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
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:

Catch sample standardization

- 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

Net width (Marport)

Headrope height (Marport)

Depth profile (SeaBird SBE39)

Bottom contact (Inertial sensor)
Survey timing

“Xerox scan snapshot”

1982 - 2015

Mean sampling date

Bristol Bay

ALASKA
Pacific cod seasonal migrations
(adapted from Shimada and Kimura 1994 & Neidetcher et al. 2014)
Survey design and trawl gear

Eastern Bering Sea
Systematic
83-112 Eastern

Northern Bering Sea
Systematic
83-112 Eastern

Bering Sea Slope
Random stratified
Poly Nor Eastern

Alaska
Russia
Survey continuity and stations

Eastern Bering Sea
1982-present
Annual
376 stations

Northern Bering Sea
One year 2010
Biennial beg. 2017
145 stations

Bering Sea Slope
Biennial*
since 2002
~200 stations
Strata & sampling density

- High density
- Standard density

St. Matthew sl.
Pribilof Isl.

Russia
Alaska
Spatial shifts in biomass by domain

Proportion of biomass

Coastal  Middle  Outer

Ontogenetic and spatial shifts

Barbeaux and Lauth (in review)
Catch sampling
Lengths and otolith pairs

Length measurements

Stratified by cm/sex/area

Also random Collection of 928 otoliths
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

[Graph showing average surface and near bottom temperatures over years, with periods labeled as 'Warm', 'Cold', 'Warm'.]
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

Map showing the distribution of Pacific cod with CPUE (catch per unit effort) for all cold years and all warm years. The color scale indicates CPUE in kg/ha, with different ranges denoted. The map also shows bottom temperature contours with -1°C, 0°C, and 1°C differentiated by color.
Pacific cod distribution

Environmental effects

Isotherms
- 1°C
- -1°C

2010

ALASKA
Products

Total survey abundance-at-age

Total survey abundance-at-length

Survey abundance trend

Survey biomass trend
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


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?

No-vertical-response behavior cartoon

100 Pacific cod in 60 to 81 cm size range
Bering Sea shelf research trawl (2.5 m)

Depth sounder detected bottom

47.3%
Gulf of Alaska research trawl (7.0 m)

Depth sounder detected bottom

91.6%
True EBS:GOA catch ratio = \( \frac{47.3}{91.6} \approx 0.5 \)

Expected if NVR behavior is mechanism

Depth sounder detected bottom
Most likely explanation

Depth sounder detected bottom
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)

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)

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)

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