Evaluation of aspects of the BSAI Atka mackerel stock assessment

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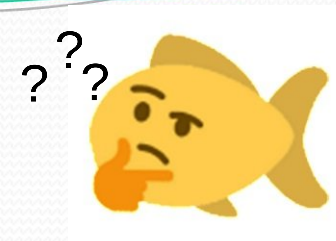
BSAI Atka Mackerel

- The Bering Sea/Aleutian Islands (BSAI) Plan Team recommended a list of 8 items to be addressed in future assessments at their November, 2017 meeting. The SSC agreed (December, 2017 SSC minutes).
- This September document is response to 6 of the 8 items
- Two items not addressed here will be addressed in the Nov. assessment
- Due to the nature of the requests, responses in separate document to be appended to Nov. assessment

From the November 2017 Plan Team minutes: The Team recommends that the authors undertake the following during one or more future assessments (as this is a long list, the Team does not expect all items to be addressed by next September, and understands that the authors can prioritize the list as they see fit):

From the Nov. 2017 Plan Team minutes and Dec. 2017 SSC minutes:



1. Investigate which parameters (including derived quantities) are changing in the retrospective peels that might contribute to the relationship between historical scale and number of peels.

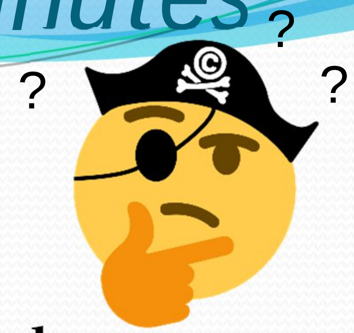
2. Consider dropping the 1986 age composition from the analysis, to be consistent with the policy of not using pre-1991 survey data.

3. Improve documentation for the process of using Francis weights to tune the constraint governing the amount of time variability in fishery selectivity.

4. Continue to investigate fishery selectivity time blocks, with blocks linked to identifiable changes in the fishery.

The elements in bold are addressed in the Sept. document

From the Nov. 2017 Plan Team minutes and Dec. 2017 SSC minutes:

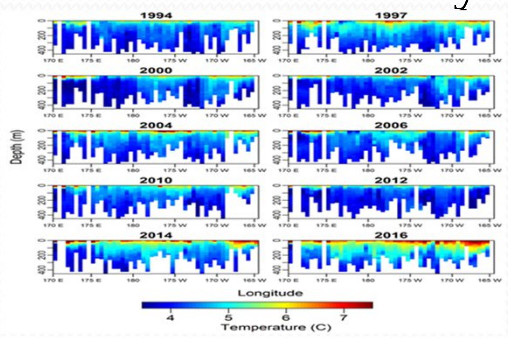


5. Evaluate the sensitivity of model results to an assumed average sample size of 100 for the fishery age composition data, or better yet (if possible), find a way to tune the sample size and the constraint governing the amount of time variability in fishery selectivity simultaneously.

6. Investigate whether a larger number of survey otoliths can be collected in a representative fashion.
   Note: Random sampling was adopted for the 2018 AI survey, with a scheme to sample approximately 300 otoliths per area, with an overall target of otoliths from 1,000 Atka mackerel. Update: 1,078 Atka otoliths collected!

7. Continue the investigation of age-dependent natural mortality.

8. Continue to include (and update) Figure 17.5.
   This will be included in the November, 2018 assessment.



Think Tank

Evaluations

- Data used for these evaluations were identical to those used in the 2017 assessment

- References to last year's (2017) assessment are based on model runs with last year's accepted model (Model 16.0b, Lowe *et al.* 2017)

- 2018 Aleutian Islands survey biomass will be incorporated in Nov. assessment

Retrospective pattern investigations

The Plan Team requested investigation of which parameters might be causing the apparent downward shift in biomass for retrospective "assessments" after about 2013

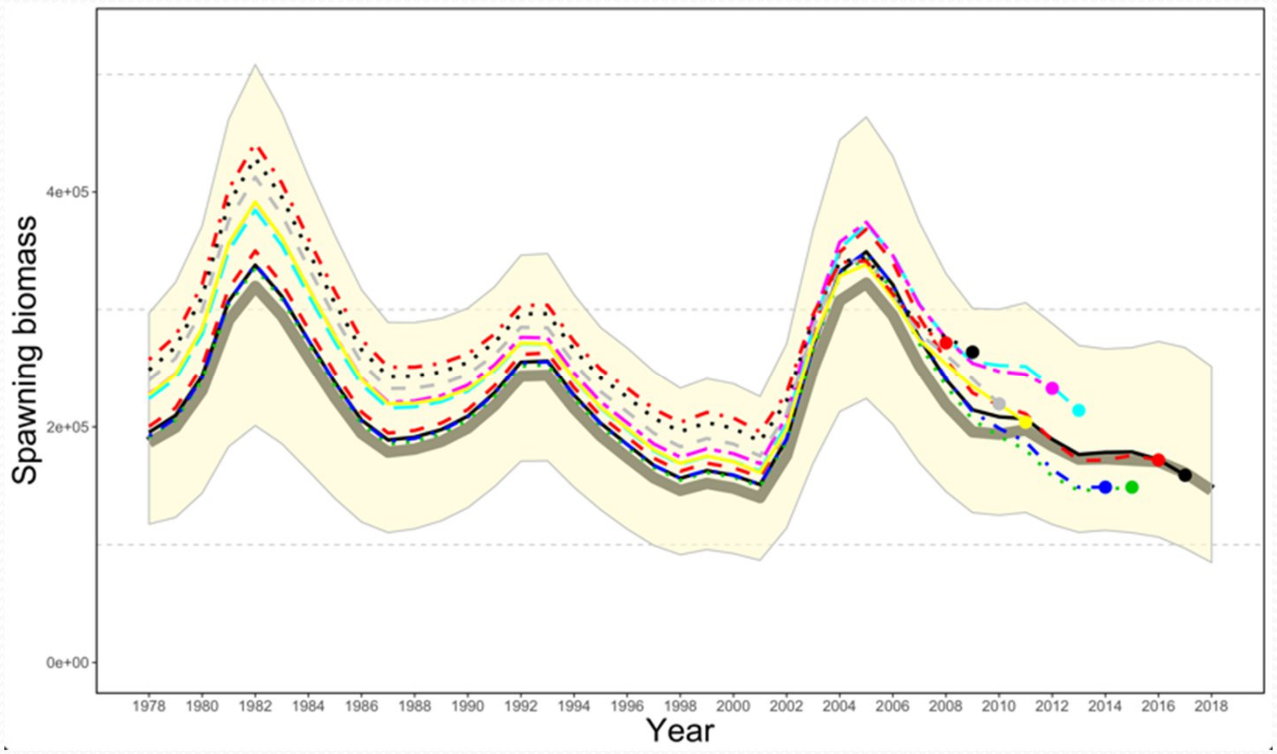


Figure 1. Retrospective plots showing the BSAI Atka mackerel spawning biomass over time for 10 different "peels".

Retrospective pattern investigations

Scale shift in biomass est.
Examined *q* and mean rec.

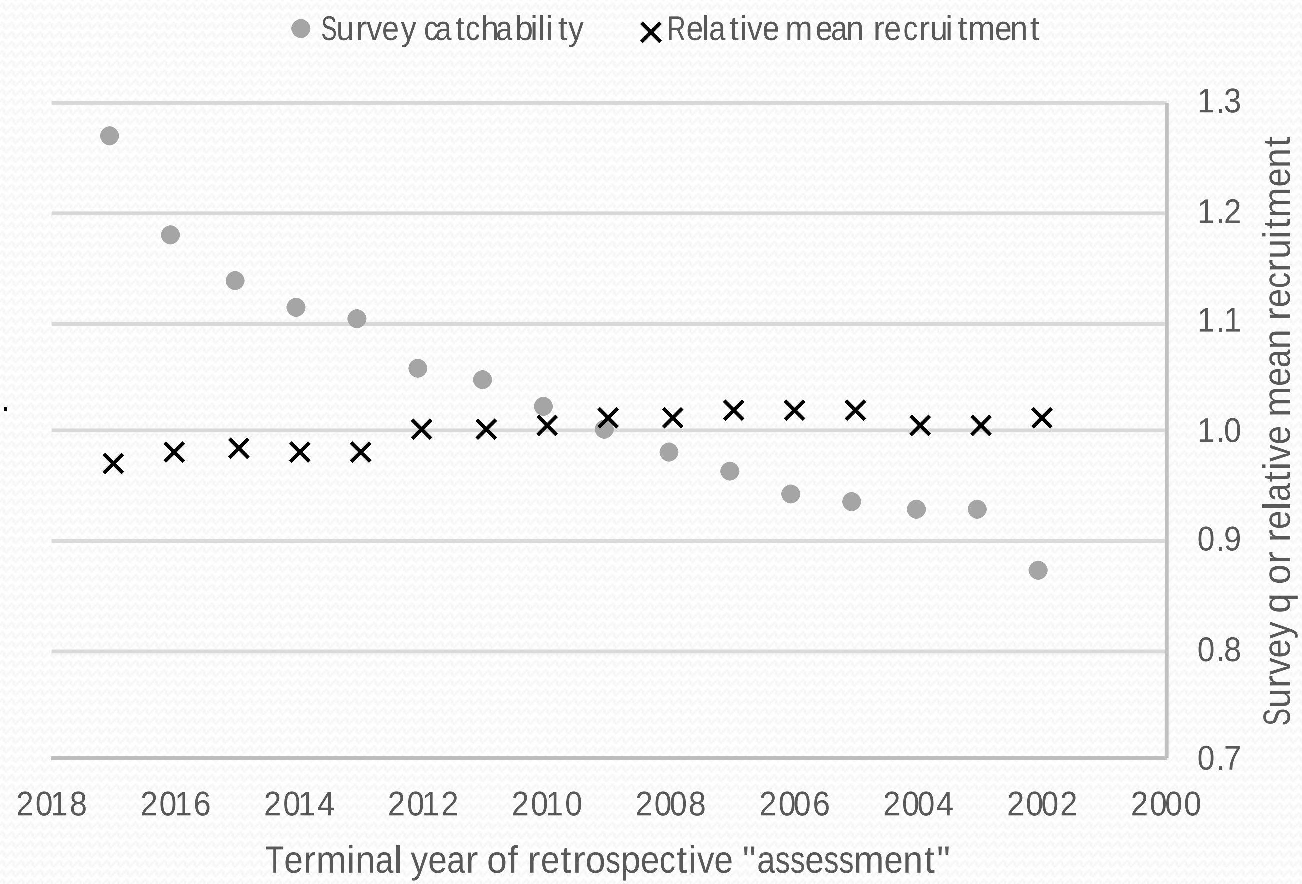


Figure 2. Atka mackerel Aleutian Islands bottom trawl survey catchability (*q*) and mean recruitment (rescaled to have mean of 1.0) over different retrospective model runs.

Retrospective pattern investigations

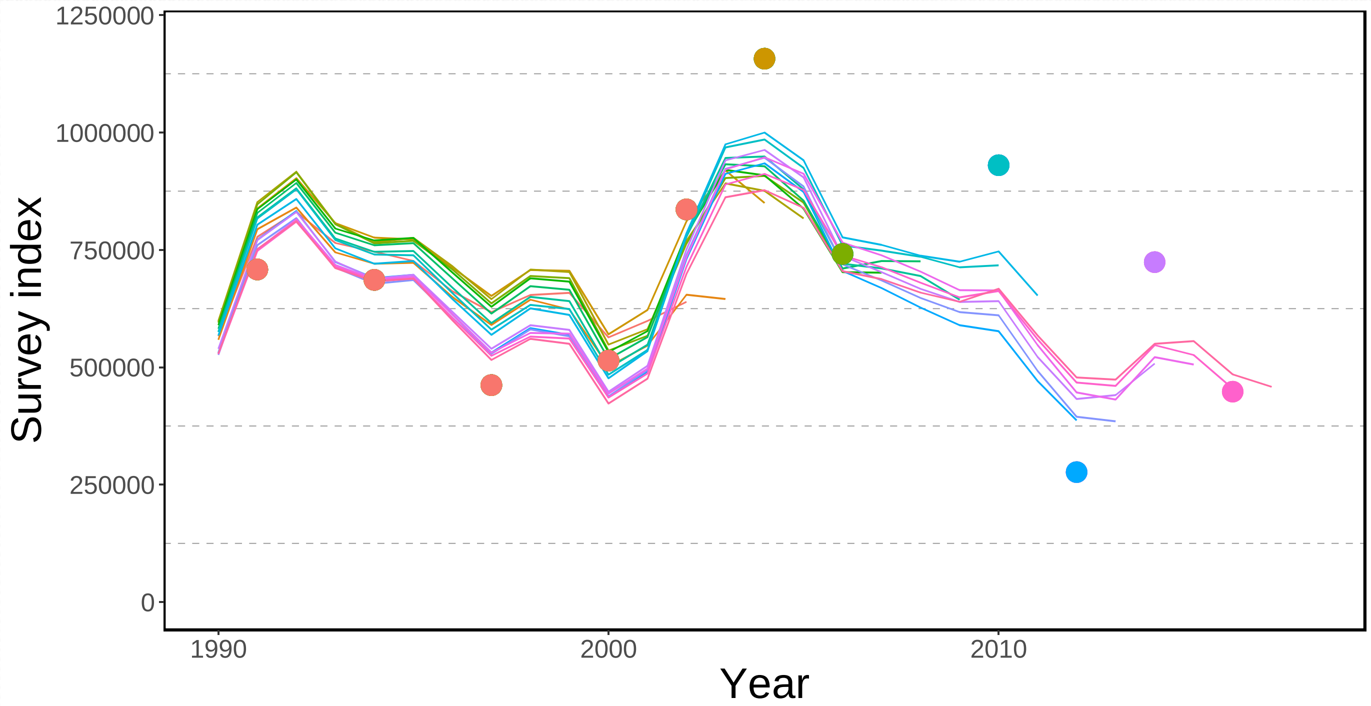


Figure 3. Fit to survey data (dots) relative to retrospective run model fits (lines).

- 2012 and 2016 (*and 2018?*) lowest survey estimates in time series
- 2002, 2004, 2010 highest survey estimates in time series
- Adding 2012 and 2016 dropped overall biomass and increased *q*
- Increase in *q* scales the population to be lower

Retrospective pattern investigations

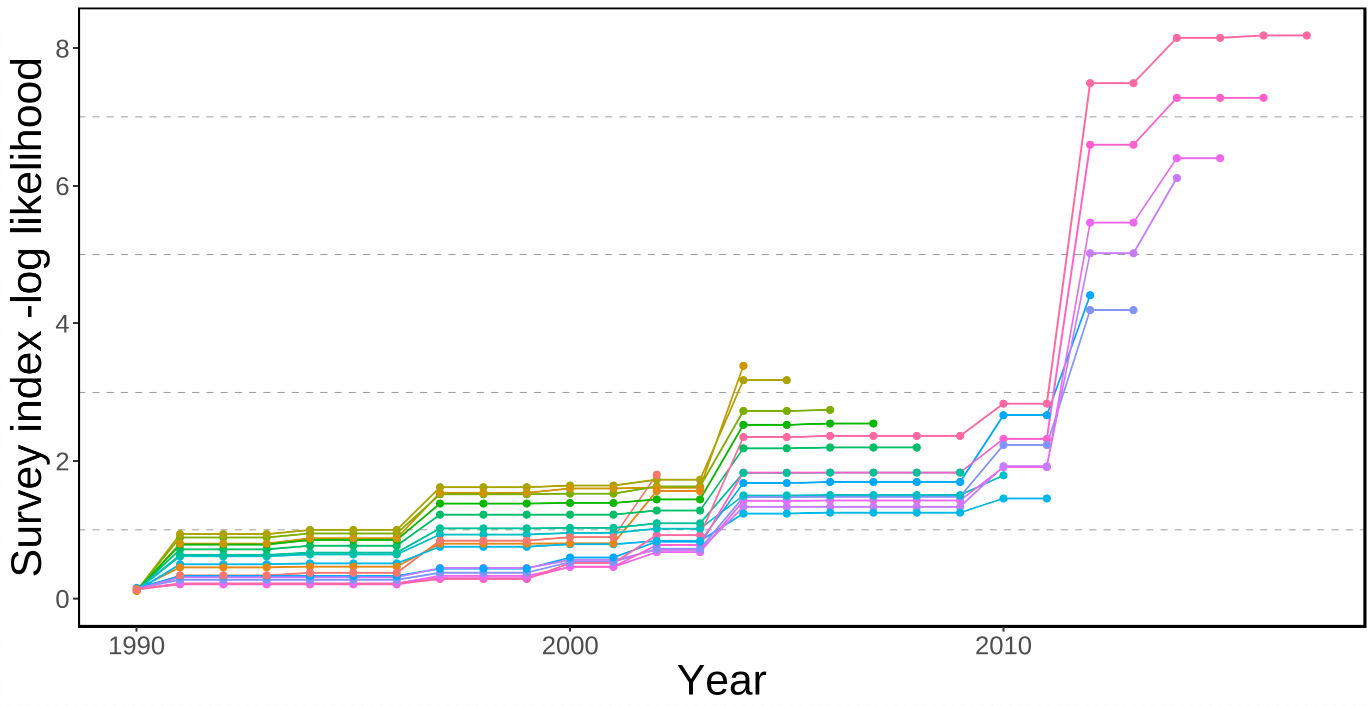


Figure 4a. Cumulative negative log-likelihood for survey index for retrospective model runs.

- Survey index—historical biomass more or less consistent with model est.
- Large jump after 2012 survey added

Retrospective pattern investigations

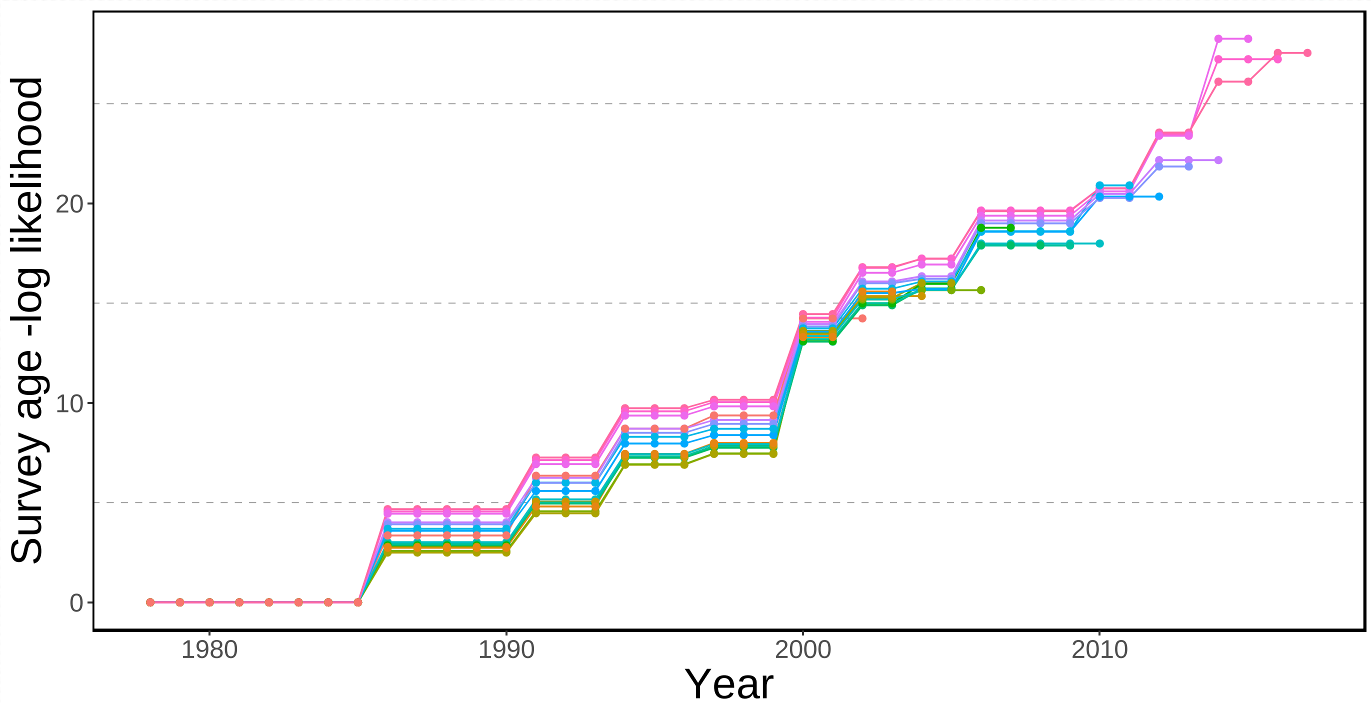


Figure 4b. Cumulative negative log-likelihood for survey age composition for retrospective model runs.

- Survey age comps—peels fairly consistent with expected jumps after 2012 and 2014 age comps added
- Jumps are much less than survey index patterns
- Comparable with adding in past years of age data

Retrospective pattern investigations

- Robust fishery age data, well fit
- Species patchily distributed
- Survey indices are highly variable
- Model is prevented from fitting the 2012, 2016 large drops in survey biomass

The observed pattern reflects the addition of recent survey estimates, and in general, seems to be consistent with the uncertainty estimates of population biomass, and trawl survey estimates that have a high level of variability.

Dropping the 1986 survey age compositions

- Inconsistencies documented in the 1980s survey data (US-Japanese cooperative surveys)
- General agreement that 1980s Aleutian Islands data are not included in stock assessments (AI pollock, AI POP, AI northern rk, ~Atka mackerel)
- BSAI Atka mackerel does not include 1986 survey biomass
  - Does include 1986 survey age composition
  - Thought to provide useful info on relative yr. class strength

Explored this further with simulations with and without 1986 survey age data

Dropping the 1986 survey age compositions

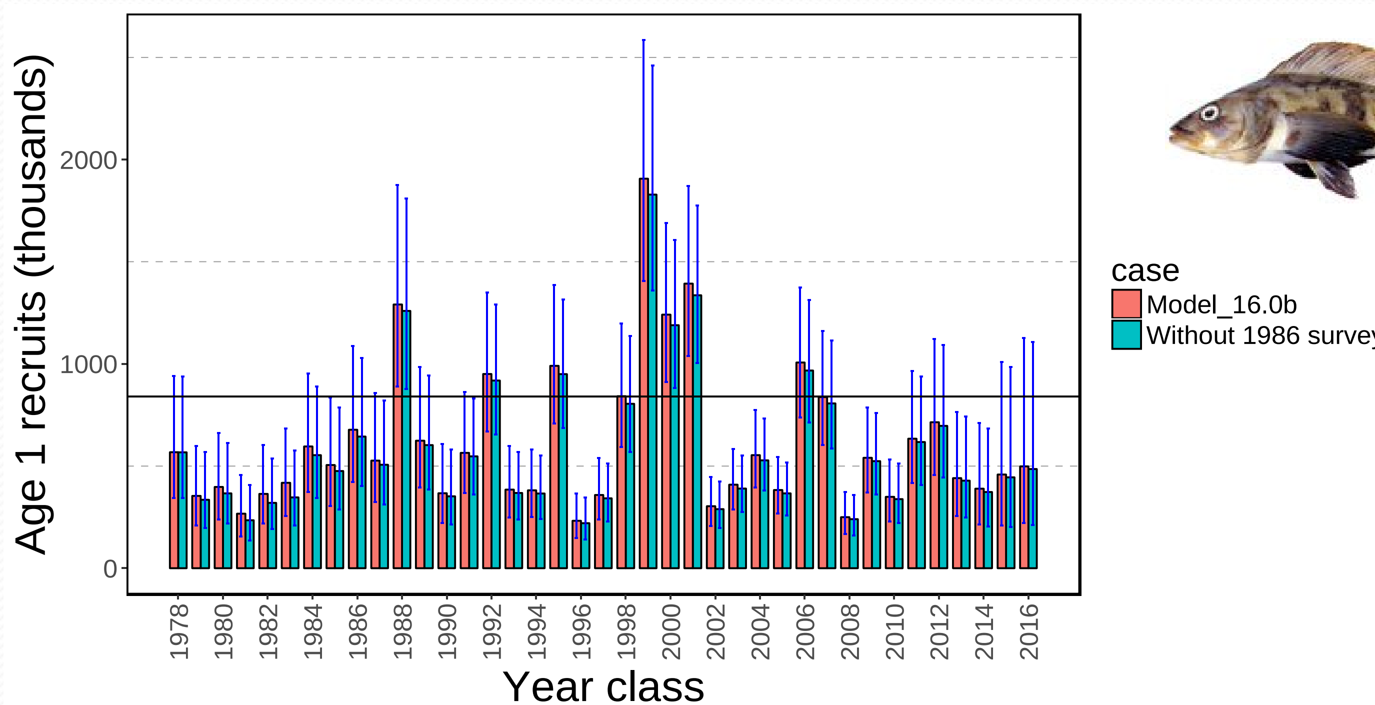


Figure 5. Age 1 recruitment estimates with and without the 1986 survey age composition included.

Without 1986 survey age data:

- Mean recruitment estimates lower by ~3.5%
- 2017 spawning biomass est. similarly affected with lower estimate
- Fit to the survey degraded (increase in -log likelihood component)
- Increase in *q;* explains some of change in rec. and spawning biomass levels

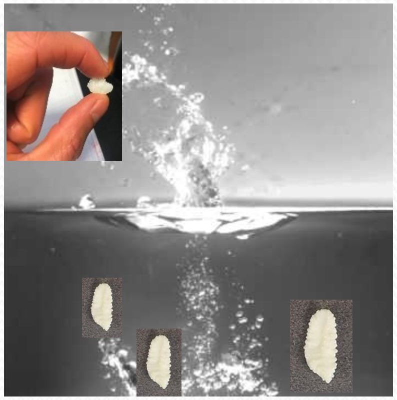
Dropping the 1986 survey age compositions

2017 Assessment:

- Sensitivity analysis of time-varying selectivity for survey
- Separate selectivity pattern for 1986 (incl. 1986 survey)
- Failed to improve fit to survey biomass
- Minimal impact on results

Conclusions:

- No real benefit to including 1986 age data
- Inconsistency to exclude survey index and include age data
- Propose to exclude the 1986 survey age data in future assessments



Investigate fishery selectivity time blocks with links to identifiable changes in fishery

Time blocks from Model 16.0c in 2017 assessment:

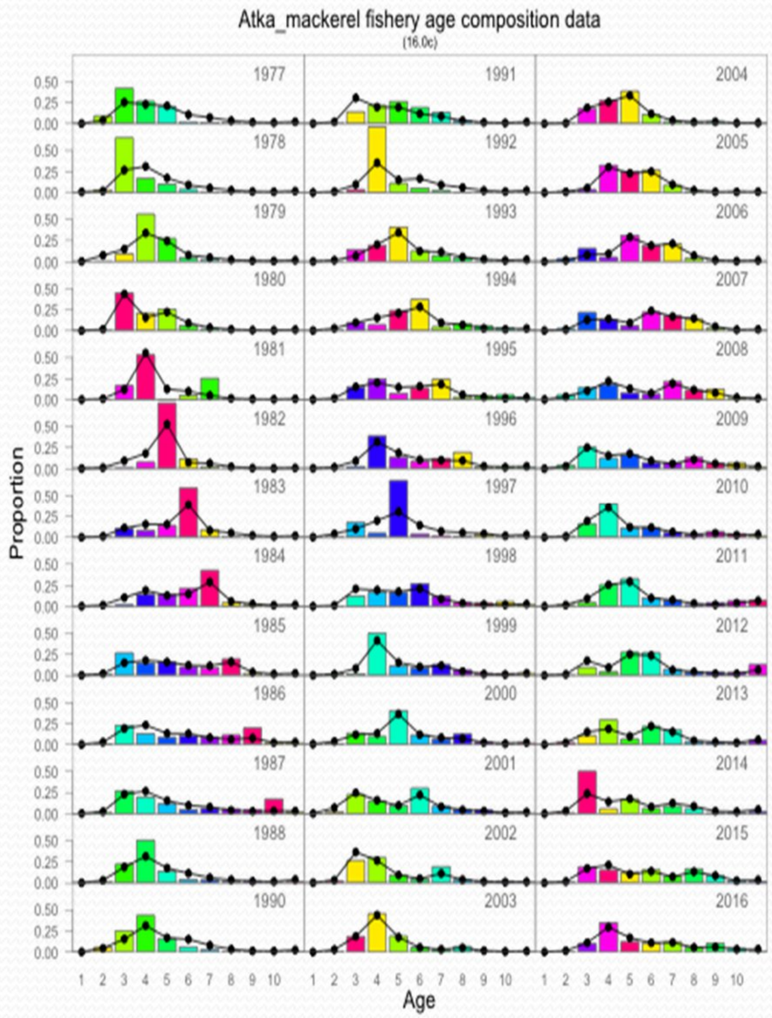
1977-1983 Foreign fishery
1984-1991 Joint venture fishery
1992-1998 Domestic fishery and 3-subarea split
1999-2010 Steller sea lion regulations
2011-2014 Steller sea lion RPAs
2015-2016 revised Steller sea lion RPAs

1999-2005 Steller sea lion regulations
2006-2010 Steller sea lion regulations, Amendments 78 and 80

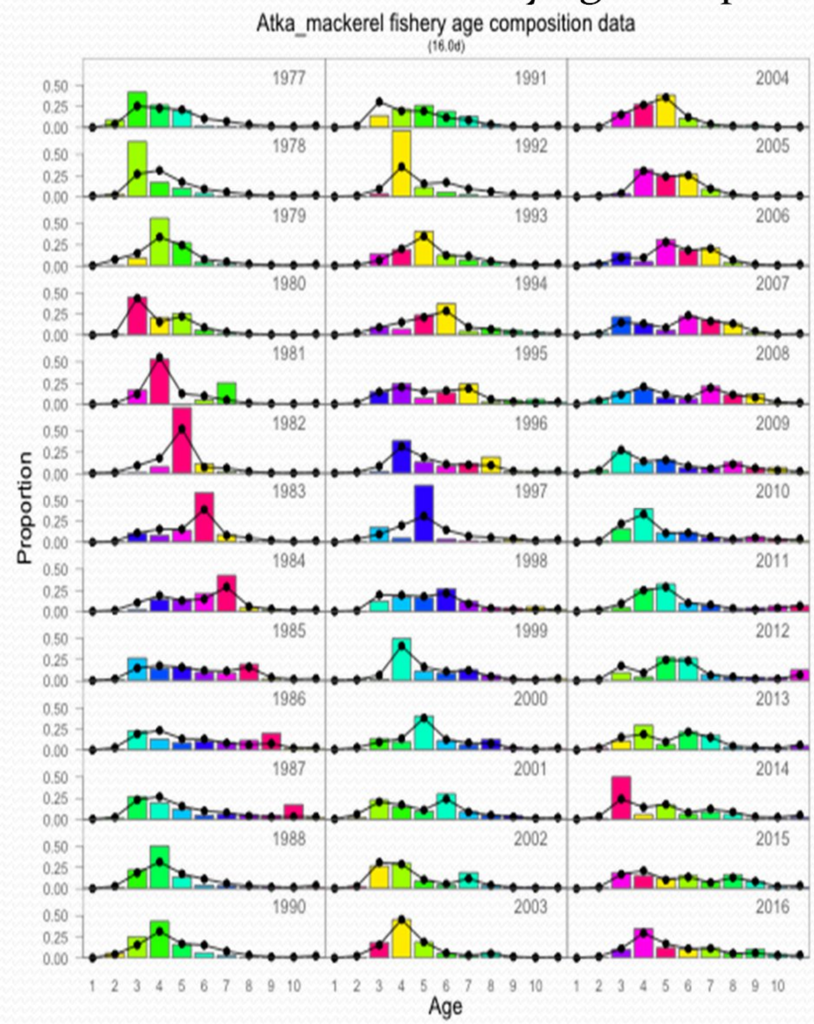
Investigate fishery selectivity time blocks

With additional time block in the 1999-2010 period:

- Fit to the fishery age composition component degraded
- Resulted in minor (negligible) improvements to the fits to the fishery age compositions



Without



With

Investigate fishery selectivity time blocks

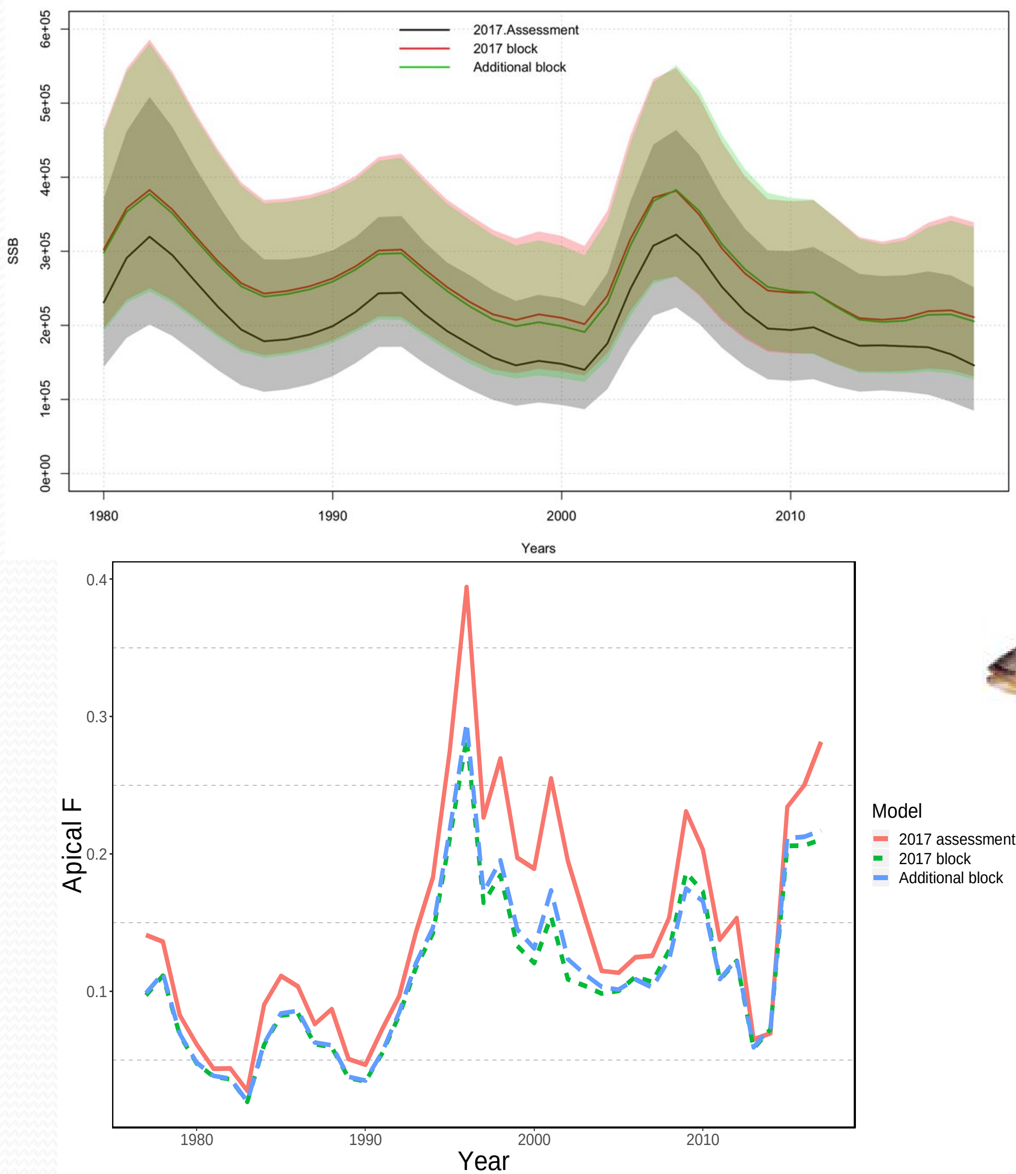
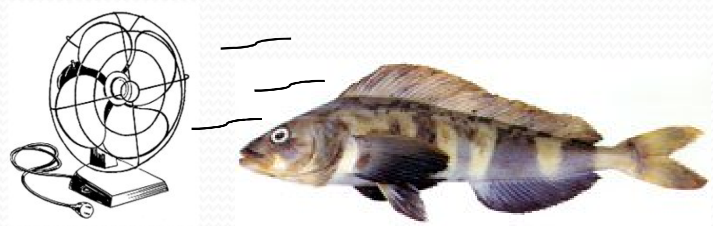


Figure 8. Spawning biomass (top) and apical fishing mortality (bottom) for the 2017 selected assessment model configuration and alternative selectivity blocking schemes.

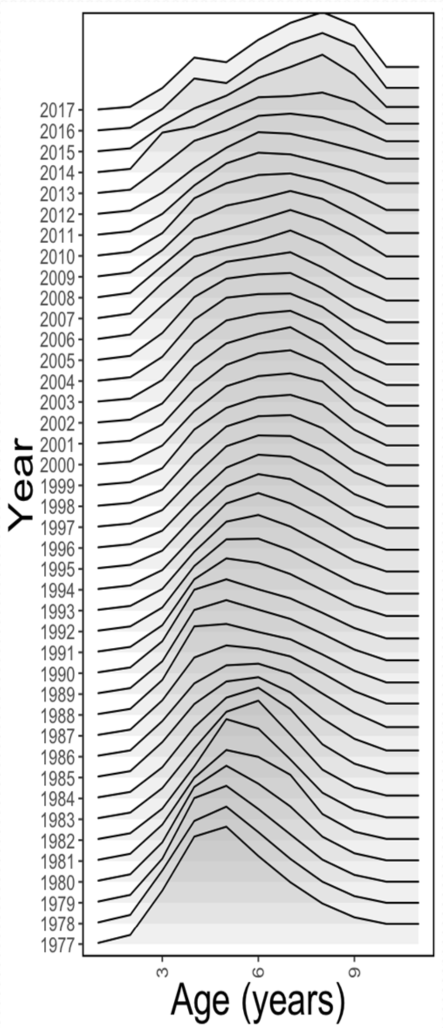
Investigate fishery selectivity time blocks

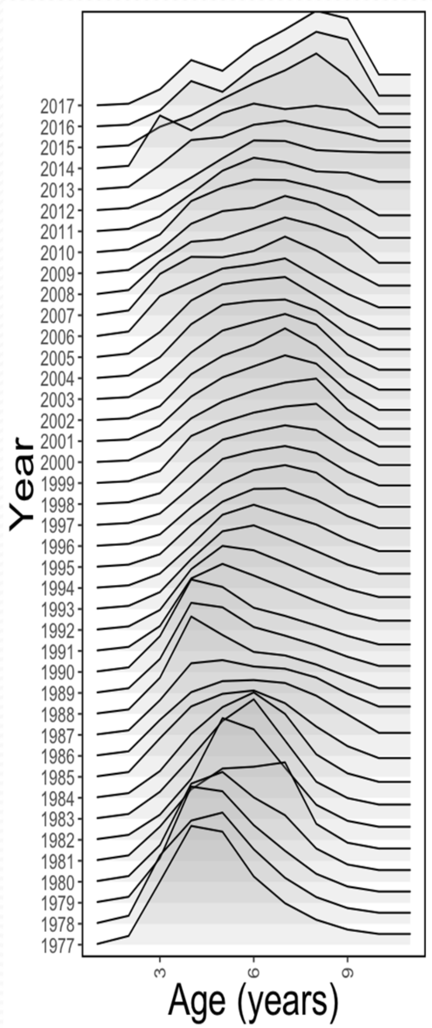
- Not a fan of time blocks  (Dorn, yesterday)
- Selectivity patterns for the time blocks selected tended to obscure significant recruitment events
- Time block based on a pattern that was only evident for a short time period (less than the number of years in the block)
- Fits to fishery age comps degraded
- 2013 assessment explored time-varying selectivity
  - Allows the model flexibility to better reflect fishery age comp.
  - Provided results consistent with fishery age distributions
- Reasonable to expect some variability given year class variability
- Reasonable to expect fishery to seek out higher CPUE areas
  - Especially when strong year classes are present
  - Would expect higher peak *F* as shown in previous figure

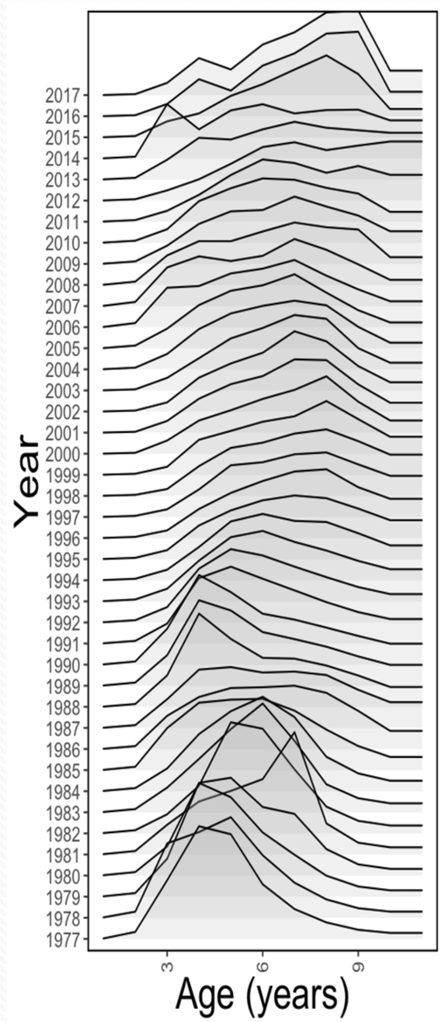
Investigate how tuning the selectivity variability parameter affects results if higher or lower samples sizes assumed for fishery

- The 2017 model assumed a mean sample size of 100 for the time period of observer data (1991-2016)
- Evaluation rescaled all the input sample sizes to half (50) and double (200) that assumption
- Resulted in expected differences in the degree of fishery selectivity variability
- Affected recruitment estimates

Investigate how tuning the selectivity variability parameter affects results if higher or lower samples sizes assumed for fishery







Sample size → 50 100 200

Fishery selectivity patterns from the BSAI Atka mackerel assessment model 16.0b

Investigate how tuning the selectivity variability parameter affects results if higher or lower samples sizes assumed for fishery

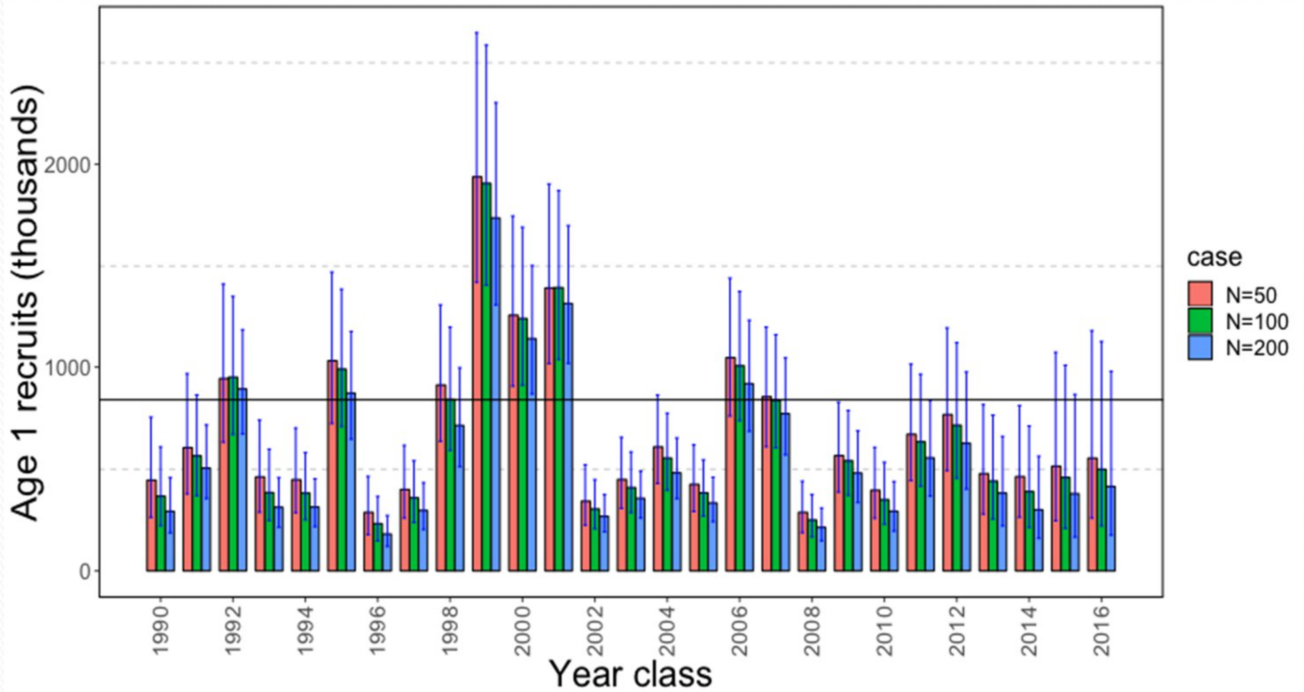


Figure 12. Estimated BSAI Atka mackerel age 1 recruitment under different assumptions about mean 1991-2016 fishery sample sizes comparing values of 100 (used in the 2017 assessment), and alternative mean 1991-2016 sample sizes equal to 50 and 200, and Francis weights tuned to approximately 1.0

Investigate how tuning the selectivity variability parameter affects results if higher or lower samples sizes assumed for fishery

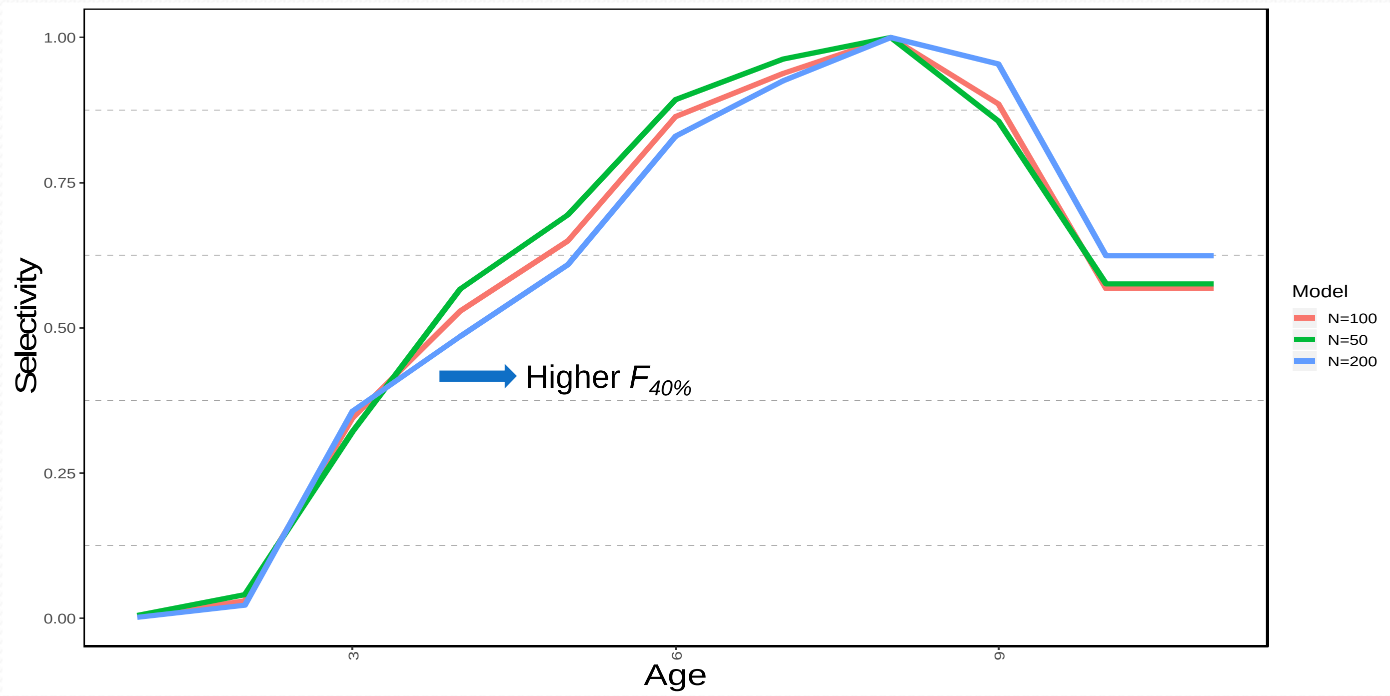


Figure 13. Average (2012-2016) selectivity at age estimates for different tuned model runs with mean 1991-2016 fishery sample sizes equal to 100 (used in the 2017 assessment), and alternatives with selectivity variability tuned to mean 1991-2016 fishery sample sizes equal to 50 and 200.

Investigate how tuning the selectivity variability parameter affects results if higher or lower samples sizes assumed for fishery

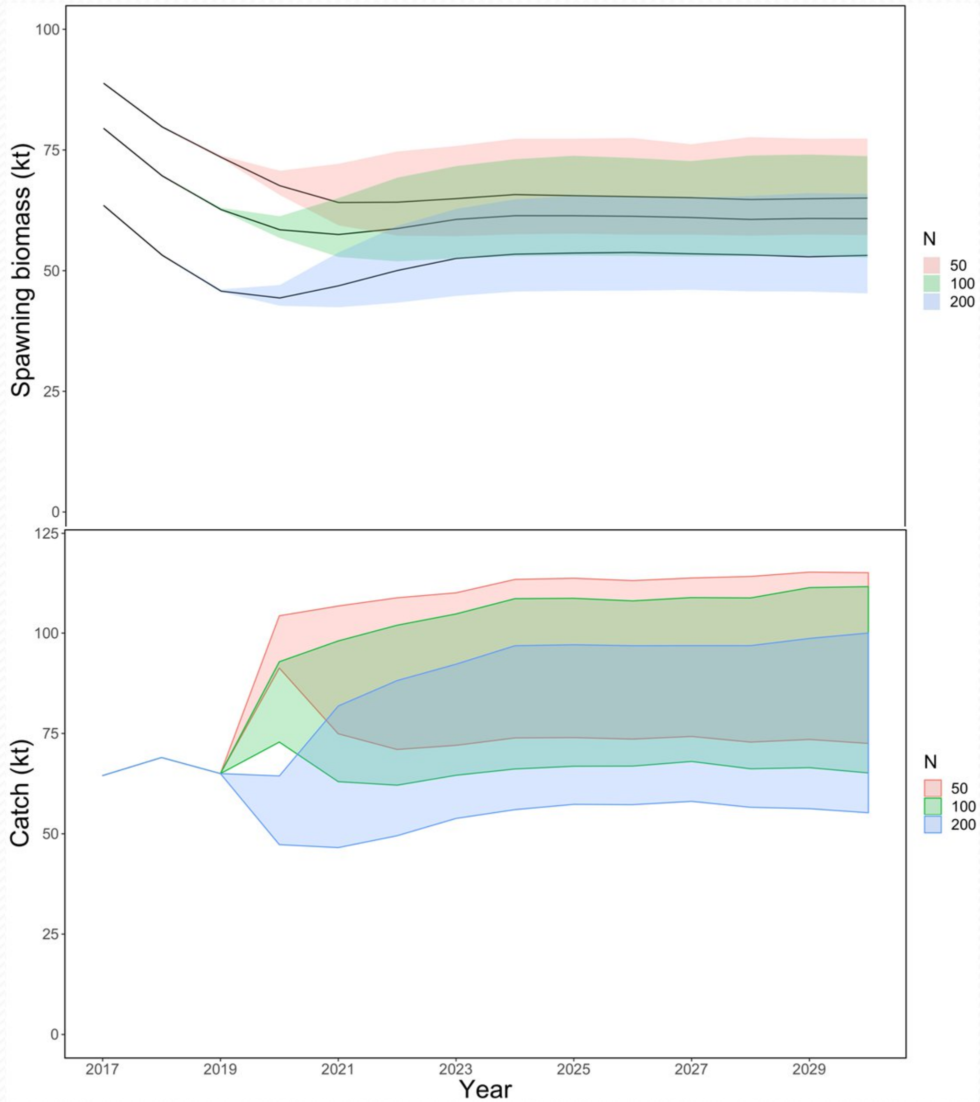


Figure 14. Projections of spawning biomass (top) and fishery catch (bottom) for different tuned model runs with mean 1991-2016 fishery sample sizes N=100 (used in 2017 assessment) and alternatives with time-varying selectivity variability tuned to mean fishery sample sizes of N=50 and N=200.

Investigation of age-dependent natural mortality (M)

Evaluation using three methods

- These methods are initially based on theoretical life history and or ecological relationships
- Methods evaluated using meta-analysis
- Resulting in an empirical equation relating *M* to more easily measured quantities of length and weight

Investigation of age-dependent natural mortality (M)

M-at-age formulation suggested in the report of the Natural Mortality Workshop held in 2009 (Brodziak *et al.* 2011)

Brodziak et al. (2011)—Age–specific *M* is given by

$$M(a) = \begin{cases} M_c \dfrac{L_{mat}}{L(a)} & for \quad a < a_{mat} \\ M_c & for \quad a \geq a_{mat} \end{cases}$$

where L_{mat} is the length at maturity, $M_c = 0.30$ is the specified natural mortality at L_{mat}, L(a) is mean length at age for the 2010-2016 Aleutian Islands summer bottom trawl surveys

Investigation of age-dependent natural mortality (M)

Lorenzen (1996)—Age-specific *M* for ocean ecosystems is given by

$$M\,(\mathrm{a}) = 3.69\ W^{-0.305},$$

where *W* is the mean weight at age from the 2010-2016 Aleutian Islands summer bottom trawl surveys

Investigation of age-dependent natural mortality (M)

Gislason et al. (2010)—Age specific M is given by

$$\ln(M) = 0.55 - 1.61 \ln(L) + 1.44 \ln(L_\infty) + \ln(K),$$

where L_∞ and K were estimated by fitting the von Bertalanffy growth curve using age data from the 2010-2016 Aleutian Islands summer bottom trawl surveys

Investigation of age-dependent natural mortality (M)

Table 1. Schedule of alternative approaches to specifying specific natural mortality rates-at-age. The “Rescaled Average” was used for evaluations

Age	Length (cm)	Weight (g)	Brodziak *et al.* (2011)	Lorenzen (1996)	Gislason *et al.* (2010)	Average	Rescaled Ave.
1	14.09	45	0.76	1.00	2.13	1.30	1.04
2	23.38	168.25	0.46	0.69	0.94	0.70	0.56
3	29.71	391	0.36	0.54	0.64	0.51	0.41
4	34.02	538.5	0.31	0.49	0.52	0.44	0.35
5	36.96	663	0.30	0.46	0.45	0.40	0.32
6	38.96	725.5	0.30	0.45	0.41	0.39	0.31
7	40.32	837.75	0.30	0.43	0.39	0.37	0.30
8	41.25	934.5	0.30	0.42	0.38	0.37	0.29
9	41.88	918.5	0.30	0.42	0.37	0.36	0.29
10	42.31	893.75	0.30	0.42	0.36	0.36	0.29
11+	42.60	1024.25	0.30	0.41	0.36	0.36	0.29

Investigation of age-dependent natural mortality (M)

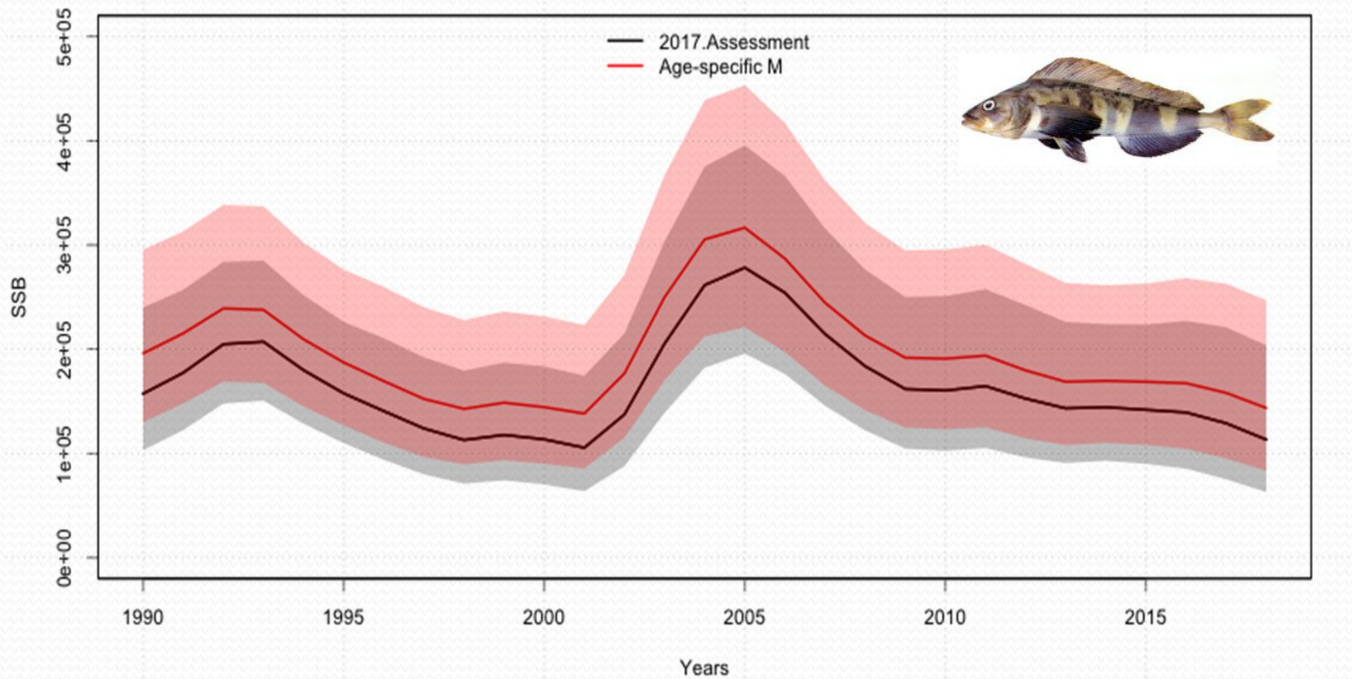


Figure 15. Comparison of Atka mackerel spawning biomass for last year's model (2017 assessment) and one with age-specific natural mortality (*M*) specified.

Investigation of age-dependent natural mortality (M)

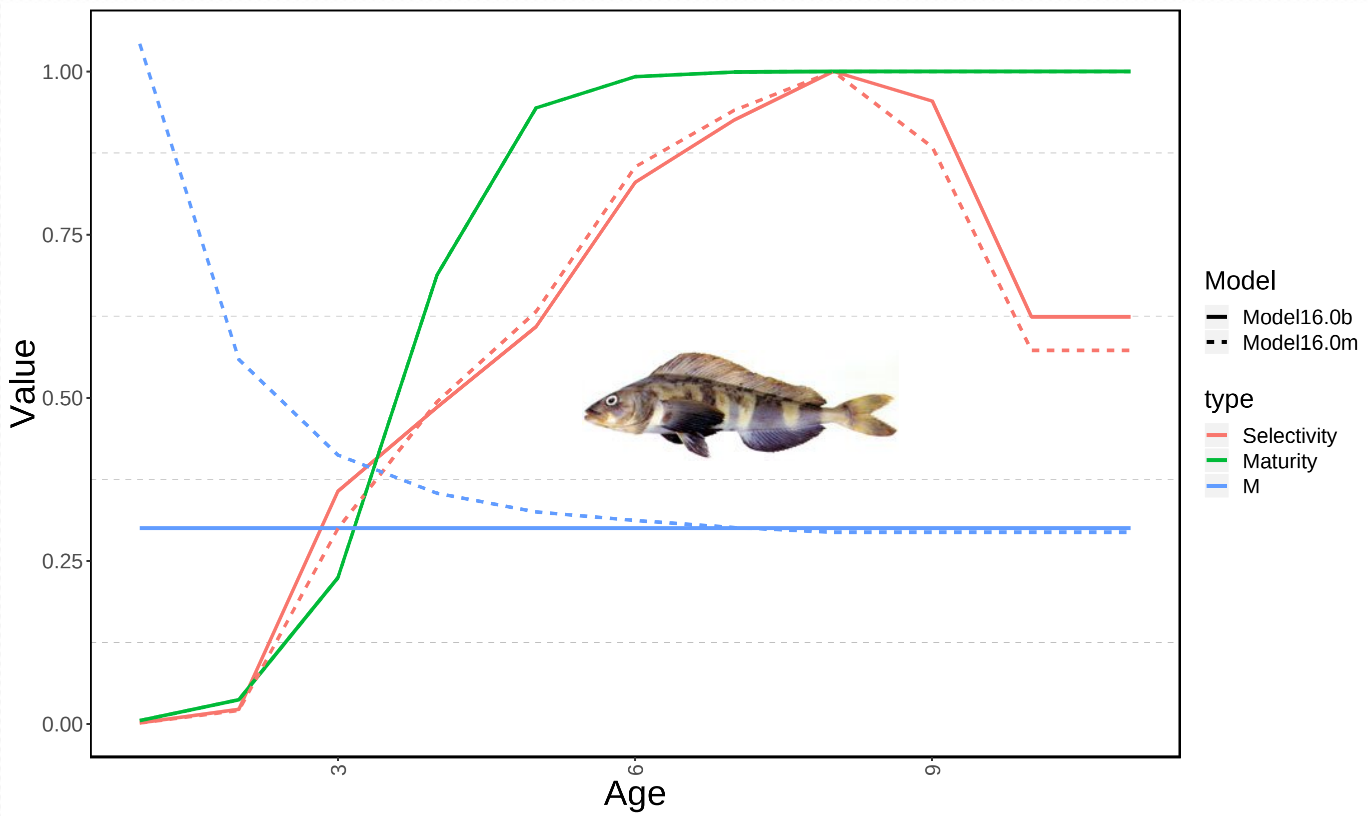
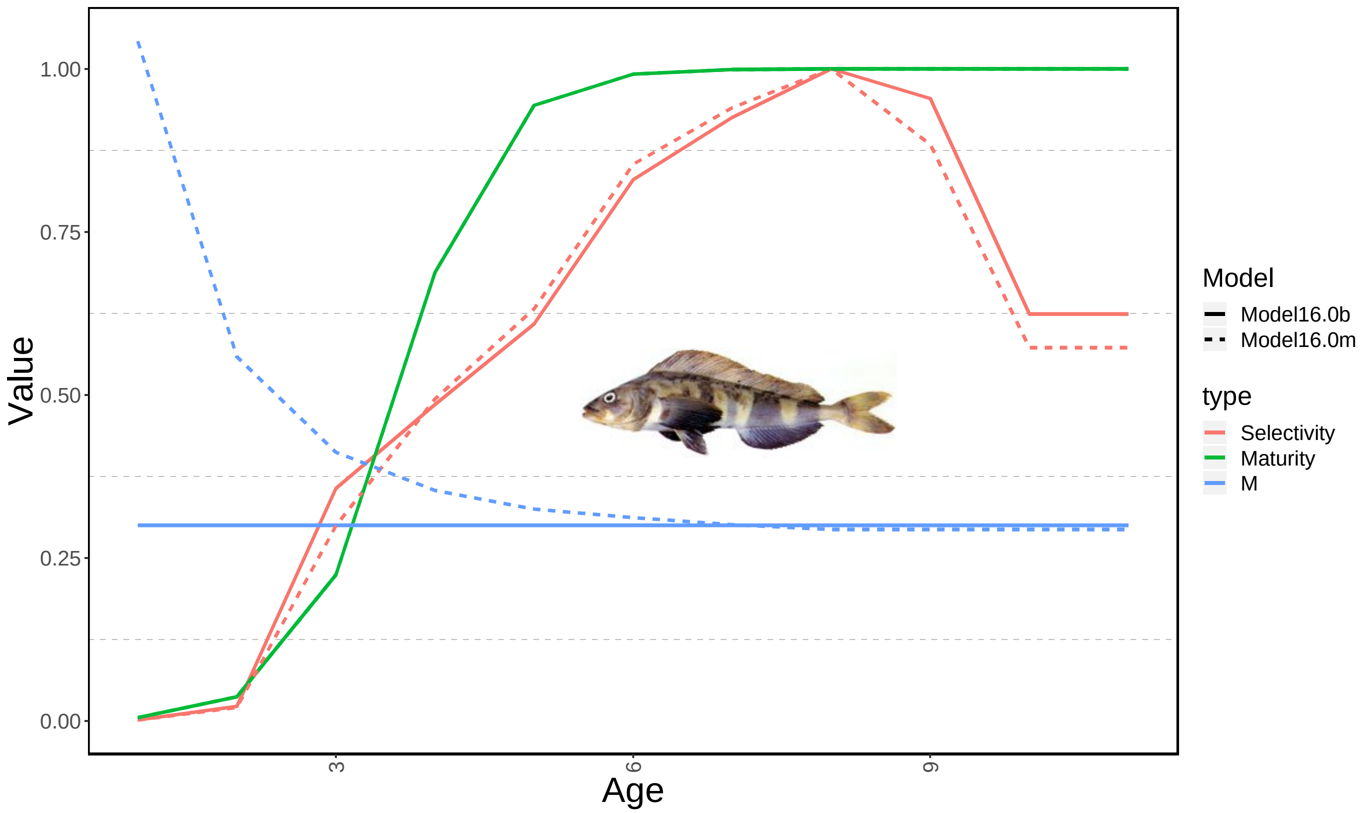


Figure 16. Age-specific schedules for Atka mackerel for the 2017 assessment model (Model 16.0b) and the one with age-specific natural mortality (Model 16.0m).

Investigation of age-dependent natural mortality (M)



- Minor increases in ABC (<3%)
- Consistent with the relatively minor differences in *M* between the two models for the >50% selected age groups

Investigation of age-dependent natural mortality (M)

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Investigation of age-dependent natural mortality (M)

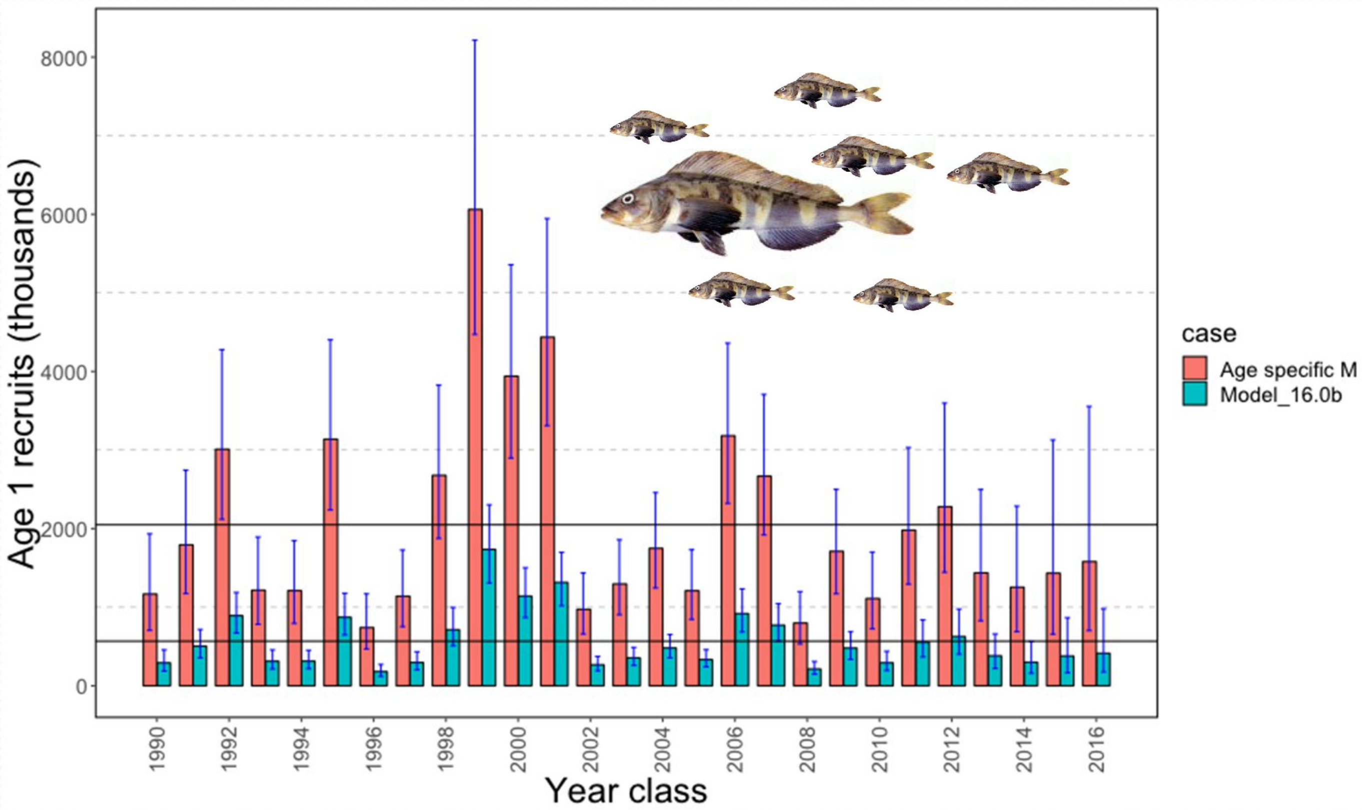


Figure 17. Age-specific schedules for Atka mackerel for the 2017 model (Model 16.0b) and the one with age-specific natural mortality (Model 16.0m).

Investigation of age-dependent natural mortality (M)

Summary

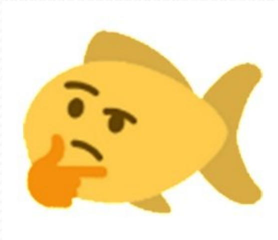
- Age-specific natural mortality improved model fits for some components, particularly fishery age composition and stock recruitment components
- Largest impacts of age-specific *M* is on the younger ages, particularly for ages 1 and 2 (age 1 *M*=1.04)
- Model has lots of flexibility for age 1 rec.

- High *M* for age 1 accommodated with highly inflated age 1 rec. estimates
- Minor increases in ABC and OFL
- Age at 50% selectivity is ~4.5 yrs for both models
- Selectivity and *M* schedules nearly identical for ages >4
- Although estimates of rec. differ greatly, age 1 recruits have little impact on stock dynamics

Investigation of age-dependent natural mortality (M)

Conclusions

- Not clear that a model configuration with age-specific mortality is an improved representation for Atka mackerel stock dynamics
- The natural mortality estimate of 0.3 is a conservative assumption based on a previous meta-analysis (Lowe and Fritz, 1997)
- This value seems to fit reasonably well with other key estimated parameters (e.g. survey catchability and selectivity)
- We suggest continuing with the current accepted model (Model 16.0b) with the assumption of fixed constant *M*=0.3
- Focus efforts on other aspects of the Atka mackerel assessment model



Questions???