GOA Pollock

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Collaborators: Bridget Ferriss, Kalei Shotwell, Denise McKelvey, David McGowan
Author’s 2023 ABC = 232,543 t
- Increase of 56% from 2023
- 2025 ABC decreases to 157,687 t
- No reduction from max ABC

Changes to model:
- No structural changes
- Converted to TMB (23.0)

Concerns:
- Extremely small recent cohorts
- Poor fit to NMFS bottom trawl index

Positives:
- 2017, 2018, 2020 cohorts above average
- 2012 estimate up to ~50 billion
- Good environmental conditions
Model overview

- Single-sex, single single, ages 1-10+
- Empirical weight at age
  - No internal length dynamics, all age-based processes
  - Length comps converted via specified matrices
- Fishery selectivity is time-varying double logistic
- Fitted to 4 surveys
  - NMFS winter (Shelikof) + summer (coast wide) acoustic
  - NMFS and ADF&G summer bottom trawl
- Time-varying catchability for Shelikof and ADF&G
- $\sigma_R=1.3$ in 2022 but up to 1.8 this year
- Francis tuning used for compositional data
Catch history

- 2022 projected catch = 129,754 t
- 2022 realized catch = 132,698 t
- 2023 projected catch = 145,215 t
2022 fishery catch distribution
Fishery catch indicators

- **Percent females**
- **Mean age**
- **Percent age 8 and older in fishery**
- **Shannon-Wiener index of age diversity**
New data available in 2023

2023 was an “on” year in the GOA

- Winter acoustic survey (index and ages)
- Summer acoustic survey (index and lengths)
- NMFS bottom trawl survey (index)
- ADF&G bottom trawl index
Conflicting signs in the data

Shelikof (3+)
259 kt (27% decrease from 2022)

Summer acoustic
740 kt (72% increase from 2021)

NMFS bottom trawl
888 kt (79% increase from 2021)

ADF&G bottom trawl
102 kt (1% decrease from 2022)

**These are the processed values used in the assessment**

**These are the raw survey estimates**
Winter acoustic results

Shelikof down and no small fish

Chirikof and Marmot Bay are both up, but within historical norm

Thanks to D. McKelvey
Thanks to D. McGowan
Summer acoustic results

Thanks to D. McGowan
NMFS bottom trawl results

Pollock 2023
Maturity: recent estimates

Estimated from Shelikof data. Data after 2003 use local abundance weighting.

Average of all years used in projections
Spawning weight at age (WAA)

- WAA from Shelikof survey
- Declined from 2012 to 2020
- Increasing again
- 5-year average used for projections
Fishery WAA

• Did the RE model accurately predict the 2022 fishery WAA last year?
• OK?
Key parameters estimated externally

- Natural mortality: age-specific
- Fishery WAA
  - Data used through 2022
  - A RE model used for 2023 and projections
- Spawning WAA
  - Annual data exclusively from Shelikof Strait
  - 5-year average for projections
- Population WAA
  - Projections use average of last 3 NMFS BT surveys
- Proportion mature at age
  - Long-term (1983-present) average used throughout
## Parameters estimated internally

<table>
<thead>
<tr>
<th>Population process modeled</th>
<th>Number of parameters</th>
<th>Estimation details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean recruitment</td>
<td>1</td>
<td>Estimated in log space</td>
</tr>
<tr>
<td>Recruitment deviations</td>
<td>Years 1970-2023 = 54</td>
<td>Estimated as log deviances from the log mean with all years constrained by random deviation process error of 1.3.</td>
</tr>
<tr>
<td>Natural mortality</td>
<td>Age-specific= 10</td>
<td>Not currently estimated in the model.</td>
</tr>
<tr>
<td>Fishing mortality</td>
<td>Years 1970-2023 = 54</td>
<td>Estimated as log deviances from the log mean</td>
</tr>
<tr>
<td>Mean fishery selectivity</td>
<td>4</td>
<td>Slope parameters estimated on a log scale, intercept parameters on an arithmetic scale</td>
</tr>
<tr>
<td>Annual changes in fishery selectivity</td>
<td>2 *(No. years-1) = 108</td>
<td>Estimated as deviations from mean selectivity and constrained by random walk process error.</td>
</tr>
<tr>
<td>Mean survey catchability</td>
<td>No. of surveys = 6</td>
<td>Catchabilities estimated on a log scale. Separate catchabilities were also estimated for age-1 and age-2 winter acoustic indices. Annual catchability for winter acoustic surveys and ADF&amp;G surveys estimated as deviations from mean catchability and constrained by random walk process error.</td>
</tr>
<tr>
<td>Annual changes in survey catchability</td>
<td>2 *(No. years-1) = 108</td>
<td>Slope parameters estimated on a log scale.</td>
</tr>
<tr>
<td>Survey selectivity</td>
<td>8 (2 each for the Shelikof and summer acoustic surveys, and the NMFS and ADF&amp;G BT surveys)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>123 estimated parameters + 216 process errors = 339</td>
<td></td>
</tr>
</tbody>
</table>
Sequential addition of data

• Big increases with addition of NMFS BT and Shelikof data
• Moderate w/ summer AT
• Recent trend but also scale
Sequential addition of data

- Big increases with addition of NMFS BT and Shelikof data
- Moderate w/ summer AT
- Recent trend but also scale
Selectivity

Fishery selectivity: double logistic with time-varying ascending limb
Fishery fits

- Switched to OSA residuals for age comps
- Fishery patterns (ages 3 & 4) remain
- Resolved w/ non-parametric models (not put forward this year)
Shelikof fits

- No concerns
NMFS BT fits

• No concerns
ADF&G bottom trawl fits

- Some large residuals and pattern of positive residuals
Summer acoustic fits

- No concerns
Index fits

- Poor fits, wrong trends for key surveys

- NMFS bottom trawl survey

- ADF&G bottom trawl survey

Expected

Observed
Index fits

- Record low age-1 estimate in 2023 fits poorly
- Will have to wait for corroboration from other data sets next year
- Although length data also imply few age 1s
Retrospective patterns

• Rho is expected to range from -0.2 to 0.3 by chance (based on bootstrapping)
• Thus rho=-0.3 this year is significant
• Uses 7 peels, previously used 10
Projections: an aside

• This year we noticed an issue in the projections
• 2023 SSB was 14% lower in “proj” than the assessment
• Why can’t proj reproduce the assessment?
  ▪ Input spawning WAA is different (2023 data vs 5-year average)
  ▪ Does that invalidate proj? No, because the 2024 initial NAA are almost identical in this case
    ▪ Due to similar fishery selectivity and fishery WAA
• How to calculate SPR-based BRP under substantial variation?
Fishery selectivity function

• **Problem:** current selectivity results in persistent residual patterns in age comp data
  - **Current approach:** parametric double logistic w/ random effects
  - **Alternative approach:**
    - Non-parametric 2D AR(1) age, year
    - 3D AR(1) by age, year, cohort using conditional variance
Performance metrics

1. One-step-ahead composition residuals
   a. Do the alternatives reduce residual patterns? **YES**

2. Marginal AIC
   a. Do the alternatives result in better model fits? **YES**

3. Retrospective analysis (SSB)
   a. Do the alternatives reduce model misspecification?
      i. Maybe?

4. Do projected selex curves outperform simple average?
   a. For the most part...
Retrospective SSB

3D-AR1 has lowest retrospective bias in SSB
Projection performance

- **Problem:** what selectivity to use for projections used to calculate reference points?
  - **Current approach:** 4 year average (e.g. 2019-2022 for 2023 assessment)
  - **Alternative approach:** use model based projections
    - Selectivity is likely more similar between year Y and Y-1 than Y and Y-5
    - Allows correlation structure to inform short-term projections (e.g. cohort, year, and age effects)
Projection performance

- **Approach**: retrospective skill testing of projected vs average age-specific selectivity
  - 7 peels
  - Age-data for terminal year not included (mimics data collection)
  - No adjustments to comp weights

**Note**: Model is slightly different assessment (estimates variance and doesn't estimate q-devs for years without data)
Retrospective analysis

- Projected selectivity in Y+1 from peeled model compared to estimated selectivity from “full model”
  - Calculate Mohn’s Rho and Mean Squared Error
  - For selex and B0, B40, OFL, and ABC

\[
RE_{age} = \sum_{p}^{N_p} \left( Sel_{M(y-p), age, y-p+1} - Sel_{M(y), age, y-p+1} \right) / Sel_{M(y), age, y-p+1} / N_p
\]

\[
MSE_{age} = \sum_{p}^{N_p} \left( Sel_{M(y-p), age, y-p+1} - Sel_{M(y), age, y-p+1} \right)^2 / N_p
\]
Retrospective bias

Selex

- Projected selectivity reduces MSE and Mohn’s Rho compared to using average selectivity

- 3D-AR1 has worse Mohn’s Rho and MSE for selex than current approach

<table>
<thead>
<tr>
<th>Model</th>
<th>Metric</th>
<th>Selex</th>
<th>Age-average</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (ParDev)</td>
<td>MSE</td>
<td>Avg</td>
<td>0.0022</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>MSE</td>
<td>Proj</td>
<td>0.0021</td>
<td>95.45%</td>
</tr>
<tr>
<td>1</td>
<td>Rho</td>
<td>Avg</td>
<td>-0.0415</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Rho</td>
<td>Proj</td>
<td>-0.0165</td>
<td>39.76%</td>
</tr>
<tr>
<td>7 (2D-AR)</td>
<td>MSE</td>
<td>Avg</td>
<td>0.0033</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>MSE</td>
<td>Proj</td>
<td>0.0028</td>
<td>84.85%</td>
</tr>
<tr>
<td>7</td>
<td>Rho</td>
<td>Avg</td>
<td>-0.0617</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Rho</td>
<td>Proj</td>
<td>-0.0513</td>
<td>83.14%</td>
</tr>
<tr>
<td>8 (3D-AR)</td>
<td>MSE</td>
<td>Avg</td>
<td>0.0099</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>MSE</td>
<td>Proj</td>
<td>0.0068</td>
<td>68.69%</td>
</tr>
<tr>
<td>8</td>
<td>Rho</td>
<td>Avg</td>
<td>-0.0673</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Rho</td>
<td>Proj</td>
<td>-0.0494</td>
<td>73.40%</td>
</tr>
</tbody>
</table>
Retrospective bias BRPs

- For AR models projected selectivity reduces MSE and Mohn’s Rho compared to using average selectivity

- 3D-AR1 has worse Mohn’s Rho and MSE for OFL and ABC than current approach, but better for B0

<table>
<thead>
<tr>
<th>Model</th>
<th>Metric</th>
<th>Selex</th>
<th>ABC</th>
<th>% Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (ParDev)</td>
<td>MSE</td>
<td>Avg</td>
<td>0.0064</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>MSE</td>
<td>Proj</td>
<td>0.0066</td>
<td>102.83%</td>
</tr>
<tr>
<td>1</td>
<td>Rho</td>
<td>Avg</td>
<td>0.2507</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Rho</td>
<td>Proj</td>
<td>0.2490</td>
<td>99.33%</td>
</tr>
<tr>
<td>7 (2D-AR)</td>
<td>MSE</td>
<td>Avg</td>
<td>0.0062</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>MSE</td>
<td>Proj</td>
<td>0.0062</td>
<td>98.56%</td>
</tr>
<tr>
<td>7</td>
<td>Rho</td>
<td>Avg</td>
<td>0.2534</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Rho</td>
<td>Proj</td>
<td>0.2492</td>
<td>98.35%</td>
</tr>
<tr>
<td>8 (3D-AR)</td>
<td>MSE</td>
<td>Avg</td>
<td>0.0077</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>MSE</td>
<td>Proj</td>
<td>0.0070</td>
<td>91.91%</td>
</tr>
<tr>
<td>8</td>
<td>Rho</td>
<td>Avg</td>
<td>0.2866</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Rho</td>
<td>Proj</td>
<td>0.2678</td>
<td>93.45%</td>
</tr>
</tbody>
</table>
Overview

3D-AR1 may outperform current selectivity
• Reduces retrospective bias in SSB, B0, & B40 at cost of increased retrospective bias in selex, ABC, & OFL

Projected selectivity outperforms average selectivity
• Projected selectivity decreases Mohn’s Rho in selex, ABC, & OFL for all models
  ▪ However increases MSE for double logistic
Next steps

• Rerun with different terminal years of the assessment
• Account for reweighting in retrospective peels
• Evaluate average vs projected weight-at-age
• Incorporate projected selex into assessment in 2024
• Any advice on how to structure these experiments?
Projections in 2023

- GOA pollock has substantial time-varying quantities (WAA, maturity)
- What to use for SPR?
- Can projections recreate 2023 assessment?
  - SSB, no 2024 NAA, yes
Projections in 2023

- GOA pollock has substantial time-varying quantities (WAA, maturity)
- What to use for SPR?
- Can projections recreate 2023 assessment?
  - SSB, no 2024 NAA, yes

<table>
<thead>
<tr>
<th></th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPR (F=0)</td>
<td>0.076</td>
<td>0.076</td>
<td>0.076</td>
<td>0.080</td>
</tr>
<tr>
<td>Mean Recruits (billions)</td>
<td>5.858</td>
<td>5.656</td>
<td>6.139</td>
<td>6.295</td>
</tr>
<tr>
<td>B100</td>
<td>443,000</td>
<td>430,000</td>
<td>469,000</td>
<td>505,000</td>
</tr>
<tr>
<td>B40</td>
<td>177,000</td>
<td>172,000</td>
<td>188,000</td>
<td>202,000</td>
</tr>
<tr>
<td>Terminal SSB</td>
<td>184,000</td>
<td>197,000</td>
<td>243,000</td>
<td>342,000</td>
</tr>
<tr>
<td>Depletion</td>
<td>0.415</td>
<td>0.458</td>
<td>0.518</td>
<td>0.677</td>
</tr>
<tr>
<td>Projected maxABC</td>
<td>105,722</td>
<td>133,081</td>
<td>148,937</td>
<td>232,543</td>
</tr>
<tr>
<td>for next year</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recruits in 2013</td>
<td>39.4887</td>
<td>40.4539</td>
<td>44.193</td>
<td>49</td>
</tr>
</tbody>
</table>
Status trends
### Risk table: overview

<table>
<thead>
<tr>
<th>Assessment-related considerations</th>
<th>Population dynamics considerations</th>
<th>Environmental/ecosystem considerations</th>
<th>Fishery Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 2: Major concern</td>
<td>Level 1: No concern</td>
<td>Level 1: No concern</td>
<td>Level 1: No concern</td>
</tr>
</tbody>
</table>

- **Assessment concerns**: poor fit to NMFS BT index, retrospective
- **Population concerns**: extreme low cohorts
Risk table: population dynamics concerns

A few vanishingly small recruits in recent years

- Are they real?
- Is that a regime shift?
- What does that mean for recruitment variability?
Risk table: population dynamics concerns

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A few vanishingly small recruits in recent years

- Are they real?
- Is that a regime shift?
- What does that mean for recruitment variability?
Risk table: assessment concerns

- The prior on NMFS BT catchability highly influences scale of stock
- But fits poorly in last 5 surveys
- Bad retrospective, but in the right direction
## Results for GOA pollock in SE (Tier 5)

<table>
<thead>
<tr>
<th>Quantity/Status</th>
<th>As estimated or specified last year for:</th>
<th>As estimated or recommended this year for:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2023</td>
<td>2024</td>
</tr>
<tr>
<td>Biomass (t)</td>
<td>50,505</td>
<td>50,505</td>
</tr>
<tr>
<td>F_OFL</td>
<td>0.30</td>
<td>0.30</td>
</tr>
<tr>
<td>maxF_ABC</td>
<td>0.23</td>
<td>0.23</td>
</tr>
<tr>
<td>F_ABC</td>
<td>0.23</td>
<td>0.23</td>
</tr>
<tr>
<td>OFL (t)</td>
<td>15,150</td>
<td>15,150</td>
</tr>
<tr>
<td>maxABC (t)</td>
<td>11,363</td>
<td>11,363</td>
</tr>
<tr>
<td>ABC (t)</td>
<td>11,363</td>
<td>11,363</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Status</th>
<th>As determined last year for:</th>
<th>As determined this year for:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2022</td>
<td>2023</td>
</tr>
<tr>
<td>Overfishing</td>
<td>No</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>n/a</td>
</tr>
</tbody>
</table>
Questions?

• Thanks!
Author’s 2023 ABC = 232,543 t
  ▪ Increase of 56% from 2023
  ▪ 2025 ABC decreases to 157,687 t
  ▪ No reduction from max ABC

Changes to model:
  ▪ No structural changes
  ▪ Converted to TMB (23.0)

Concerns:
  ▪ Extremely small recent cohorts
  ▪ Poor fit to NMFS bottom trawl index

Positives:
  ▪ 2017, 2018, 2020 cohorts above average
  ▪ 2012 estimate up to ~50 billion
  ▪ Good environmental conditions
References


References

Punt, A. E. 2023. Those who fail to learn from history are condemned to repeat it: A perspective on current stock assessment good practices and the consequences of not following them. Fisheries Research 261:106642.


