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Alaska Fisheries
Science Center

Report of the September 2020 BSAI Groundfish Plan Team meeting

Grant Thompson

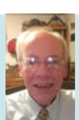
September 29, 2020

Meeting overview

- Dates: September 9-10
- Place: Cyberspace
- Leaders: Grant Thompson, Steve Barbeaux (co-chairs); Steve MacLean (coordinator)
- Participation: 12 Team members present, plus numerous AFSC and AKRO staff and members of the public
- Documents and presentation files available on the Team agenda site
  - Link provided on SSC agenda (under item C2 “Joint Groundfish Plan Team – Report”)

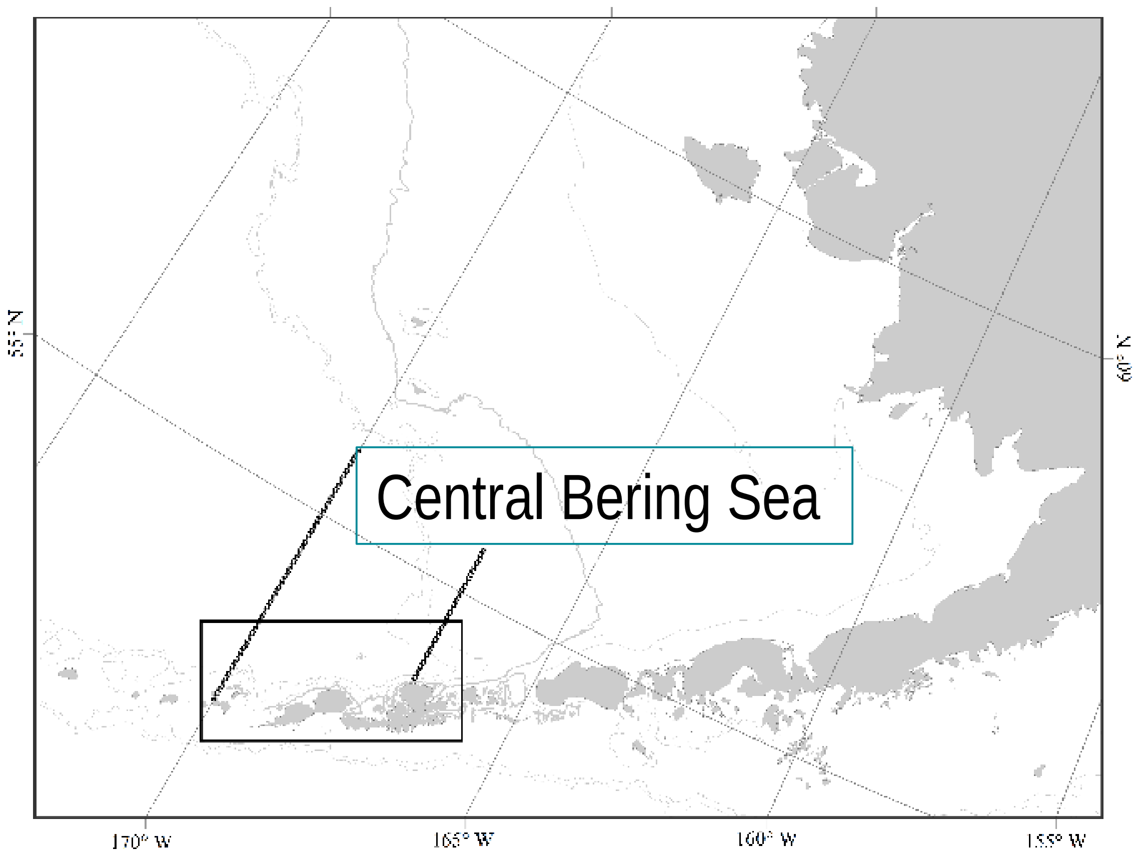
Agenda (action items in red)

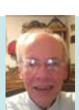
- Administrative
- EBS and Bogoslof Pollock
- BSAI Blackspotted/Rougheye Rockfish
- BSAI Northern Rock Sole
- NBS Pacific Cod Tagging
- BSAI Yellowfin Sole
- EBS Pacific Cod
- Octopus Stock Structure
- 2021 and 2022 Harvest Specification Recommendations



EBS and Bogoslof Pollock (1 of 12)

- Presentation #1: Denise McKelvey presented the 2020 winter acoustic trawl survey for the Aleutian Islands and Bogoslof Island



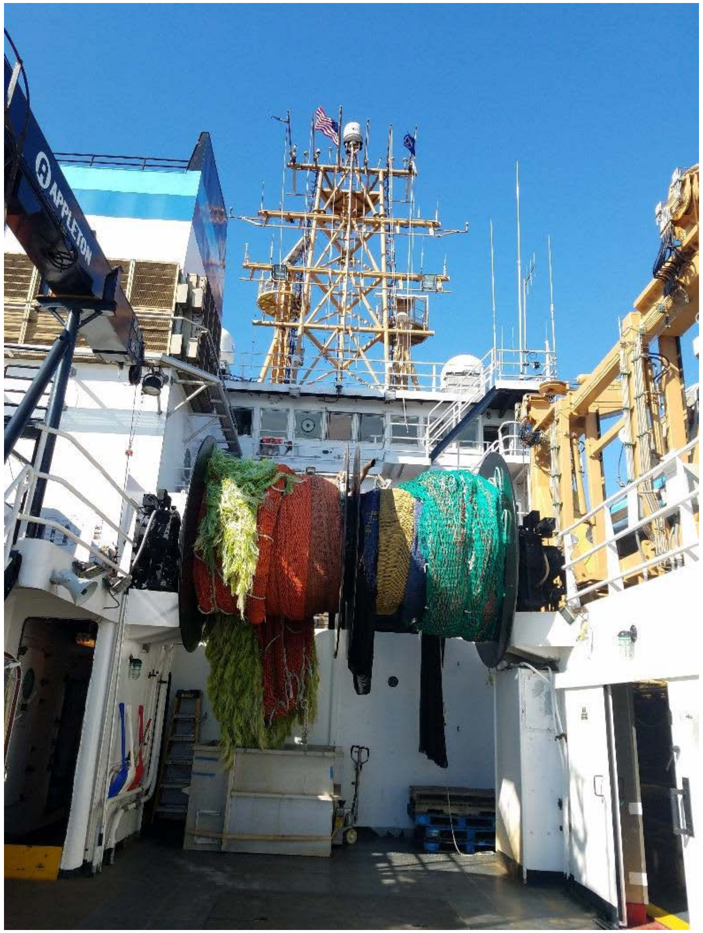


EBS and Bogoslof Pollock (2 of 12)

- Survey is conducted biennially (last one was in 2018)
- Provides an index of abundance for the Bogoslof Island pollock assessment and is key for the internationally managed “Donut Hole”
- The 2020 survey took place 2 weeks earlier than in 2018
- Two nets were deployed to enable comparative sampling: AWT (current net) and LFS (candidate for future net)
    - LFS: finer codend mesh liner (1/8” vs 1/2”), smaller overall, more nimble, smaller vertical opening (17m vs 30m)
- Next Bogoslof survey is planned for 2022

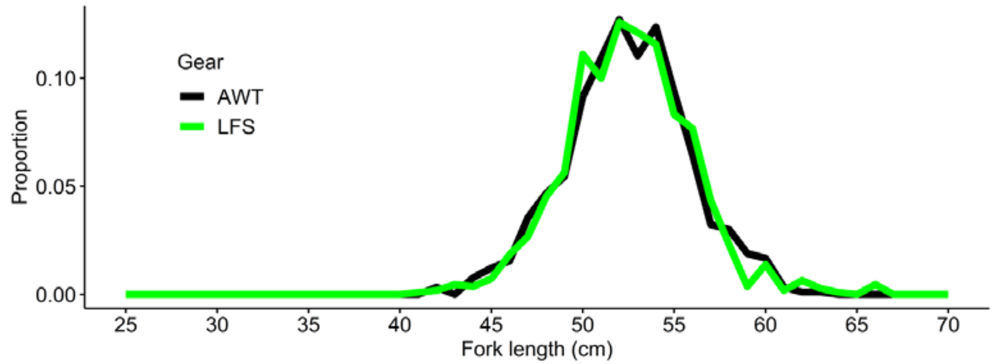
EBS and Bogoslof Pollock (3 of 12)

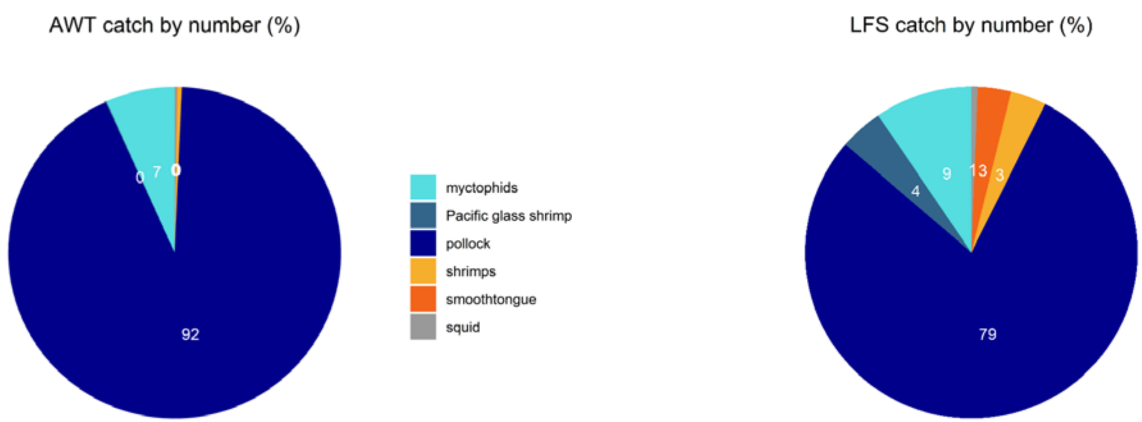
- AWT mounted on the left, LFS on the right



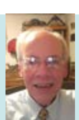
EBS and Bogoslof Pollock (4 of 12)

- Results of 4 paired tows:



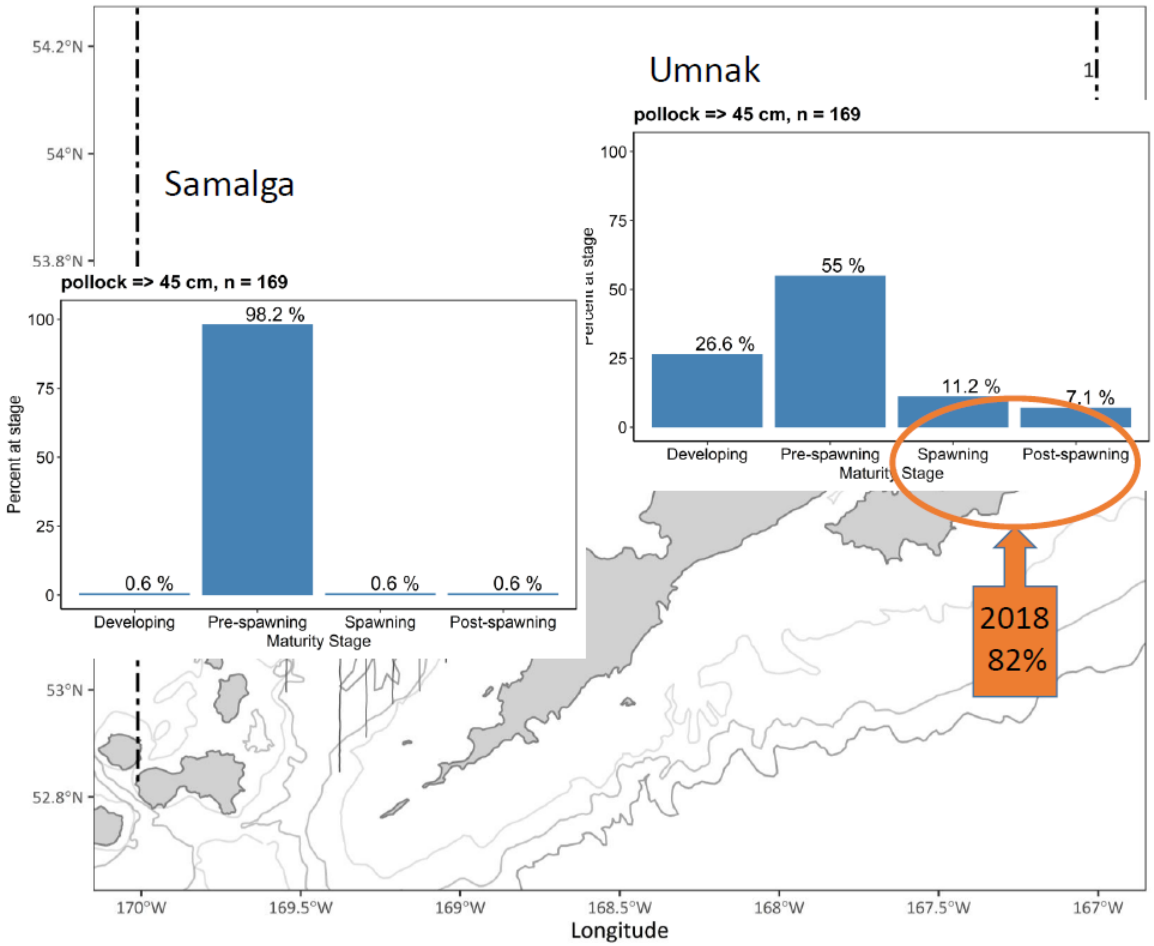


- For next survey (2022), intent is to continue paired tow experiement



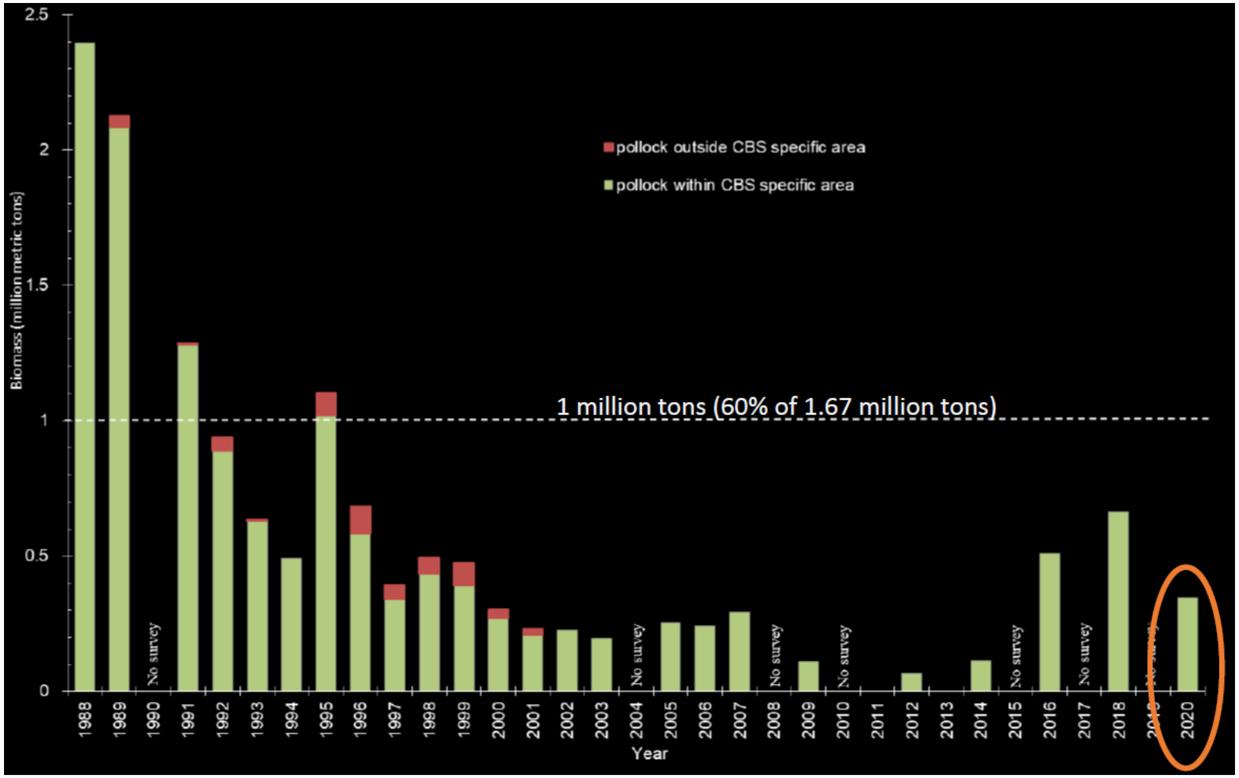
EBS and Bogoslof Pollock (5 of 12)

- Most fish were in pre-spawning condition (i.e., timing was good)



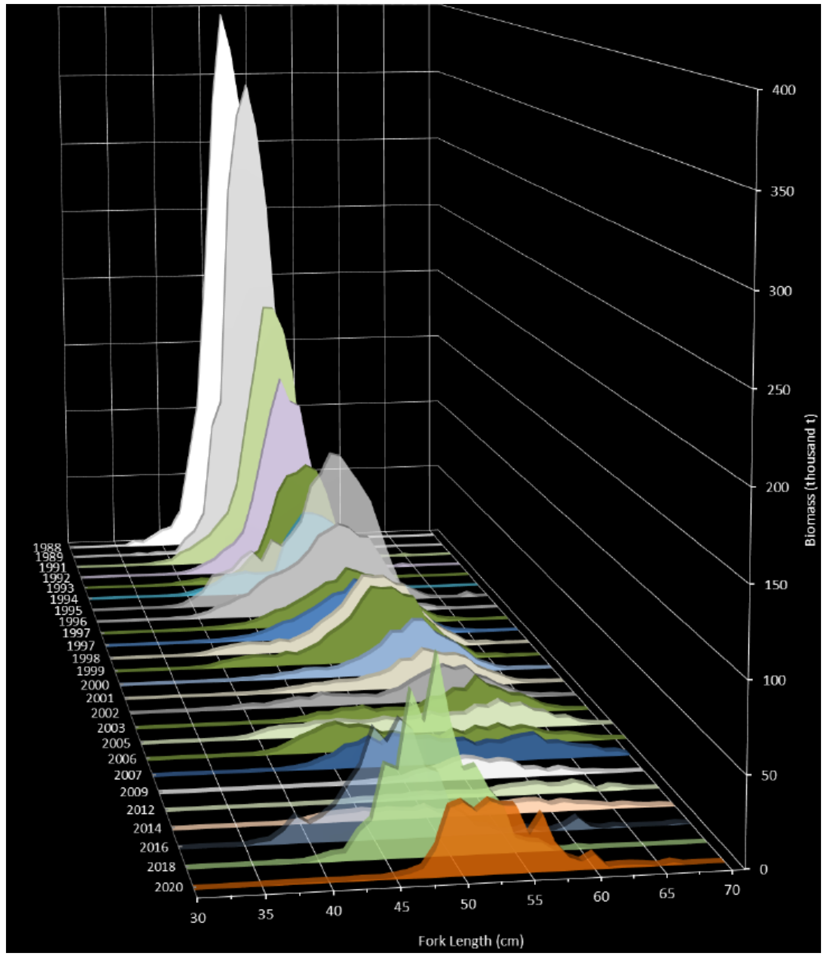
EBS and Bogoslof Pollock (6 of 12)

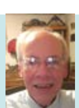
- 2020 biomass estimate: 345,000 t, 85% of which was in Samalga region
- This represents a 48% decrease in biomass from 2018 (663 thousand t)
- 1 million t threshold required for fishery to open



EBS and Bogoslof Pollock (7 of 12)

- Size composition time series (2020 mode likely from 2009/2010 cohorts)





EBS and Bogoslof Pollock (8 of 12)

- Presentation #2: Alex De Robertis and Jim Ianelli described the 2020 saildrone survey and plans for this year's assessment

EBS and Bogoslof Pollock (9 of 12)

- Saildrones are wind- and solar-powered robots and include both a calibrated 38/200 kHz echosounder and a series of oceanographic and meteorological sensors
- The AFSC saildrone survey was developed as a contingency plan in case surveys were cancelled
- The goal was to use unmanned surface vehicles to add a data point to the existing acoustic timeseries
- Methods for data collection/processing have been worked out such that saildrones produce pollock backscatter comparable to surveys via the Dyson (De Robertis et al. (2019) *ICES J. Mar Sci.* 76:2459-2470)

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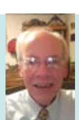
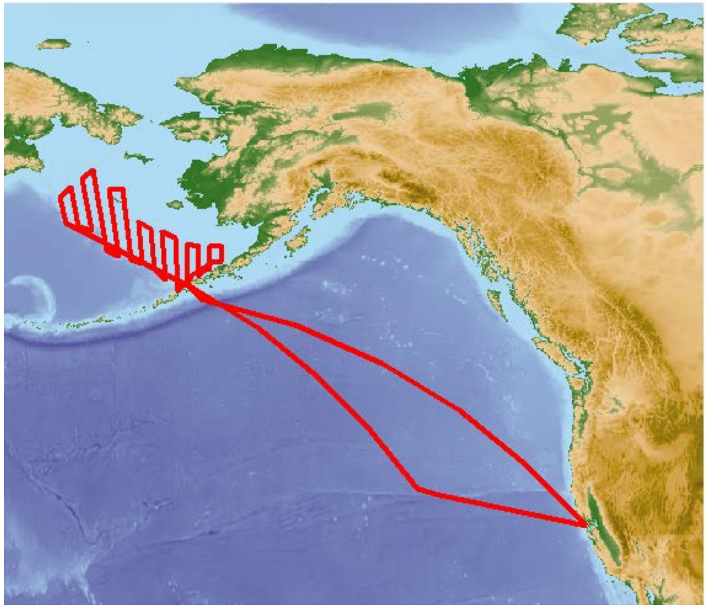


EBS and Bogoslof Pollock (10 of 12)



- Approach:
  - Sail to/from Alaska
  - 3 saildrones
  - 40 nmi spacing
    - 20 nmi for acoustic survey
  - Survey July 4 – August 20
  - Data recovery in mid-October
- Limitations:
  - No size/age composition
  - Lower sampling density
  - No data until vehicles are recovered

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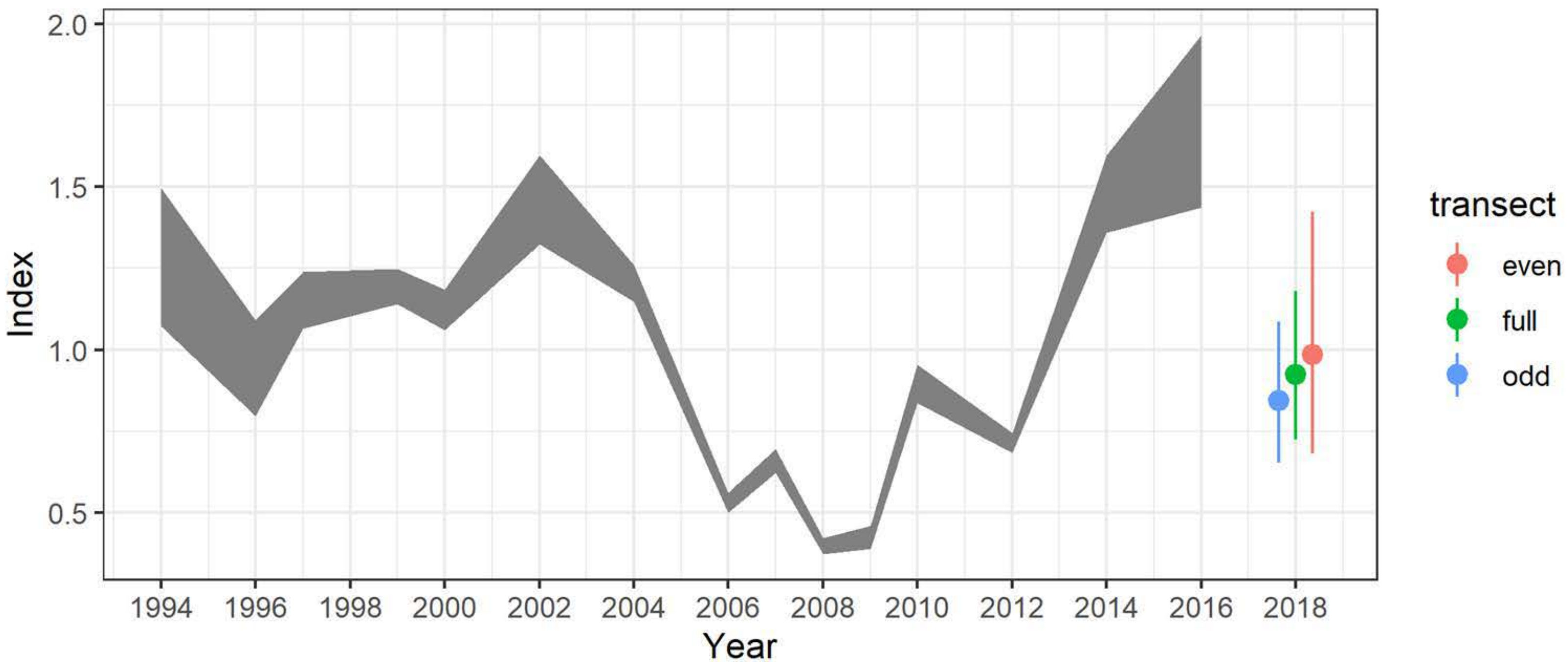
EBS and Bogoslof Pollock (11 of 12)

- Is switching from 20 nmi spacing to 40 nmi spacing a major concern?
- Compare full 2018 data set against even-only or odd-only transects
- Point estimates are similar, but larger spacing → more uncertainty



- Future work will repeat the analysis for earlier years

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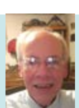

EBS and Bogoslof Pollock (12 of 12)

- The Team thanked the authors and researchers involved with this project on the effort, speed, and ingenuity needed to collect 2020 biomass index for 2020 pollock assessment
- The November assessment will include the saildrone index of abundance (if possible) and updated catch data
- The Team supports the plan to evaluate model results that include saildrone-based acoustic data in the 2020 EBS pollock assessment
- The SSC went with a different model in 2019 than the Team
  - Both will be presented again this year
- VAST estimates with and without cold pool covariate will be included
- In terms of fishing reports, there is evidence that the B season is poor and there are anecdotal reports of lots of small fish while overall fishing conditions are quite poor (qualitative)

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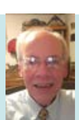

Blackspotted/Rougheye rockfish (1 of 15)

- Paul Spencer discussed issues with previous modeling efforts, responded to Team suggestions, and evaluated several new models
- Issues:
  - In recent years there has been a dramatic decline in older fish and a concurrent increase in younger fish in both the fishery and survey, but the model does not have a mechanism to explain this, and the composition data appear to be in conflict with the abundance data
  - Estimates of recruitment from large year classes have proven to be unstable, and have typically been revised downward over time
  - Choice of model has major implications for management

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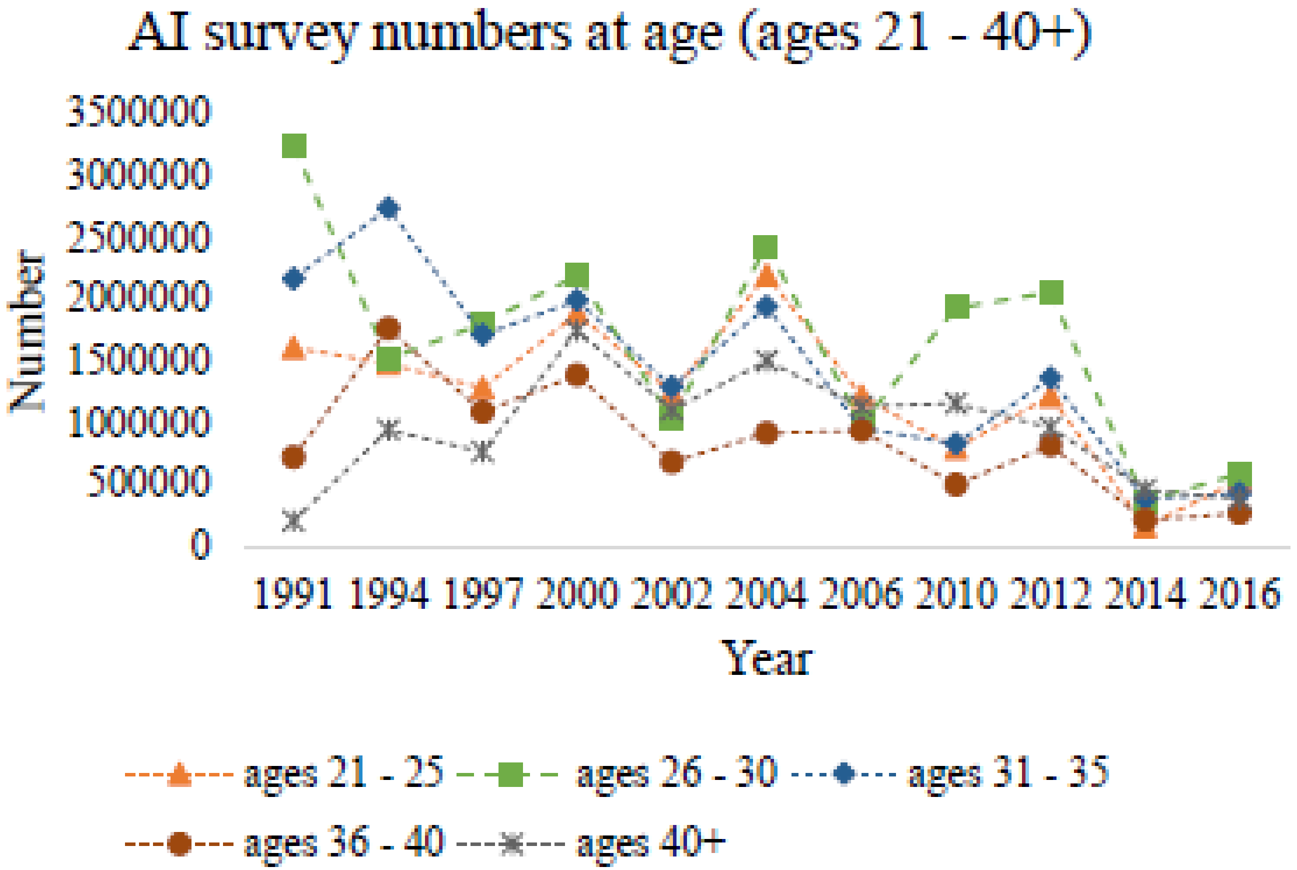
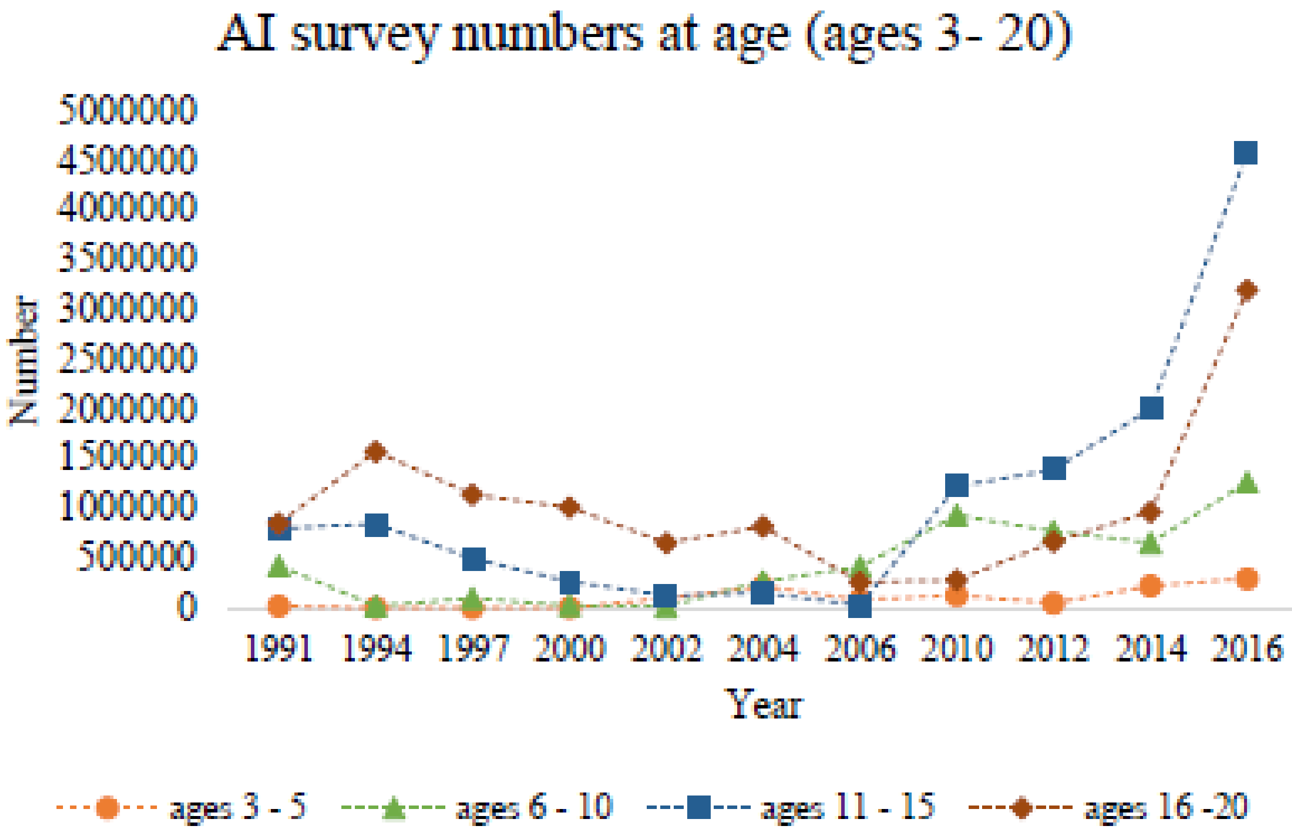
Blackspotted/Rougheye rockfish (2 of 15)

- The number of old fish in recent surveys has gone down



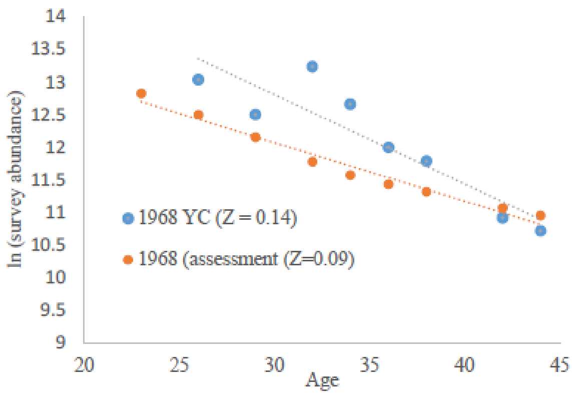
Blackspotted/Rougheye rockfish (3 of 15)

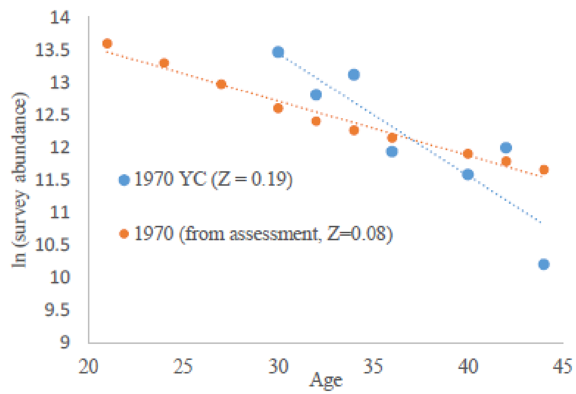
- The number of young fish in recent surveys has gone up

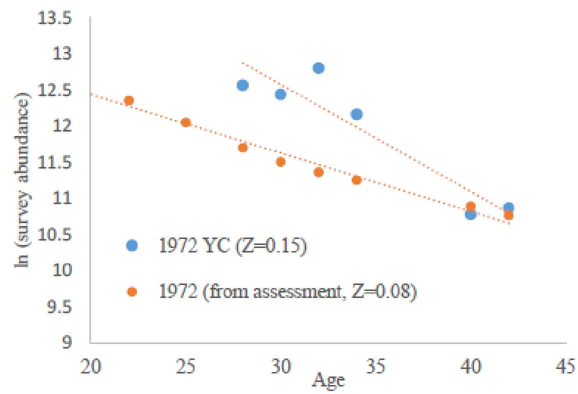


Blackspotted/Rougheye rockfish (4 of 15)

- Example catch curves from survey data (blue) versus model (orange)



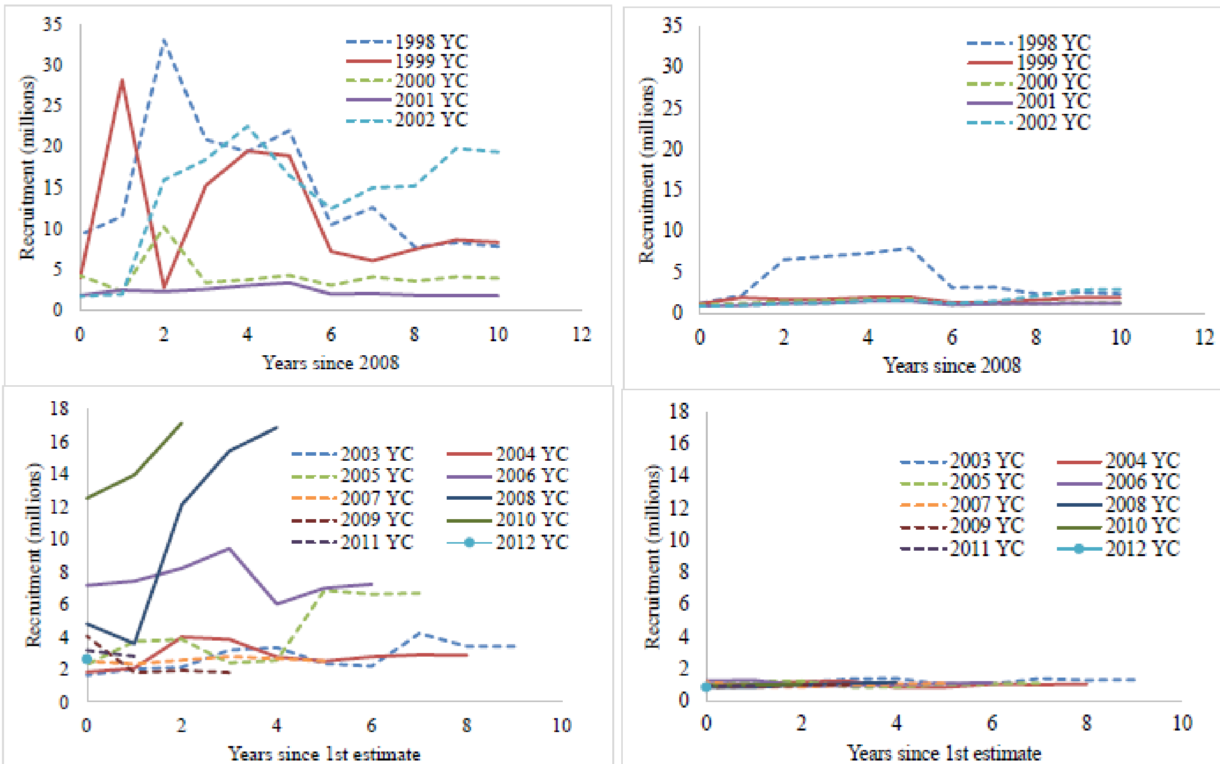


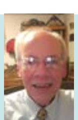


Blackspotted/Rougheye rockfish (5 of 15)

- Variability of estimated year class strengths, by model and rank

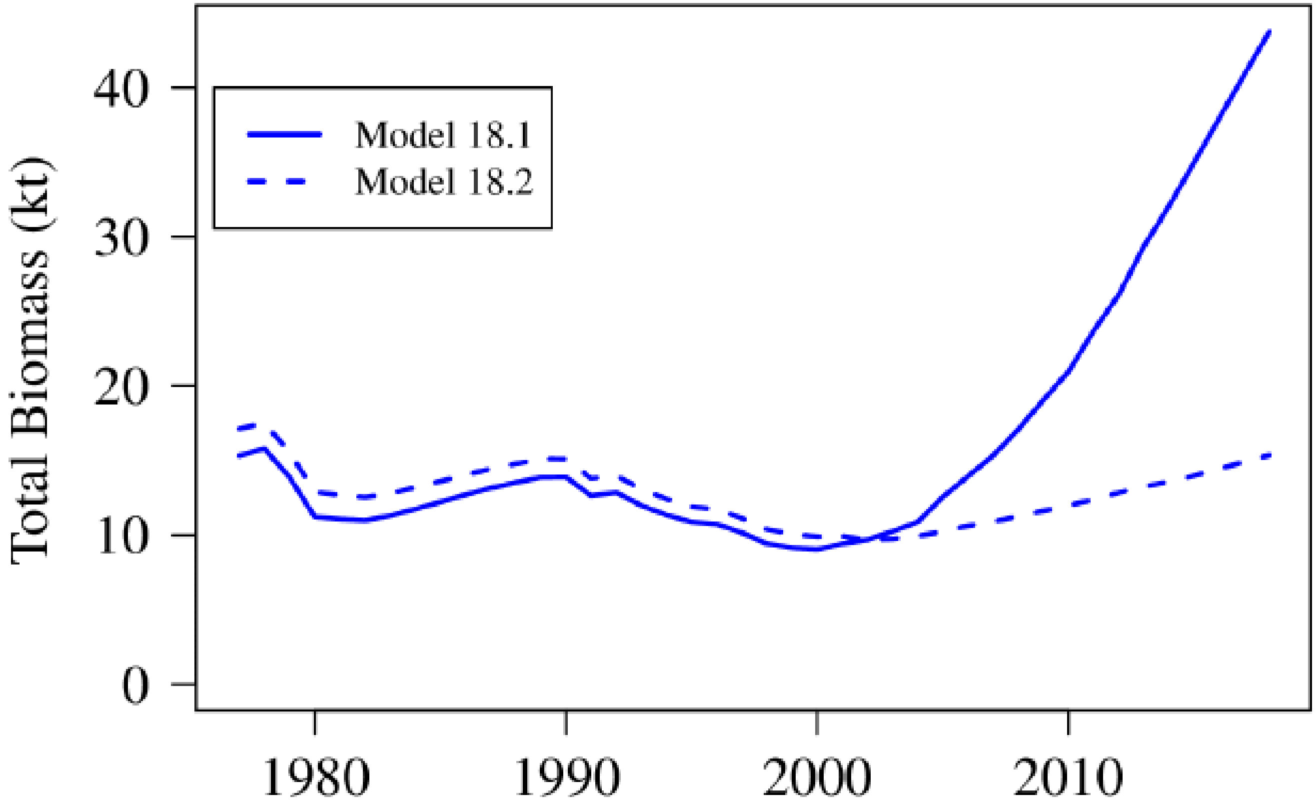
Model 18.1 Model 18.2





Blackspotted/Rougheye rockfish (6 of 15)

- Choice of model has major implications for biomass trajectory



Blackspotted/Rougheye rockfish (7 of 15)

- Paul reviewed the three recommendations from the Team to address the conflict between the biomass estimates and the composition data:
  - Update the ageing error matrix
  - Update the mean and variance of the prior for natural mortality
  - Evaluate dome-shaped selectivity for the survey
- Responses to the three suggested model specifications:
  - The CV of ageing error was increased through a likelihood-based method using data from BSAI samples
  - Both the mean and the variance of the natural mortality prior were increased, representing a range of methods and recent estimates from the literature
  - Dome-shaped selectivity was implemented using the standard double normal curve with an offset parameter

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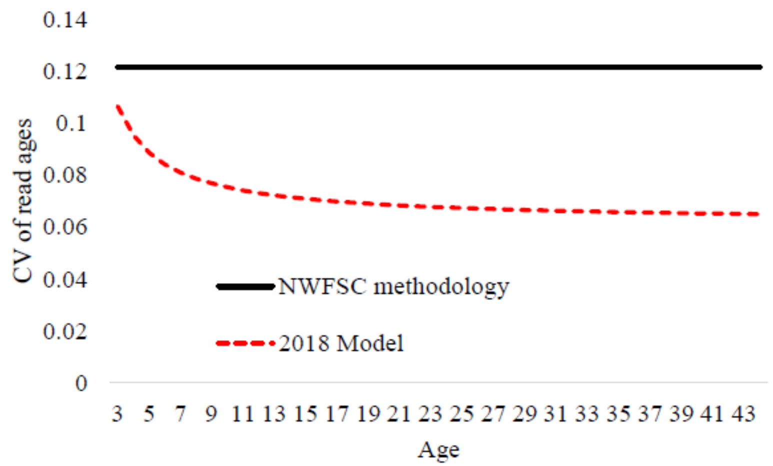
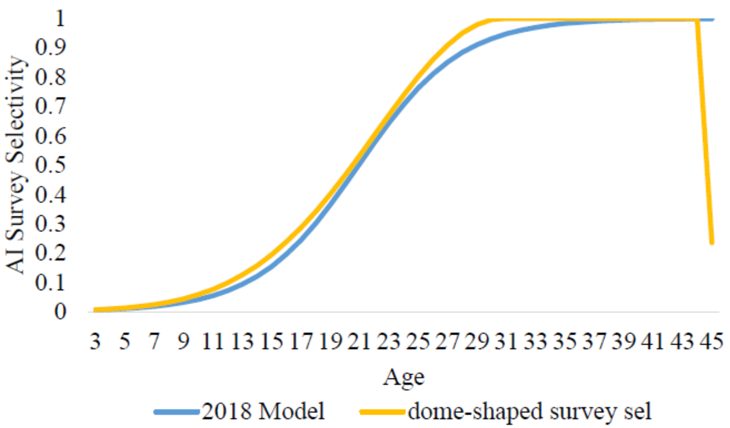
Blackspotted/Rougheye rockfish (8 of 15)

- Old M prior: $\mu=0.030$, $CV=0.05$; new M prior: $\mu=0.045$, $CV=0.10$
  - Results: point estimates ranged from $M=0.052$ to $M=0.091$
- Ageing error matrix

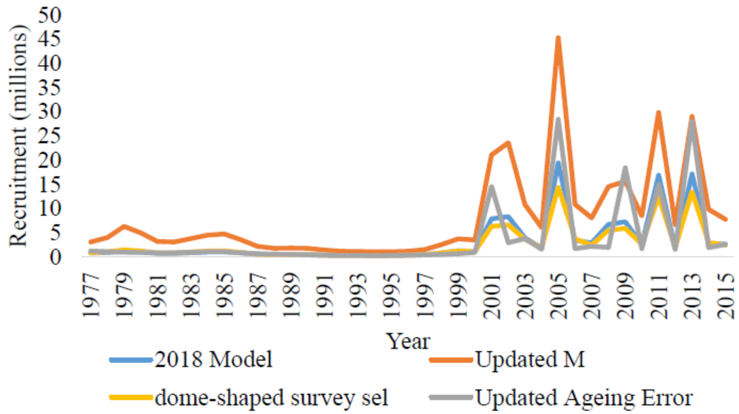


Double-normal survey selectivity

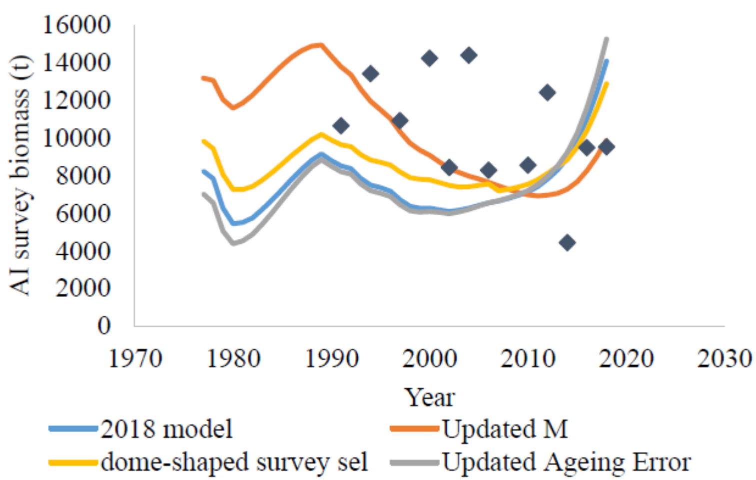


Blackspotted/Rougheye rockfish (9 of 15)

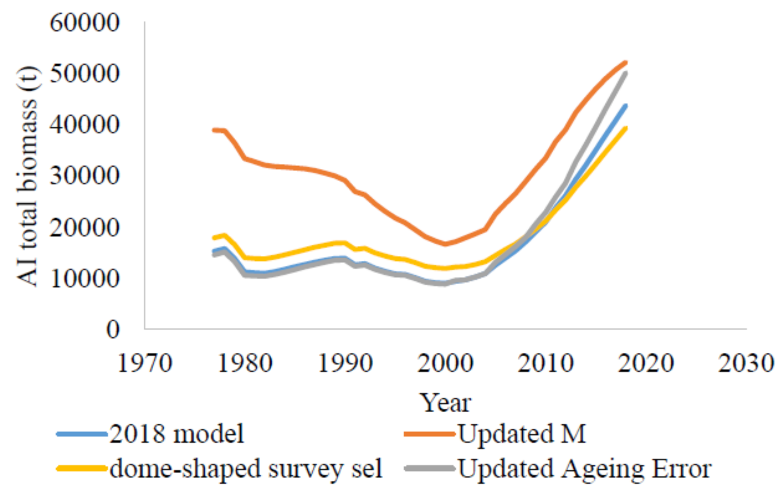
- Age 3 recruitment



- Fit to AI survey biomass



Total AI biomass



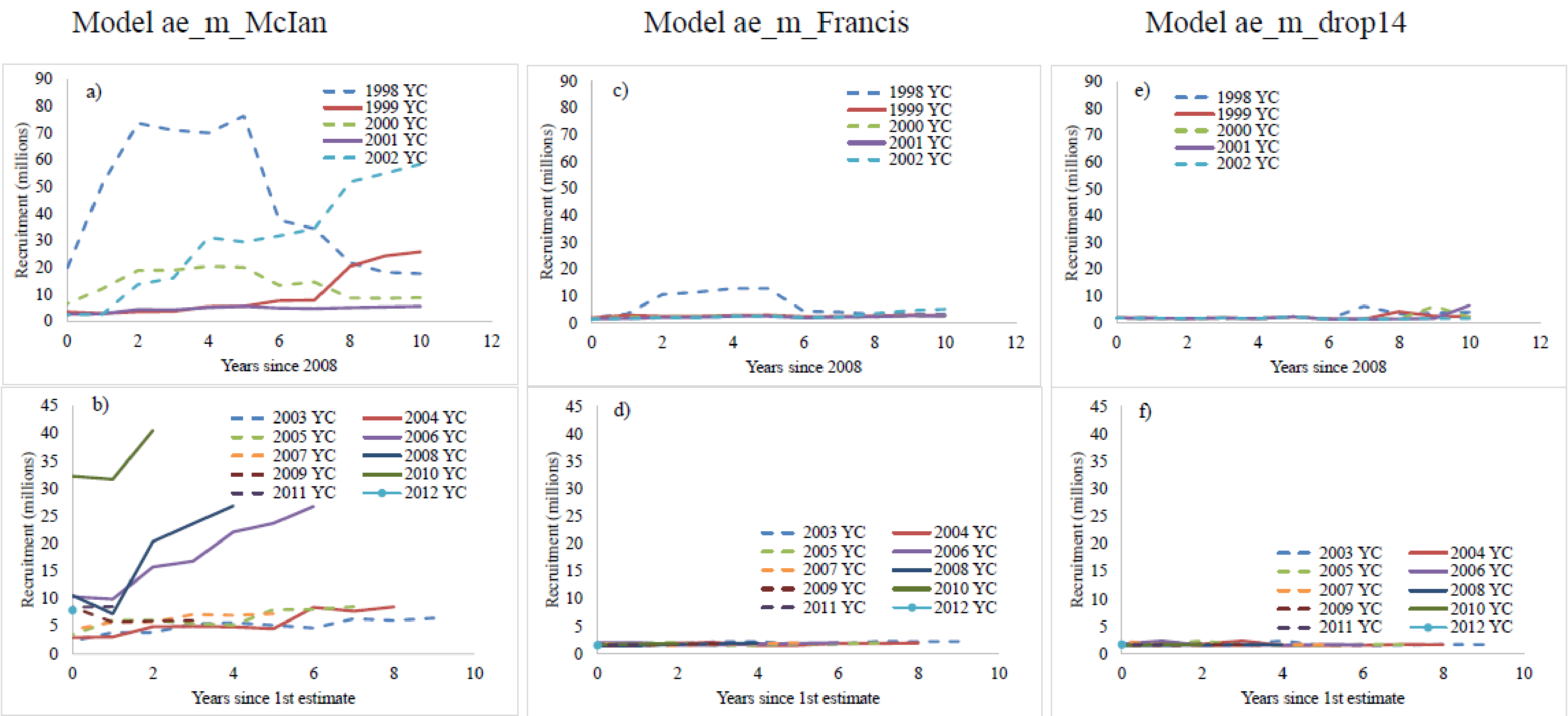
Blackspotted/Rougheye rockfish (10 of 15)

- Because none of the models achieved a substantially better fit to the survey index, three new models were then evaluated, which were the same as the base model (18.1) except that they all use the revised ageing error matrix and natural mortality prior, and:
  - ae_m_McIan: update weights based on McAllister-Ianelli approach
  - ae_m_Francis: update weights based on Francis approach
  - ae_M_drop14: same as ae_m_Francis, but last 14 cohorts = mean
- Evaluation of these three models focused on retrospective behavior, particularly retrospective estimates of recruitment (ρ shown below)

Model	*Recruitment*	*SSB*
18.1	0.59	0.77
18.2	0.22	0.47
ae_m_McIan	0.22	0.59
ae_m_Francis	0.17	0.44
ae_m_drop14	-0.16	0.36

Blackspotted/Rougheye rockfish (11 of 15)

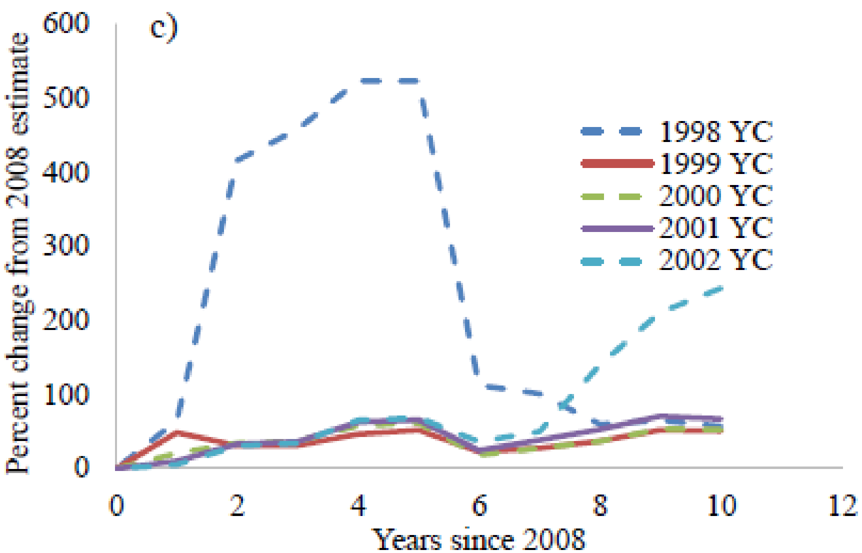
- Retrospective estimates of recruitment (1998-2012 cohorts)



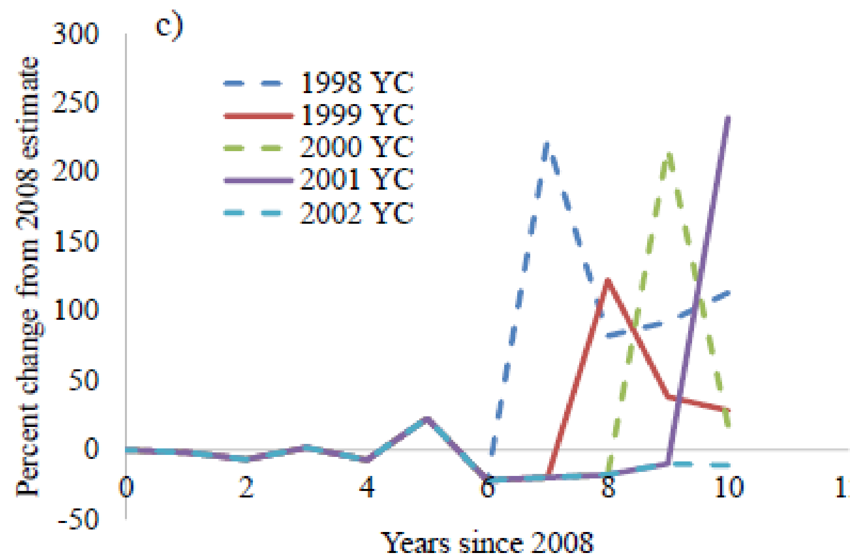
Blackspotted/Rougheye rockfish (12 of 15)

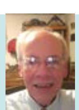
- Retrospective estimates of recruitment (1998-2002 cohorts only)

Model ae_m_Francis



Model ae_m_drop14





Blackspotted/Rougheye rockfish (13 of 15)

- Discussion:
  - Paul hopes that, as we get more survey data, we can see if the lack of older fish is a process or observation question
  - We should discount the highly uncertain recruitment estimates by giving less weight to composition data
  - A member of the public discussed recent gear and procedural changes that enable fishing shallower for Pacific ocean perch as a means to avoid blackspotted and rougheye rockfish
    - They also use excluders for halibut and cod that could be used to exclude rougheye, but mostly avoidance is achieved through shallow fishing
    - They are seeing a lot more small rougheye and blackspotted rockfish (~18cm), particularly this year
  - (Continued on next slide)

Blackspotted/Rougheye rockfish (14 of 15)

- Discussion (continued):
  - Another member of the public asked if observers are getting samples from discarded fish and if this could bias the observed composition data in the event that a certain size class gets discarded
    - A Team member responded that observers do collect samples from unsorted catch regardless of whether it is discarded or retained; it is more about the dominance of the stock in the haul
  - Paul has discussed ways for increasing the number of hauls sampled for rougheye and blackspotted since it is often not a dominant portion of the catch
  - A member of the public also responded that the industry would be happy to help with any special projects that would improve the data available from the fishery

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Blackspotted/Rougheye rockfish (15 of 15)

- Paul recommends using the updated ageing error matrix and natural mortality point estimate or prior, as these make the best use of the available data, and switching to Francis weighting, as this improves the retrospective behavior of the model, in particular the stability of the recruitment estimates
- The Team agrees with the author's recommendation to pursue the following three elements for the November 2020 assessment:
  1. Updating either the natural mortality point estimate or prior distribution using recent literature,
  2. Updating the ageing error matrix with likelihood-based estimates, and
  3. Using the Francis method for weighting composition data
- The Team also recommends exploring the updated maturity data for blackspotted and rougheye rockfish

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BSAI Northern Rock Sole (1 of 2)

- Jim Ianelli presented a brief update on northern rock sole which highlighted a coding error in last year's assessment and the plan to move back to a single model approach (rather than an ensemble) this coming November
- In preparing for this year's assessment, a datafile error was found in which the spawning month was not read in correctly
- Subsequently, the authors updated the Executive Summary table for this assessment
- The corrected values for projected total biomass and female spawning biomass were approximately 10% greater than documented last year
- The Team recommends using the corrected ABC and OFL values for BSAI northern rock sole in the 2021-2022 harvest specifications
  - (See 2021 and 2022 Harvest Specifications section)

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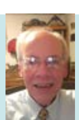


BSAI Northern Rock Sole (2 of 2)

- In 2018, the SSC asked the author to examine ensemble approaches and the authors provided a preliminary examination for this stock
- Four models were brought forward in an example ensemble, but for simplicity, a single model was selected
- The last accepted model (15.1) will be brought forward in November along with the possibility of including one or more of the individual models that were part of the ensemble

BSAI Yellowfin Sole (1 of 7)

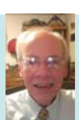
- Ingrid Spies responded to Team and SSC comments on last year's assessment and summarized differences between last year's models
- An alternative model (18.2) had been presented last November, but it had not been reviewed previously and, given that there were no conservation or other concerns indicating that an immediate switch to Model 18.2 was necessary, the Team recommended staying with the base model (18.1a) last year
- Ingrid reviewed the results of last year's model comparison:
  - The objective function for M18.2 was lower than for M18.1a
  - Mohn's ρ for M18.2 was smaller (in absolute value) than for M18.1a
  - M18.2 estimated higher biomass, OFL, and ABC than M18.1a

BSAI Yellowfin Sole (2 of 7)

- Objective function comparison:

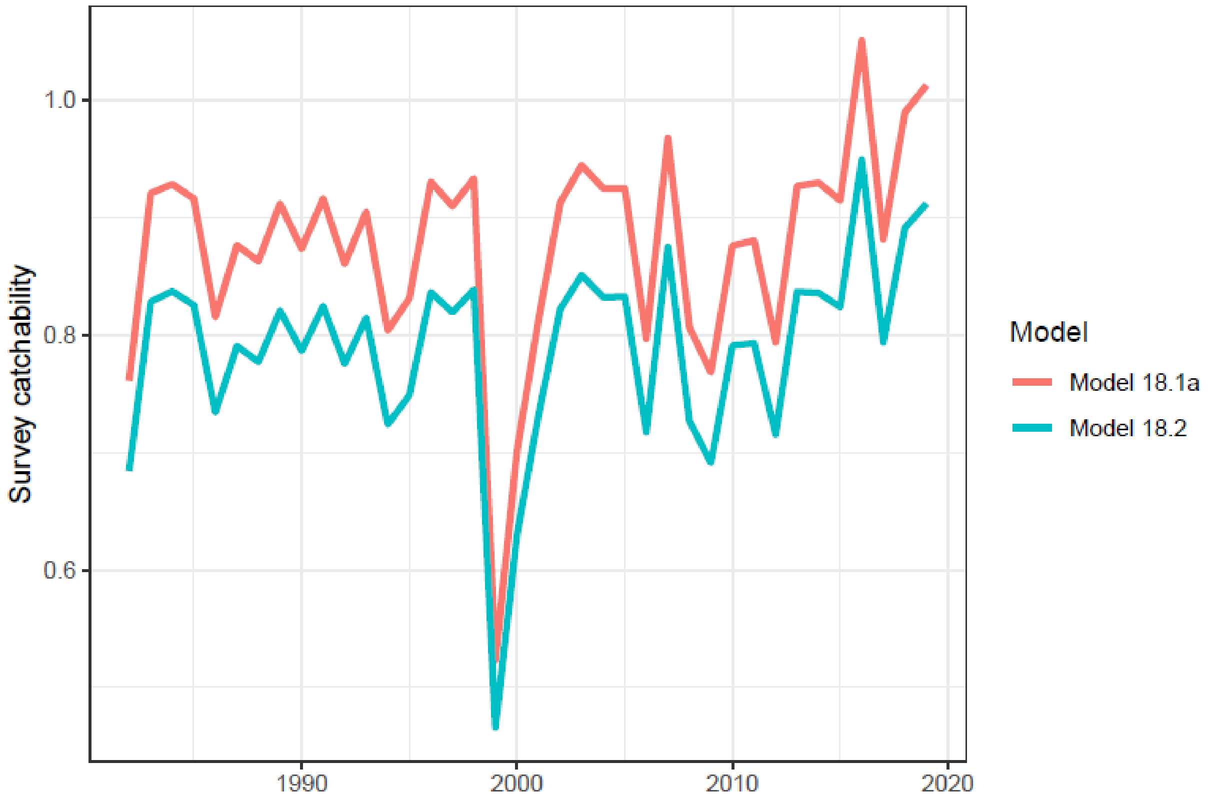
Likelihood component	Model 18.1a	Model 18.2
Survey age	589.18	560.25
Fishery age	651.62	609.64
Selectivity	63.4	62.81
Survey biomass	91.98	95.08
Recruitment	26.9	28.25
Catchability	0.0083	0.0069
Total	1423.09	1356.03

- Retrospective comparison:
  - Model 18.1a: Mohn's $\rho = -0.254$
  - Model 18.2: Mohn's $\rho = -0.219$
- Natural mortality:
  - Model 18.1a: Male $M = 0.12$ (fixed), female $M = 0.12$ (fixed)
  - Model 18.2: Male $M = 0.135$ (estimated), female $M = 0.12$ (fixed)



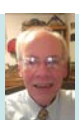
BSAI Yellowfin Sole (3 of 7)

- Catchability is lower in Model 18.2



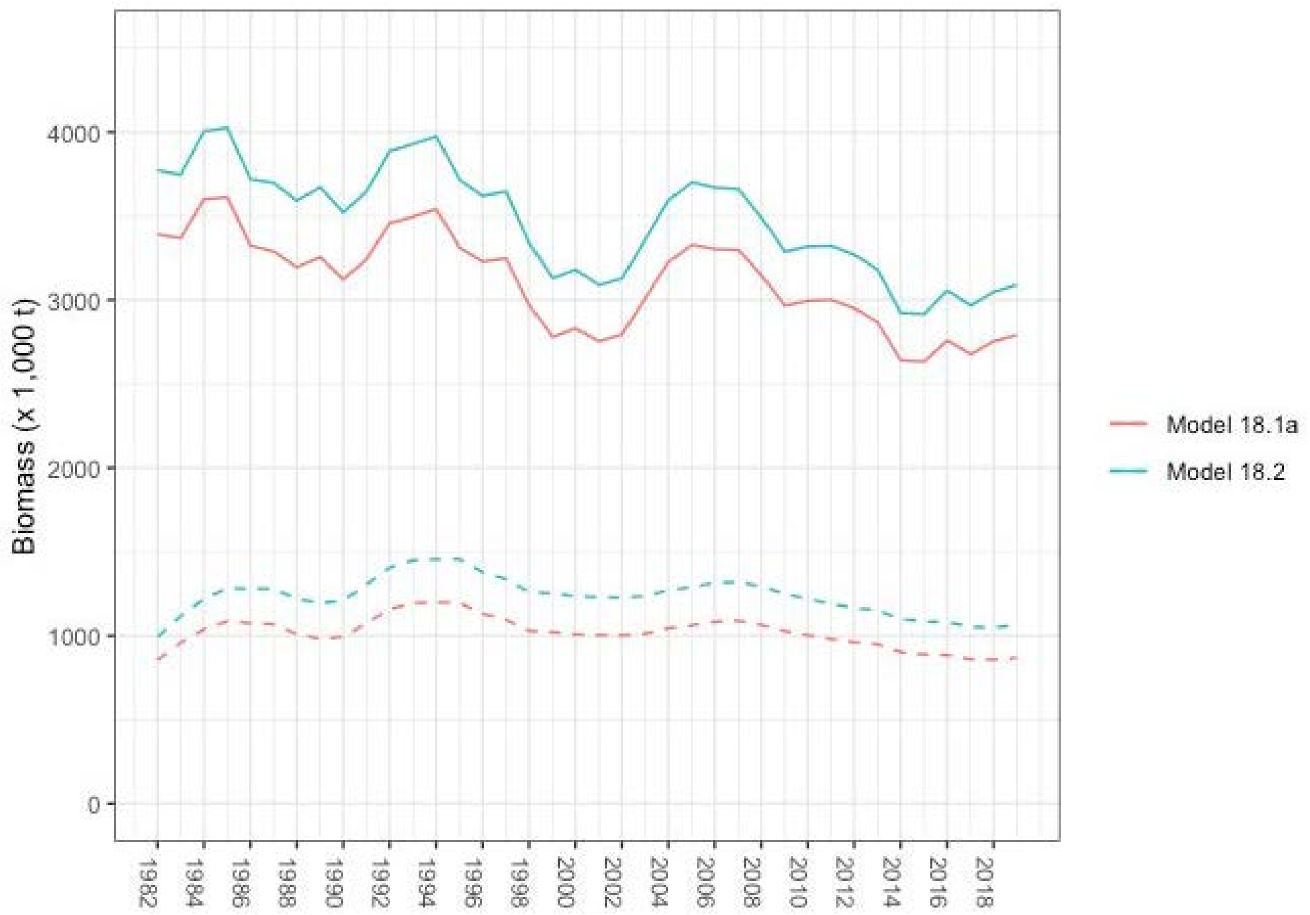
BSAI Yellowfin Sole (4 of 7)

- Differences in fit to survey index may be difficult to see



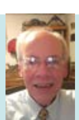
BSAI Yellowfin Sole (5 of 7)

- Estimated total biomass (solid lines), spawning biomass (dotted lines)



BSAI Yellowfin Sole (6 of 7)

- SSC (12/19): “The SSC requests the authors clarify and justify why natural mortality is estimated in the model for males, rather than for females or both sexes, and whether the value previously used for both sexes combined (M = 0.12) is appropriate for a single sex.”
- Ingrid reviewed the rationale for fixing female M at the current combined-sexes estimate of 0.12 and allowing male M > female M
  - Because there are more females than males, the combined-sexes estimate is likely more representative of females than males
  - Because there are more females than males, it is likely that males are dying faster, suggesting that they have a higher M
  - Sex-specific M is a common feature of flatfish assessments (e.g., arrowtooth flounder)
  - A previous assessment (Wilderbuer and Turnock 2009) estimated female M at 0.10 to 0.33 and male M at 0.16 to 0.51



BSAI Yellowfin Sole (7 of 7)

- The Team discussed the SSC comment further, noting that:
  - If the best estimate of M, averaged across both sexes, is 0.12; and
  - If male M is estimated in the model at a value *greater* than 0.12;
  - Then female M has to be *less* than 0.12, by about the same amount that the male M exceeds 0.12 (depending on the sex ratio)
- The Team requested that both models be included for consideration in November
- The Team recommends that, if the authors have time this year, or else in the future, they should consider estimating male M freely but with female M adjusted so that the average across sexes is equal to 0.12 (e.g., $M\_female = (0.12 - (1-P\_female) \times M\_male)/P\_female$, where P_female is the proportion of the population that is female)

EBS Pacific cod (1 of 57)

- Grant Thompson gave the EBS Pacific cod presentation
- The main document develops two versions of a possible ensemble and describes an application of cross-conditional decision analysis (CCDA)
  - The "primary ensemble" consists of 8 models:
    - 2 models *do not* include a separate NBS survey
    - 6 models *do* include a separate NBS survey
      - These include a prior distribution for NBS survey *Q*
  - The "alternative ensemble" contains the same models as the primary, *except that* the prior distribution for NBS survey *Q* is dropped from the 6 models that *do* include a separate NBS survey
- A second document ("An alternative version of the base model for EBS Pacific cod with constrained catchability") describes a model run requested by an industry representative

EBS Pacific cod (2 of 57)

- A total of 24 Team and SSC comments were acknowledged
- Breakdown by commenter and general or specific to this assessment:

Commenter	General	Specific	Combined
JPT	2	0	2
BPT	0	9	9
SSC	4	9	13
Total	6	18	24

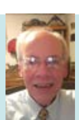
- Breakdown by general subject and where comments will be addressed:

	Where addressed		
Subject	Sept. 2020	Nov. 2020	2021 (CIE)
Risk table	0	7	0
Other	14	0	3

NOAA FISHERIES

EBS Pacific cod (3 of 57)

- Base model:
  - Sexes combined
  - One season per year
  - Natural mortality (constant across age and time) freely estimated
  - Mean length at age follows a Richards growth function:
    - Base value of length at age 1.5 freely estimated
      - With constrained annual deviations on the log scale
    - Von Bertalanffy (Brody) growth coefficient freely estimated
    - Asymptotic length freely estimated
    - Richards growth coefficient freely estimated
  - SD of L_at_A varies linearly with L_at_A, parameters freely estimated
  - Weight at length varies annually, estimated outside the model
  - (Continued on next 4 slides)



EBS Pacific cod (4 of 57)

- Base model (continued):
  - Maturity at length (constant across time) estimated outside the model
  - Mean ageing error varies with age, freely estimated within each block:
    - 1977-2007
    - 2008-present
  - Recruitment is independent of stock size:
    - Mean freely estimated within each block:
      - Pre-1977
      - 1977-present
    - With constrained annual deviations on the log scale
  - (Continued on next 3 slides)

NOAA FISHERIES

EBS Pacific cod (5 of 57)

- Base model (continued):
  - One survey, covering the EBS and NBS combined
    - Base value of log catchability freely estimated
      - With constrained annual deviations
    - Size-based, double-normal selectivity, with parameters as follow:
      - Base value of first size with selectivity=1 freely estimated
        - With constrained annual deviations on the log scale
      - Base value of log of SD for 1st normal pdf freely estimated
        - With constrained annual deviations
      - Other 4 parameters fixed at values that assure asymptotic selectivity with negligible value at minimum size (4 cm)
  - (Continued on next 2 slides)

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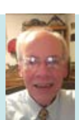

EBS Pacific cod (6 of 57)

- Base model (continued):
  - One fishery, covering the EBS and NBS combined
    - Size-based, double-normal selectivity, with parameters as follow:
      - First size with selectivity=1 freely estimated
      - Logit of size range with selectivity=1 freely estimated
      - Base value of log of SD for 1st normal pdf freely estimated
        - With constrained annual deviations
      - Log of standard deviation for 2nd normal pdf freely estimated
      - Logit of selectivity at minimum size fixed at -10.0
      - Base value of logit of selectivity at max. size freely estimated
        - With constrained annual deviations
  - (Continued on next slide)

EBS Pacific cod (7 of 57)

- Base model (continued):
  - Input sample sizes ($Nsamp$) for compositional data range between zero and an initial number ($Ninit$) according to a formula involving a time-invariant parameter $ln\theta$, freely estimated for each of the compositional data types (fishery size composition data, survey size composition data, and survey age composition data), where:
    - For survey compositional data, $Ninit$ = number of sampled hauls
    - For fishery compositional data, $Ninit$ = number of sampled hauls rescaled so that the average $Ninit$ for the fishery is equal to the average $Ninit$ for the survey (so that, on average, fishery data are emphasized equally with survey data)

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EBS Pacific cod (8 of 57)

- The primary ensemble was based on a factorial design
- Four topics from Team/SSC comments were interpreted as factors:

Topic	Comment(s)	Binary factor: Does the model...
M19.12 over-parameterization	SSC9	...allow time-varying survey catchability (*Q*)?
Spatial structure	BPT2	...treat the EBS and NBS as separate areas?
Hypotheses #2 and #3	BPT2, BPT5, SSC7	...use area-specific surveys?
Movement	BPT5, SSC11	...incorporate explicit inter-area movement?

- Suggests 2^4=16 models, but note that some combinations are infeasible
- This leaves the following 8 models (color = constrained to be the same):

Time-varying *Q*?	No				Yes			
Separate areas?	No		Yes		No		Yes	
Separate surveys?	No	Yes	Yes		No	Yes	Yes	
Movement?	No		No	Yes	No		No	Yes
Temporary name	A1	B1	C1	D1	A2	B2	C2	D2

  - Model A2 is the base model (19.12)

EBS Pacific cod (9 of 57)

- Two-area models are complicated!
  - Require at least one parameter specifying allocation of recruits
  - If movement is allowed, require at least seven other parameters
    - Movement parameterization in SS described in Attachment 2.1.1
    - Two parameters for EBS→NBS, two others for NBS→EBS
    - These define ramps from age 2 to age 7 (first move at age 2)
  - If distribution or movement is time-varying, more parameters required
    - Tried annual random deviations (failed)
    - Instead, deterministic linkage to environmental covariates tried
      - For distribution and EBS→NBS, sea ice extent fit best
      - For NBS→EBS, North Pacific Index (NPI) fit best

NOAA FISHERIES

EBS Pacific cod (10 of 57)

- Because no fishery size composition or age composition data are available for the NBS, all NBS fishery selectivity parameters were assumed to “mirror” their EBS counterparts
- NBS catchability
  - As models were being developed, no NBS catch data were available
  - For the models that treat the EBS and NBS as separate areas, this made estimation of $\ln(Q)$ for the NBS survey difficult
  - Therefore, those models included an informative prior distribution
  - More specifically: normal prior with unit variance and mean equal to the point estimate of the EBS survey $\ln(Q)$
  - This involved tuning the prior mean iteratively for each such model
  - Although the two models that use area-specific surveys without separate areas appeared to be capable of estimating $\ln(Q)$ without the prior distribution, it was used for those models also

EBS Pacific cod (11 of 57)

- Counts of parameters, for data through 2019, are as follow:

Time-varying Q?	No				Yes			
Separate areas?	No		Yes		No		Yes	
Separate surveys?	No	Yes	Yes		No	Yes	Yes	
Movement?	No		No	Yes	No		No	Yes
Temporary name	A1	B1	C1	D1	A2	B2	C2	D2
True parameters	25	30	37	46	25	30	37	46
Annual deviations	267	267	267	267	305	343	343	343
Total parameters	292	297	304	313	330	373	380	389

- Counts of "true" parameters are the same in both halves of the table
  - Increase L to R within a given half
- Counts of annual devs are equal in 1st half, increase L to R in 2nd half
- Counts of total parameters increase L to R across whole table
- Text contains detailed descriptions of differences between models

EBS Pacific cod (12 of 57)

- Alternative ensemble:
  - After the models in the primary ensemble had already been largely developed, a small amount of NBS catch data became available
  - It might be possible to estimate NBS survey $\ln(Q)$ in the 4 models that treat the EBS and NBS as separate areas after all
  - Prior-less analogues were therefore developed for all 6 models that used separate *surveys* (not just the 4 that used separate *areas*)
  - These 6 models, together with Models A1 and A2 from the primary ensemble, can be considered to constitute an alternative ensemble
  - Note that, when the prior distribution on NBS $\ln(Q)$ is removed from Model B2, it is identical to Model 19.15
  - Results in this presentation will focus on the primary ensemble, with a brief set of results for the alternative ensemble

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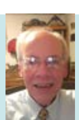
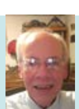


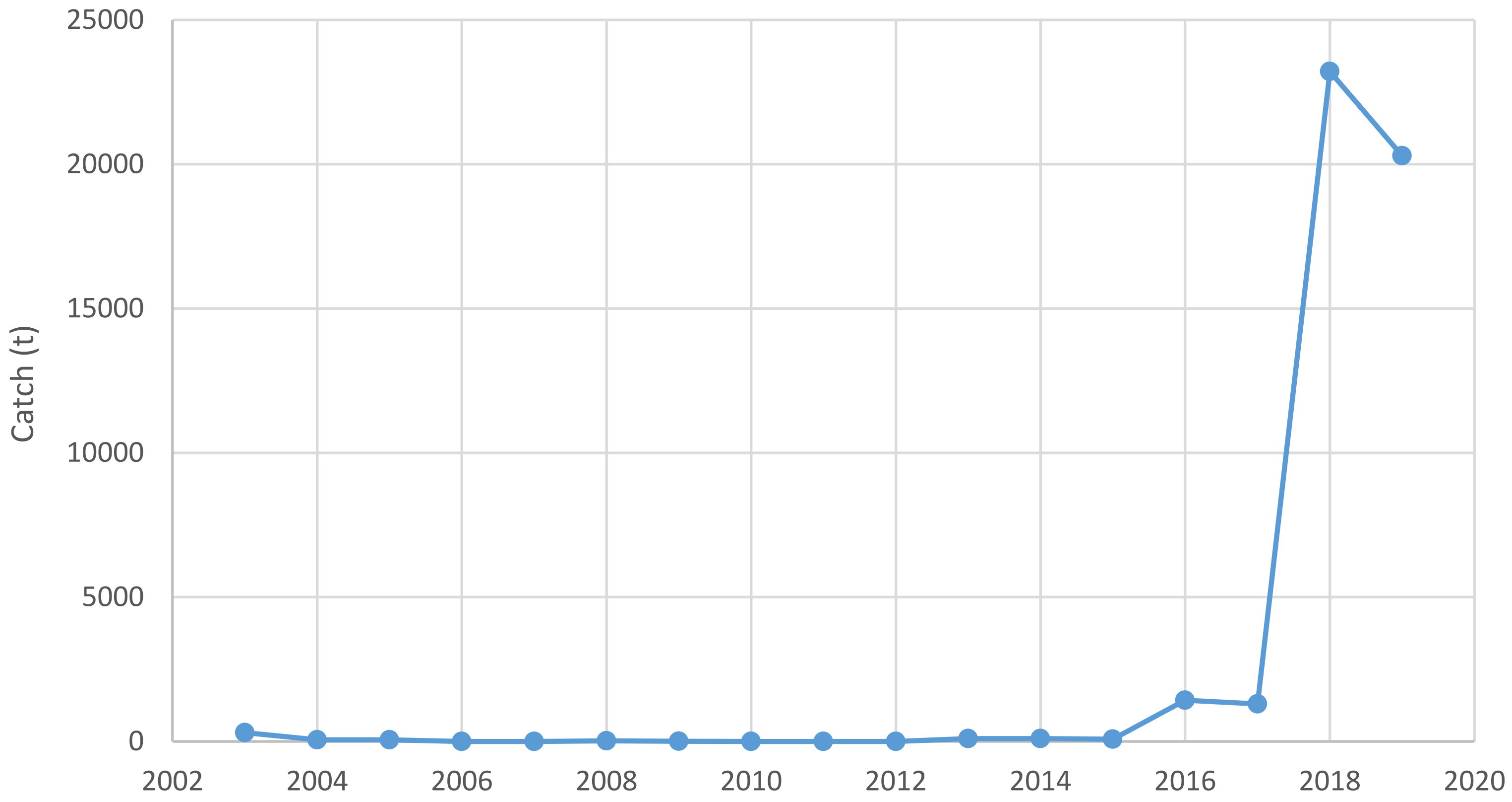
EBS Pacific cod (13 of 57)

- All data are the same as in last year's assessment, except:
  - A small change was made in the method used to compile the fishery size composition data
    - Used in all models
  - NBS catch time series was added
    - Used in the four 2-area models
  - Time series for a pair of environmental covariates were added
    - Used in the two models that incorporate movement
- As in last year's assessment, survey index and age composition data came from VAST runs, but VAST specifications are now explicitly documented, per SSC request



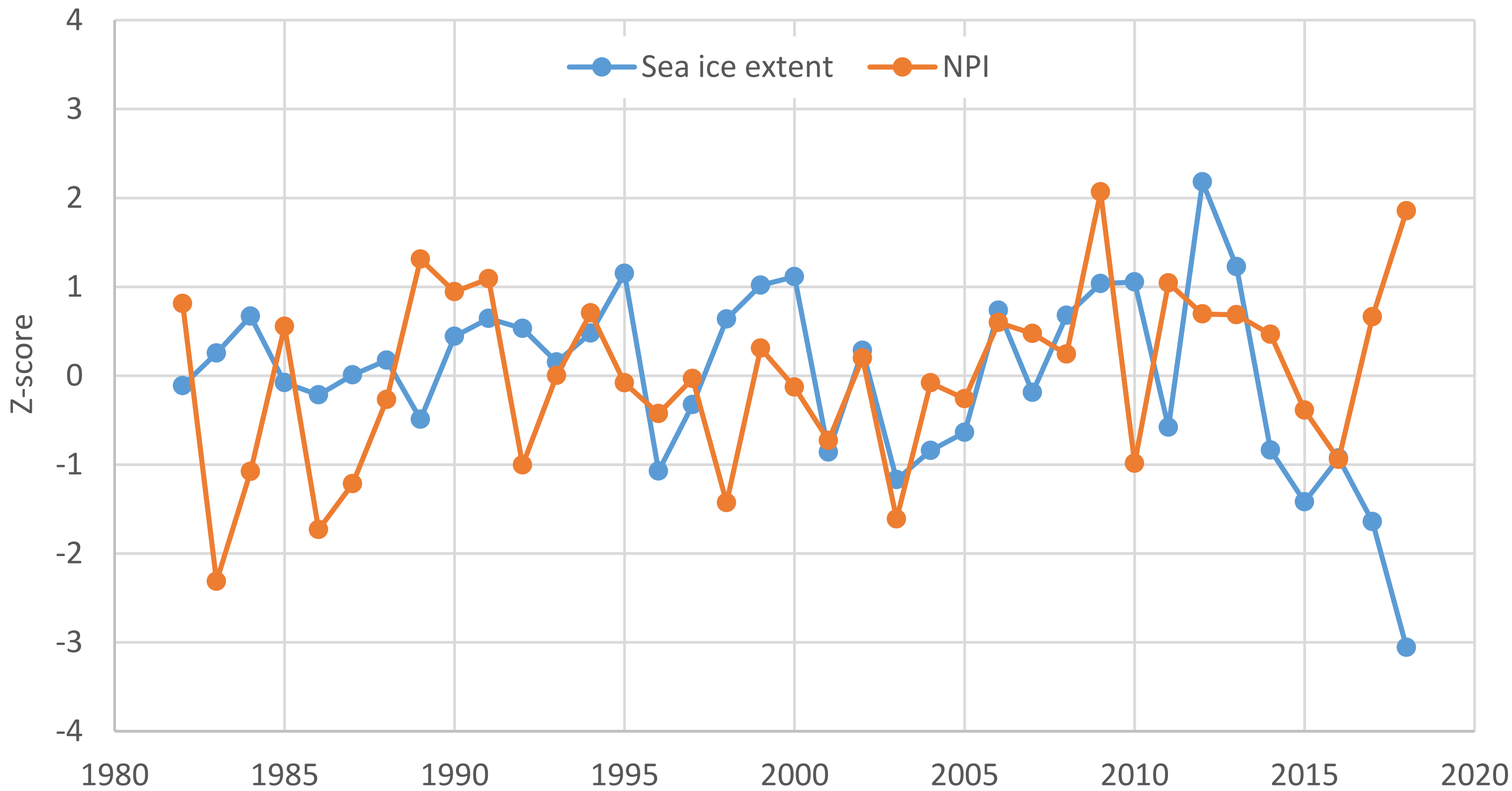
EBS Pacific cod (14 of 57)

- (New) NBS catch time series (Catch-In-Areas not available before 2003)



EBS Pacific cod (15 of 57)

- (New) sea ice extent and NPI, expressed as z-scores



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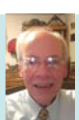
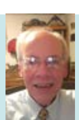
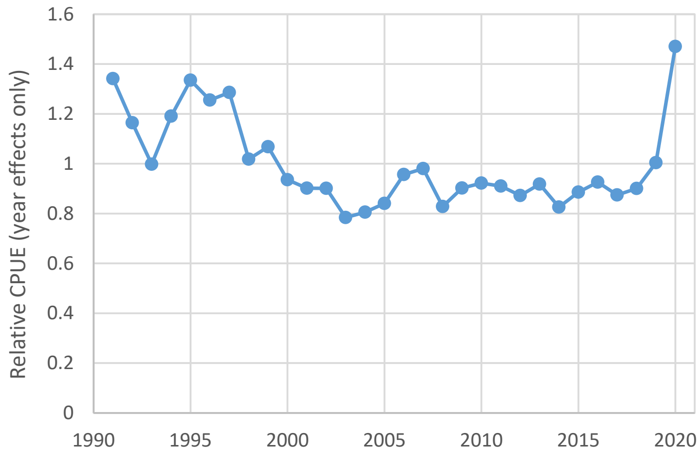


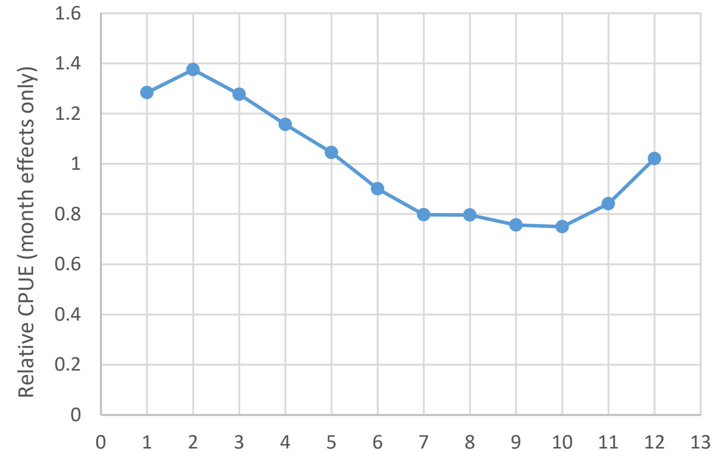
EBS Pacific cod (16 of 57)

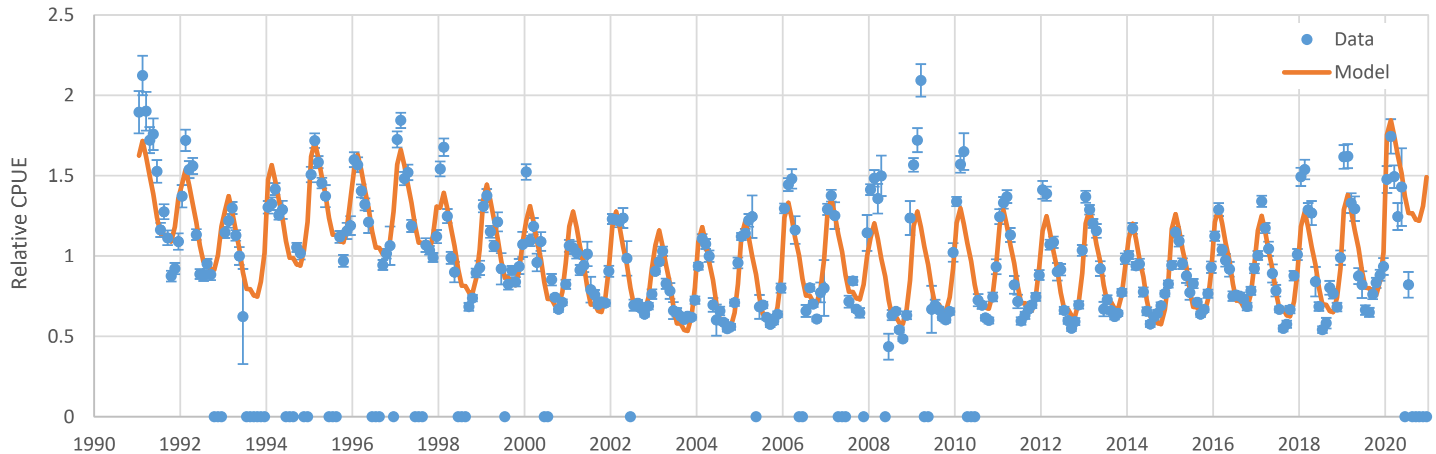
- Preview of data changes anticipated for final draft:
  - Environmental covariate time series (existing z-scores will change)
    - Sea ice extent z-scores: -2.114 (2019), -0.763 (2020)
    - NPI z-scores: 0.245 (2019), 1.284 (2020)
  - Size composition
    - Fishery size compositions have been updated through 8/20
      - Mode has been shifting rightward each of last 3 years
      - Few age 2 fish are taken, but some hint of strong 2018 cohort
    - NBS survey time series currently includes a record for 2018
      - This will likely be dropped, due to unbalanced design
  - Age composition from 2019 EBS survey
    - Confirms strength of 2018 cohort implied by size composition

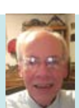


- Longline fishery CPUE (provided for context only; not used in models)





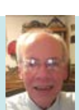




EBS Pacific cod (18 of 57)

- Final model names:
  - Based on the spawning biomass time series, ADSB values...
  - ... < 0.1 imply *minor* changes from the base model (19.12), and so get names of the form “19.12x,” where x is a letter
  - ... ≥ 0.1 imply *major* changes from the base model (19.12), and so get names of the form “20.j,” where j is a number

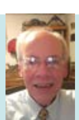
Time-varying *Q* ?	No				Yes			
Separate areas?	No		Yes		No		Yes	
Separate surveys?	No	Yes	Yes		No	Yes	Yes	
Movement?	No		No	Yes	No		No	Yes
Temporary name	A1	B1	C1	D1	A2	B2	C2	D2
ADSB	0.0755	0.0981	1.2983	0.0732	n/a	0.0775	0.1692	0.3918
Final name	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.2	20.3



EBS Pacific cod (19 of 57)

- Common time-invariant parameters (T2.1.3a, slide 1 of 2)

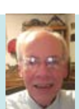
Time-varying *Q*?	No								Yes							
Separate areas?	No				Yes				No				Yes			
Separate surveys?	No		Yes		Yes				No		Yes		Yes			
Movement?	No				No		Yes		No				No		Yes	
Model	M19.12a		M19.12b		M20.1		M19.12c		M19.12		M19.12d		M20.2		M20.3	
Parameter	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
Natural_mortality	0.358	0.011	0.372	0.012	0.372	0.011	0.332	0.011	0.348	0.013	0.358	0.012	0.374	0.011	0.344	0.013
L_at_1.5_base	14.815	0.398	14.799	0.400	14.794	0.404	14.805	0.400	14.894	0.401	14.903	0.418	14.807	0.416	14.594	0.400
L_infinity	113.4	3.123	114.2	3.340	112.9	3.189	118.2	4.594	115.1	3.315	114.6	3.265	116.5	4.188	111.2	3.467
VonBert_K	0.117	0.009	0.117	0.010	0.118	0.010	0.106	0.011	0.114	0.009	0.117	0.009	0.108	0.011	0.123	0.011
Richards_coef	1.444	0.042	1.435	0.045	1.444	0.043	1.480	0.047	1.445	0.042	1.419	0.043	1.479	0.047	1.438	0.046
SD_len_at_1	3.493	0.067	3.483	0.066	3.466	0.066	3.481	0.066	3.510	0.066	3.473	0.065	3.485	0.067	3.490	0.065
SD_len_at_20	9.905	0.383	9.945	0.397	10.136	0.387	10.153	0.446	9.705	0.388	9.882	0.391	10.014	0.430	9.397	0.392
RecrDist_NBS_base					-0.676	0.759	-3.037	0.245					-3.345	0.177	-1.690	0.213
AgeBias_at_1_1977_2007	0.339	0.017	0.349	0.015	0.349	0.015	0.347	0.015	0.337	0.017	0.347	0.015	0.348	0.014	0.346	0.015
AgeBias_at_1_2008_2019	0.014	0.025	-0.002	0.025	0.001	0.024	0.009	0.023	0.019	0.025	0.002	0.026	0.004	0.023	0.008	0.024
AgeBias_at_20_1977_2007	0.859	0.221	0.776	0.205	0.772	0.198	0.843	0.200	0.898	0.221	0.804	0.204	0.825	0.200	0.954	0.205
AgeBias_at_20_2008_2019	-1.532	0.316	-1.697	0.325	-1.646	0.313	-1.698	0.305	-1.708	0.326	-1.930	0.345	-1.790	0.324	-2.179	0.365
ln(Recr_ave_1977_2018)	13.208	0.097	13.271	0.099	13.678	0.271	12.991	0.089	13.121	0.105	13.144	0.103	13.313	0.097	13.185	0.123
ln(Recr_ave_pre1977_offset)	-0.903	0.202	-0.885	0.204	-0.862	0.206	-0.986	0.181	-0.925	0.195	-0.909	0.199	-0.839	0.208	-0.919	0.180
InitF_main_fsh	0.122	0.038	0.127	0.040	0.119	0.037	0.147	0.046	0.127	0.039	0.134	0.043	0.114	0.035	0.173	0.056
InitF_NBS_fsh					0.000	0.000	0.000	0.000					0.000	0.000	0.000	0.000



EBS Pacific cod (20 of 57)

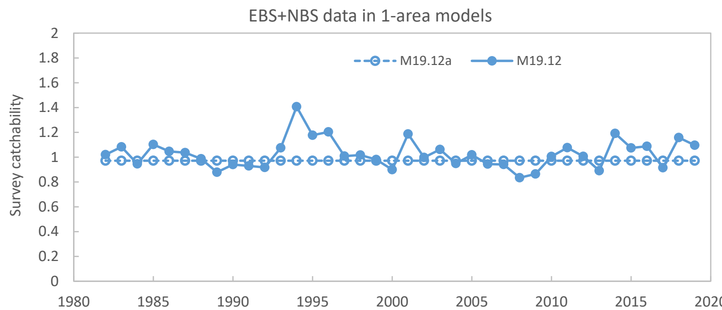
- Common time-invariant parameters (T2.1.3a, slide 2 of 2)

Time-varying *Q* ?	No								Yes							
Separate areas?	No				Yes				No				Yes			
Separate surveys?	No		Yes		Yes				No		Yes		Yes			
Movement?	No				No		Yes		No				No		Yes	
Model	M19.12a		M19.12b		M20.1		M19.12c		M19.12		M19.12d		M20.2		M20.3	
Parameter	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
lnQ_main_srv_base	-0.029	0.063	-0.111	0.066	-0.102	0.057	0.172	0.059	0.019	0.069	-0.037	0.068	-0.116	0.064	0.261	0.065
lnQ_NBS_srv_base			-0.788	0.105	-0.747	0.767	-0.260	0.108			-1.842	0.254	0.827	0.325	-1.466	0.284
Main_fsh_sel_PeakStart	74.984	0.039	75.220	0.598	74.971	0.196	74.982	0.528	74.985	0.035	74.986	0.030	74.931	0.520	75.968	0.590
Main_fsh_sel_logitPeakWidth	-9.765	6.733	-5.712	18.562	-9.439	14.705	0.208	0.465	-9.782	6.361	-9.761	6.755	0.469	0.593	0.097	0.522
Main_fsh_sel_lnSD1_base	5.908	0.029	5.913	0.039	5.898	0.029	5.907	0.039	5.911	0.028	5.905	0.027	5.896	0.037	5.950	0.039
Main_fsh_sel_lnSD2	-9.867	4.111	-1.410	8.489	-9.091	18.173	4.707	1.251	-9.883	3.621	-9.886	3.556	4.345	1.767	4.827	1.357
Main_fsh_sel_logitEnd_base	2.135	0.313	1.987	0.301	3.114	0.786	-3.140	3.513	2.225	0.348	2.084	0.296	-2.647	3.443	-2.855	3.301
Main_srv_sel_PeakStart_base	20.923	0.779	21.036	0.801	20.986	0.794	21.110	0.811	20.817	0.807	20.699	0.831	20.970	0.819	21.827	0.905
Main_srv_sel_lnSD1_base	3.529	0.151	3.532	0.151	3.522	0.151	3.535	0.154	3.503	0.156	3.460	0.161	3.513	0.155	3.613	0.157
NBS_srv_sel_PeakStart			79.998	0.072	74.051	8.817	15.530	1.383			79.997	0.113	68.696	7.855	14.453	1.161
NBS_srv_sel_lnSD1			7.784	0.139	8.881	0.882	2.067	0.640			7.821	0.146	7.925	0.490	1.750	0.675
lnDM_size_main_fish	9.989	0.337	9.989	0.351	9.989	0.358	9.990	0.325	9.989	0.355	9.989	0.358	9.990	0.347	9.989	0.343
lnDM_size_main_sur	9.984	0.520	9.984	0.524	9.985	0.499	9.984	0.496	9.984	0.540	9.984	0.522	9.985	0.470	9.984	0.482
lnDM_size_NBS_sur			9.656	9.374	9.717	7.603	9.923	2.327			9.756	7.420	9.712	8.223	9.935	1.982
lnDM_age_main_srv	-0.006	0.213	0.281	0.252	0.444	0.278	0.478	0.280	0.075	0.225	0.432	0.274	0.522	0.297	0.541	0.282
lnDM_age_NBS_srv			0.213	0.568	-1.511	0.343	0.381	1.052			0.383	0.609	-1.342	0.362	-0.201	0.578



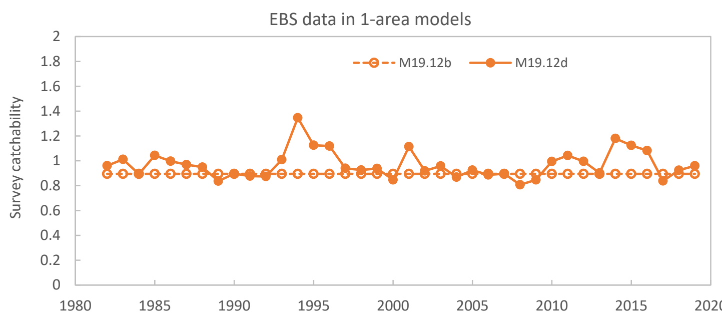
EBS Pacific cod (21 of 57)

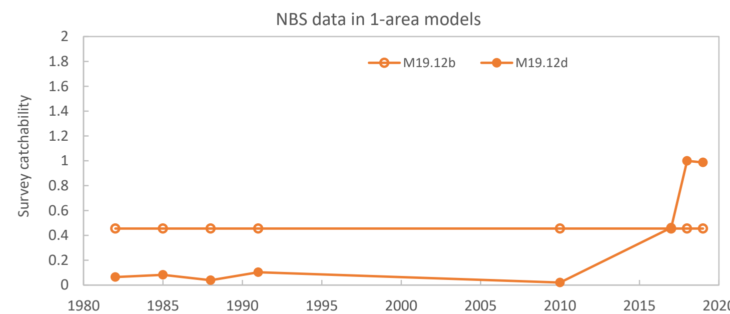
- Survey catchability (F2.1.5)

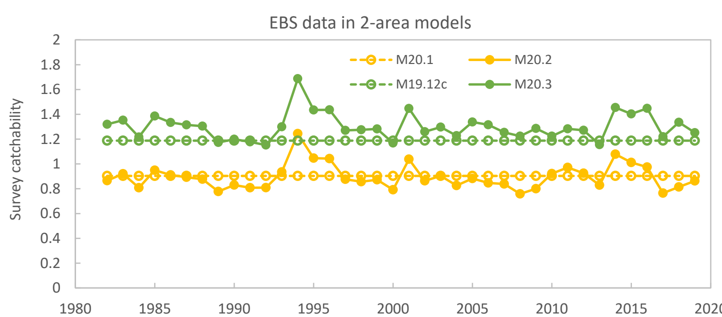


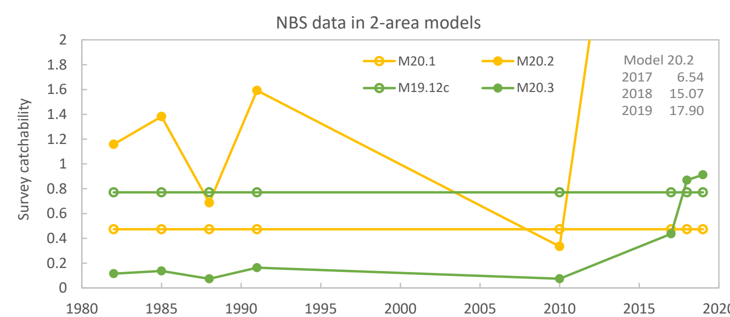
blue = 1-area models *without* separate surveys
orange = 1-area models *with* separate surveys
yellow = 2-area models *without* movement
green = 2-area models *with* movement

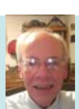
dashed lines with open circles = models *without* time-varying Q
solid lines with filled circles = models *with* time-varying Q











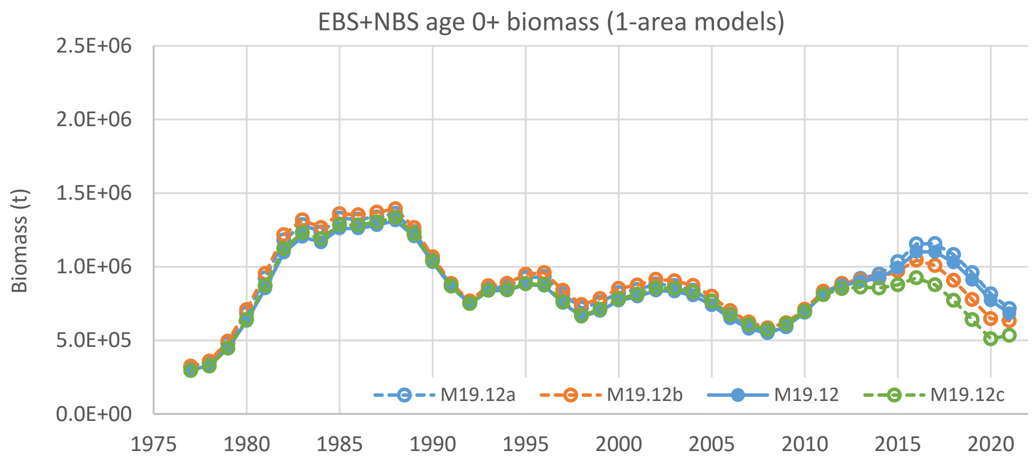
EBS Pacific cod (22 of 57)

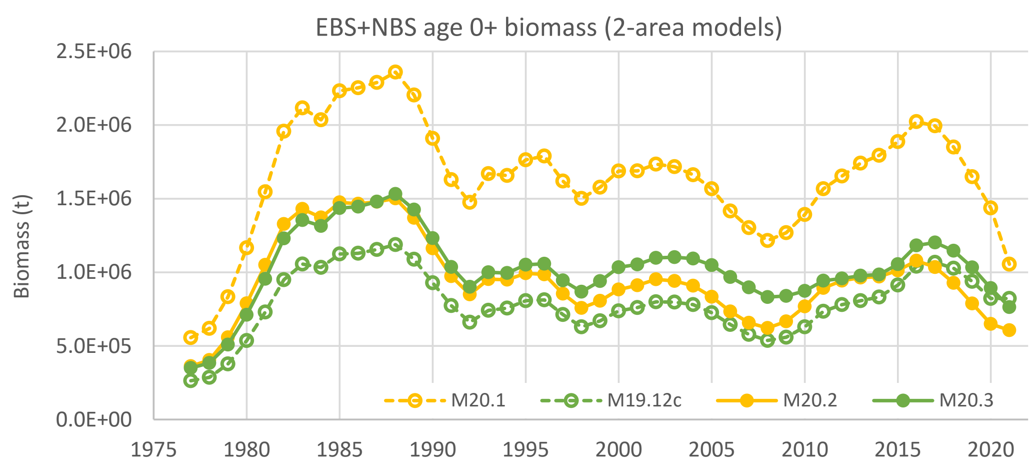
- Movement probabilities (excerpt from T2.1.6)

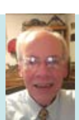
Year	Src.	Dst.	M19.12c						M20.3					
			2	3	4	5	6	7+	2	3	4	5	6	7+
2007	EBS	NBS	0.046	0.009	0.002	0.000	0.000	0.000	0.213	0.025	0.002	0.000	0.000	0.000
	NBS	EBS	0.019	0.034	0.061	0.106	0.180	0.288	0.007	0.013	0.022	0.037	0.062	0.103
2008	EBS	NBS	0.010	0.001	0.000	0.000	0.000	0.000	0.113	0.007	0.000	0.000	0.000	0.000
	NBS	EBS	0.005	0.012	0.026	0.056	0.119	0.234	0.002	0.004	0.009	0.021	0.047	0.103
2009	EBS	NBS	0.006	0.000	0.000	0.000	0.000	0.000	0.085	0.004	0.000	0.000	0.000	0.000
	NBS	EBS	0.993	0.985	0.968	0.931	0.860	0.735	0.994	0.976	0.903	0.683	0.333	0.104
2010	EBS	NBS	0.005	0.000	0.000	0.000	0.000	0.000	0.084	0.004	0.000	0.000	0.000	0.000
	NBS	EBS	0.000	0.000	0.000	0.002	0.010	0.065	0.000	0.000	0.000	0.001	0.010	0.102
2011	EBS	NBS	0.087	0.027	0.008	0.002	0.001	0.000	0.276	0.044	0.006	0.001	0.000	0.000
	NBS	EBS	0.318	0.342	0.367	0.393	0.419	0.446	0.212	0.185	0.161	0.139	0.120	0.103
2012	EBS	NBS	0.001	0.000	0.000	0.000	0.000	0.000	0.033	0.001	0.000	0.000	0.000	0.000
	NBS	EBS	0.061	0.090	0.131	0.186	0.257	0.345	0.029	0.037	0.048	0.063	0.081	0.103
2013	EBS	NBS	0.004	0.000	0.000	0.000	0.000	0.000	0.073	0.003	0.000	0.000	0.000	0.000
	NBS	EBS	0.058	0.087	0.127	0.182	0.254	0.343	0.027	0.036	0.047	0.061	0.080	0.103
2014	EBS	NBS	0.129	0.054	0.022	0.008	0.003	0.001	0.323	0.064	0.010	0.001	0.000	0.000
	NBS	EBS	0.018	0.033	0.059	0.104	0.177	0.286	0.007	0.012	0.021	0.036	0.062	0.103
2015	EBS	NBS	0.290	0.230	0.180	0.138	0.105	0.079	0.441	0.139	0.032	0.007	0.001	0.000
	NBS	EBS	0.000	0.001	0.002	0.009	0.035	0.125	0.000	0.000	0.001	0.004	0.022	0.103
2016	EBS	NBS	0.148	0.068	0.030	0.013	0.006	0.002	0.340	0.072	0.012	0.002	0.000	0.000
	NBS	EBS	0.000	0.000	0.000	0.002	0.011	0.068	0.000	0.000	0.000	0.001	0.011	0.102
2017	EBS	NBS	0.375	0.360	0.346	0.331	0.317	0.304	0.489	0.184	0.050	0.012	0.003	0.001
	NBS	EBS	0.052	0.079	0.118	0.172	0.245	0.337	0.024	0.032	0.043	0.058	0.078	0.103
2018	EBS	NBS	0.876	0.969	0.993	0.998	1.000	1.000	0.767	0.650	0.513	0.374	0.253	0.161
	NBS	EBS	0.978	0.960	0.929	0.878	0.797	0.682	0.978	0.931	0.804	0.556	0.276	0.104
2019	EBS	NBS	0.018	0.020	0.023	0.026	0.029	0.033	0.187	0.019	0.002	0.000	0.000	0.000
	NBS	EBS	0.001	0.004	0.010	0.028	0.075	0.185	0.000	0.001	0.004	0.011	0.035	0.103

EBS Pacific cod (23 of 57)

- Age 0+ biomass time series, combined areas

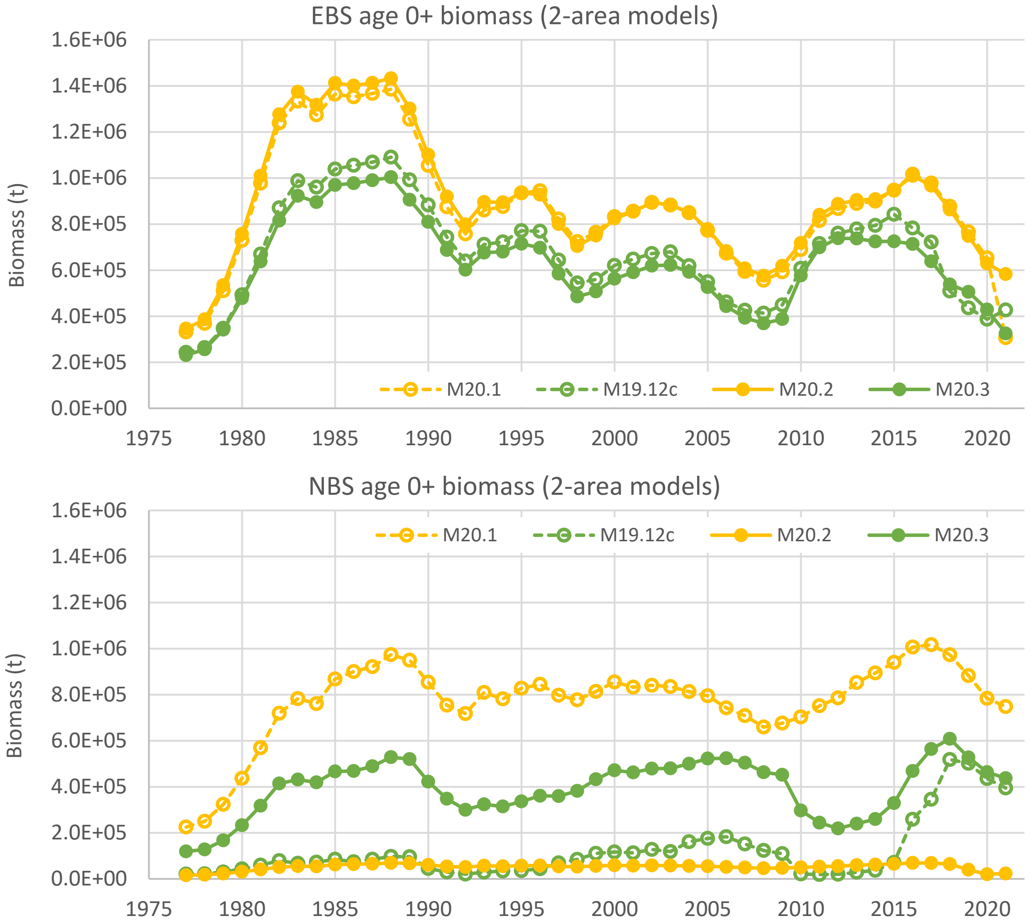






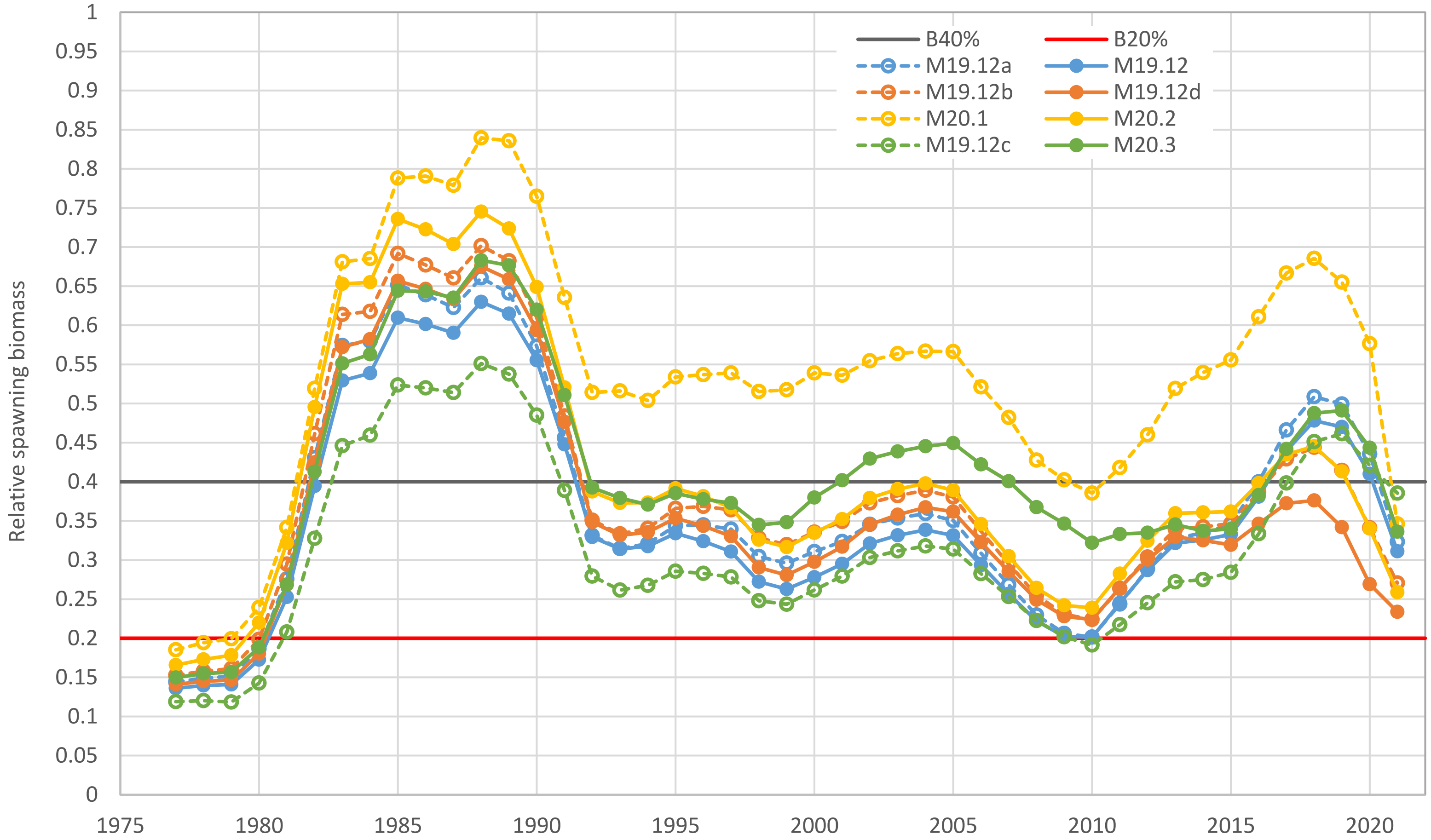
EBS Pacific cod (24 of 57)

- Age 0+ biomass time series, separate areas (2-area models only)



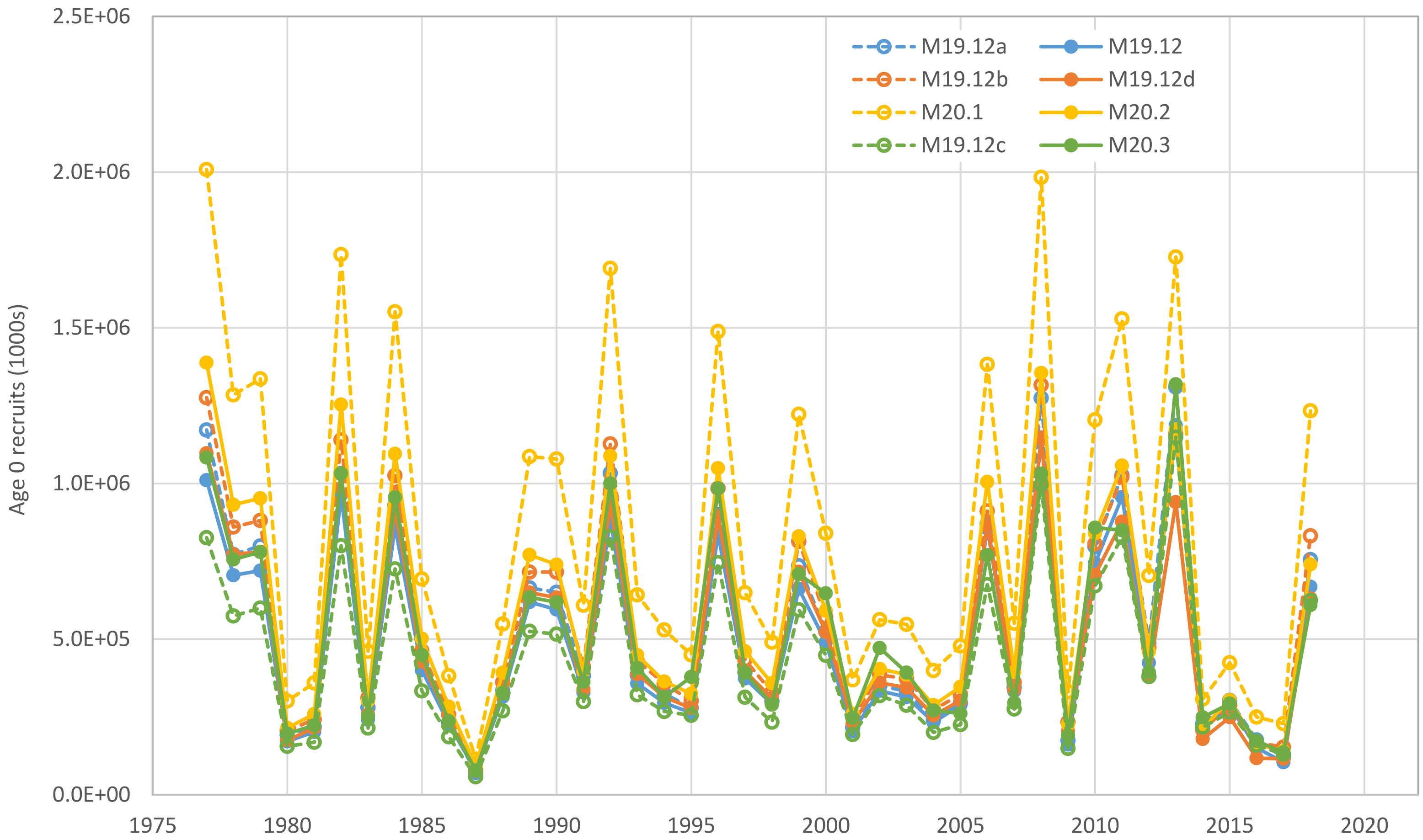
EBS Pacific cod (25 of 57)

- Relative spawning biomass time series, combined areas



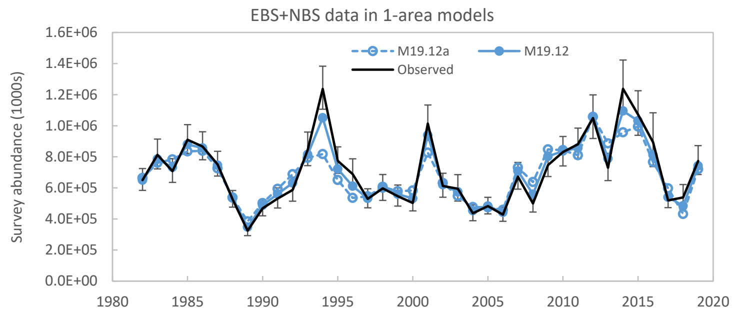
EBS Pacific cod (26 of 57)

- Age 0 recruitment, combined areas



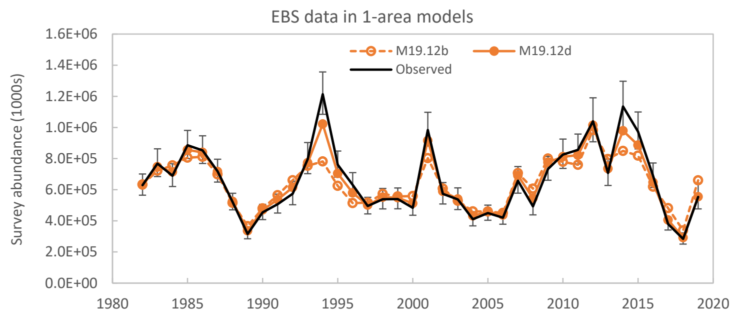
EBS Pacific cod (27 of 57)

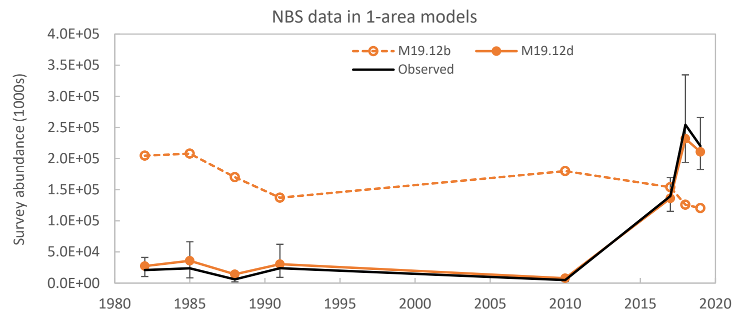
- Fit to survey indices (F2.1.7)

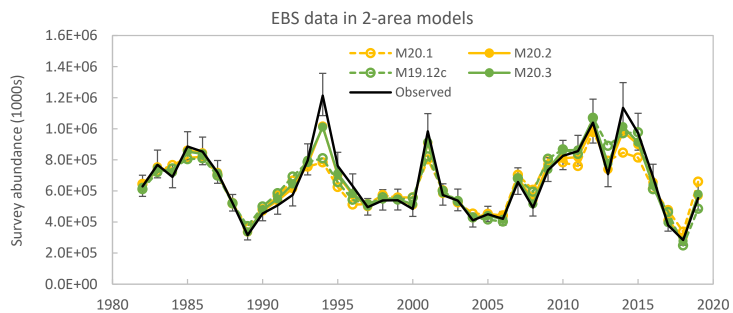


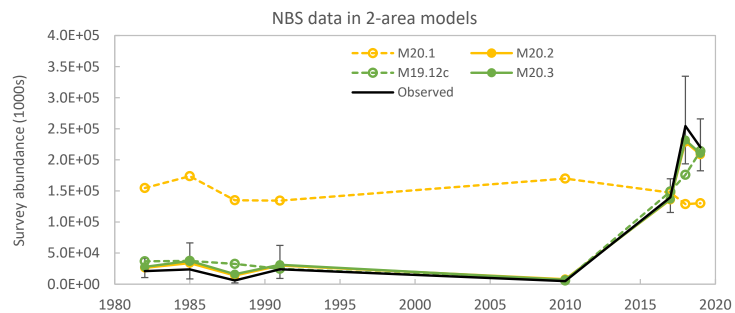
blue = 1-area models *without* separate surveys
orange = 1-area models *with* separate surveys
yellow = 2-area models *without* movement
green = 2-area models *with* movement

dashed lines with open circles = models *without* time-varying Q
solid lines with filled circles = models *with* time-varying Q







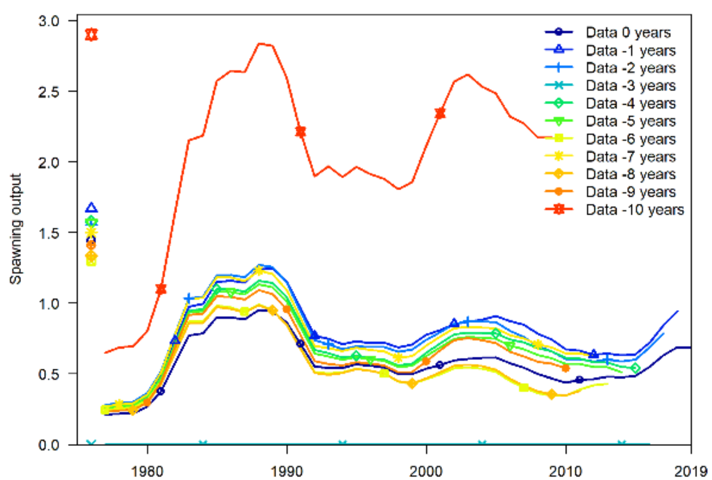


EBS Pacific cod (28 of 57)

- Bootstrap estimates of the st. dev. and 95% confidence interval for ρ:

Statistic	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.2	20.3
mean	-0.070	-0.079	-0.539	0.100	-0.053	-0.025	-0.109	0.466
st. dev.	0.022	0.034	0.045	0.038	0.014	0.023	0.022	0.339
L95%	-0.116	-0.146	-0.615	0.027	-0.081	-0.074	-0.150	0.028
U95%	-0.031	-0.015	-0.443	0.174	-0.028	0.014	-0.065	1.212

- The value of Mohn's ρ for Model 20.3 is heavily influenced by the 10^{th} peel, which will disappear when the final draft is produced



EBS Pacific cod (29 of 57)

- Alternative ensemble:
  - Model names:

Time-varying *Q* ?	No				Yes			
Separate areas?	No		Yes		No		Yes	
Separate surveys?	No	Yes	Yes		No	Yes	Yes	
Movement?	No		No	Yes	No		No	Yes
ADSB:	0.0755	0.1105	36.5771	0.0724	n/a	n/a	0.1874	0.3642
Model name:	19.12a	20.4	20.5	19.12e	19.12	19.15	20.6	20.7

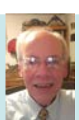
    - Models 19.12a and 19.12 (gray) are common to both ensembles
    - Model 19.15 was already named (last year)
  - (Continued on next 5 slides)

EBS Pacific cod (30 of 57)

- Alternative ensemble (continued):
  - Changes in time-invariant parameters (slide 1 of 2)
  - These are parameters that are expressed on the “natural” scale
  - Changes here are expressed in *relative* terms (i.e., Alt/Pri – 1)

Time-varying Q?	No									Yes								
Separate areas?	No			Yes						No			Yes					
Separate surveys?	Yes			Yes						Yes			Yes					
Movement?	No			No			Yes			No			No			Yes		
Parameter	19.12b	20.4	Δ	20.1	20.5	Δ	19.12c	19.12e	Δ	19.12d	19.15	Δ	20.2	20.6	Δ	20.3	20.7	Δ
Natural_mortality	0.372	0.373	0.004	0.372	0.369	-0.006	0.332	0.332	0.001	0.358	0.359	0.004	0.374	0.373	-0.001	0.344	0.346	0.006
L_at_1.5_base	14.799	14.798	0.000	14.794	14.796	0.000	14.805	14.804	0.000	14.903	14.900	0.000	14.807	14.808	0.000	14.594	14.577	-0.001
L_infinity	114.2	113.5	-0.006	112.9	115.9	0.027	118.2	118.1	0.000	114.6	114.5	-0.001	116.5	116.5	0.000	111.2	111.1	-0.001
VonBert_K	0.117	0.119	0.019	0.118	0.109	-0.074	0.106	0.106	0.000	0.117	0.117	0.000	0.108	0.108	0.000	0.123	0.123	0.002
Richards_coef	1.435	1.427	-0.006	1.444	1.477	0.023	1.480	1.480	0.000	1.419	1.420	0.001	1.479	1.478	0.000	1.438	1.439	0.001
SD_len_at_1	3.483	3.484	0.000	3.466	3.465	0.000	3.481	3.481	0.000	3.473	3.474	0.000	3.485	3.485	0.000	3.490	3.490	0.000
SD_len_at_20	9.945	9.892	-0.005	10.136	10.393	0.025	10.153	10.150	0.000	9.882	9.869	-0.001	10.014	10.017	0.000	9.397	9.384	-0.001
InitF_main_fsh	0.127	0.124	-0.018	0.119	0.119	0.003	0.147	0.147	-0.001	0.134	0.132	-0.011	0.114	0.115	0.004	0.173	0.172	-0.002
InitF_NBS_fsh				0.000	0.000	-0.965	0.000	0.000	-0.005				0.000	0.000	0.040	0.000		
Main_fsh_sel_PeakStart	75.220	75.012	-0.003	74.971	74.889	-0.001	74.982	74.980	0.000	74.986	74.986	0.000	74.931	74.937	0.000	75.968	75.976	0.000
Main_srv_sel_PeakStart_base	21.036	21.054	0.001	20.986	20.932	-0.003	21.110	21.112	0.000	20.699	20.704	0.000	20.970	20.968	0.000	21.827	21.893	0.003
NBS_srv_sel_PeakStart	79.998	79.998	0.000	74.051	73.453	-0.008	15.530	15.528	0.000	79.997	79.996	0.000	68.696	69.355	0.010	14.453	14.418	-0.002

- (Continued on next 4 slides)

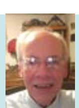


EBS Pacific cod (31 of 57)

- Alternative ensemble (continued):
  - Changes in time-invariant parameters (slide 2 of 2)
  - Changes here are expressed in *absolute* terms (i.e., Alt – Pri)

Time-varying *Q* ?	No									Yes								
Separate areas?	No			Yes						No			Yes					
Separate surveys?	Yes			Yes						Yes			Yes					
Movement?	No			No			Yes			No			No			Yes		
Parameter	19.12b	20.4	Δ	20.1	20.5	Δ	19.12c	19.12e	Δ	19.12d	19.15	Δ	20.2	20.6	Δ	20.3	20.7	Δ
RecrDist_NBS_base				-0.676	2.691	3.367	-3.037	-3.033	0.004				-3.345	-3.382	-0.037	-1.690	-1.640	0.050
AgeBias_at_1_1977_2007	0.349	0.349	0.000	0.349	0.348	-0.001	0.347	0.347	0.000	0.347	0.347	0.000	0.348	0.348	0.000	0.346	0.347	0.001
AgeBias_at_1_2008_2019	-0.002	-0.002	0.000	0.001	0.001	0.000	0.009	0.009	0.000	0.002	0.002	0.000	0.004	0.004	0.000	0.008	0.007	-0.001
AgeBias_at_20_1977_2007	0.776	0.771	-0.005	0.772	0.782	0.010	0.843	0.842	0.000	0.804	0.802	-0.002	0.825	0.825	0.000	0.954	0.954	0.000
AgeBias_at_20_2008_2019	-1.697	-1.700	-0.003	-1.646	-1.648	-0.002	-1.698	-1.698	0.000	-1.930	-1.932	-0.003	-1.790	-1.790	0.000	-2.179	-2.201	-0.022
ln(Recr_ave_1977_2018)	13.271	13.285	0.014	13.678	16.000	2.321	12.991	12.993	0.002	13.144	13.157	0.013	13.313	13.308	-0.005	13.185	13.220	0.034
ln(Recr_ave_pre1977_offset)	-0.885	-0.877	0.008	-0.862	-0.866	-0.004	-0.986	-0.986	0.001	-0.909	-0.903	0.006	-0.839	-0.841	-0.002	-0.919	-0.912	0.007
lnQ_main_srv_base	-0.111	-0.121	-0.010	-0.102	-0.085	0.017	0.172	0.171	-0.001	-0.037	-0.046	-0.009	-0.116	-0.114	0.002	0.261	0.254	-0.007
lnQ_NBS_srv_base	-0.788	-0.804	-0.016	-0.747	-4.122	-3.375	-0.260	-0.265	-0.005	-1.842	-1.967	-0.125	0.827	0.933	0.106	-1.466	-1.618	-0.151
Main_fsh_sel_logitPeakWidth	-5.712	-9.672	-3.960	-9.439	0.434	9.873	0.208	0.208	0.001	-9.761	-9.772	-0.011	0.469	0.470	0.001	0.097	0.093	-0.004
Main_fsh_sel_lnSD1_base	5.913	5.903	-0.010	5.898	5.892	-0.006	5.907	5.907	0.000	5.905	5.905	0.000	5.896	5.896	0.000	5.950	5.951	0.000
Main_fsh_sel_lnSD2	-1.410	-9.947	-8.537	-9.091	4.406	13.497	4.707	4.707	0.000	-9.886	-9.880	0.006	4.345	4.342	0.00	4.827	4.829	0.00
Main_fsh_sel_logitEnd_base	1.987	2.000	0.013	3.114	-2.759	-5.873	-3.140	-3.137	0.003	2.084	2.079	-0.006	-2.647	-2.643	0.005	-2.855	-2.860	-0.005
Main_srv_sel_lnSD1_base	3.532	3.535	0.003	3.522	3.512	-0.010	3.535	3.535	0.000	3.460	3.460	0.000	3.513	3.513	0.000	3.613	3.620	0.006
NBS_srv_sel_lnSD1	7.784	7.790	0.006	8.881	8.930	0.049	2.067	2.066	-0.001	7.821	7.834	0.014	7.925	7.922	-0.003	1.750	1.738	-0.012
lnDM_size_main_fish	9.989	9.989	0.000	9.989	9.990	0.001	9.990	9.990	0.000	9.989	9.989	0.000	9.990	9.990	0.000	9.989	9.989	0.000
lnDM_size_main_sur	9.984	9.984	0.000	9.985	9.984	-0.001	9.984	9.984	0.000	9.984	9.984	0.000	9.985	9.985	0.000	9.984	9.984	0.000
lnDM_size_NBS_sur	9.656	9.655	0.000	9.717	9.714	-0.003	9.923	9.924	0.002	9.756	9.687	-0.069	9.712	9.712	0.000	9.935	9.936	0.001
lnDM_age_main_srv	0.281	0.252	-0.029	0.444	0.520	0.076	0.478	0.475	-0.002	0.432	0.419	-0.013	0.522	0.527	0.005	0.541	0.540	0.000
lnDM_age_NBS_srv	0.213	0.196	-0.017	-1.511	-1.528	-0.016	0.381	0.377	-0.005	0.383	0.380	-0.003	-1.342	-1.346	-0.004	-0.201	-0.192	0.009

- (Continued on next 3 slides)



EBS Pacific cod (32 of 57)

- Alternative ensemble (continued):
  - Relative change in age 0+ biomass (Alt/Pri – 1), combined areas:

Q vary?	No			Yes		
2 area?	No	Yes		No	Yes	
2 srv?	Yes	Yes		Yes	Yes	
Move?	No	No	Yes	No	No	Yes
Pri. model	M19.12b	M20.1	M19.12c	M19.12d	M20.2	M20.3
Alt. model	M20.4	M20.5	M19.12e	M19.5	M20.6	M20.7
Ave. change	0.0120	13.2172	0.0014	0.0095	-0.0045	0.0362

  - Relative change in age 0+ biomass (Alt/Pri – 1), separate areas:

Area:	Eastern Bering Sea				Northern Bering sea			
Q vary?	No		Yes		No		Yes	
2 area?	Yes		Yes		Yes		Yes	
2 srv?	Yes		Yes		Yes		Yes	
Move?	No	Yes	No	Yes	No	Yes	No	Yes
Pri. mod.	M20.1	M19.12c	M20.2	M20.3	M20.1	M19.12c	M20.2	M20.3
Alt. mod.	M20.5	M19.12e	M20.6	M20.7	M20.5	M19.12e	M20.6	M20.7
Ave. chg.	-0.0200	0.0010	-0.0025	0.0071	27.9210	0.0044	-0.0399	0.0830

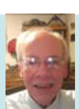
  - (Continued on next 2 slides)

EBS Pacific cod (33 of 57)

- Alternative ensemble (continued):
  - Objective function comparison (Alt – Pri), major components:

Time-varying *Q* ?	No			Yes		
Separate areas?	No	Yes		No	Yes	
Separate surveys?	Yes	Yes		Yes	Yes	
Movement?	No	No	Yes	No	No	Yes
Primary model	M19.12b	M20.1	M19.12c	M19.12d	M20.2	M20.3
Alternative model	M20.4	M20.5	M19.12e	M19.15	M20.6	M20.7
Catch	0.00	0.00	0.00	0.00	0.00	0.00
Initial_eq_catch	0.00	0.00	0.00	0.00	0.00	0.00
Survey index	-0.31	-1.08	-0.02	-0.39	0.20	-0.39
Size composition	-0.74	-1.20	0.00	-0.22	-0.09	0.60
Age composition	0.39	-0.48	0.04	0.34	-0.11	-0.44
Recruitment	-0.01	0.06	0.00	0.02	-0.01	-0.01
Initial_eq_recr	-0.11	0.10	-0.02	-0.11	0.03	-0.17
Priors	-0.23	-0.21	-0.09	-1.64	-0.46	-1.52
"Softbounds"	0.01	0.00	0.00	0.00	0.00	0.00
Deviations	0.17	0.27	-0.01	0.24	-0.06	0.27
Total	-0.84	-2.55	-0.09	-1.76	-0.50	-1.65

  - (Continued on next slide)



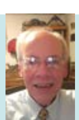
EBS Pacific cod (34 of 57)

- Alternative ensemble (continued):
  - Mohn's ρ values for the primary ensemble (reprise):

Statistic	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.2	20.3
mean	-0.070	-0.079	-0.539	0.100	-0.053	-0.025	-0.109	0.466
st. dev.	0.022	0.034	0.045	0.038	0.014	0.023	0.022	0.339
L95%	-0.116	-0.146	-0.615	0.027	-0.081	-0.074	-0.150	0.028
U95%	-0.031	-0.015	-0.443	0.174	-0.028	0.014	-0.065	1.212

  - Mohn's ρ values for the alternative ensemble, for comparison:

Statistic	19.12a	20.4	20.5	19.12e	19.12	19.15	20.6	20.7
mean	-0.070	-0.094	-0.012	0.790	-0.053	-0.034	-0.013	0.052
st. dev.	0.022	0.032	0.012	0.329	0.014	0.023	0.038	0.075
L95%	-0.116	-0.158	-0.036	0.231	-0.081	-0.082	-0.078	-0.091
U95%	-0.031	-0.034	0.010	1.509	-0.028	0.006	0.068	0.199



EBS Pacific cod (35 of 57)

- Cross-conditional decision analysis
  - CCDA was introduced during Sept/Oct 2019 Team/SSC meetings
  - Briefly, CCDA is a systematic method for answering a question that regularly plagues attempts to choose a single model from a set of alternatives, namely, *“But what if we’re wrong?”*
  - CCDA answers this question by considering not only the performance of a given model within the ensemble when the structure of that model is the “true” one, but also the performance of that model when any of the *other* models in the ensemble is the “true” one, repeating this process for each model in the ensemble
  - (Continued on next 5 slides)

EBS Pacific cod (36 of 57)

- Cross-conditional decision analysis (continued):
  - Performances are measured by generating a series of bootstrap data sets from each fitted model, then applying each model to each data set and comparing the respective estimates of the quantity of interest to the best estimate from the model that generated the bootstrap data (the “pivot” model)
  - Those performances, together with a set of user-specified values representing the subjective probabilities that each of the models in the ensemble is the “true” one, are then used to estimate a set of model weights that optimize the performance of the overall ensemble
  - This results in a probability mass function for the estimated quantity
  - (Continued on next 4 slides)

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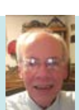

EBS Pacific cod (37 of 57)

- Cross-conditional decision analysis (continued):
  - Comparison of CCDA (as described so far) to machine learning
    - Some resemblance to “bagging” (bootstrap aggregating)
      - Bootstrapping = form a distribution of a *statistic obtained by direct calculation from* each of n bootstrapped data sets
      - Bagging = form a distribution of a *result obtained by fitting the same model to* each of n bootstrapped data sets
    - Some resemblance to 3-level “stacking”
      1. fit a set of different models
      2. weight *conditional* MSEs by model *probabilities*
      3. estimate model *weights* by minimizing *ensemble* MSE
  - (Continued on next 3 slides)

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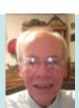
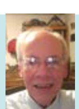


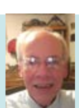
EBS Pacific cod (38 of 57)

- Cross-conditional decision analysis (continued)
    - Finally, decision theory is then used to obtain an optimal point estimate, given the pmf and a specified level of risk aversion, ra, where $ra<0$ implies risk proclivity, $ra=0$ implies risk neutrality, and $ra>0$ represents true risk aversion
    - (Continued on next 2 slides)



EBS Pacific cod (39 of 57)

- Cross-conditional decision analysis (continued):
  - CCDA was applied here to the primary ensemble for the purpose of developing preliminary estimates of the OFL and ABC for 2021
  - Given $ra=0$, the estimate of OFL from CCDA is simply the arithmetic mean of the *pmf*; and given $ra=2$ (see Attachment 2.1.4), the estimate of ABC from CCDA is simply the harmonic mean of the *pmf*
  - The arithmetic and harmonic means of the ensemble *pmf* are 127,119 t (OFL) and 114,101 t (ABC), respectively, representing a buffer of approximately 10%
  - Of course, the maxABC harvest control rule identified in the BSAI Groundfish FMP still applies, so the CCDA estimate of ABC could be used only if it does not exceed maxABC from the control rule
  - (Continued on next slide)



EBS Pacific cod (40 of 57)

- Cross-conditional decision analysis (continued):
  - The main reason to use CCDA is that it provides a statistically rigorous answer to the "*But what if we're wrong?*" question
  - However, there are some problems:
    - *Much* harder to understand than typical ensemble approaches
    - Use of bootstrap distributions as an approximation of Bayesian posterior distributions is controversial
      - But what is the alternative?
    - For this analysis, CCDA was *very* time-consuming
      - A major impediment: some models have spatial structures that are nested within those of other models
      - Only enough time to use 10 bootstraps per model!
      - In practical terms, use in final assessment is likely precluded

EBS Pacific cod (41 of 57)

- Post-script:
  - At the request of an industry representative, an alternative version of the current base model for EBS Pacific cod (M19.12) was run
  - In the base model, the base value of catchability (Q) for the trawl survey is estimated freely at 1.034
  - In the alternative version, the base value of catchability was fixed at 0.465, which is the value that sets the average of the product of Q and survey selectivity for fish in the 60-81 cm size range equal to 0.47, corresponding to the proportion of the population within that size range estimated by Nichol et al. (2007) to be present within the depth range sampled by the survey gear
  - The values of the "sigma" terms that constrain the various vectors of annual random deviations were not re-tuned
  - (Continued on next slide)

EBS Pacific cod (42 of 57)

- Post-script (continued):
  - As expected, fixing Q in the manner described has a substantial impact on projections for 2021:
    - Estimate of 2021 rel. spawn. biom. increases (0.30 $\longrightarrow$ 0.60)
      - i.e., the stock goes from being well below, to well above, the kink in the harvest control rule
    - Estimate of $F_{40\%}$ increases (0.415 $\longrightarrow$ 0.522)
    - Estimate of 2021 maxABC increases (113,071 t $\longrightarrow$ 371,530 t)
      - Conditional on the 2020 catch being equal to the 2020 ABC
  - Also as expected, fixing Q in the manner described causes the objective function to increase substantially (1080.68 $\longrightarrow$ 1117.58)
  - Document describes the history of the Nichol et al. (2007) estimate as used in the assessments, and reasons for its discontinuation

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EBS Pacific cod (43 of 57)

- Team discussion of model choices and methods:
  - Models 19.12b and 20.1 (no time-varying catchability, no movement, separate surveys, and a single area) showed poor fits to the NBS survey time-series, specifically a high predicted biomass in 2010
  - A Team member noted that high predicted biomass may be implausible prior to 2017 with very little fishing occurring in the NBS and an extremely low survey estimate in 2010, despite a sizable model estimate
    - A member of the public commented that it is possible that fishing may not have occurred in the NBS regardless of the amount of biomass due to the distance needed to travel
    - However, it was also noted that local halibut and crab fishermen have anecdotally commented on recent increases of Pacific cod
  - (Continued on next 12 slides)

EBS Pacific cod (44 of 57)

- Team discussion of model choices and methods:
  - Models 20.1 and 20.3 showed retrospective patterns with Mohn's ρ values of concern
  - The Team noted that when including a survey time-series such as for the NBS, there is the potential for significant retrospective patterns when sparse data are removed
  - The Team agreed that the CCDA work is promising, but it was noted that it is challenging and may be difficult to implement in a short period of time, thus may not be available in November
  - (Continued on next 11 slides)

EBS Pacific cod (45 of 57)

- Team discussion of model choices and methods (continued):
  - Public comment:
    - Three public comment letters were provided for this topic: one from FLC, one from an industry work group, and one from an experienced fisheries consultant hired by industry
    - It was noted that these models are different from models conducted prior to 2016, whereas the alternative model described in a separate document is more consistent with those earlier models, although dome-shaped selectivity is not included
    - Concern with the lack of fit; wondering if that is expected given the assumptions in these models
      - Grant noted that age composition data are the only data used by the models that are not fit well by the models
  - (Continued on next 10 slides)

EBS Pacific cod (46 of 57)

- Team discussion of model choices and methods (continued):
  - Public comment (continued):
    - CPUE has been the highest seen since 1991, and there are good signs of a strong 2018 year class
    - Concern about model misspecification, given the above
    - Even though fishing did not occur in the NBS in the past, this does not mean that fish were not there
    - Is there potential for parameter confounding in the model, and could a table of parameter correlations be included?
    - Industry has tried to provide information from the fisheries that would be useful given the lack of a survey in 2020, and would be pleased to provide additional information in November
    - Prefer that the Team retain the ability to choose a single model
  - (Continued on next 9 slides)

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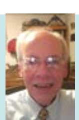
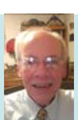


EBS Pacific cod (47 of 57)

- Team discussion of model choices and methods (continued):
  - The discussion mainly revolved around the eight models and working to identify four new priority models for evaluation in November, in addition to last year's base model (19.12)
  - Models 20.1 (or 20.5) and 20.2 (or 20.6) were removed as they were not well fit and because they have separate areas but no movement, in contrast to multiple lines of evidence suggesting high rates of migratory behavior in the EBS/NBS, including recent tagging results that show migrations across the system in less than 1 year
  - (Continued on next 8 slides)

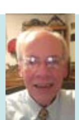


EBS Pacific cod (48 of 57)

- Team discussion of model choices and methods (continued):
  - The Team would like to acknowledge that 20.3 and 20.7 represent models that address past requests and the Team would like to see continued development of these models, but not as a 2020 priority
  - Future work could include evaluation through peer review, use of ESP/ESR information, information from tagging data, etc.
  - Model 20.3 (or 20.7) included movement and separate areas, but also included time varying Q, which is likely confounded with movement
  - (Continued on next 7 slides)

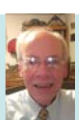
EBS Pacific cod (49 of 57)

- Team discussion of model choices and methods (continued):
  - Model 19.12c has movement and separate areas, satisfying Team recommendations for model development
    - Some Team members expressed concern over novel methods and covariates that need further review
    - Other Team members were interested in seeing the model included in the November ensemble along with additional detail and indices in order to enable deeper evaluation
  - The Team discussed that Model 19.12c (or 19.12e) represents an innovation that potentially may address multiple issues facing this stock, especially regarding environmentally driven movement of the stock into and out of the NBS
  - (Continued on next 6 slides)



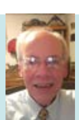
EBS Pacific cod (50 of 57)

- Team discussion of model choices and methods (continued):
  - That said, 19.12c (or 19.12e) is a new model at the front edge of the field of fisheries assessment modeling and additional review and validation is needed to understand how the model performs
  - The Team applauds the use of environmental covariates in the movement model and would like to see more details of the process to select these indices and continued development of this approach
  - That said, the Team raised concerns regarding the sensitivity and effect of the covariate in the model that warrants further validation
  - ESP and ESR coordination could work towards a set of indices that can be used to validate the emergent patterns in movement and recruitment distribution
  - (Continued on next 5 slides)



EBS Pacific cod (51 of 57)

- Team discussion of model choices and methods (continued):
  - The Team recommends that the ESR and/or ESP provide an index of movement (e.g., using the standard EBS survey stations, evaluate the proportion of Pacific cod biomass over time in the northernmost survey stations that are located between 59°N and 60°N in years 1982-2019) to validate the movement indices in this model
    - This would be needed in November if these models move forward, or if not, should be included in the 2021 Pacific cod ESP
  - Additionally, it may be useful to review other models with movement to identify if there are best practices or lessons learned
  - The Team discussed the approach of asking for the ensemble to include the 19.12c (or 19.12e) model, given that it may be removed in November after review of the requested validation information
  - (Continued on next 4 slides)

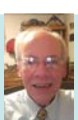


EBS Pacific cod (52 of 57)

- Team discussion of model choices and methods (continued):
  - Models 20.1 (or 20.5) and 20.2 (or 20.6), with separate surveys, no time-varying Q, and no movement predicted a high biomass in the NBS over all years, which was anomalous relative to other models
    - Also counter to multiple lines of evidence that both NBS biomass and catch have increased considerably in recent years
  - It was agreed that, if in November model 19.12c (or 19.12e) is determined to be problematic and results in high weights in the ensemble, the Team will instead advance a *single* recommended model that best addresses the stock assessment needs of 2020
  - (Continued on next 3 slides)

EBS Pacific cod (53 of 57)

- Team discussion of model choices and methods (continued):
  - A prior on NBS survey Q was used in the primary ensemble but not the alternative ensemble; latter is more consistent with past models
  - The Team recommends moving forward with the alternative ensemble for November because this represents continuity with the past, and because these models are relatively stable (based on ρ)
  - The Team recommends the author run the model ensemble averaging approach using models 19.12a., 20.4, 19.12e, 19.12, 19.15, and using last year's ensemble averaging methodology (without the exponential weighting as per the SSC recommendations from 2019)
  - (Continued on next 2 slides)



EBS Pacific cod (54 of 57)

- Team discussion of model choices and methods (continued):
  - Table 2.22 from last year’s assessment, with 2 new rows added:

		Hypothesis 1			Hypothesis 2			Hypothesis 3			
		Basic	Simple	Complex	Basic	Simple	Complex	Basic	Simple	Complex	
Criterion	Emphasis	M19.7	M19.8	M19.9	M19.10	M19.11	M19.12	M19.13	M19.14	M19.15	M16.6i
Plausible hypothesis	3	0	0	0	1	1	1	1	1	1	1
Plausible catchability	3	1	1	1	1	1	1	0	0	0	1
Acceptable retrospective bias	3	1	1	1	1	1	1	1	0	1	1
Comparable complexity	2	1	1	0	1	1	0	1	1	0	1
Dev sigmas estimated appropriately	2	0	1	1	0	1	1	0	1	1	0
Fits consistent with variances	2	0	0	1	0	0	1	0	0	1	0
Incremental changes	1	1	0	0	1	0	0	1	0	0	1
Objective criterion for sample sizes	1	0	0	1	0	0	1	0	0	1	0
Change in ageing criteria addressed	1	0	0	1	0	0	1	0	0	1	0
Exponential average emphasis:		0.0001	0.0003	0.0025	0.0025	0.0067	0.0498	0.0001	0.0000	0.0025	0.0025
Model weight:		0.0019	0.0052	0.0384	0.0384	0.1044	0.7712	0.0019	0.0003	0.0384	
Average emphasis:		0.5000	0.5556	0.6667	0.6667	0.7222	0.8333	0.5000	0.3889	0.6667	
Model weight:		0.0909	0.1010	0.1212	0.1212	0.1313	0.1515	0.0909	0.0707	0.1212	

  - (Continued on next slide)

EBS Pacific cod (55 of 57)

- Team discussion of model choices and methods (continued):
  - Finally, following from comments made in the November 2019 Team minutes, use of the VAST model was briefly discussed
    - The Team is still interested in seeing a cross-validation analysis done to determine the efficacy of predicting missing data using areas in the EBS and years with data
    - It was acknowledged that this work was ongoing

EBS Pacific cod (56 of 57)

- Team discussion of economics and specification of ABC:
  - The Team included a section in the minutes in response to several public comments noting that the industry is suffering economically for a variety of reasons, including decline in access to markets and large reductions in ABC and TAC in recent years
  - The Council passed the following motion in October 2018:
    - *"The Council clarifies its policy is that the Plan Team develop, and the SSC recommend, ABCs which are based on biological and environmental scientific information through the stock assessment and Tier process*
    - *“Socio-economic factors should be considered during the TAC-setting process at the Council, and not incorporated into the ABC recommendations”*
  - (Continued on next slide)

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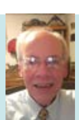
EBS Pacific cod (57 of 57)

- Team discussion of economics and specification of ABC (continued):
  - The Team interprets this policy to mean that we have no latitude to consider any economic hardship in setting the ABC for the coming year, or to make trade-offs between the ABCs over the next two years, consistent with the 2016 Revisions to National Standard 1 Guidelines, which allow a “phase-in” of ABC recommendations based on 2- or 3-year timeframes as long as they do not exceed annual OFLs
  - Information is provided in the ESP, EPR, ESR, and Groundfish Economic SAFE that may characterize both ecosystem and economic conditions related to the stock, but the Team cannot use the economic data to adjust the ABC
  - The Team welcomes any clarification from the Council regarding industry comments on considering economic factors in ABC recommendations

Octopus stock structure (1 of 8)

- Olav Ormseth presented the stock structure template for octopus
- The octopus complex is a data-limited, Tier 6 stock comprised of several individual species, none of which are targeted in a directed fishery
- For these reasons, the author noted that applying the stock structure template to this stock complex is problematic
- Octopus catch – both as bycatch in the fishery and in the survey – is a rare event, which can influence biomass estimates
- Biomass estimates are likely underestimates due to the untrawlable habitat octopus typically inhabit
- There are also limited species ID data available, as they have been collected only since 2010 in the survey, and not at all in the fishery



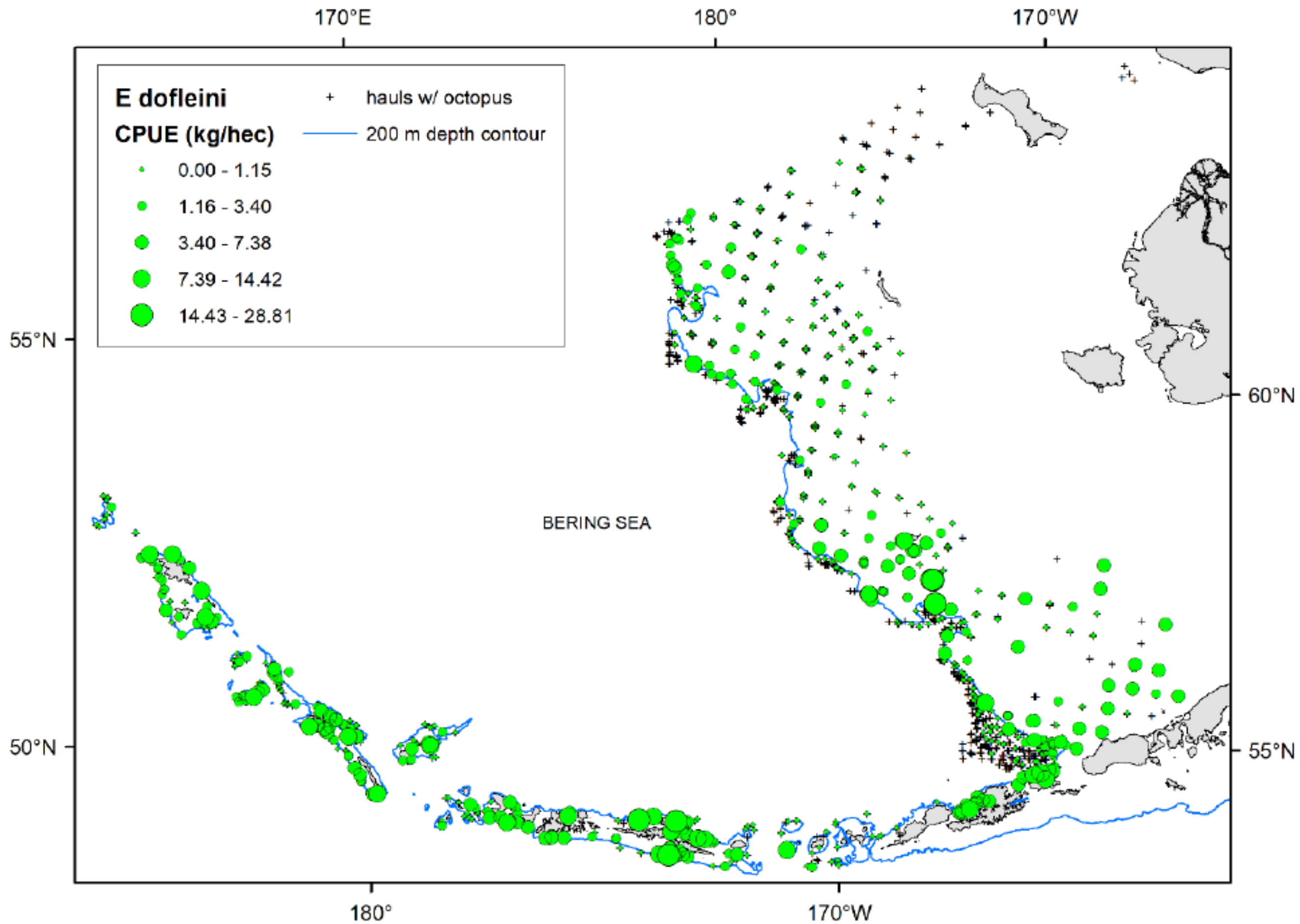
Octopus stock structure (2 of 8)

- Taxonomy and distribution

		Common Name	General Distribution
Order	Vampyromorpha		
	Vampyroteuthis infernalis	vampire squid	Southeast BS slope below 300 m
Order	Octopoda		
Group	Cirrata		
Family	Opisthoteuthidae		
	Opisthoteuthis californiana	flapjack devilfish	BS deeper than 200 m
Group	Incirrata		
Family	Bolitaenidae		
	Japetella diaphana	pelagic octopus	Pelagic
Family	Octopodidae		
	Benthoctopus leioderma	smooth octopus	southern BS deeper than 250 m
	Benthoctopus oregonensis	none	BS shelf break
	Enteroctopus dofleini	giant octopus	all BSAI, from 50 - 1400 m
	Graneledone boreopacifica	none	BS slope 650 - 1550 m
	Sasakiopus salebrosus	stubby octopus	BS slope, 200 - 1200 m

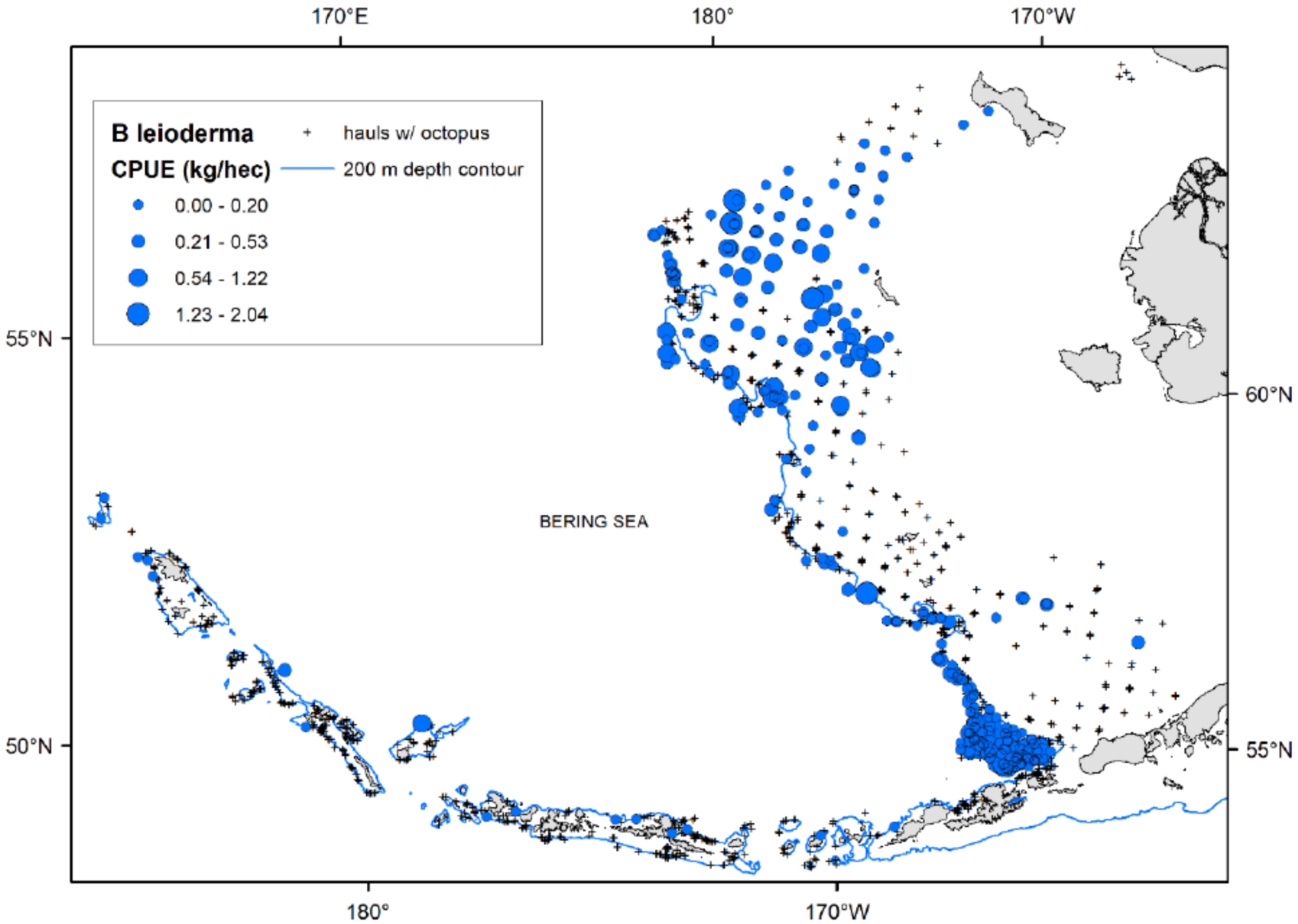
Octopus stock structure (3 of 8)

- Giant Pacific octopus (*Enteroctopus dofleini*) in bottom trawl surveys



Octopus stock structure (4 of 8)

- Smoothskin octopus (*Benthoctopus leioderma*) in bottom trawl surveys



Octopus stock structure (5 of 8)

- Exploitation rates (based on highly uncertain survey biomass estimates)

	Biomass (t)		Catch (t)		exploitation rate	
year	EBS	AI	EBS	AI	EBS	AI
2004	6,914	4,095	548	20	0.079	0.005
2010	1,441	3,075	133	49	0.092	0.016
2012	3,986	2,779	127	10	0.032	0.004
2016	9,776	3,833	585	11	0.060	0.003

Octopus stock structure (6 of 8)

- Relatively few movement/tagging data are available, but movement of *E. dofleini* appears to be relatively limited once larvae settle out
  - Adult octopus are stationary 94% of the time in Prince William Sound and maintain small home ranges
  - Adult *E. dofleini* do not move over large distances (movement is measured in meters), which might contribute to geographic isolation and a high degree of population structuring
- However, there is no evidence of isolation by distance across the range from the few studies of genetic differentiation in Alaska and other regions
  - This may be due to dispersal of the planktonic larval life stage

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Octopus stock structure (7 of 8)

- Given the inconclusive results, the author questioned the utility of stock structure analyses for Tier 6 stocks
- A Team member, who had completed three similar analyses of Tier 6 stocks and had encountered similar frustrations, contended that the "lessons learned" from completing the template provided valuable insights into the stocks that made the analyses worthwhile
- The Team agreed and concluded that, in general, a somewhat inconclusive stock structure analysis report for a Tier 6 stock is acceptable given the data availability limitations
- The Team will still need to make a determination
- A Team member noted that we sometimes interpret lack of information as "little or no concern," which is different from a clear demonstration that no problems exist

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Octopus stock structure (8 of 8)

- The following categories have been used by the Teams since 11/14, defined in terms of the steps of the Council's spatial management policy:
  1. *Little or no concern*, in which case no action needs to be taken
  2. *Moderate concern*, in which case special monitoring (e.g., frequent updating of the template) is required at a minimum and Steps 2 and 3 of the Council's process may be activated
  3. *Strong concern*, in which case Steps 2 and 3 of the Council's process must be activated
  4. *Emergency*, in which case the Team will recommend separate harvest specifications at the ABC level, the OFL level, or both, for the next season (straight to Step 4 of the Council policy)
- With respect to stock structure issues, the Team agreed with the author that the octopus complex be given a rating of "little or no concern"

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2021 and 2022 Harvest Specifications (1 of 2)

- The Team approved the proposed harvest specifications for 2021 and 2022 by recommending the 2021 BSAI final harvest specifications for OFLs and ABCs as published in the Federal Register in March 2020, with the exception of BSAI northern rock sole
- The Team recommends the revised 2021 OFL and ABC for the proposed 2021 and 2022 from the model correction discussed under the northern rock sole agenda item above

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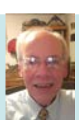

2021 and 2022 Harvest Specifications (2 of 2)

Species	Area	2019 OFL	2019 ABC	2019 TAC	Catch as of 12/31/2019	2020 OFL	2020 ABC	2020 TAC	Catch as of 8/29/2020	Proposed 2021 and 2022 OFL	Proposed 2021 and 2022 ABC	Proposed 2021 and 2022 TAC
Pollock	EBS	3,914,000	2,163,000	1,397,000	1,409,219	4,085,000	2,043,000	1,425,000	1,097,046	3,385,000	1,767,000	
	AI	64,240	52,887	19,000	1,663	66,973	55,120	19,000	2,786	70,970	58,384	
	Bogoslof	183,080	137,310	75	8	183,080	137,310	75	37	183,080	137,310	
Pacific cod	BS	216,000	181,000	166,475	164,098	191,386	155,873	141,799	107,705	125,734	102,975	
	AI	27,400	20,600	14,214	12,941	27,400	20,600	13,796	3,436	27,400	20,600	
Sablefish	BSAI	n/a	n/a	n/a	n/a	50,481	n/a	n/a	n/a	64,765	n/a	
	BS	3,221	1,489	1,489	3,191	n/a	2,174	1,861	2,382	n/a	2,865	
	AI	4,350	2,008	2,008	661	n/a	2,952	2,039	1,015	n/a	3,891	
Yellowfin sole	BSAI	290,000	263,200	154,000	128,061	287,307	260,918	150,700	93,718	287,943	261,497	
Greenland turbot	BSAI	11,362	9,658	5,294	2,850	11,319	9,625	5,300	2,199	10,006	8,510	
	BS	n/a	8,431	5,125	2,678	n/a	8,403	5,125	1,530	n/a	7,429	
	AI	n/a	1,227	169	171	n/a	1,222	175	669	n/a	1,081	
Arrowtooth flounder	BSAI	82,939	70,673	8,000	10,063	84,057	71,618	10,000	8,122	86,647	73,804	
Kamchatka flounder	BSAI	10,965	9,260	5,000	4,488	11,495	9,708	6,800	7,093	11,472	9,688	
Northern rock sole	BSAI	122,000	118,900	47,100	25,799	157,300	153,300	47,100	21,480	251,800	245,500	
Flathead sole	BSAI	80,918	66,625	14,500	15,912	82,810	68,134	19,500	6,526	86,432	71,079	
Alaska plaice	BSAI	39,880	33,600	18,000	16,164	37,600	31,600	17,000	17,552	36,500	30,700	
Other flatfish	BSAI	21,824	16,368	6,500	3,784	21,824	16,368	4,000	3,767	21,824	16,368	
Pacific Ocean perch	BSAI	61,067	50,594	44,069	43,614	58,956	48,846	42,875	28,507	56,589	46,885	
	BS	n/a	14,675	14,675	14,518	n/a	14,168	14,168	3,690	n/a	13,600	
	EAI	n/a	11,459	11,009	10,945	n/a	11,063	10,613	7,929	n/a	10,619	
	CAI	n/a	8,435	8,385	8,263	n/a	8,144	8,094	6,993	n/a	7,817	
	WAI	n/a	16,025	10,000	9,888	n/a	15,471	10,000	9,895	n/a	14,849	
Northern rockfish	BSAI	15,507	12,664	6,500	9,063	19,751	16,243	10,000	7,643	19,070	15,683	
Blackspotted/Rougheye Rockfish	BSAI	676	555	279	393	861	708	349	412	1,090	899	
	EBS/EAI	n/a	351	75	89	n/a	444	85	115	n/a	560	
	CAI/WAI	n/a	204	204	304	n/a	264	264	297	n/a	339	
Shortraker rockfish	BSAI	722	541	358	383	722	541	375	166	722	541	
Other rockfish	BSAI	1,793	1,344	663	1,269	1,793	1,344	1,088	816	1,793	1,344	
	BS	n/a	956	275	699	n/a	956	700	236	n/a	956	
	AI	n/a	388	388	569	n/a	388	388	580	n/a	388	
Atka mackerel	BSAI	79,200	68,500	57,951	57,206	81,200	70,100	59,305	47,355	74,800	64,400	
	EAI/BS	n/a	23,970	23,970	23,654	n/a	24,535	24,535	13,845	n/a	22,540	
	CAI	n/a	14,390	14,390	14,110	n/a	14,721	14,721	13,531	n/a	13,524	
	WAI	n/a	30,140	19,591	19,441	n/a	30,844	20,049	19,979	n/a	28,336	
Skates	BSAI	51,152	42,714	26,000	20,205	49,792	41,543	16,313	13,639	48,289	40,248	
Sculpins	BSAI	53,201	39,995	5,000	5,606	67,817	50,863	5,300	3,837	n/a	n/a	
Sharks	BSAI	689	517	125	146	689	517	150	156	689	517	
Octopuses	BSAI	4,769	3,576	400	268	4,769	3,576	275	643	4,769	3,576	
Total	BSAI	5,340,955	3,367,578	2,000,000	1,937,052	5,584,382	3,272,581	2,000,000	1,478,038	4,857,384	2,984,264	

Sources: 2019 OFLs, ABCs, and TACs and 2020 OFLs and ABCs are from harvest specifications adopted by the Council in December 2018 and December 2019, respectively; 2019 catches