
   i. Winter Surveys
      1. Area priorities (Shelikof, Shumagin, Kenai, PWS, other?)
      2. Frequency (annual/biennial)?
   ii. Summer Survey
      1. Ship time concerns
         a. Area priorities, Spp. priorities

III) CIE Review (GOA) Recommendations
   i. REFM response - (action items, time schedules)
   ii. MACE response - (action items, time schedules)

IV) BASIS Surveys (EBS, GOA)
   i. Stock assessment value – Anne, Jim, Martin
   ii. MACE participation costs

V) Advanced Sampling Tech Working Group (ASTWG) Issues
   i. ASTWG-funded MACE activities – current/future
      1. Combined BT/AT EBS survey – status
      2. Automated Image Analysis - status
      3. Trigger Cameras (Acoustic Dead Zone) – status
      4. Moored Echosounder Index of Abundance (Shelikof) - 2014?
   ii. AFSC annual "ASTWG-focused" meeting to improve stock assessment – survey collaborations
      1. Proposed meeting format/objectives

VI) Miscellaneous
   i. Other AT survey areas/spp. (Aleutian Islands? Rockfishes? Atka mackerel?)
   ii. MACE survey method changes
      1. Proportional allocation of backscatter by catch composition - status

MACE-REFM Survey Needs meeting Agenda

Date: 22 Jan 2013. 13:00-15:00
Location: rm 2134

I) EBS Needs
   i. Winter Surveys
      1. Bogoslof – triennial?
   ii. Summer Survey
      1. 0.25 m vs 3 m index (spp. comp, ADZ) – status
      2. AVO - status
II) GOA Needs

AVO Project:

1) Acoustic data collected aboard charter vessels during "annual" EBS Bottom Trawl Survey
2) Acoustic data used to estimate "index" of *midwater* pollock abundance
3) Index of abundance fills data gaps in "biennial" MACE EBS acoustic-trawl survey

V) Advanced Sampling Tech Working Group (ASTWG) Issues
   i. ASTWG-funded MACE activities – current/future
      1. Combined BT/AT EBS survey – status
      2. Automated Image Analysis - status
      3. Trigger Cameras (Acoustic Dead Zone) – status
      4. Moored Echosounder Index of Abundance (Shelikof) - 2014?
   ii. AFSC annual "ASTWG-focused" meeting to improve stock assessment – survey collaborations
      1. Proposed meeting format/objectives
VI) Miscellaneous
   i. Other AT survey areas/spp. (Aleutian Islands? Rockfishes? Atka mackerel?)
   ii. MACE survey method changes
      1. Proportional allocation of backscatter by catch composition - status

MACE-REFM Survey Needs meeting Agenda

Date: 22 Jan 2013. 13:00-15:00
Location: rm 2134

I) EBS Needs
   i. Winter Surveys
      1. Bogoslof – triennial?
   ii. Summer Survey
      1. 0.25 m vs 3 m index (spp. comp, ADZ) – status
      2. AVO - status

II) GOA Needs
   i. Winter Surveys
      1. Area priorities (Shelikof, Shumagin, Kenai, PWS, other?)
      2. Frequency (annual/biennial)?
   ii. Summer Survey
      1. Ship time concerns
         a. Area priorities, Spp. priorities

III) CIE Review (GOA) Recommendations
   i. REFM response - (action items, time schedules)
   ii. MACE response - (action items, time schedules)

IV) BASIS Surveys (EBS, GOA)
   i. Stock assessment value – Anne, Jim, Martin
   ii. MACE participation costs

V) Advanced Sampling Tech Working Group (ASTWG) Issues
   i. ASTWG-funded MACE activities – current/future
      1. Combined BT/AT EBS survey – status
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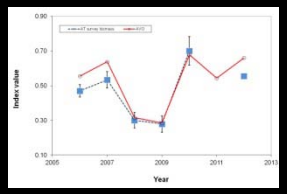
Ad hoc Interactions: Collaborative Research Projects

1) E. Kodiak Fisheries Interaction Team project (2000-2006) [Hollowed]

Walline et al. 2012 CJFAS



2) Acoustics from Vessels of Opportunity (AVO; 2006+)

Honkalehto et al. 2011 CJFAS [Ianelli]

3) CamTrawl to groundtruth species/size composition of acoustic backscatter

Williams et al. 2011 Sea Technology [Hollowed]

4) Combining EBS BT and AT Surveys

Wilson et al. 2012 ASTWG proposal [Ianelli]

5) Untrawlable Rockfish work (acoustics-optics)

Rooper, MACE [Spencer, Hanselman, Heifetz]

(Proposals: 2008 NPRB, 2011 EFH, 2012 Assess Methods)

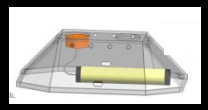
Williams et al. 2010 Fish.Bull.

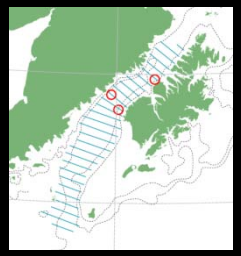
Jones et al, 2012 Fish.Bull .* ; Rooper et al. 2012 Fish. Bull.

Weber et al. 2012 Fish Bull.

6) Moored Echosounders for Indices of Pollock Abundance [Dorn]

Wilson et al. 2012 ASTWG proposal





Data/Results Dissemination and Documentation

- 2-Page Summary of Survey Preliminary Results at cruise end (2005+)

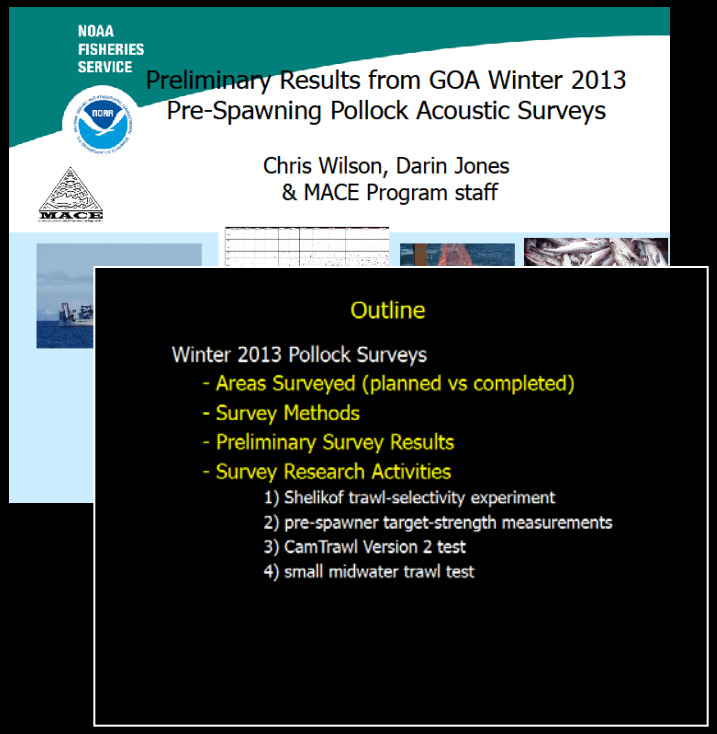
- Post-Cruise Briefing at cruise end
  GOA (~1995+) vs EBS

- AFSC Plan Team Presentations
  for each Survey

- AFSC Processed Report for each Survey

- NGDC-MACE Pilot Study (2011+)
  Archiving ME70 data (...EK60...?)

- Peer-Reviewed Publications
  survey-related research,
  ecosystem processes research
  (2007+: n>60 & n>30 where MACE lead author)



Questions?

More Information Included in Handout Package (zipped file):

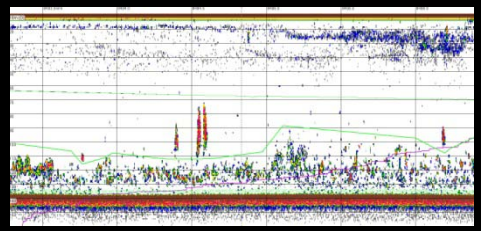
1) AFSC Processed Reports – most recent AT survey/area
2) MACE AT survey sampling protocols
3) 2012 CIE Pollock (GOA) Review: MACE response (Appx. 3)
4) Peer-reviewed publications supporting this Presentation
5) Proposals for the work-in-progress

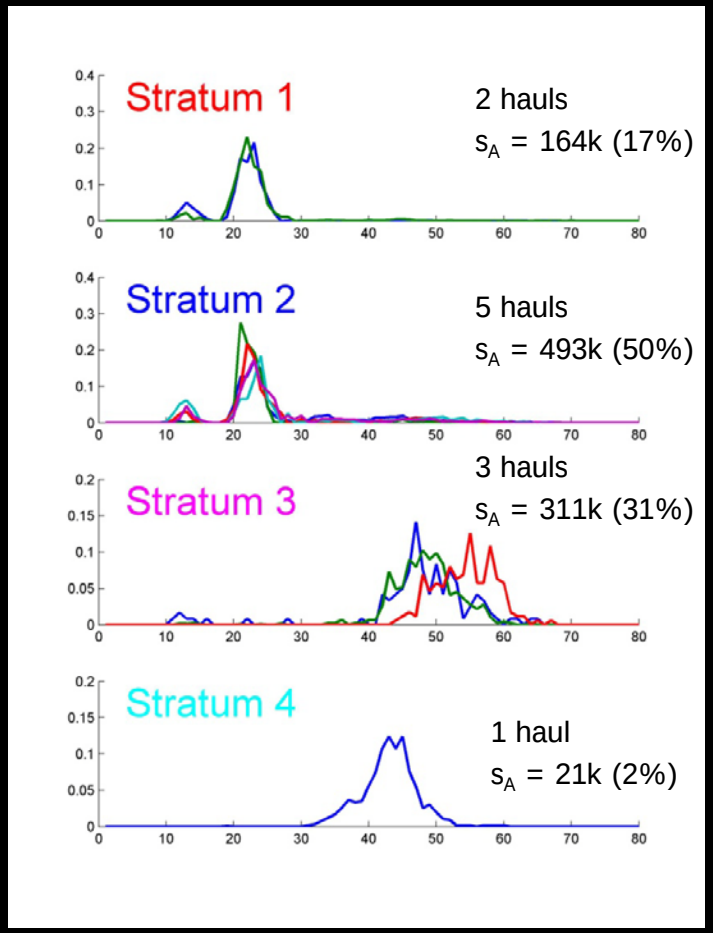
Chris Wilson (206-526-6435, chris.wilson@noaa.gov)

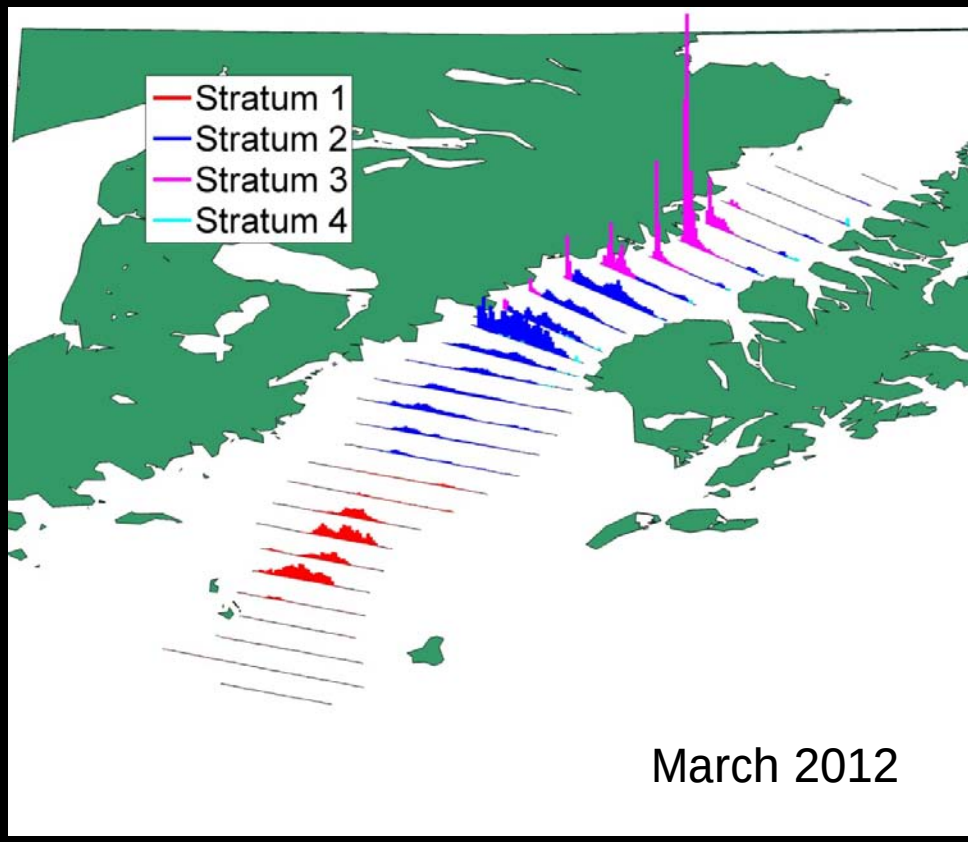
Length Strata Construction based on

L/F trawl data & echogram spatial pattern

Hauls with similar L/F grouped into stratum

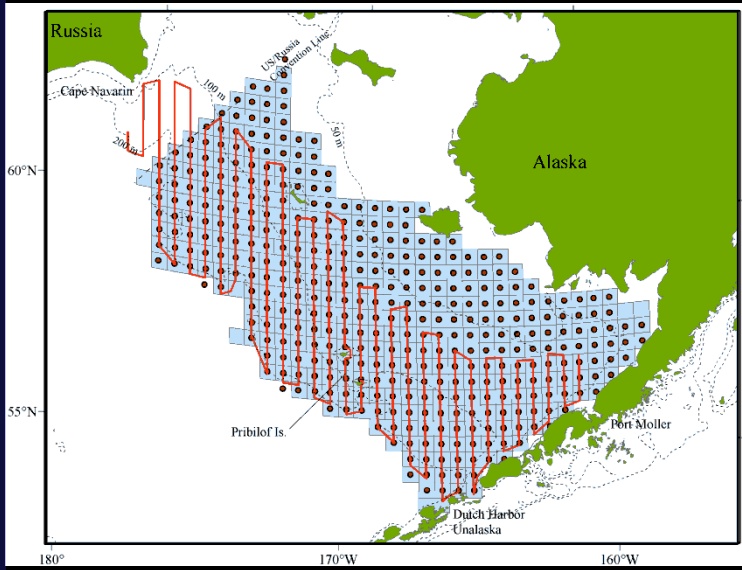






- **TS weighted by stratum mean L/F sample….**
- **Develop more objective clustering procedure….**

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	June - July	June - July	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 2.5m above	3m above to sea surface	sea surface to 1000 m
No. Trawl hauls	375	75-100	10-15
Acoustic data	AVO	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