Alaska Sablefish
September Updates
(post-prioritization version)

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Outline

- Longline survey preliminary results
- Juvenile tagging
- CIE review
  - Summary and responses
- Preliminary model responses
  - Gaining imprecision
  - Whale depredation
  - Sensitivity runs
- Future prospects
Longline survey 2016
Aleutian year, Preliminary results
Survey Geographic Coverage

Western Gulf of Alaska
Central Gulf of Alaska
Shumagin
Chirikof
Kodiak
Yakutat
Southeast

Bering Sea
Odd Years Only

Aleutian Islands
Even Years Only

△ Longline Survey Station
--- 1000 m Depth Contour

km
0 250 500 1,000
Preliminary results

- Just compiled over the weekend so use caution
- These use the new area sizes calculated in Echave et al. (2013)
- These also use the 150-200 m depth strata allowed by using the new area sizes
Number of fish caught per year

Thousands

Species

Year

2012
2013
2014
2015
2016

Sablefish
Grenadier
PacificCod
SST
Halibut
Rougheye
ATF
GOA Halibut longline survey RPNs w/ 95% CIs

RPN

Year

1990
2000
2010

-10%
Recent Rougheye length frequencies

Proportion

Length

Year
- 10YearMean
- 2013
- 2014
- 2015
- 2016
Recent Arrowtooth length frequencies

Year
10 Year Mean
2013
2014
2015
2016

Proportion
0.10
0.05
0.00

Length
40
60
80
100
Recent Turbos length frequencies

![Graph showing length frequencies over different years. The x-axis represents length ranging from 40 to 100, and the y-axis represents proportion ranging from 0.00 to 0.15. The graph includes lines for 10 Year Mean, 2013, 2014, 2015, and 2016.]
Recent male sablefish length frequencies

Year
- 10 Year Mean
- 2013
- 2014
- 2015
- 2016

Proportion

Length

Proportion
Recent female sablefish length frequencies
Bring on the blob?

- **2014:**
  - Lots of YOYs caught in surface trawl surveys
  - Lots of fishermen reports of YOY in coho bellies

- **2015:**
  - One year olds reported all over by sport fishermen
  - YOYs found in coho and pomfret stomachs on GOA project survey
  - More fisherman reporting YOY in coho stomachs

- **2016:**
  - Many YOY caught in new surface trawl experiment EGOA
  - More fisherman reporting YOY in coho stomachs
Juvenile sablefish tagging 2015

~500

~30

~50

~500

~500
Juvenile sablefish tagging 2016
Sablefish CIE 2016

• May 10 – 12, Auke Bay Labs, Juneau
  • Noel Cadigan, Memorial University, Newfoundland
  • Neil Klaer, CSIRO (retired), Australia
  • Tom Carruthers, University of British Columbia
• May 27: Consensus recommendations
• July 27: Individual CIE reports
• September 13: Responses to consensus recommendations, some preliminary model responses
Terms of Reference A.

• Evaluation, findings, and recommendations on quality of input data and methods used to process them for inclusion in the assessment
  • “Assessment authors have generally carefully considered the data inputs regarding error and bias and have appropriately processed them for inclusion in the assessment.” -- Klaer
  • “…further improvements may be possible, particularly concerning the development of a recruitment index from the trawl survey, calculation of fishery CPUE, and the calculation of age-length keys with consideration of measurement error in length and age” -- Cadigan
Terms of Reference B.

- Evaluation, findings, and recommendations of the analytical approach used to assess stock condition and stock status

- “The outstanding negative feature of the model is that it provides unrealistically precise estimates of stock biomass (CV~ 5%). Simulation studies have consistently found stock assessments of similar structure to provide unreliable estimates of absolute current biomass (Deroba et al. 2015). This may suggest the model is on a particular end of the bias-variance trade-off.” -- Carruthers

- “Of the many stock assessments that I have reviewed this was arguably the most comprehensive, supported by excellent data and subject to careful consideration of alternative modelling assumptions. The fits to the various data were very good to excellent and there was little evidence of model misspecification or pathological model behavior such as strong patterns in residual errors or consistent retrospective patterns in model predictions.” -- Carruthers
Terms of Reference C.

• Evaluation, findings, recommendations on estimation and strategies for accounting for whale depredation

• “I found the text on this model to be confusing. The Binomial and Poisson model structure should be clearly defined. I struggled with Equation (7) in Peterson and Hanselman. This should be more clearly defined and explained ...The above models used to estimate depredation effects are fairly complicated because the data are fairly complicated...” -- Cadigan

• “Although I am not experienced in estimation of- and accounting for- depredation by mammals, the general framework for estimating depredation (presented by Petersen and Hanselman) appears to be defensible” -- Carruthers
Terms of Reference D.

- Evaluation, findings, recommendations of areal harvest apportionment strategy as related to movement and optimizing spawning stock biomass
- “Tagging and other research indicate high sablefish movement rates throughout their lives which indicate a well-mixed stock. My reservation and uncertainty here is that little is known (or presented to RP) about the spatial spawning dynamics of this stock.” -- Cadigan
- “Available evidence mainly from tagging shows that the stock is highly mixed across all areas and that spawning on the slope is also widely distributed across areas. Compared with many other stocks that are likely to be sub-structured but generally treated as one for management purposes, this is favorable for the Alaska sablefish assessment” -- Klaer
Terms of Reference E.

- Recommendations for further improvements
  - “Continue to conduct ecosystem research that may be used to provide improved tactical fisheries management advice (e.g. definition of regimes, improved precision of short term recruitment forecasts, incorporation of environmental variables in long term recruitment forecasts, essential fish habitat).” -- Cadigan
  - “A spatial operating model can also be used to prioritize regional fishery data collection protocols, establish suitable design of tagging studies and investigate assessment biases due to phenomena such as variable regional recruitment trends.” -- Carruthers
CIE Responses (Appendix)

- Short-term
  - Gaining imprecision
  - Incorporate whale depredation
  - Show structural uncertainty
- Long-term
  - Tag-integrated model
  - Growth inside model
  - Consider Canadian catches
  - Fishery CPUE
Models (with poor numbering)

- Maintenance updates (B1)
  - Variance estimates on the longline survey
  - New area sizes for the longline survey
- Addressing imprecision
  - Tuning SDNR of LL survey to 1 (B2)
  - Estimating M (B3 & B4)
  - Estimating maturity inside model (B5)
- Including whale depredation (W2 & W3)
LL Survey variance estimates

- Currently use a CV of 5% on the longline survey
  - Based on bootstrapping the data
  - Doesn’t account for annual variability
- Now have analytical estimates that assume:
  - Station-stratum combinations are a representative sample
  - There is significant sample covariance between station stratum means:
Annual analytical sablefish CVs

Year

Longline survey CV

SurveyCV

0.070
0.065
0.060
0.055
0.050
Variance estimates

- Other species have higher CVs:
  - Pacific cod in the GOA: 15%
  - Rougheye in the GOA: 18%

- And when estimated for smaller areas are larger
  - E.g., sablefish in the WGOA: CV = 16%

- Will be useful for fitting spatial models and exploring apportionment scenarios
New area sizes


- Estimated area sizes using GIS instead of a plenometer
- Updated bathymetry
- Calculated area sizes for 150-200 m depths
New area sizes

Ratio of new area sizes to old

Geographic RPN area

- W Yakutat slope
- SW Aleutians slope
- Spencer Gully
- Southeast slope
- Shumagin slope
- SE Aleutians slope
- Ommaney Trench
- NW Aleutians slope
- NE Aleutians slope
- Kodiak slope
- East Yakutat slope
- Dixon Entrance
- Chirikof slope
- Bering 4 slope
- Bering 3 slope
- Bering 2 slope
- Bering 1 slope

Ratio

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<tr>
<th>Ratio</th>
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<tr>
<td>0.0</td>
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<tr>
<td>0.5</td>
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<td>1.0</td>
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<tr>
<td>1.5</td>
</tr>
<tr>
<td>2.0</td>
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</tbody>
</table>
New area sizes

Ratio of new area sizes to old

Depth Stratum (meters)

200-300  300-400  400-600  600-800  800-1000

Ratio

0.0  0.5  1.0  1.5

Ratio

1.0  1.1  1.2  1.3
Gaining imprecision
Profiling over natural mortality

Test

Percent difference from reference model

Like
ABC
Catchability
SSBProj
1008Recr
B40

M=0.050
M=0.055
M=0.060
M=0.065
M=0.070
M=0.075
M=0.080
M=0.085
M=0.090
M=0.095
M=0.100
M=0.105
M=0.110
M=0.115
M=0.120
M=0.125
M=0.130
M=0.135
M=0.140
M=0.145
M=0.150
M=0.155
M=0.160
M=0.165
Maturity Data

- Annual Longline Surveys
- Combined Longline Surveys
- Current Assessment

Proportion mature vs. Age
## Gaining Imprecision

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<tr>
<th>Description</th>
<th>B₀</th>
<th>B₁</th>
<th>B₂</th>
<th>B₃</th>
<th>B₄</th>
<th>B₅</th>
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<td><strong>Variance estimates</strong></td>
<td>2015 model</td>
<td>New area sizes</td>
<td>Tune LL survey to SDNR = 1</td>
<td>Estimate M with 20% CV prior</td>
<td>Estimate M with 500% CV prior</td>
<td>Estimate maturity inside model</td>
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<td>Japanese Fishery CPUE</td>
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<td>Fixed fishery lengths</td>
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<td>Coop. LL survey lengths</td>
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<tr>
<td>GOA trawl survey lengths</td>
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<td><strong>Precision/parameters</strong></td>
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<td>2015 SSB</td>
<td>86.6</td>
<td>83.3</td>
<td>85.5</td>
<td>88.6</td>
<td>88.6</td>
<td>83.9</td>
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<td>2015 SSB CV</td>
<td>4%</td>
<td>5%</td>
<td>6%</td>
<td>12%</td>
<td>13%</td>
<td>13%</td>
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<tr>
<td>ABC CV</td>
<td>7%</td>
<td>10%</td>
<td>12%</td>
<td>25%</td>
<td>27%</td>
<td>27%</td>
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<tr>
<td>M</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.102</td>
<td>0.103</td>
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<td>Domestic q</td>
<td>7.63</td>
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<td>7.39</td>
<td>7.17</td>
<td>7.12</td>
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<td>-lnL</td>
<td>1558.7</td>
<td>1532.3</td>
<td>1363.9</td>
<td>1361.1</td>
<td>1361.1</td>
<td>1361.1</td>
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Whale depredation and the sablefish stock assessment
Sperm whale and killer whale depredation
Outline

PART 1: Longline survey abundance index

PART 2: Commercial fishery abundance index

PART 3: Stock assessment application
PART 1: Longline survey abundance index
Increasing trend presence

Increasing trend presence & evidence

Increasing trend presence & evidence
4 across-area models

All across-area models treat area \((A_i)\), depth stratum \((D_j)\), and their interaction \((AD)_{ij}\) as fixed-effects and all remaining terms as random effects, Poisson distribution

\[
\log(C_{ijk[i]}) = \log(H_{ijk[i]}) + Y_i + A_i + D_j + (YA)_i + (YD)_j + (AD)_{ij} + (YAD)_{ij} \\
+ S_{k[i]} + (YS)_{dk[i]} + (DS)_{jk[i]} + (YDS)_{ijk[i]},
\]

Results

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<tr>
<th>Model</th>
<th>Flag</th>
<th>Area</th>
<th>Estimate ((\lambda))</th>
<th>SE</th>
<th>P value</th>
<th>Proportional change</th>
<th>Delta</th>
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<tbody>
<tr>
<td>1</td>
<td>Evidence</td>
<td>All</td>
<td>-0.133</td>
<td>0.03</td>
<td>&lt;0.001</td>
<td>0.88</td>
<td>0.82</td>
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<td>2</td>
<td>Evidence</td>
<td>CGOA</td>
<td>-0.117</td>
<td>0.06</td>
<td>0.07</td>
<td>0.89</td>
<td>0.78</td>
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<tr>
<td></td>
<td></td>
<td>WY</td>
<td>-0.13</td>
<td>0.06</td>
<td>&lt;0.001</td>
<td>0.88</td>
<td>0.78</td>
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<tr>
<td></td>
<td>EY/SE</td>
<td>-0.148</td>
<td>0.05</td>
<td>&lt;0.001</td>
<td>0.86</td>
<td>0.77</td>
<td>0.96</td>
</tr>
</tbody>
</table>
Results con’t....

➢ 12% CPUE reduction across areas (95% CI: 6% - 18%) based on evidence alone

➢ 9% CPUE reduction across areas (95% CI: 3% - 15%) based on presence

*Evidence flag desirable but presence still a useful/practical proxy for depredation
PART 2: Commercial fishery depredation
Issues with observer data

• Limited observer coverage (especially on smaller vessels)
• Marine mammal interactions monitored sometimes...
• “Considerable whale depredation”
Commercial sablefish fishery observed sets 1995-2014

Western Alaska (n=19,921 sets)  
Gulf of Alaska (n=16,443 sets)
Proportion of sets impacted by whales

Western Alaska

Year

1995 2000 2005 2010

Proportion Depredated Killer Whales

Eastern Alaska

Year


Proportion Depredated Sperm Whales
Compared a number of model formats using area-specific models

- GLMs
- GLMMs
- GAMs
- GAMMs

Point estimates, standard errors, bootstrap/simulations

→ selected GAM model with random effects included

\[ \log(\text{sable}_{CPUE}) = \beta_0 + \text{whale}_{dep} + \text{depth} + \text{jul}\_\text{day} + \text{(lat,long)} + \text{gren}_{CPUE} + \text{hal}_{CPUE} + \text{year} + \text{vessel} + \epsilon \]
\[ \text{Log(sable}_{\text{CPUE}}) = \beta_0 + \text{whale}_{\text{dep}} + \text{depth} + \text{year} + \text{jul}_{\text{day}} + (\text{lat, long}) + \text{vessel} + \text{gren}_{\text{CPUE}} + \text{hal}_{\text{CPUE}} + \epsilon \]

<table>
<thead>
<tr>
<th>Area</th>
<th>Depredation coefficient (% CPUE red)</th>
<th>2 * SE</th>
<th>n</th>
<th>%dev</th>
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<tbody>
<tr>
<td>Bering Sea</td>
<td>45.7%</td>
<td>40.2% - 51.2%</td>
<td>4339</td>
<td>49.7%</td>
</tr>
<tr>
<td>Aleutians</td>
<td>57.7%</td>
<td>50.1% - 65.2%</td>
<td>6744</td>
<td>37.2%</td>
</tr>
<tr>
<td>Western Gulf of Alaska</td>
<td>69.4%</td>
<td>63.0% - 75.9%</td>
<td>5950</td>
<td>31.0%</td>
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<tr>
<td>Central Gulf of Alaska</td>
<td>23.8%</td>
<td>19.4% - 28.1%</td>
<td>8218</td>
<td>46.4%</td>
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<tr>
<td>West Yakutat</td>
<td>26.3%</td>
<td>21.5% - 31.1%</td>
<td>3919</td>
<td>52.7%</td>
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<tr>
<td>Southeast</td>
<td>29.4%</td>
<td>22.6% - 36.2%</td>
<td>2865</td>
<td>43.5%</td>
</tr>
</tbody>
</table>
Estimating sablefish removals due to whales

- Data gridded into 1/3° by 1/3° (approx 36 km by 25 km)
- Fishery characteristics averaged or summed per grid
- Zero Inflated Poisson (ziP) distribution GAM to model # sets depredated per grid

\[
\text{sable mort} = \frac{\hat{\text{prop} \_ \text{dep per grid}} \times \text{landings per grid} \times 1}{(1 - \hat{\text{prop} \_ \text{reduct}}) - 1}
\]

- Landings per grid from Catch-in-Areas database based on Catch Accounting and VMS data (pers.comm. Steve Lewis – AKRO)
Whale depredation in fishery
PART 3: Stock assessment application
Incorporating Depredation

- Comparing to Model B1 presented earlier that uses new area sizes and variance estimates
- W1 – correct for sperm whales in survey
- W2 – add additional catch in the fishery
- W3 – do both
Effect of correcting for depredation

% Change in key results

Index
- W1
- W2
- W3

Result/Estimate
- InL
- ABC
- SSBProj
- MeanR
- B40
- Q

Effect of correcting for depredation
Effect on female spawning biomass

Ratio of corrected to uncorrected

Year

Index

W1

W2

W3
Depredation impacts sablefish stock assessment & fishery operations
- Increased uncertainty
- 5% - 7% higher ABC (if included in longline survey index) - translates to $6 million
- Impact of additional catch (fishery depredation) to ABC is small (+/-1% lower ABC)

Complicating factors - should sperm whale depredation be included?
- Depredation pre-1998??
- Additional mortality in the commercial fishery?
- Variability in killer whale depredation
2015 Example

<table>
<thead>
<tr>
<th></th>
<th>EY</th>
<th>WY</th>
<th>CG</th>
<th>WG</th>
<th>AI</th>
<th>BS</th>
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<tbody>
<tr>
<td>2015 ABC</td>
<td>2,823</td>
<td>1,567</td>
<td>4,658</td>
<td>1,473</td>
<td>1,802</td>
<td>1,333</td>
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<tr>
<td>Apportionment</td>
<td>11%</td>
<td>34%</td>
<td>11%</td>
<td>13%</td>
<td>10%</td>
<td>11%</td>
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<tr>
<td>2016 ABC</td>
<td>2,438</td>
<td>1,353</td>
<td>4,023</td>
<td>1,272</td>
<td>1,556</td>
<td>1,151</td>
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</table>

Run with whale corrections for survey and fishery

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<th>EY</th>
<th>WY</th>
<th>CG</th>
<th>WG</th>
<th>AI</th>
<th>BS</th>
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<tbody>
<tr>
<td>Inflated ABC</td>
<td>2,585</td>
<td>1,435</td>
<td>4,265</td>
<td>1,349</td>
<td>1,650</td>
<td>1,220</td>
</tr>
<tr>
<td>3 year average depredation</td>
<td>77</td>
<td>48</td>
<td>104</td>
<td>112</td>
<td>91</td>
<td>63</td>
</tr>
</tbody>
</table>

Ratio of 2016 ABC/2015 ABC = 0.86

Deduct 3 year average * 0.86

<table>
<thead>
<tr>
<th></th>
<th>EY</th>
<th>WY</th>
<th>CG</th>
<th>WG</th>
<th>AI</th>
<th>BS</th>
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<tbody>
<tr>
<td>2016 ABC\text{wc}</td>
<td>2,518</td>
<td>1,393</td>
<td>4,175</td>
<td>1,252</td>
<td>1,571</td>
<td>1,166</td>
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<tr>
<td>Change</td>
<td>3.3%</td>
<td>2.9%</td>
<td>3.8%</td>
<td>-1.6%</td>
<td>1.0%</td>
<td>1.3%</td>
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</table>
Sensitivity

Like
ABC
Catchability
SSBpol
X2008Recruit
B40

Percent difference from reference model

Test

DOME F1LENH F3LENH F3LENL FAGEH FAGEL FLEN1L M=0.08 M=0.12 NCFPUE NLLS1 NLLS2 NOQPR NTS S1LENH S1LENL S2LENH S2LENL S7LENH S7LENL SAGEH SAGEL SigR=0.8 SigR=1.6
Sensitivities (-3)

Percent difference from reference model vs. Test

Like
ABC
Catchability
SSBProj
X2008Recruit
B40
For November

- Model with ‘maintenance updates’
- Model with SDNRs tuned
- Model with M estimates
- Model with whale depredation
- Maybe all of it (BW.3)
Apportionment

- CIE recommends seeking further input on objectives
- CIE not concerned with static apportionment
- We believe it is best to stay put (and we have no new alternatives prepared)
- MSEs and spatial work continue (and we have a new hire)
Future

• Consider estimating growth within model
• Spatial modeling
• Continue work on recruitment/environmental relationships to improve projections
• Consider alternative recruitment regimes
• Continue maturity work