Population Abundance Indices II

LO: evaluate the ability to estimate population abundances

Estimating Adult Stock Abundance

Direct Sampling Methods:
nets (trawls, gill nets, seines), weirs, pot traps, long lines

Advantages: species identification, few assumptions, long history

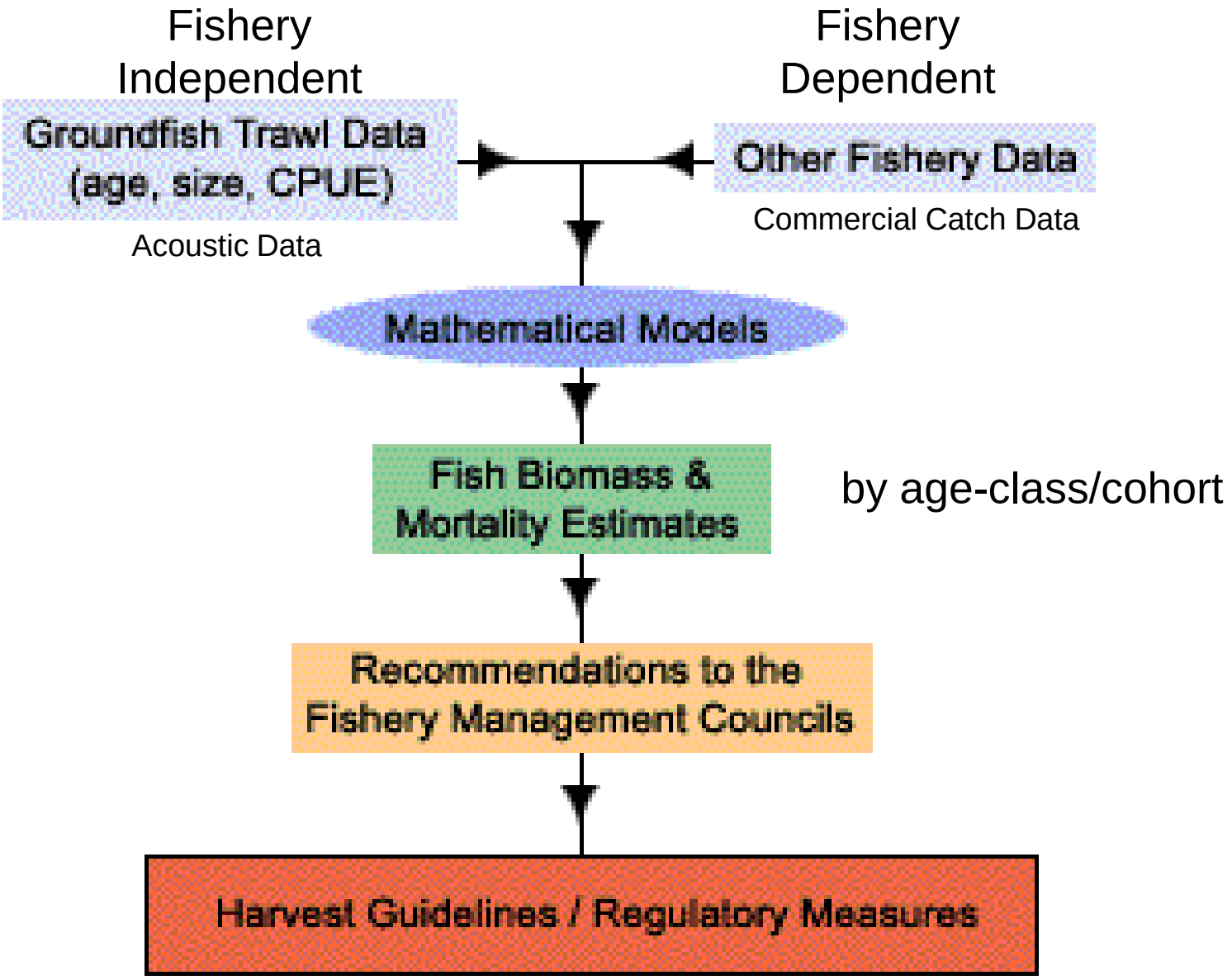
Constraints: invasive, discrete, selective (q), portion of water column

Indirect Sampling Methods (aka Remote Sensing):
acoustics, optics (camera, video, laser)

Advantages: noninvasive, continuous, possible whole water column

Constraints: species identification, assumed relationships, near boundary detection

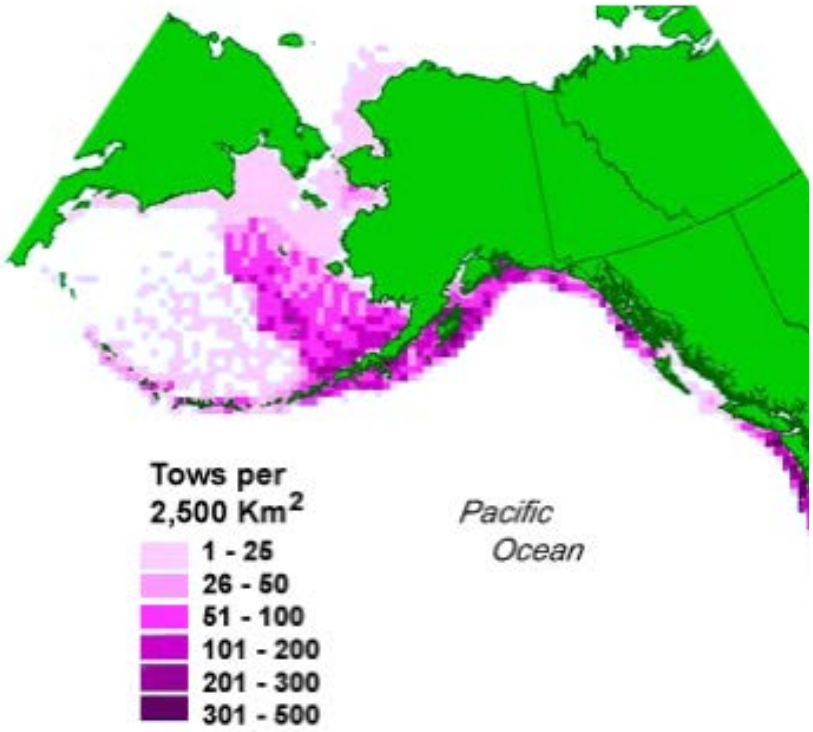
Stock Assessment and Allocation

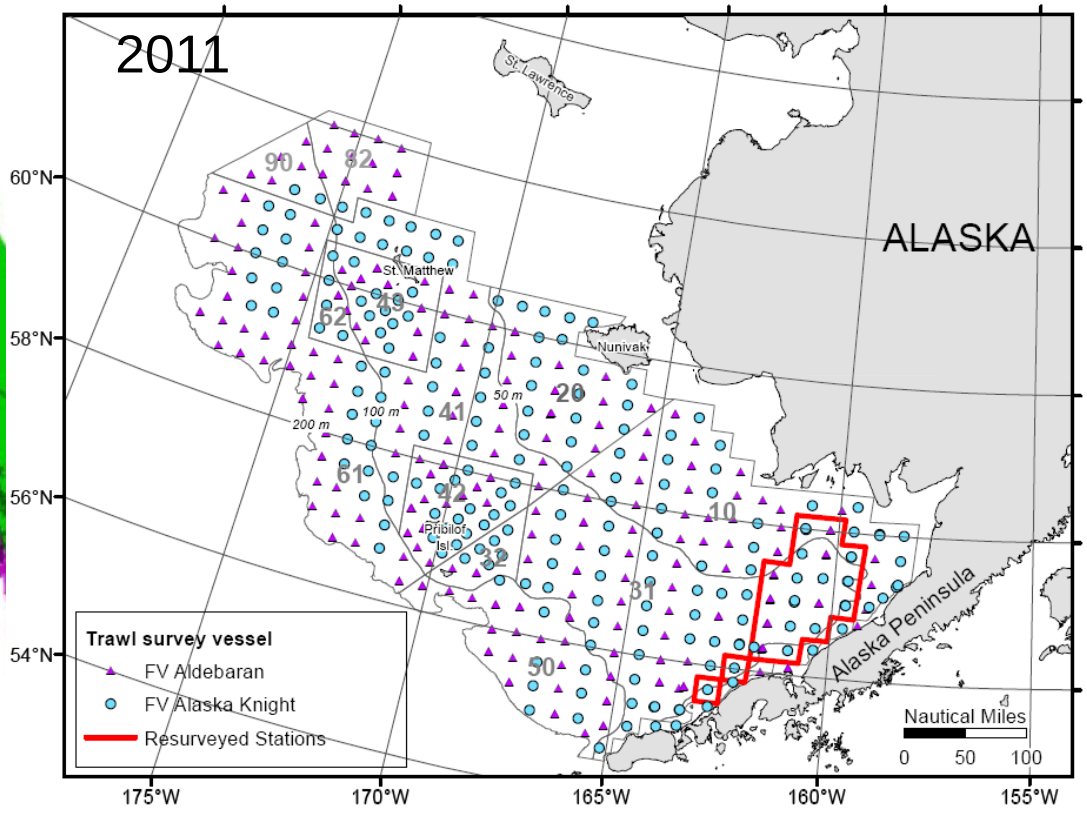


Demersal Trawl & Catch Processing

- Trawl at approximate center of each grid square for 30 min at 3 knots, acoustic catch, spread, and bottom contact sensors to monitor fishing effort
- Catches sorted and weighed (process total if < 1,150 kg; subsampled if larger catch)
- Individual species aggregate weighed and counted (expanded to total catch)
- Random subsamples for each species for length and gender measurements (up to 300 per species)
- other biological collections: stomachs, otoliths, energy density

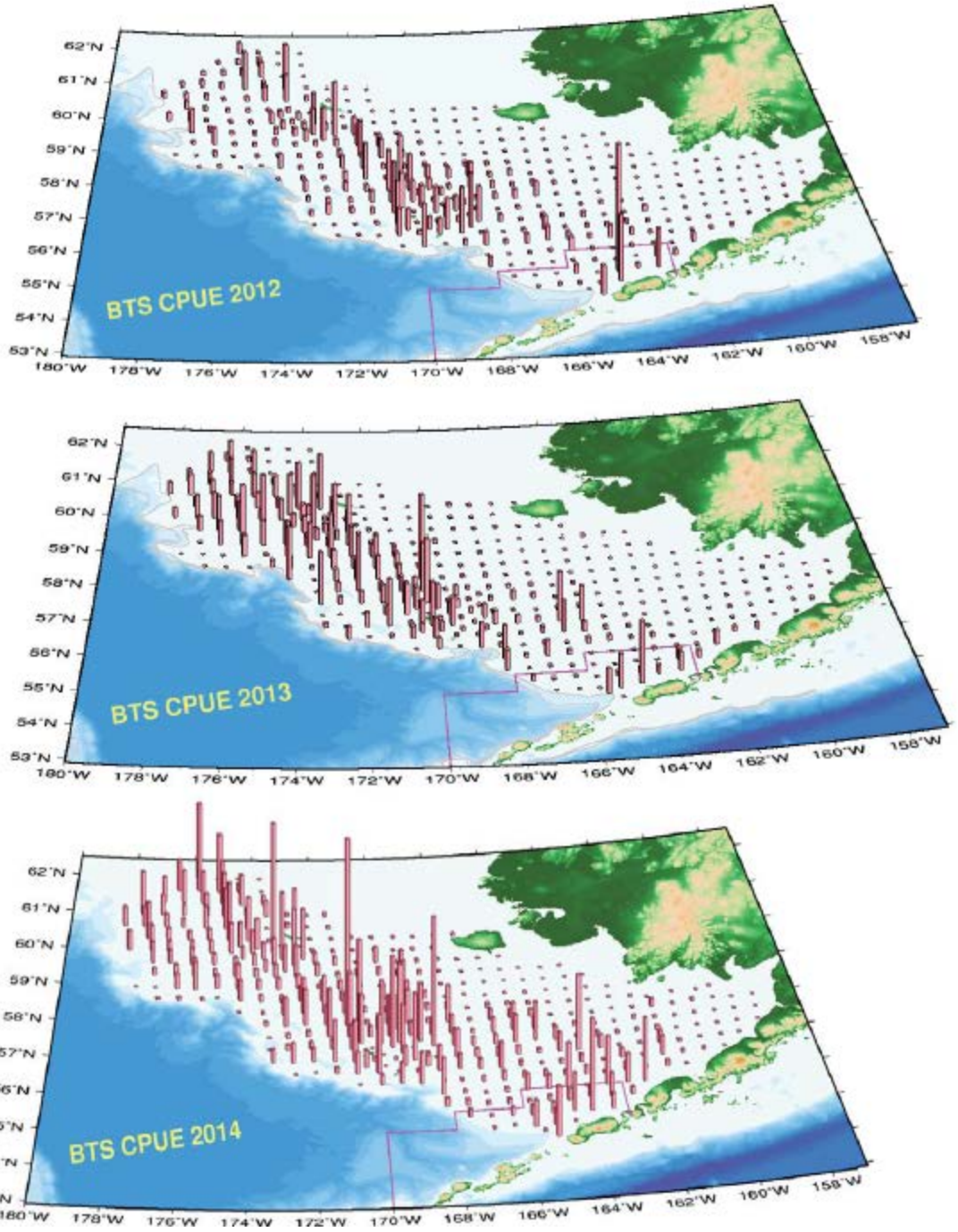
Tow Density for AFSC Surveys





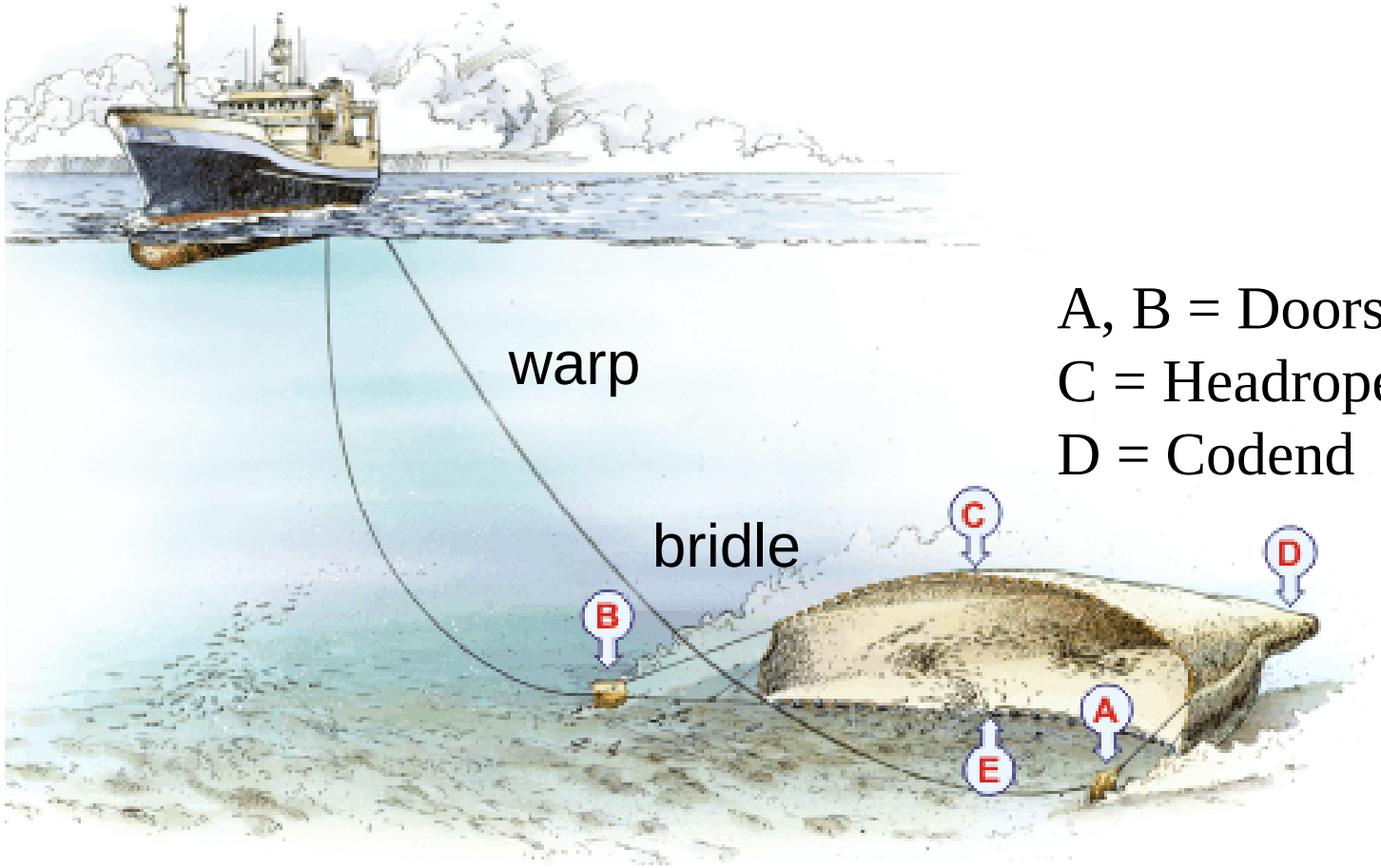
http://www.afsc.noaa.gov/RACE/groundfish/survey_data/default.htm

EBS Bottom Trawl Survey Station Grid and CPUE

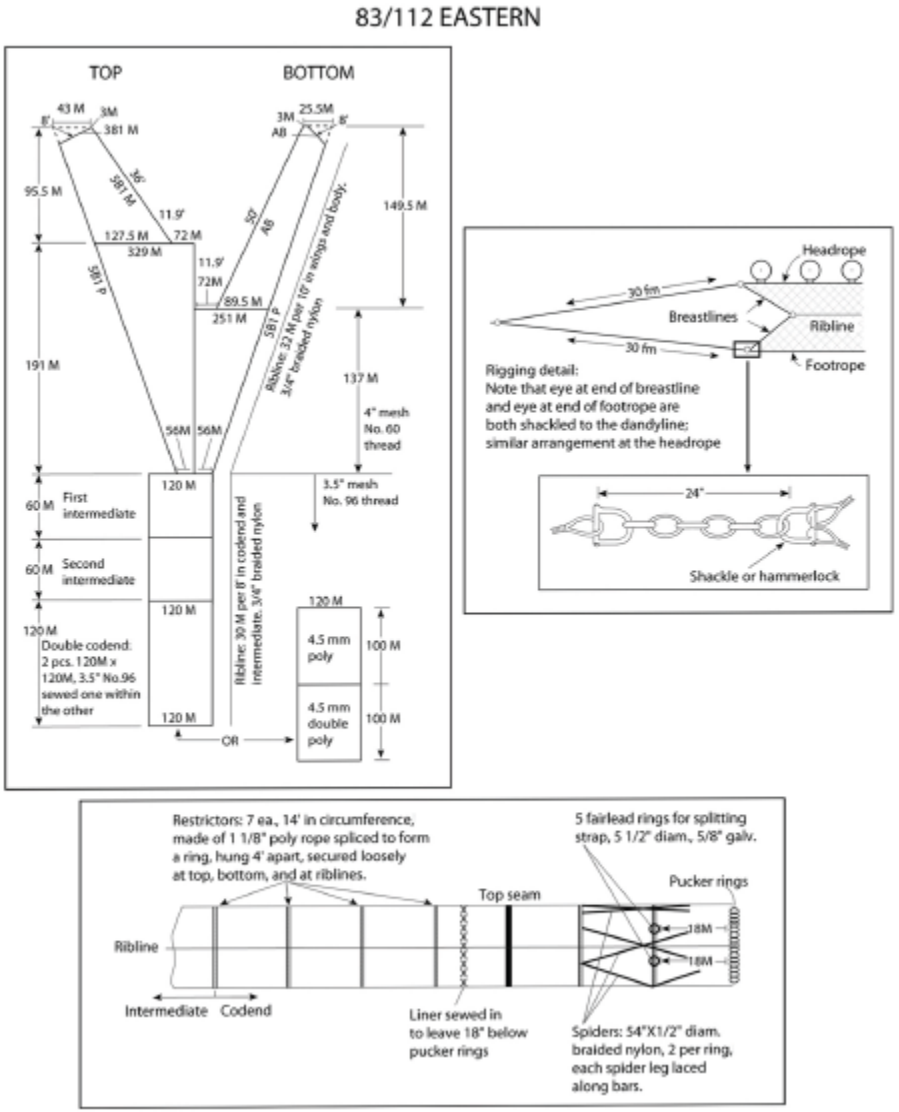


units: kg/ha
based on 30 min trawl time

Demersal, Otter, or Bottom Trawl



Net: 83/112 Eastern Otter Trawl



2011 BT Gadid Biomass Estimates

Table 6. -- Biomass estimates (t) for major fish species and groups taken during the 2011 eastern Bering Sea bottom trawl survey.

Taxon	Estimated total biomass (t)[a] and 95% confidence	Proportion of total animal biomass[b]	Estimated biomass by stratum (t)							
			10	20	30	40	50	60	82	90
Gadidae (cods)										
Walleye pollock	3,112,312 ± 18%	0.2021	20,865	7,043	329,628	316,732	142,475	1,414,483	67	51,126
Pacific cod	911,082 ± 15%	0.0592	40,031	24,163	120,024	123,137	18,631	95,303	28	8,769
Other cods	560 ± 45%	0.0000	99	46	2	36	1	0	324	1
Total cods	**4,023,954 ± 14%**	**0.2613**	**60,994**	**31,252**	**449,654**	**439,905**	**161,107**	**1,509,786**	**419**	**59,896**

Estimate:
relative abundance, biomass, population numbers, abundance by size class

mean CPUE (kg/ha) for each stratum and overall survey area: number fish/ha for each stratum/ area swept (ha; distance towed x mean net width)

biomass: sum of each stratum mean CPUE x stratum area

size class: % fish at each length interval x CPUE x stratum area

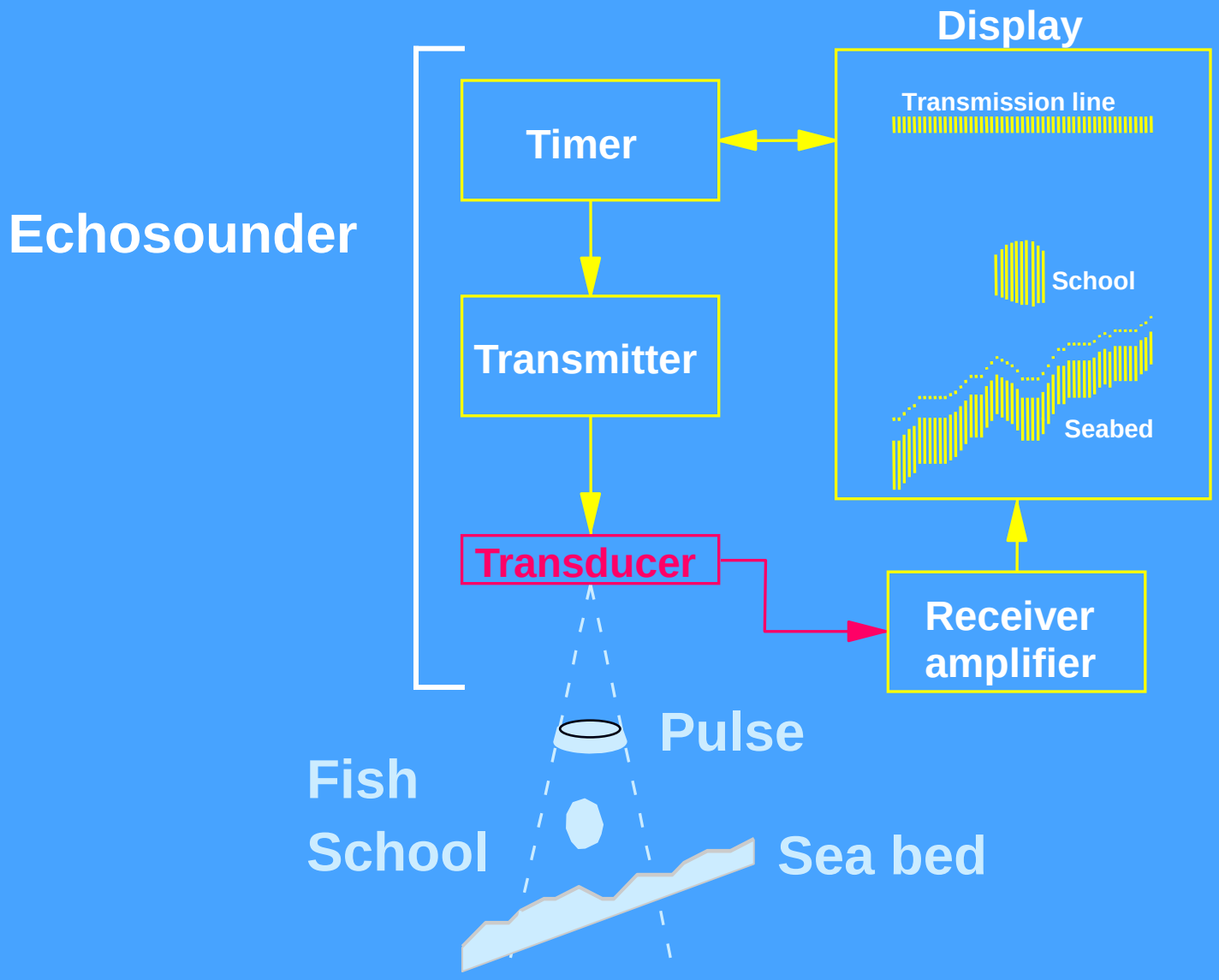
Acoustic-Trawl Survey

Why not use light?

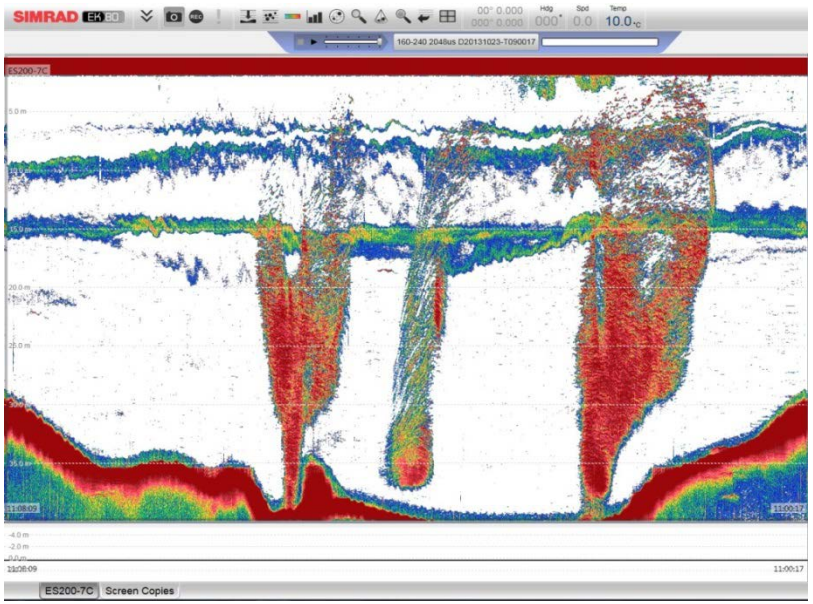
Light: 2/3 energy lost in 30 m; Sound: 2/3 energy lost in 30 km

- systematic transect grid over domain of interest
- measure reflected energy (energy $\propto$ density)
- use directed midwater or demersal trawls to verify species and sample lengths
- Density: divide total energy by amount from ‘representative’ individual
- Abundance: average density x area
- Biomass: abundance x L-W conversion factor

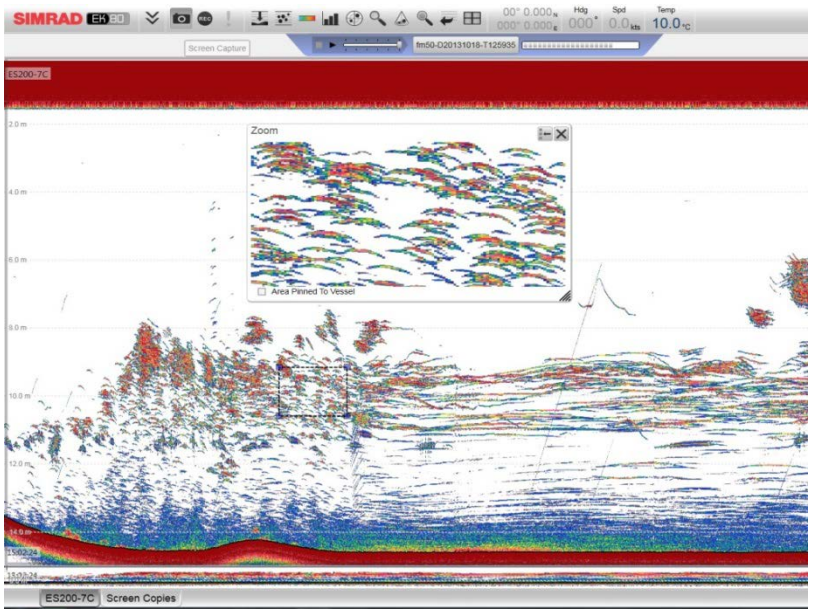
The Echosounder



Backscatter Data

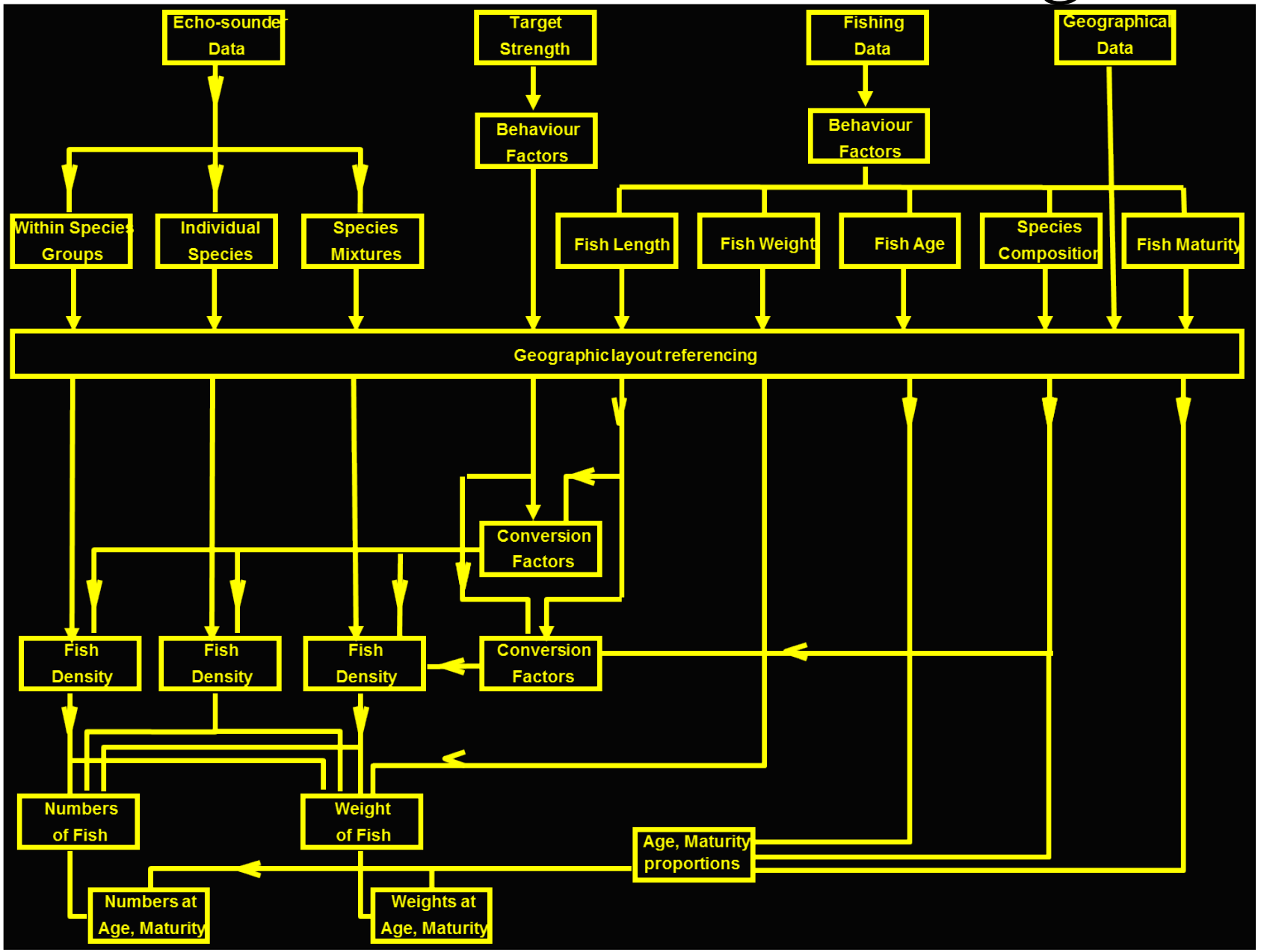


- marine
- chirp 160-240 kHz
- plankton layers
- herring schools



- freshwater
- chirp 160-260 kHz
- larval fish bottom
- schooling fish, methane

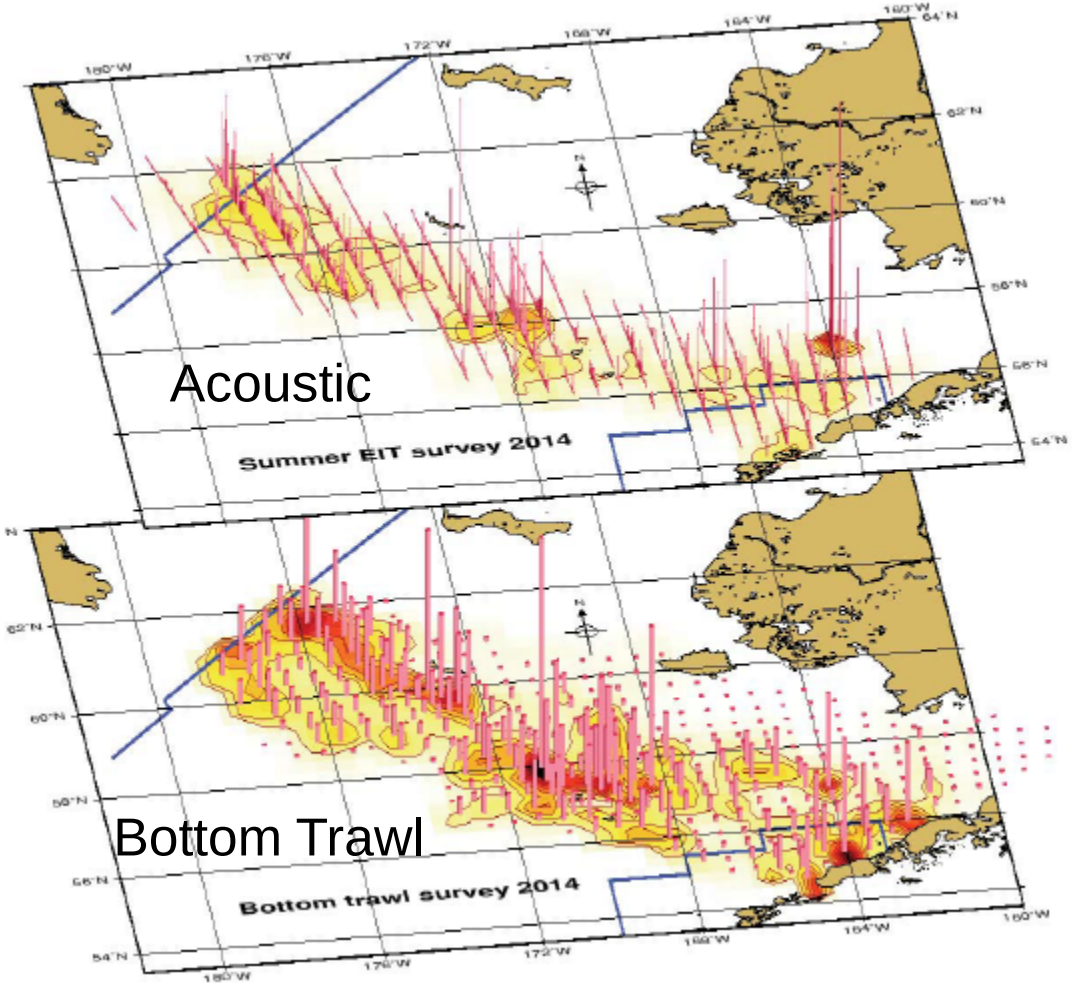
Acoustic Data Processing



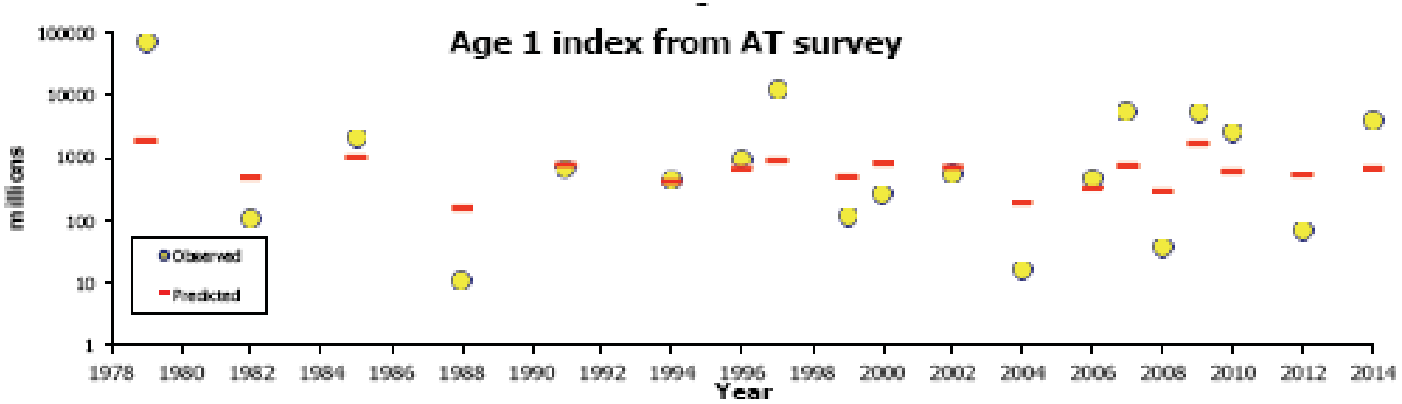
Aleutian Wing Trawl

Comparisons of Densities

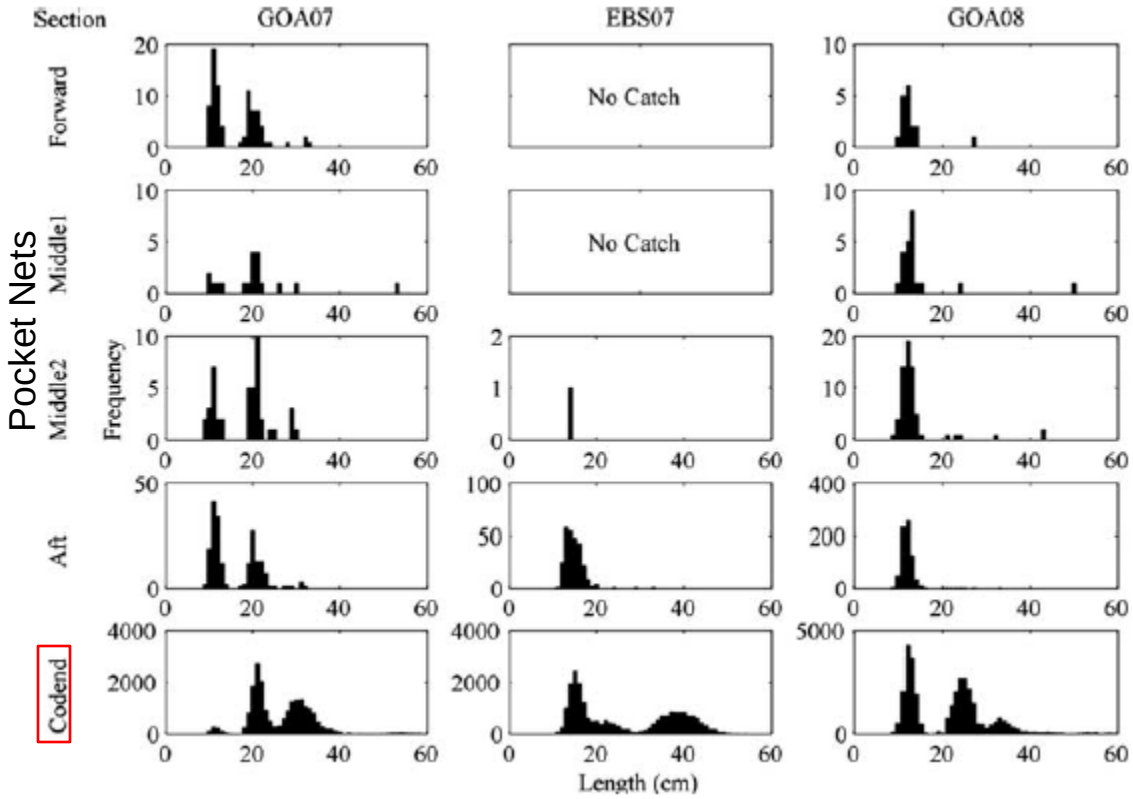
2014 Eastern Bering Sea Walleye Pollock Surveys



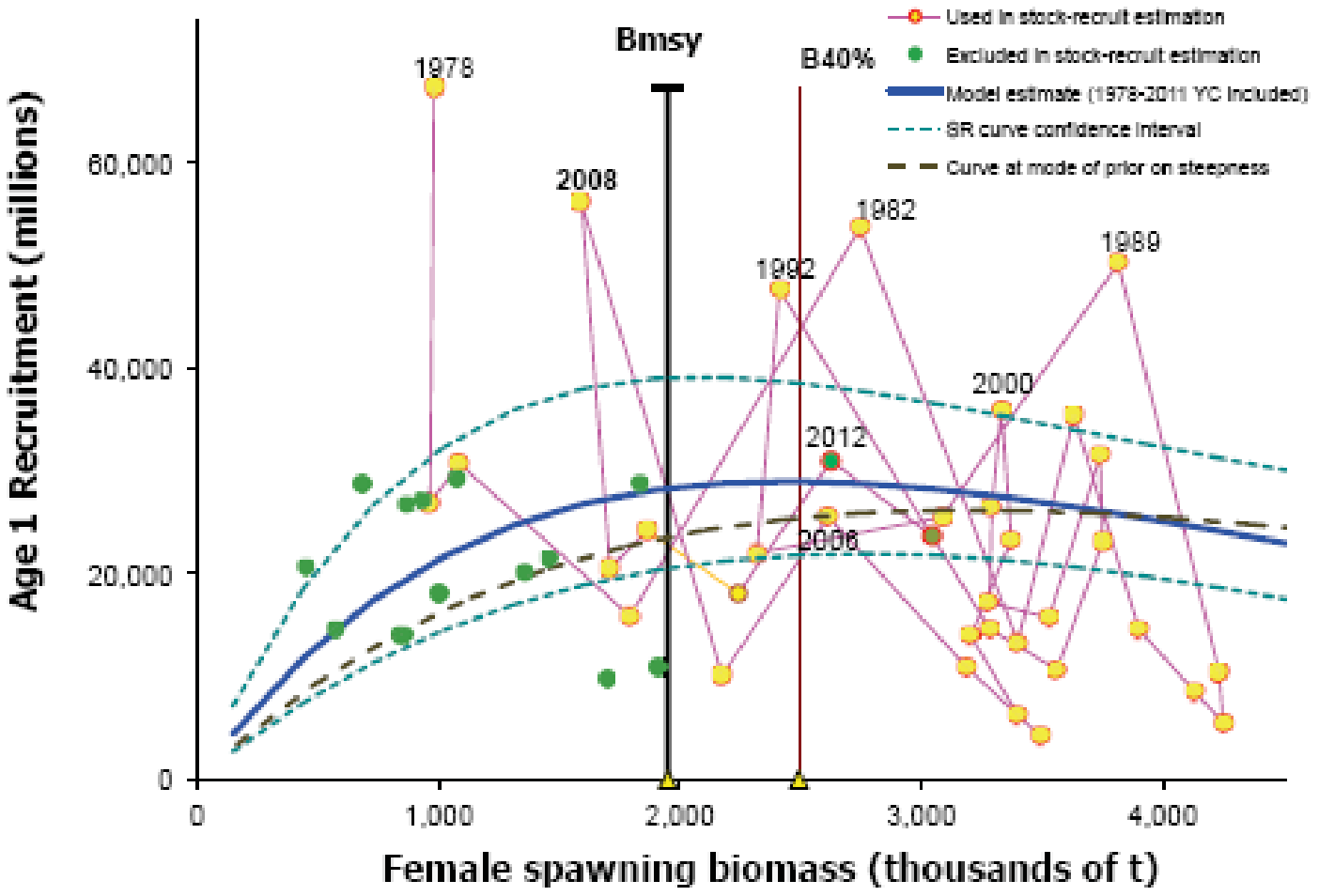
Age-1 Walleye Pollock Abundance



but biased due to midwater trawl efficiency and selectivity (Williams et al. 2011)



Walleye Pollock S-R Index



SAFE 2014

Wpol EBS Biomass Yield Model

Model details

An explicit age-structured model with the catch equation and population dynamics model as described in Fournier and Archibald (1982) and elsewhere (Hilborn and Walters 1992, Schnute and Richards 1995, McAllister and Ianelli 1997). Catch in numbers at age in year t ($C_{t,a}$) and total catch biomass (Y_t) were

$$
\begin{aligned}
C_{t,a} &= \frac{F_{t,a}}{Z_{t,a}}\left(1-e^{-Z_{a,t}}\right)N_{t,a}, \qquad 1 \le t \le T \quad 1 \le a \le A \\
N_{t+1,a+1} &= N_{t,a}e^{-Z_{t,a}} \qquad 1 \le t \le T \quad 1 \le a < A \\
N_{t+1,A} &= N_{t,A-1}e^{-Z_{t,A-1}} + N_{t,A}e^{-Z_{t,A}} \quad 1 \le t \le T \\
Z_{t,a} &= F_{t,a} + M_{t,a} \\
C_{t\cdot} &= \sum_{a=1}^{A} C_{t,a} \\
p_{t,a} &= C_{t,a}/C_{t\cdot} \\
Y_t &= \sum_{a=1}^{A} w_a C_{t,a} \text{ , and}
\end{aligned}
\qquad \text{..... (Eq. 1)}
$$

where

T is the number of years,

A is the number of age classes in the population,

$N_{t,a}$ is the number of fish age a in year t,

$C_{t,a}$ is the catch of age class a in year t,

$p_{t,a}$ is the proportion of the total catch in year t, that is in age class a,

$C_{t\cdot}$ is the total catch in year t,

w_a is the mean body weight (kg) of fish in age class a,

Y_t is the total yield biomass in year t,

$F_{t,a}$ is the instantaneous fishing mortality for age class a, in year t,

M_{a} is the instantaneous natural mortality in year t for age class a, and

Z_{a} is the instantaneous total mortality for age class a, in year t.