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DRAFT MEMORANDUM

DATE: September 7, 2018

TO: Herring AP and Committee

FROM: Herring PDT

SUBJECT: **Amendment 8 updates incorporating 2018 benchmark assessment results**

The PDT met on August 1, 2018 and discussed that there are several sections of the Draft EIS that should be updated based on the 2018 Atlantic herring benchmark assessment that was recently completed (August 2018). This memo has been prepared for the Herring Committee to consider during its development of final preferred alternatives for Amendment 8. These updated analyses that will be incorporated into the Final Environmental Impact Statement (FEIS) for Amendment 8.

The primary sections that will be updated are:

1) Affected Environment related to trends in biomass and the status of the stock (pages 2-7 of this memo);

2) Short-term impacts of the ABC control rule alternatives (pages 8-21 of this memo); and

3) Updates to the summary of potential biological impacts of the No Action ABC control rule (page 22).

Sections of the current DEIS are included here. Text highlighted in yellow will be updated or removed for the final EIS. Text underlined is new or will replace other text.

1) Affected Environment

3.1.4 Trends in Abundance and Biomass (this section needs to be completely updated)

The Atlantic herring stock was most recently assessed during the 65th Stock Assessment Workshop (SAW)(NEFSC 2018). When the DEIS was published in April 2018 the most recent benchmark assessment was the 54th SAW using data through 2011 (NEFSC 2012). The final EIS has been updated to include the most recent information about the resource and stock status.

The 2018 assessment used all the same data sources of the previous assessment (NMFS spring, fall and summer shrimp bottom trawl survey) and added an acoustic time series collected during the NMFS fall bottom trawl survey of age 3+ herring abundance. Overall, SSB has generally declined from 1965 to a time series low in 1978 and then generally increased from 1978 through the mid-90s. SSB declined again from 1997 to 2010, increased for several years until 2014, and has been decreasing since. In addition, fishing mortality has been relatively stable since the decreases in the 1990s, with a gradual increase in 2009, followed by a general declining fishing mortality since then (Figure 1).

The same overall assessment model was used in both SAW54 and SAW56, an Age Structured Assessment Model (ASAP) with several structural changes this time around. One important change was the natural mortality (M) rate. Natural mortality was previously thought to vary by time and age, but SAW65 concluded that M should be held constant for all years and ages (set at 0.35).

With model modifications and data updates, the 2017 SSB was estimated to be 141,473 mt (80% probability interval: 114,281-182,138), compared to the full range of estimated biomass of 53,084 mt in 1982 to 1,352,700 mt in 1967 (Figure 1). Total biomass in 2017 was 239,470 mt, compared to the full range of total biomass of 169,860 mt in 1982 to 2,035,800 mt in 1967. The average F between ages 7 and 8 was used for reporting results related to fishing mortality (F7-8) because these ages are fully selected by the mobile gear fishery, which has accounted for most of the landings since 1986. F7-8 in 2017 equaled 0.45 (80% probability interval: 0.32-0.57) and ranged from 0.13 in 1965 to 1.04 in 1975 (Figure 1).

Age-1 recruitment has been below average since 2013 (Figure 2). The time series high for recruitment was in 1971 (1.4 billion age-1 fish). The estimates for 2009 and 2012 are of relatively strong cohorts, as in previous assessments. The time series low (1.7 million fish) occurred in 2016, and the second lowest (3.9 million fish) occurred in 2017, although this estimate is highly uncertain. Four of the six lowest annual recruitment estimates have occurred since 2013 (2013, 2015, 2016, and 2017).

The estimated numbers at age in 2017 indicate that the population had more age 6 fish than age 1 and age 2 combined. This suggests most biomass is the ageing 2011 cohort (age 6 in 2017). If the estimated recent record low recruitment holds true, then the SSB is likely to remain relatively low in the near term, putting the stock at relatively high risk of becoming overfished. Without improved recruitment, the probability of overfishing under recent catch levels is also likely relatively high.

Previous assessments have concluded that there is likely sub-stock structure unaccounted for, but there has been no ability to trace survey and fishery catches to stock of origin. This data gap of stock of origin has precluded this assessment from accounting for any sub-stock structure. In SAW65 an attempt was made to use an assessment model (Stock Synthesis) that accounted for stock structure on a coarse level (i.e., inside and outside of Gulf of Maine), but estimating area-specific recruitment and movement rates required unrealistic assumptions and the model generally performed poorly (e.g., poor convergence). Thus, identifying if there is sub-stock structure (and changing the stock definition if there is) is still not possible, and continued research on the topic is warranted.

Figure 1 - Atlantic herring spawning stock biomass (mt) and fishing mortality (F.report averaged over ages 7 and 8; F.full is fully selected) time series from the ASAP model for 1965-2017 (SARC 65)

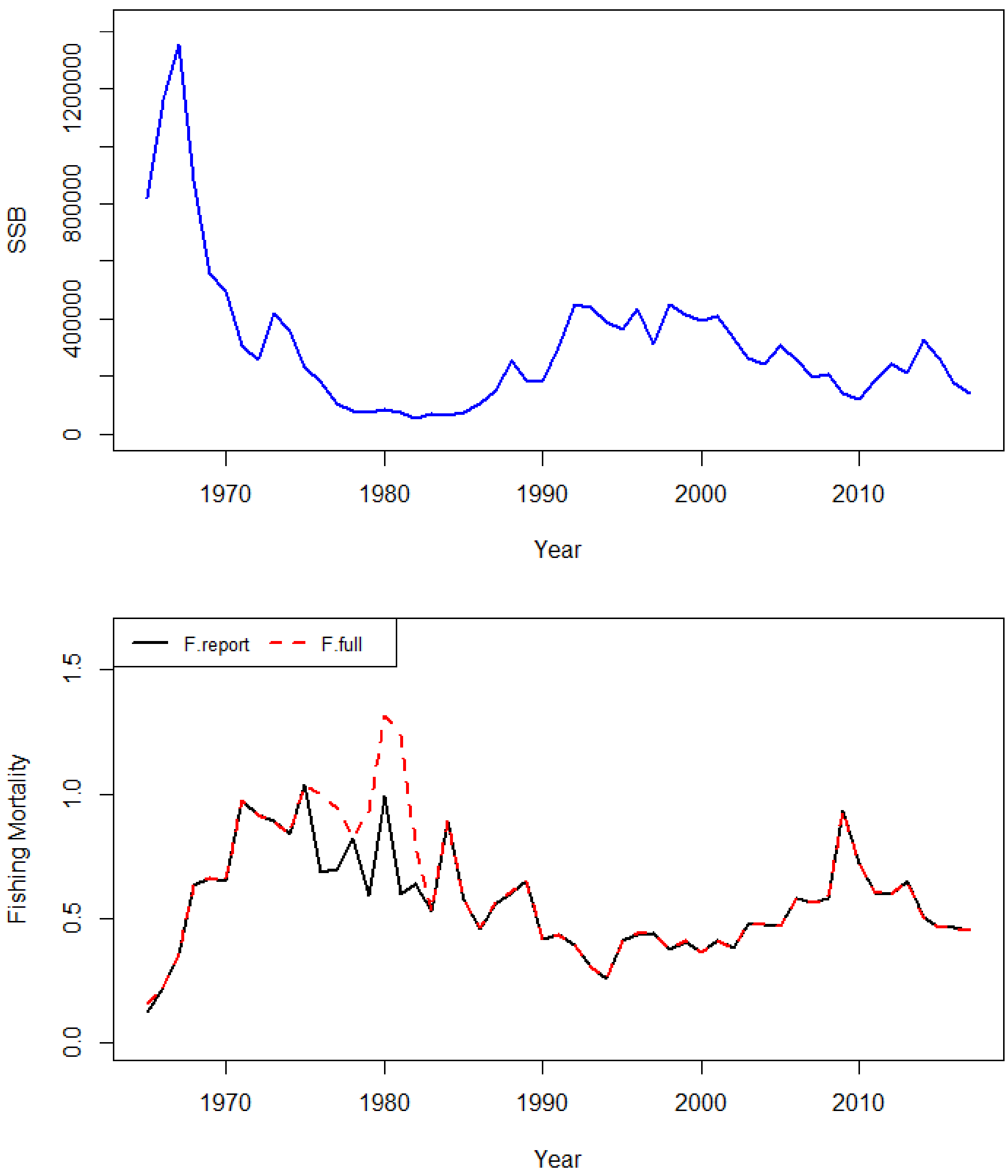
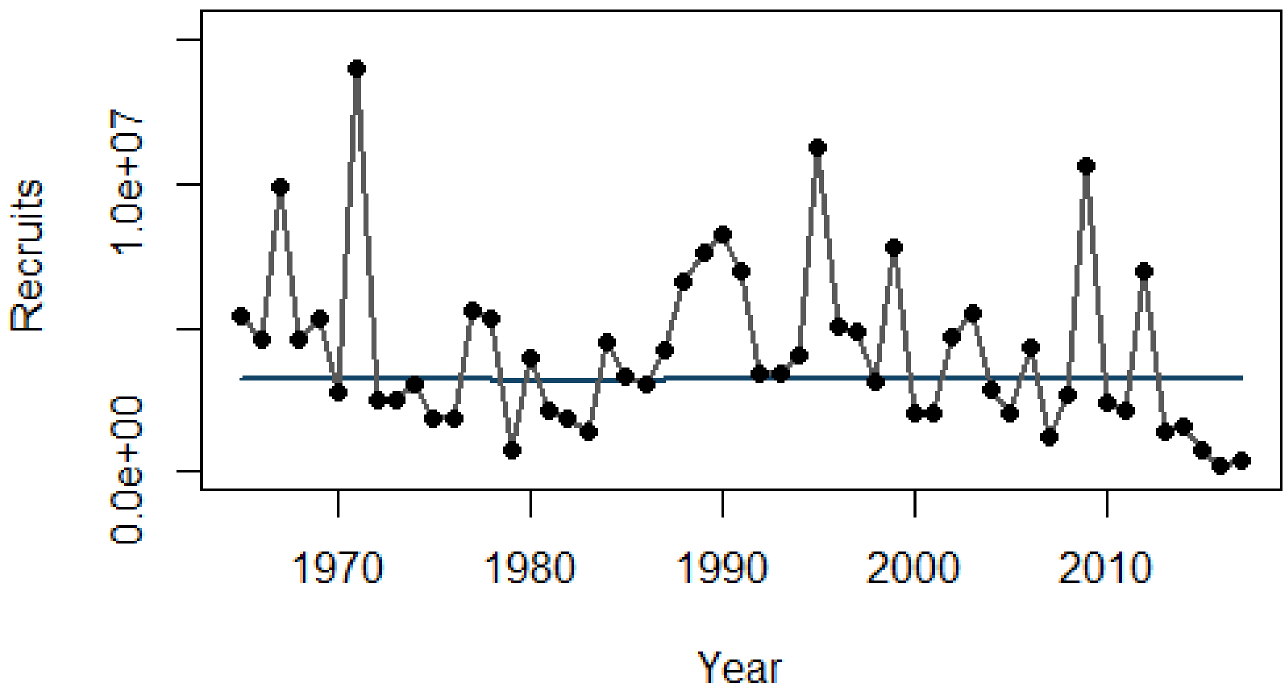


Figure 2 – Atlantic herring annual recruit (000s) time series, 1965-2017. The horizontal line is the average over the time series (SARC65)



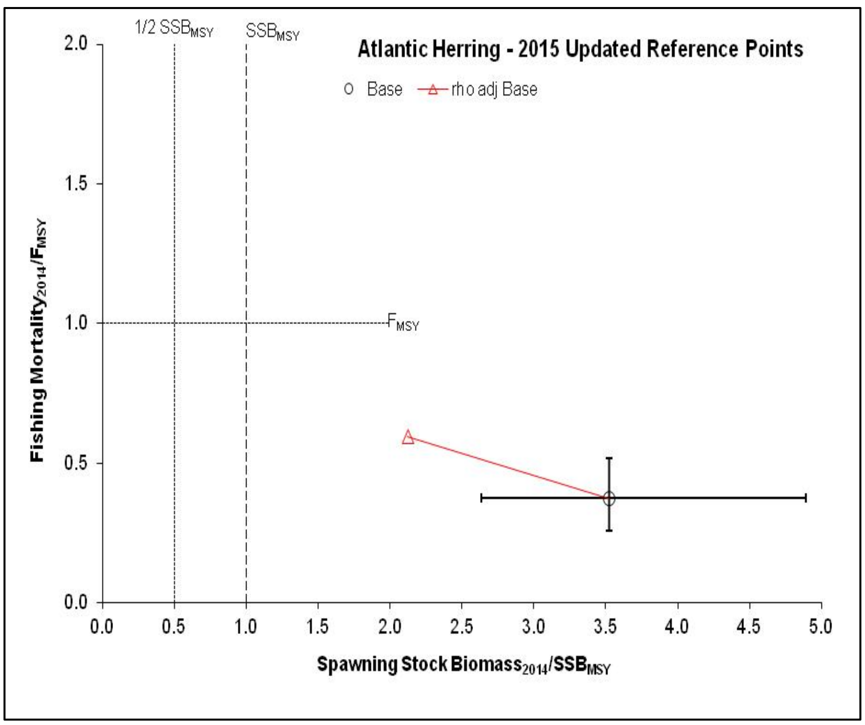
3.1.6 Atlantic Herring Stock Status (this excerpt from DEIS and will be replaced with the text on pages 6-7 of this memo)

Overall, the 2015 assessment concluded that the Atlantic herring resource continues to remain well above its biomass target (rebuilt), and fishing mortality remains well below the F_{MSY} threshold. Atlantic herring was ***neither overfished nor subject to overfishing.*** However, a retrospective pattern re-emerged when updating the assessment model, which suggested that Atlantic herring spawning stock biomass (SSB) is likely to be overestimated and fishing mortality (F) is likely to be underestimated in the terminal year of the assessment. As a result, the assessment review panel applied a retrospective adjustment to the SSB and F values for the terminal year (2014) using Mohn's Rho. The retrospective adjustments resulted in about a 40% decrease in the terminal year (2014) SSB estimate and a 60% increase in the 2014 F estimate. Even with the retrospective adjustments, the Atlantic herring stock complex remained above the biomass target and below the fishing mortality threshold (Table 1, Figure **3**).

Table 1 - Atlantic herring reference points and terminal year SSB/F estimates from the Benchmark Assessment (2012) and Update Assessment (2015)

	2012 SAW 54 Benchmark	**2015 Update (Non-Adjusted)**	**2015 Update (Retro-Adjusted)**
Terminal Year SSB	518,000 mt (2011)	1,041,500 mt (2014)	**622,991 mt (2014)**
Terminal Year F	0.14 (2011)	0.10 (2014)	**0.16 (2014)**
SSB_{MSY}	157,000 mt	311,145 mt	
F_{MSY}	0.27	0.24	
MSY	53,000 mt	77,247 mt	

Figure 3 - Atlantic herring operational assessment: 2014 fishing mortality and SSB relative to F_{MSY} and SSB_{MSY} reference points, including retrospective adjustment (red line)



Note: Error bars represent 10th and 90th percentiles of 2014 F/SSB estimates.

MSY reference points from SAW 54 (Deroba 2015) were based on the fit of a Beverton-Holt stock-recruitment curve, but this approce was not possible in the 2018 assessment because the stock-recruit curve further deteriorated. Proposed reference points from SARC65 in 2018 no longer rely on a stock-recruit relationship; thus MSY reference points were estimated based on a proxy of F40%. The newly proposed reference points no longer rely on a poorly estimated stock-recruit relationship.

FMSYproxy = 0.51

SSBMSYproxy = 189,000 mt

(½ SSBMSYproxy = 94,500), and

MSYproxy = 112,000 mt.

Therefore, SAW65 concluded that the Atlantic herring resource is above its biomass target (2017 biomass of 141,473 mt), and fishing mortality is below the F_{MSY} threshold (2017 F7-8 = 0.45). Therefore, Atlantic herring is ***neither overfished nor subject to overfishing.***

The assessment did include some cautionary notes about the status of the stock. In the short-term, the relatively poor recruitments in 2013-2017 will increase the vulnerability of the stock to becoming overfished. The 2016 and 2017 cohorts were imprecisely estimated and so estimates of these cohorts may change significantly in either direction in future assessments, and decisions should likely consider this uncertainty. Growth (i.e., weight at age) also continues to be relatively low when compared to the 1990s, and this seems to be a longer-term feature of the stock that also reduces production. The stock, however, seems to be capable of producing relatively large and small year classes regardless of growth, and so recruitment is likely the more significant driver of short-term vulnerability.

Special Comments from Assessment Summary document

- Note that based on the recent run of below average estimated annual recruitments and the assumed catch in 2018 in both example projection scenarios (**Table *2***), the projected status would change to the stock being overfished and overfishing occurring in 2018 and likely overfished in years 2019-2021.
- If the recent estimates (since 2013) of poor recruitment are confirmed and continue into the future, then projected stock status will continue to decline.
- The model's reduced ability to estimate the stock-recruit relationship is likely related to changes in M and various likelihood penalties.
- Selectivity, natural mortality, and the lack of a stock-recruitment curve have changed from the previous assessment, thus preventing comparison of the FMSY between this assessment and the previous assessment.

Figure 4 - Atlantic herring stock status based on the ASAP model. Error bars represent the 80% probability intervals. The red triangle represents the model result if an adjustment were to be made for the retrospective pattern (SARC 2018)

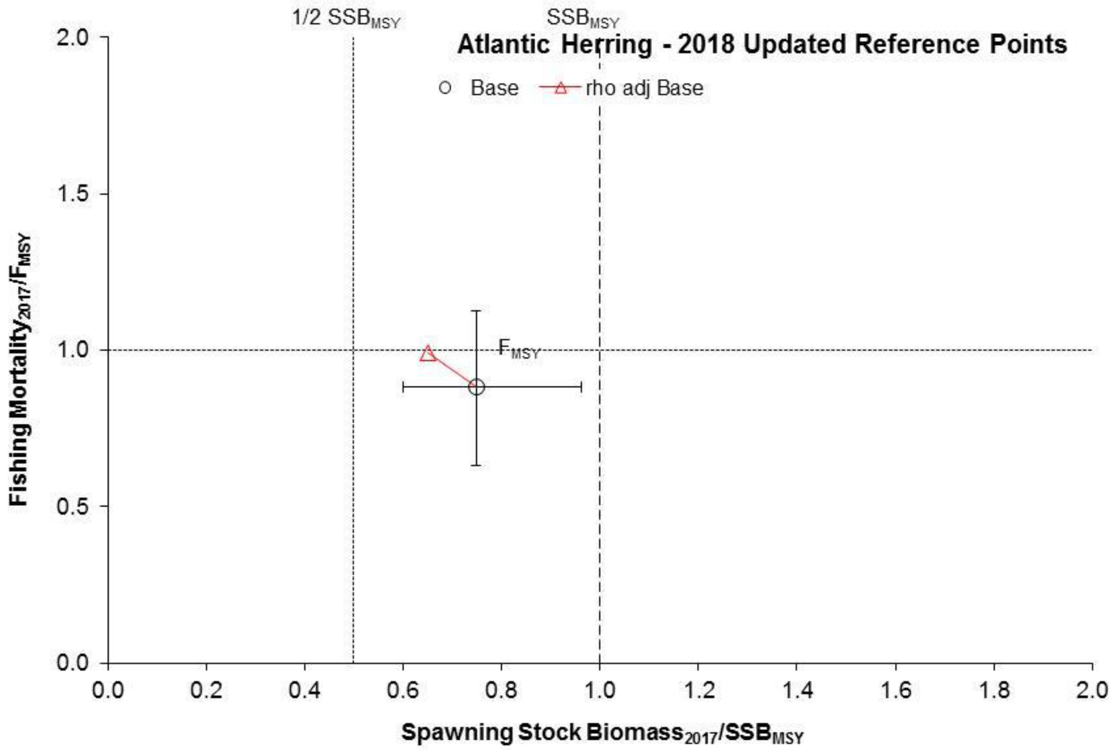


Table 2 – Short-term projections of future stock status for two different 2018 catch scenarios (Scenario 1 – full ABC harvested and Scenario 2 – 50% of ABC harvested) (SARC 2018)

Scenario 1	**2018**	**2019**	**2020**	**2021**
Catch (mt)	111,000	13,700	31,000	55,700
$F_{7\text{-}8}$	1.7	0.51	0.51	0.51
SSB (mt)	32,900	19,700	31,700	85,800
P(overfishing)	0.95	--	--	--
P(overfished)	0.96	0.94	0.93	0.58

Scenario 2	**2018**	**2019**	**2020**	**2021**
Catch (mt)	55,000	28,900	38,000	59,400
$F_{7\text{-}8}$	0.58	0.51	0.51	0.51
SSB (mt)	75,300	43,500	42,600	91,000
P(overfishing)	0.69	--	--	--
P(overfished)	0.76	0.92	0.91	0.53

2) *Additional short-term impacts of ABC control rule alternatives (Section 4.1.1.6 of DEIS, page 260)*

Single year estimates (Section 4.1.1.6.1 of DEIS)

MSE analyses focus on the potential long-term impacts; they are designed to consider impacts over a wide variety of resource conditions and time. But it is also important to consider the short-term effects of control rules, i.e., the expected impacts over the next several years. Amendment 8 also included two shorter-term analyses. First, four different herring biomass levels were selected that have been observed in the past and a single-year estimate of biomass and catch was produced for the various ABC control rule alternatives. Second, for each alternative, data from the last assessment (Deroba 2015) were used to prepare three-year projections of herring biomass and ABC. These analyses give a sense of how the various ABC CR alternatives would have performed in terms of shorter-term catch and biomass if they were used in the last specifications (FY2016-2018).

The numbers of herring at age from the last assessment (2015), as well as three other times in the past were used to give a range of possible short-term impacts. Because it is relatively uncertain what the herring resource conditions will be in the next several years, a range of possible resource conditions were evaluated to illustrate the range of possible short-term biomass and yield estimates that would result from the various ABC alternatives. "High (recent)" is the 2015 numbers at age, which is about 2.0*B_{MSY}, "Poor (1980)" was selected to reflect potential biomass and yield estimates for when the herring resource was at very low numbers (about 0.16*B_{MSY}), and two "medium" years were selected as well, 1986 (0.5*B_{MSY}) and 1995 (1.24*B_{MSY}). These different levels of biomass are used as starting points, and the fishing mortality rates from each control rule alternative was applied to those biomass values. The High (recent) biomass scenario is most likely to be in effect in the near future. The results from the other biomass scenarios provide some insight into the sensitivity of the outcomes relative to changes in biomass.

When the DEIS was published in April 2018, the near-term biomass was assumed to be high based on the results of the 2015 assessment so the most relevant panel for estimates of near term yields and economic impacts was the lower left panel, "high (recent)" biomass (Figure 6 through

Figure **9**). However, the estimate of biomass is now much lower and is likely somewhere between the "medium" and "poor" biomass scenarios depicted. Specifically, the most recent estimate of SSB/SSBmsy is 0.75 (2017). Due to poor recruitment, that estimate is expected to decrease in 2018 and drop even lower in 2019. The assessment projects the SSB/SSBmsy ratio to be 0.42 in 2018, which is lower than the panel that represents 0.5 (medium 1986).

Therefore, if actual biomass is closer to the updated estimates (SSB/SSBmsy of 0.4-0.75), the more relevant panels for estimating near term impacts of the ABC control rules are between "poor (1980)" and "medium (1986)". It is important to note that the impacts of the alternatives are all relative, and the rank order does not change when different biomass levels (or panels) are considered.

In summary, the relative ranking of the alternatives are the same regardless of biomass level, but the short-term impacts can vary dramatically depending on what level of biomass is assumed. Figure 5 shows the dramatic difference between the estimated biomass from the last assessment (2014) compared to the updated assessment (2017), as well as the current estimate of biomass for 2018.

Figure 5 – Amendment 8 ABC control rule alternatives (Alternatives 1-4f) compared to estimates of biomass from 2014, 2017 and projections for 2018

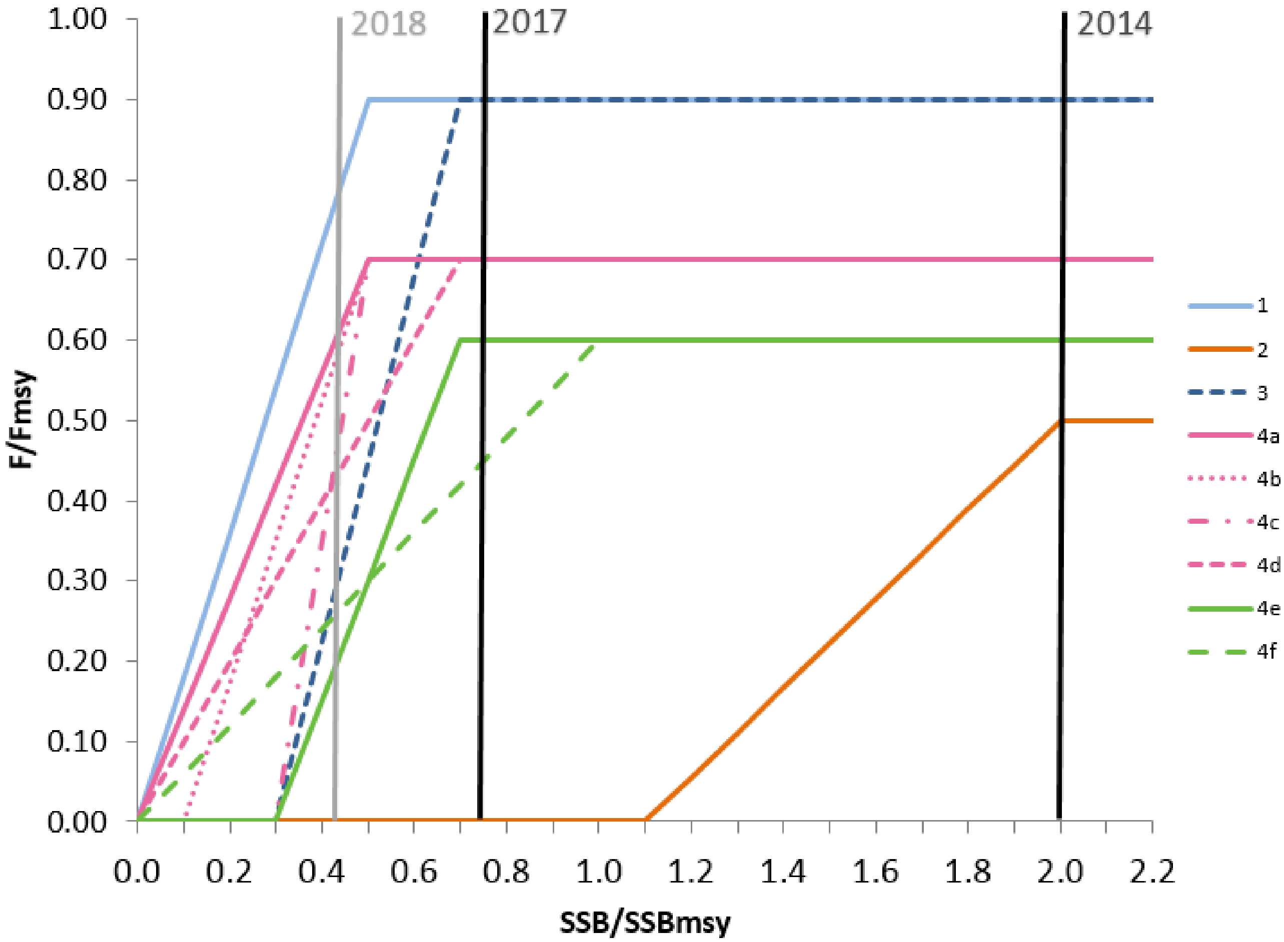


Figure 6 – Estimate of spawning stock biomass (SSB) under four different herring resource conditions for the control rules under consideration in Amendment 8

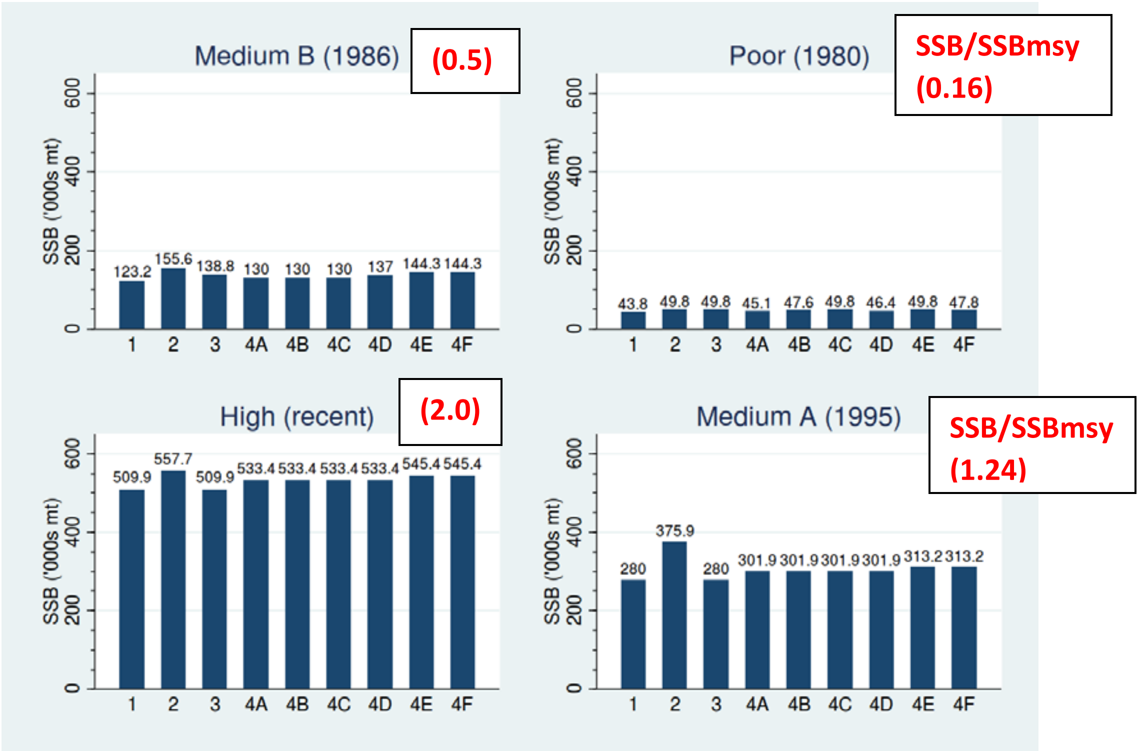


Figure 7 – Estimate of short-term ABC under four different herring resource conditions for the control rules under consideration in Amendment 8

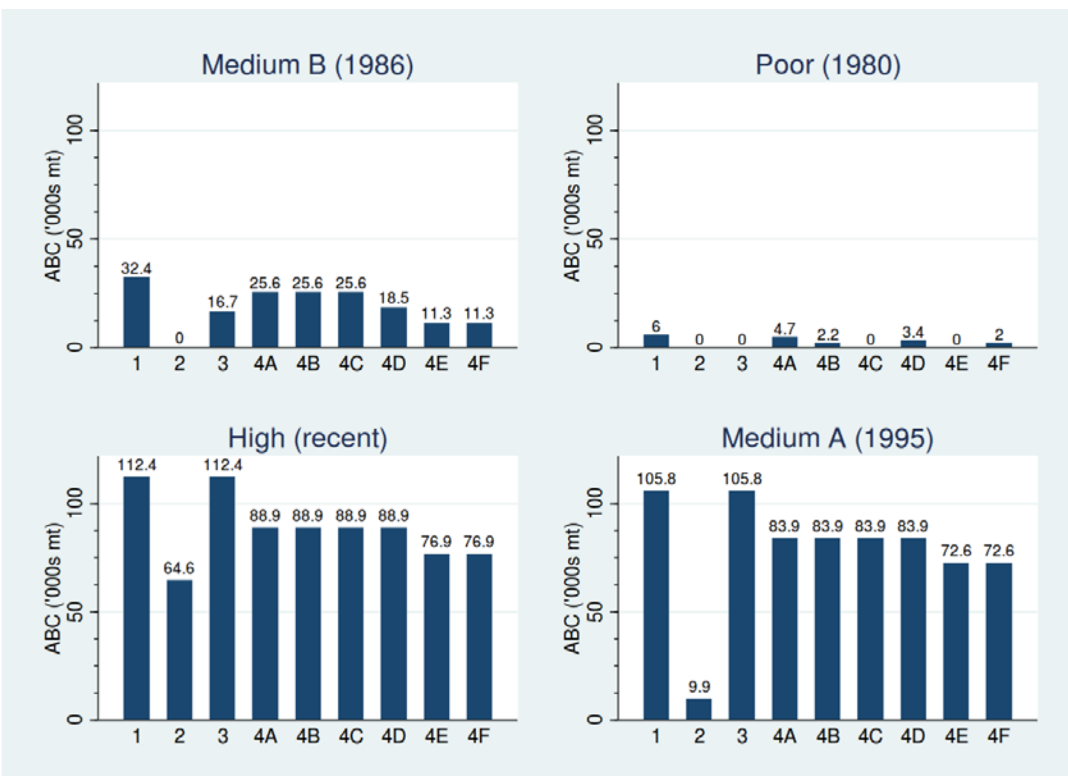


Figure 8 – Estimate of short-term gross revenue under four different herring resource conditions for the control rules under consideration in Amendment 8, using the New Price economic model

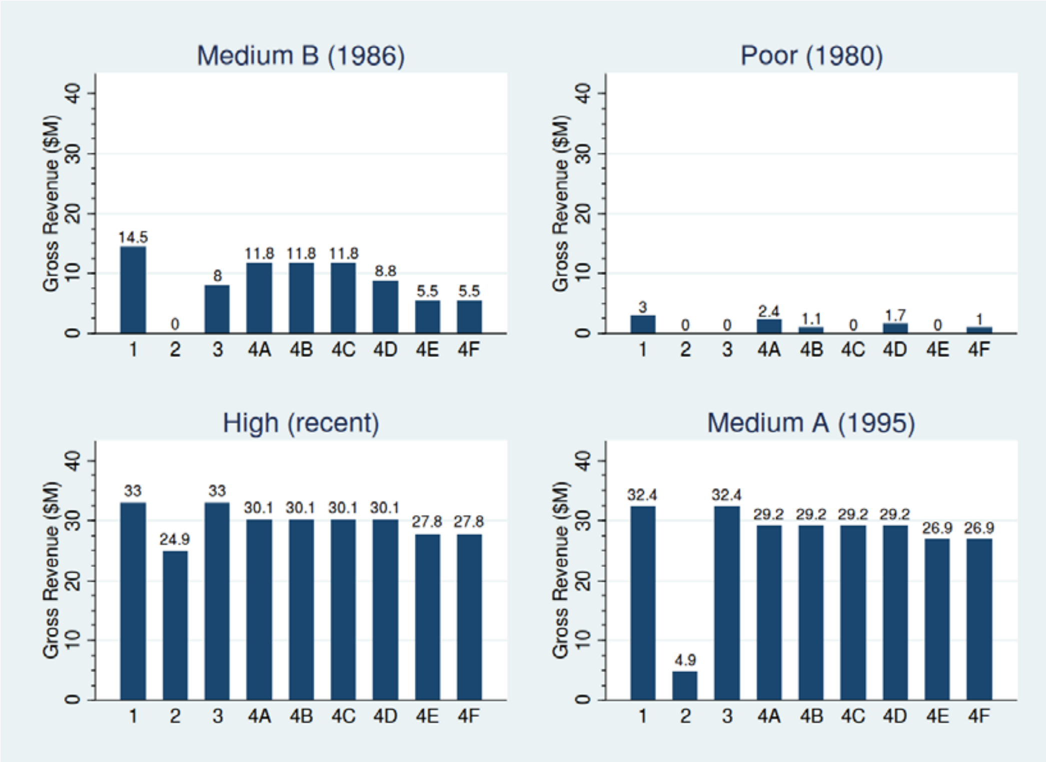
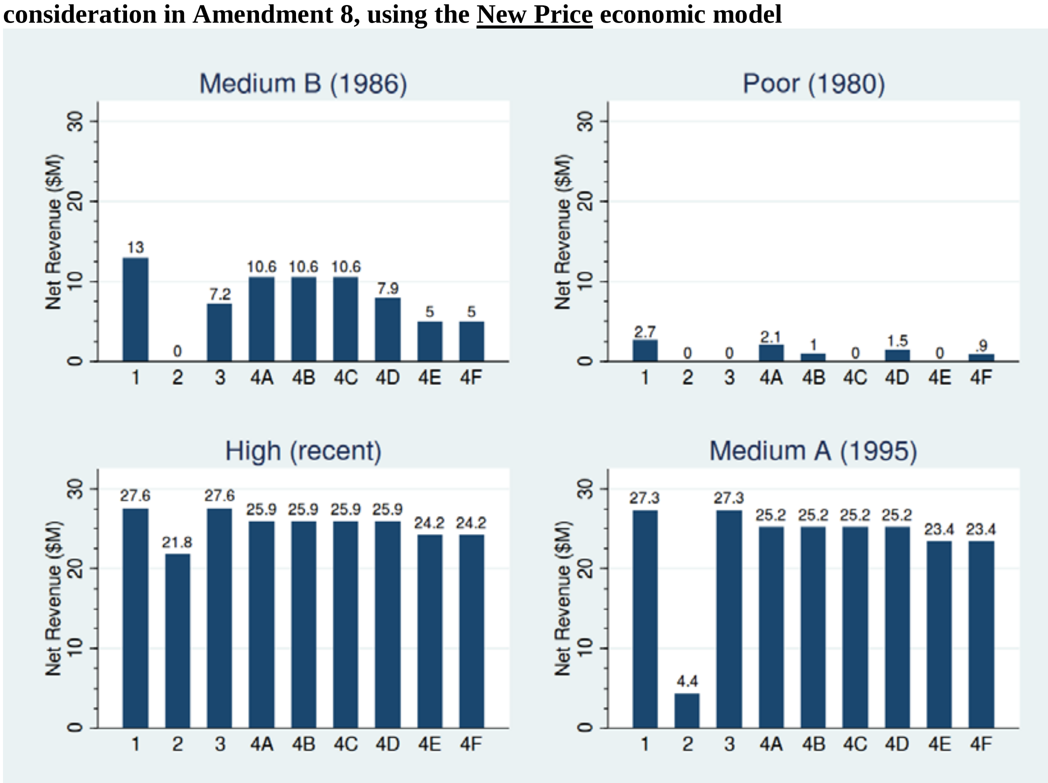


Figure 9 – Estimate of short-term net revenue under four different herring resource conditions for the control rules under consideration in Amendment 8, using the New Price economic model



Three-year projections (Section 4.1.1.6.2 of DEIS)

During review of the draft impacts, the members of the herring industry commented that it would be useful to understand how the ABC CR alternatives would function in reality; specifically, what the recent specifications would have been under different control rules. Therefore, the PDT revisited the last specifications document prepared for FY2016-2018, and produced example specifications by applying various fishing mortality rates (0.5 – 0.9) to the most recent (2015) estimate of herring biomass. The other elements of the CR were unnecessary to incorporate (upper and lower biomass thresholds – or inflection points in the CR shapes, because herring biomass is well above B_{MSY}) (*Because this is no longer the case (biomass is not well above Bmsy), the PDT has prepared additional analyses based on new biomass estimates to more accurately reflect likely near term impacts of the various control rule alternatives – see pages 15-21 below*). Table 3 gives the median fishing mortality rates, ABC (catch), and biomass levels as if these CR alternatives were used in the last specifications. This table includes the estimates of ABCs for both alternatives for multiple year ABCs. The No Action multiyear ABC method, the alternative that would use one consistent value for a three-year period is in the column farthest to the right (3-year). Results for the annual alternative that would set ABC at varying levels over the three-year period is the catch associated with each year (2016-2018).

Under the No Action control rule, the constant catch CR that sets ABC at the value that produces 50% probability of $F>F_{MSY}$ in year 3, used in the last specifications package, the ABC was 111,000 mt. Under Alternative 1 and Alternative 3, both with a fishing mortality max of 0.9, the 3-year ABC is also about 111,000 for the 3-year ABC alternative, and under the annual ABC alternative, the ABCs would vary between 123,000 and 98,000 mt. This is the only alternative under consideration where the ABC from year 1 could not be used for all three years, because it would produce an ABC in year 3 with > 50% probability of $F>F_{MSY}$. All the CRs under consideration in this action state that if ABC is projected to have more than a 50% probability of $F>F_{MSY}$, then ABC has to be reduced. Therefore, under Alternative 1 and 3 combined with the 3-year ABC alternative, ABC would need to be reduced to a value between 123,000 and 98,000. In this case, that is about 111,000 mt so that the median F in year 3 did not have more than a 50% probability of exceeding F_{MSY} (estimated at 0.24 in the last assessment). Based on these results, an ABC of 111,000 mt produces an F of 0.24 in 2018. For Alternative 2, which has a max fishing mortality rate of 0.5, the 3-year ABC would equal 73,000 and the annual ABC would range between 73,000 and 64,000 mt. Alternatives 4a-4d (max F = 0.7) range between 100,000 and 84,000 mt, and finally Alternatives 4e and 4f (max F = 0.6) range between 74,000 and 86,000.

Alternatives 1 and 3 produce essentially the same ABC in the short term as No Action (111,000 mt) under current biomass conditions from the last specification package. If the annual ABC alternative is used, the total ABC over the three years is slightly lower than under the 3-year approach (324,000 vs. 333,000), but the probability that biomass is less than B_{MSY} is also lower for the annual ABC approach. The ABC under Alternatives 2, 3 and 4 are all lower than No Action, for both the 3-year and annual approaches. These alternatives use lower maximum fishing mortality limits; therefore, the probability of biomass being less than B_{MSY} are all lower for these alternatives compared to No Action, as well as Alternatives 1 and 3.

Table 3 – Example specification projections for all ABC CR alternatives for FY2016-2018, as well as both alternatives under consideration for setting three-year ABC (annual and 3-year alternatives)

	No Action (Constant Catch that Produces Prob $F>F_{MSY}$ = 0.50 in 2018)			3-year
	2016	**2017**	**2018**	
Median F	0.19	0.23	0.24	
Median Catch mt	111,000	111,000	111,000	111,000
Median SSB mt	557,000	458,000	427,000	
Prob SSB < SSBMSY	0.06	0.16	0.24	
Prob SSB < $0.5SSB_{F=0}$	0.24	0.41	0.49	
Prob SSB < $0.75SSB_{F=0}$	0.63	0.80	0.82	
	Alts. 1 and 3 ($0.9F_{MSY}$)			**3-year**
	2016	**2017**	**2018**	
Median F	0.22	0.22	0.22	
Median Catch mt	123,000	103,000	98,000	*~ 111,000**
Median SSB mt	547,000	457,000	433,000	
Prob SSB < SSBMSY	0.04	0.07	0.13	
Prob SSB < $0.5SSB_{F=0}$	0.22	0.39	0.47	
Prob SSB < $0.75SSB_{F=0}$	0.65	0.86	0.88	
	Alt. 2 ($0.5F_{MSY}$)			**3-year**
	2016	**2017**	**2018**	
Median F	0.12	0.12	0.12	
Median Catch mt	73,000	64,000	64,000	73,000
Median SSB mt	584,000	517,000	506,000	
Prob SSB < SSBMSY	0.02	0.03	0.04	
Prob SSB < $0.5SSB_{F=0}$	0.17	0.24	0.27	
Prob SSB < $0.75SSB_{F=0}$	0.60	0.75	0.76	
	Alts. 4a,4b,4c,4d ($0.7F_{MSY}$)			**3-year**
	2016	**2017**	**2018**	
Median F	0.17	0.17	0.17	
Median Catch mt	100,000	86,000	84,000	100,000
Median SSB mt	565,000	484,000	466,000	
Prob SSB < SSBMSY	0.03	0.04	0.08	
Prob SSB < $0.5SSB_{F=0}$	0.19	0.33	0.38	
Prob SSB < $0.75SSB_{F=0}$	0.63	0.81	0.83	
	Alts. 4e, 4f ($0.6F_{MSY}$)			**3-year**
	2016	**2017**	**2018**	
Median F	0.15	0.15	0.15	
Median Catch mt	86,000	75,000	74,000	86,000
Median SSB mt	574,000	501,000	486,000	
Prob SSB < SSBMSY	0.03	0.03	0.06	
Prob SSB < $0.5SSB_{F=0}$	0.18	0.28	0.32	
Prob SSB < $0.75SSB_{F=0}$	0.61	0.78	0.80	

** Because F estimate is close to Fmsy for year 3 for this alternative, it is likely that ABC will not be set at year 1 value, (123,000).*
That would voliate ABC CR definition; ABC cannot have greater than 50% probability of exceeding Fmsy.
Therefore, in this case, the ABC in year 1 needs to be reduced to something less than 123,000, but something higher than 98,000.
The 3-year allocation would likely be about 111,000 mt for alternatives 1 and 3 in this example to be set at F < 0.24 (Fmsy).

When considering these ABC projections, it is also important to keep in mind that in the Herring FMP there are reductions taken from the ABC before catch levels, or ACLs are allocated to the fishery. A buffer for management uncertainty is removed first, followed by a set amount of ABC to support the Herring RSA program. In the last specifications, the management uncertainty buffer was set at 6,200 mt, and 3% of the ABC was set-aside for the RSA program (NEFMC 2016). Additionally, the ACL is divided into sub-ACLs by management area. In the last specifications, those allocations were as follows: 28.9% for Area 1A, 4.3% for Area 1B, 27.8% for Area 2, and 39% for Area 3. There are different restrictions in place that limit which vessels and gears can access each herring management area, including seasonal restrictions. Specifically, Area 1A is closed to all fishing from Jan – May, and in June-Sept Area 1A is only open to purse seine gear with 72.8% of the Area 1A sub-ACL, and from Oct-Dec the remaining 27.2% of the Area 1A TAC is available to all gear types.

To further evaluate the potential impacts of these ABC CR alternatives on the herring fishery, the short-term ABCs from above were sub-divided into sub-ACLs, according to the method in the 2016-2018 specifications (Table 4). This example is for the 3-year ABC CR alternative only, but the same idea would apply to the annual ABC alternative, similar reductions and sub-ACLs would be applied to those ABCs as well, but the allocations would vary every year, compared to being consistent for three years. Overall, the ACL and subsequent sub-ACLs are again lower for Alternatives 2, 3, and 4; the allocations are the same for Alternatives 1 and 3, as well as No Action, since the starting ABC is identical.

Table 4 – Example ABC and ACL allocations for FY2016-2018

	No Action	**Alt. 1 and 3**	**Alt. 2**	**Alt. 4a-4d**	**Alt. 4e-4f**
Example 3-year ABC	**111,000**	**111,000**	**73,000**	**100,000**	**86,000**
Management uncertainty	**6,200**	**6,200**	**6,200**	**6,200**	**6,200**
RSA (3%)	**3,330**	**3,330**	**2,190**	**3,000**	**2,580**
ACL	**101,470**	**101,470**	**64,610**	**90,800**	**77,220**
Area 1A (28.9%)	**29,325**	**29,325**	**18,672**	**26,241**	**22,317**
Area 1B (4.3%)	**4,363**	**4,363**	**2,778**	**3,904**	**3,320**
Area 2 (27.8%)	**28,209**	**28,209**	**17,962**	**25,242**	**21,467**
Area 3 (39%)	**39,573**	**39,573**	**25,198**	**35,412**	**30,116**
Area 1A					
Jan-May (0%)	**0**	**0**	**0**	**0**	**0**
Jun-Sept (72.8%)	**21,348**	**21,348**	**13,593**	**19,104**	**16,246**
Oct-Dec (27.2%)	**7,976**	**7,976**	**5,079**	**7,138**	**6,070**

Because the updated estimate of biomass is no longer “well above Bmsy”, the PDT completed additional analyses to illustrate potential near term ABCs at lower biomass levels. The estimates prepared for 2016-2018 above are still useful to show how the various ABC control rules would have functioned in the last specification package, but it is also informative to compare the various ABC control rules moving forward. The PDT has summarized catch limits for all ABC control rule alternatives for FY2019-2021 using the projections from the 2018 assessment. The initial conditions for these analyses assume fishery catches of 49,900 for FY2018, which is the adjusted total allowable catch for 2018 based on the in-season action implemented by NMFS in late August. The PDT felt this was the most appropriate value to use for 2018 assumed landings.

These analyses have been completed for both ABC timeframe options, Alternative 1 which would keep ABC at the same level for three years, and Alternative 2, which would allow ABC to vary on an annual basis over a three year timeframe.

The projected catches, fishing mortality, SSB, Probability of overfishing probability of overfished, and ratio of SSB/SSBmsy for all ABC control rule alternatives are shown in Table *5* as combined with ABC timeframe Alternative 1 (stable ABC for 3 years), and in Table 6 as combined with ABC timeframe Alternative 2 (annual ABC approach).

The interim control rule (No Action) that has been used in the last two specification cycles is no longer appropriate to use. Since biomass is expected to increase over the three-year timeframe (2019-2021)m the approach used in the past would set fishing levels too high for years 1 and 2, with probability of overfishing exceeding 0.50, which is not legal. Therefore, the PDT has developed an option, for analysis purposes only, that is similar to recent ABC setting policy but would be feasible under the current biomass scenario, which has increasing biomass.

Table 7 shows the comparison of this control rule to the interim control rule that has been used in recent years. The cells in red identify why the interim control rule would not be feasible in this case when biomass is expected to increase, the probability of overfishing is greater than 50% (87% in 2019 and 78% in 2020).

Figure 10 compares projected catches for each fishing year across all alternatives.

Figure 11 compares the total projected catch for each alternative over the three year period, for Alternative 1 that would keep catch constant for three years (black) compared to Alternative 2, the alternative that would allow ABC to vary annually over three years (blue).

Table 5 – Summary of short-term projections (2019-2021) for A8 ABC CR alternatives with 3-YEAR option

		2018	2019	2020	2021		2019-2021
Alt.1	Catch	49,900	24,553	24,553	24,553		73,659
StrawA	F(ages 7-8)	0.51	0.39	0.29	0.17		
3year	SSB	79,673	50,599	53,074	121,154		
	P(overfishing)	0.50	0.26	0.13	0.02		
	P(overfished)	0.72	0.86	0.83	0.33		
	SSB/SSBmsy	0.42	0.27	0.28	0.64		
Alt.2	Catch	49,900	0	0	0		0
StrawB	F(ages 7-8)	0.51	0.00	0.00	0.00		
3year	SSB	79,673	68,015	80,332	166,042		
	P(overfishing)	0.50	0.00	0.00	0.00		
	P(overfished)	0.72	0.81	0.67	0.07		
	SSB/SSBmsy	0.42	0.36	0.43	0.88		
Alt.3	Catch	49,900	74	74	74		222
	F(ages 7-8)	0.51	0.00	0.00	0.00		
3year	SSB	79,673	67,964	80,230	165,824		
	P(overfishing)	0.50	0.00	0.00	0.00		
	P(overfished)	0.72	0.81	0.67	0.07		
	SSB/SSBmsy	0.42	0.36	0.42	0.88		
Alt.4a	Catch	49,900	19,557	19,557	19,557		58,671
	F(ages 7-8)	0.51	0.30	0.22	0.13		
3year	SSB	79,673	54,162	58,342	130,132		
	P(overfishing)	0.50	0.11	0.04	0.00		
	P(overfished)	0.72	0.85	0.81	0.27		
	SSB/SSBmsy	0.42	0.29	0.31	0.69		
Alt.4b	Catch	49,900	18,980	18,980	18,980		56,940
	F(ages 7-8)	0.51	0.29	0.21	0.13		
3year	SSB	79,673	54,576	58,960	131,177		
	P(overfishing)	0.50	0.10	0.03	0.00		
	P(overfished)	0.72	0.85	0.81	0.27		
	SSB/SSBmsy	0.42	0.29	0.31	0.69		
Alt.4c	Catch	49,900	14,800	14,800	14,800		44,400
	F(ages 7-8)	0.51	0.22	0.16	0.10		
3year	SSB	79,673	57,557	63,503	138,746		
	P(overfishing)	0.50	0.03	0.00	0.00		
	P(overfished)	0.72	0.84	0.79	0.22		
	SSB/SSBmsy	0.42	0.3	0.34	0.73		
Alt.4d	Catch	49,900	14,183	14,183	14,183		42,549
	F(ages 7-8)	0.51	0.21	0.15	0.09		
3year	SSB	79,673	57,994	64,173	139,867		
	P(overfishing)	0.50	0.02	0.00	0.00		
	P(overfished)	0.72	0.84	0.78	0.21		
	SSB/SSBmsy	0.42	0.31	0.34	0.74		
Alt.4e	Catch	49,900	6,380	6,380	6,380		19,140
	F(ages 7-8)	0.51	0.09	0.06	0.04		
3year	SSB	79,673	63,513	72,967	154,209		
	P(overfishing)	0.50	0.00	0.00	0.00		
	P(overfished)	0.72	0.82	0.73	0.13		
	SSB/SSBmsy	0.42	0.34	0.39	0.82		
Alt.4f	Catch	49,900	9,066	9,066	9,066		27,198
	F(ages 7-8)	0.51	0.13	0.09	0.06		
3year	SSB	79,673	61,622	69,903	149,262		
	P(overfishing)	0.50	0.00	0.00	0.00		
	P(overfished)	0.72	0.83	0.75	0.16		
	SSB/SSBmsy	0.42	0.33	0.37	0.79		

Table 6 – Summary of short-term projections (2019-2021) for A8 ABC CR alternatives with ANNUAL option

		2018	2019	2020	2021	2019-2021
Alt.1	Catch	49,900	24,553	21,414	36,130	82,097
StrawA	F(ages 7-8)	0.51	0.39	0.25	0.26	
Annual	SSB	79,673	50,509	54,342	118,086	
	P(overfishing)	0.50	0.26	0.07	0.09	
	P(overfished)	0.72	0.9	0.86	0.31	
	SSB/SSBmsy	0.42	0.27	0.29	0.62	
Alt.2	Catch	49,900	0	0	0	0
StrawB	F(ages 7-8)	0.51	0.00	0.00	0.00	
Annual	SSB	79,673	68,015	80,332	166,042	
	P(overfishing)	0.50	0.00	0.00	0.00	
	P(overfished)	0.72	0.81	0.67	0.07	
	SSB/SSBmsy	0.42	0.36	0.43	0.88	
Alt.3	Catch	49,900	74	110	178	362
	F(ages 7-8)	0.51	0.00	0.00	0.00	
Annual	SSB	79,673	67,963	80,227	165,822	
	P(overfishing)	0.50	0.00	0.00	0.00	
	P(overfished)	0.72	0.81	0.67	0.07	
	SSB/SSBmsy	0.42	0.36	0.42	0.88	
Alt.4a	Catch	49,900	19,557	18,050	31,980	69,587
	F(ages 7-8)	0.51	0.30	0.20	0.22	
Annual	SSB	79,673	54,103	58,920	125,415	
	P(overfishing)	0.50	0.11	0.02	0.04	
	P(overfished)	0.72	0.88	0.84	0.26	
	SSB/SSBmsy	0.42	0.29	0.31	0.66	
Alt.4b	Catch	49,900	18,980	15,541	29,615	64,136
	F(ages 7-8)	0.51	0.29	0.17	0.20	
Annual	SSB	79,673	54,526	60,355	128,666	
	P(overfishing)	0.50	0.10	0.01	0.02	
	P(overfished)	0.72	0.88	0.83	0.24	
	SSB/SSBmsy	0.42	0.29	0.32	0.68	
Alt.4c	Catch	49,900	14,800	989	19,596	35,385
	F(ages 7-8)	0.51	0.22	0.01	0.12	
Annual	SSB	79,673	57,516	69,486	146,541	
	P(overfishing)	0.50	0.03	0.00	0.00	
	P(overfished)	0.72	0.86	0.77	0.15	
	SSB/SSBmsy	0.42	0.3	0.37	0.78	
Alt.4d	Catch	49,900	14,183	15,194	25,885	55,262
	F(ages 7-8)	0.51	0.21	0.16	0.17	
Annual	SSB	79,673	57,961	63,655	133,501	
	P(overfishing)	0.50	0.02	0.01	0.01	
	P(overfished)	0.72	0.86	0.81	0.21	
	SSB/SSBmsy	0.42	0.31	0.34	0.71	
Alt.4e	Catch	49,900	6,380	3,131	11,842	21,353
	F(ages 7-8)	0.51	0.09	0.03	0.07	
Annual	SSB	79,673	63,506	74,410	153,869	
	P(overfishing)	0.50	0.00	0.00	0.00	
	P(overfished)	0.72	0.83	0.73	0.11	
	SSB/SSBmsy	0.42	0.34	0.39	0.81	
Alt.4f	Catch	49,900	9,066	10,026	17,724	36,816
	F(ages 7-8)	0.51	0.13	0.10	0.11	
Annual	SSB	79,673	61,611	69,408	144,236	
	P(overfishing)	0.50	0.00	0.00	0.00	
	P(overfished)	0.72	0.84	0.77	0.15	
	SSB/SSBmsy	0.42	0.33	0.37	0.76	

Table 7 – Summary of interim control rule used for Amendment 8 analysis (bottom) compared to ABC control rule as applied in recent specifications (top)

		2018	2019	2020	2021
Interim CR	Catch	49,900	52,000	52,000	52,000
(used in the past)	F(ages 7-8)	0.51	1.03	0.86	0.51
ABC = Pof = 0.50	SSB	79,673	31,282	28,226	74,387
in year 3	P(overfishing)	0.50	**0.87**	**0.78**	0.50
Decreasing biomass	P(overfished)	0.72	0.91	0.9	0.62
	SSB/SSBmsy	0.42	0.17	0.15	0.39
Interim CR	Catch	49,900	30,668	30,668	30,668
(for analysis only)	F(ages 7-8)	0.51	0.51	0.39	0.23
ABC = Pof = 0.50	SSB	79,673	46,237	46,908	110,320
in year 1	P(overfishing)	0.50	0.50	0.30	0.07
Increasing biomass	P(overfished)	0.72	0.87	0.85	0.4
	SSB/SSBmsy	0.42	0.24	0.25	0.58

Note: cells in red are above 0.50, not legal to set catch at levels with higher than 50% probability of overfishing.

Figure 10 – ABC projections for Amendment 8 alternatives (both ABC control rule alternatives and ABC timeframe options)

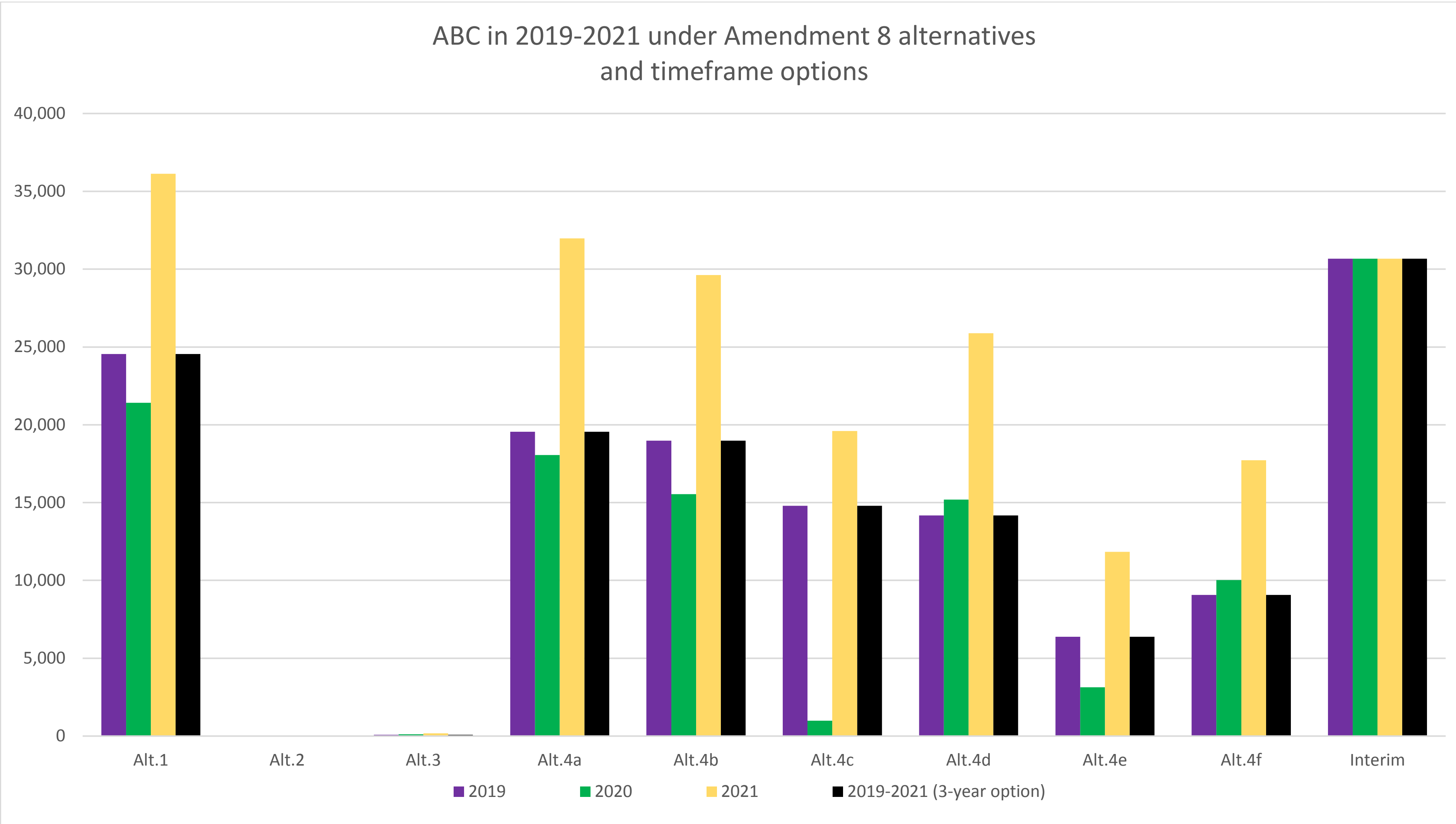
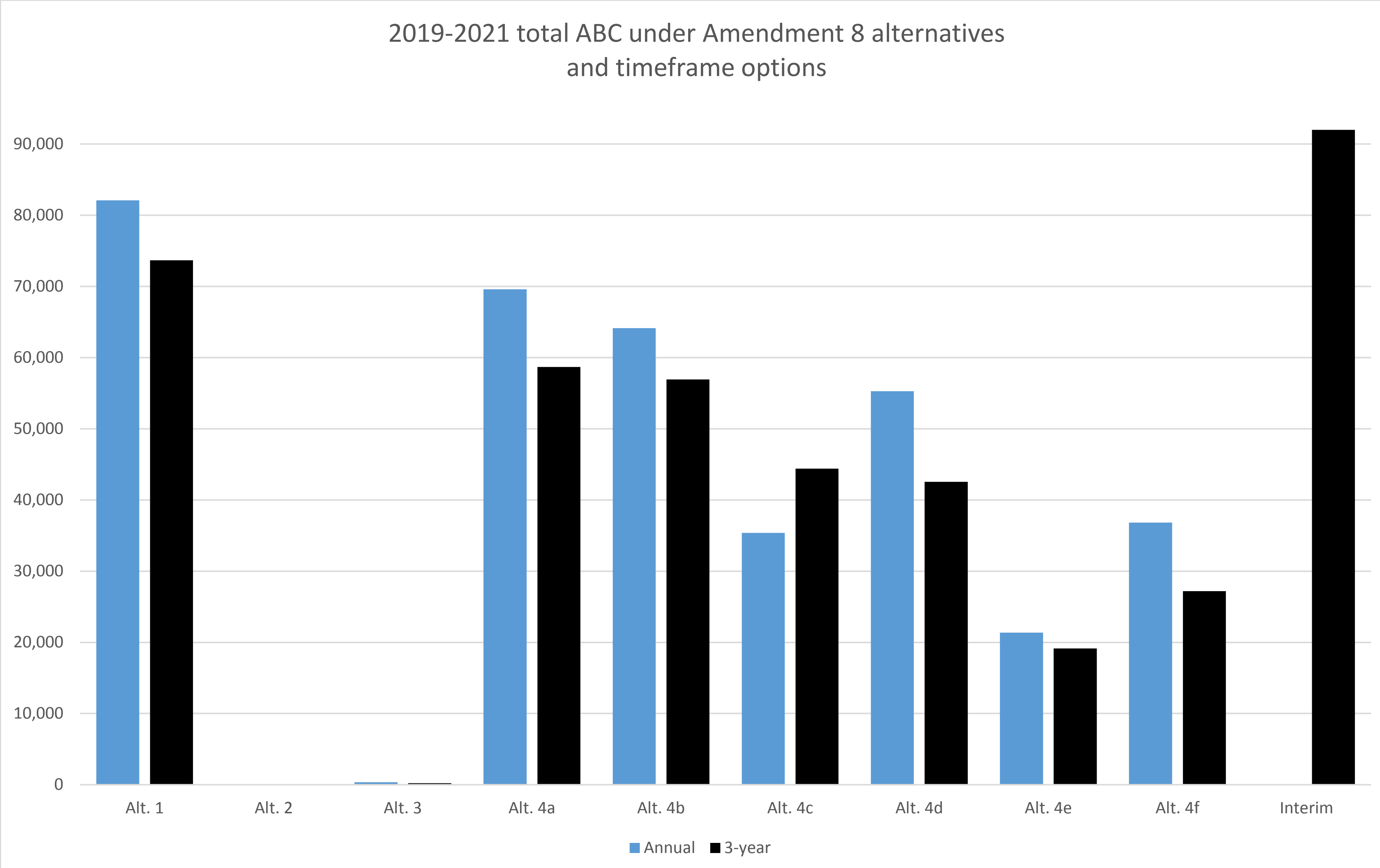
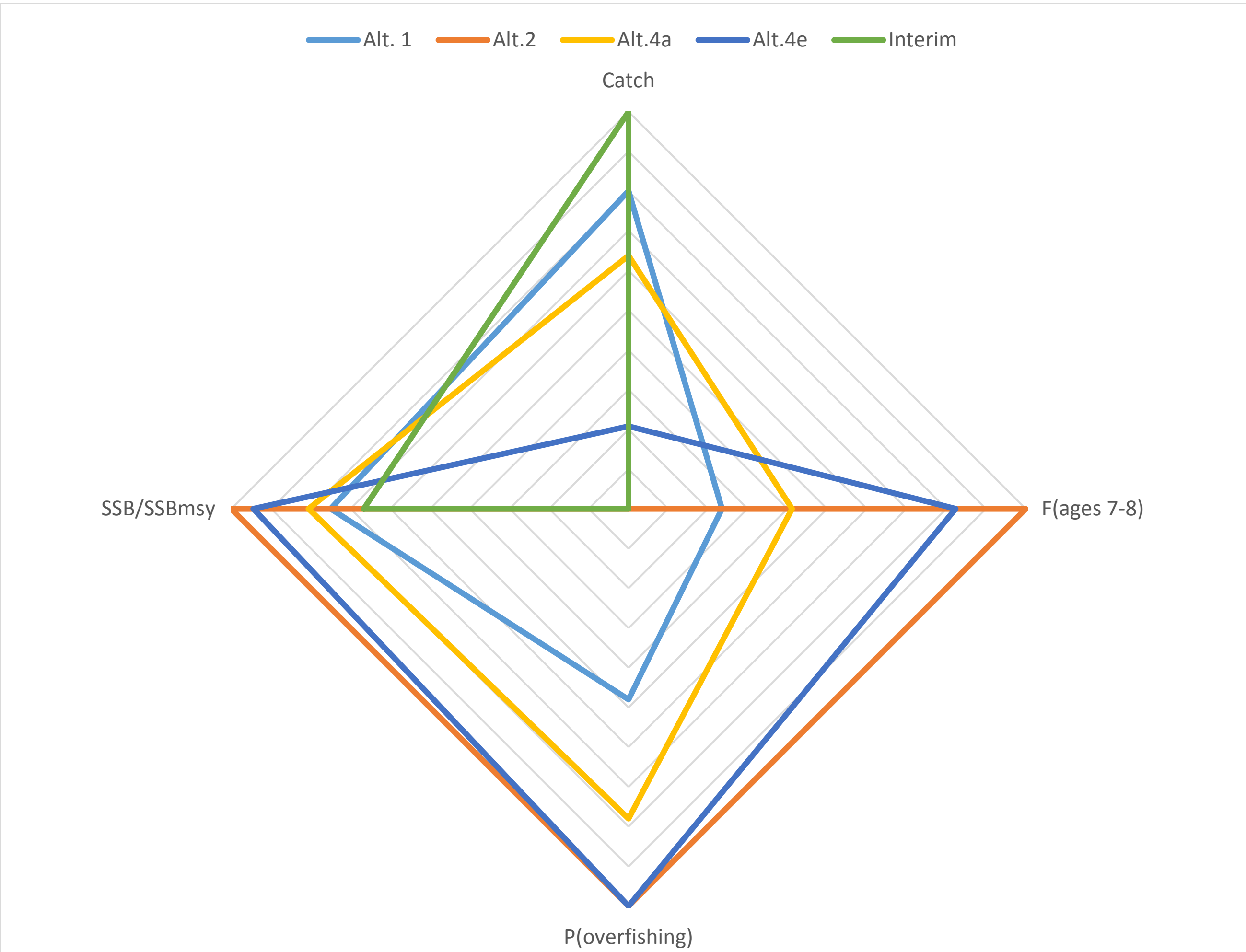


Figure 11 – Total ABC over three years for Amendment 8 ABC control rule alternatives



Like the web diagrams (i.e. radar plots) in Section 4.1.1.5 of Amendment 8 that compare the long-term tradeoffs of various ABC control rules across metrics, (e.g. catch, probability of overfishing), Figure 12 plots short-term results for catch, fishing mortality, probability of overfishing, and SSB/SSBmsy. Again, alternatives that fall toward the outside of the web are considered to have more positive benefits for that metric. These plots are on a relative scale, not the actual value per metric. In general, the alternatives with higher short-term yields also have higher probability for overfishing.

Figure 12 – Tradeoff web diagrams for several ABC control rule alternatives (all 3-year timeframe options)



3) Adjustments to potential biological impacts of No Action and Alternative 1 ABC control rule alternatives (Section 4.2.1.1.1 of Amendment 8 DEIS)

No Action: Interim Control Rule – Policy used in recent specification setting processes (fishing years 2013-2018)

Under No Action, the ABC control rule used for the last two specification cycles, or six fishing years (2013-2018), would be used. The interim or sometimes called "status quo" or "default" control rule is biomass based, but the ABC is set at the same level for three years. ABC is set at the catch that is projected to produce a ≤50% probability of exceeding F_{MSY} in the third year.

Overall, the No Action ABC control rule is expected to have generally ***positive impacts*** on the herring resource. For the last six years, it has prevented overfishing, and the stock is not overfished, ~~and it has helped maintain sufficient biomass to support above average recruitment in recent years. Estimated biomass is well above B_{MSY}; the most recent updated stock assessment estimated biomass at over 600,000 mt, about twice the SSB_{MSY} of 311,145 mt.~~ As with most fisheries, there is some uncertainty in the assessment and fishery projections; therefore, the impacts may be low positive if the assessment is overly optimistic and biomass is actually lower than estimated levels. A retrospective pattern re-emerged when updating the assessment model in 2015, which suggests that Atlantic herring spawning stock biomass (SSB) is likely to be overestimated and fishing mortality (F) is likely to be underestimated in the terminal year of the assessment. As a result, the assessment review panel applied a retrospective adjustment to the SSB and F values for the terminal year, and even with those adjustments, the Atlantic herring stock complex remains above the biomass target and below the fishing mortality threshold (Deroba 2015).

The interim control rule has been used on a relatively short-term scale, three years at a time. The ***long-term benefits of this control rule for the herring resource are more uncertain***, and may not be as positive under other scenarios (i.e., when abundance is decreasing). Compared to other alternatives under consideration, the long-term benefits on the herring resource of this alternative are estimated to be lower.

It is important to note that the status of the herring resource is not exclusively generated by the ABC control rule used. There are other factors that likely have an even greater influence on herring biomass, including environmental factors such as primary production, water temperature, etc., that are unaffected by the ABC control rule used to set fishery catch levels. These factors will continue to play a large part in the overall herring abundance, regardless of the ABC control rule established. For example, the current resource conditions with biomass over two times B_{MSY} are not likely to persist, regardless of the control rule selected. There is a high degree of variability in this system. The MSE analyses prepared for this action does consider a wide range of operating models, or potential states of nature, to help evaluate the uncertainties in the system. These analyses enable the Council to assess the performance of different control rule alternatives under various assumptions of natural mortality, growth, and overall assessment bias. While a wide range of operating models have been considered, they still may not reflect the range of actual states of nature.

The MSE analyses do provide direct quantitative information about the potential long-term impacts of different control rule alternatives on the herring resource, as well as other valued ecosystem components (VECs). Because the interim control rule as defined does not have parameters that enable it to be included in the MSE model (i.e., not fishing mortality limit or defined biological parameters), it could not be integrated into the MSE model. Therefore, a modified control rule was developed to approximate the average performance of the No Action interim control rule in recent years (Strawman A). Strawman A is a proxy for the No Action ABC control rule, and for analysis purposes, the other ABC control rule alternatives in this action are compared to that option to illustrate how other control rules compare to the average performance of the No Action ABC control rule.