DRAFT

Economic Trade-offs of Additional Alternative ABC Control Rules for Summer Flounder and Implications for Scup and Butterfish

Cyrus Teng (University of Maryland College Park)
Doug Lipton (NOAA Fisheries Senior Scientist for Economics)

Preliminary Report to the Mid-Atlantic Fishery Management Council

December 9, 2019

Introduction

At the February 2018 Mid-Atlantic Fishery Management Council (MAFMC) meeting, John Wiedenmann presented his results on the "Evaluation of Alternative ABC Control Rules for Mid-Atlantic Fisheries" (Wiedenmann 2018). In that study, control rules were varied as to how the probability of overfishing (P*) was implemented: fixed, 2-step, 3-step, and ramped. Using a management strategy evaluation (MSE) simulated over 30 years for scup, summer flounder and butterfish; performance of the control rules was evaluated in terms of the average biomass, long-term and initial catch, probability of overfishing, probability of becoming overfished, risk of very low biomass, mean F/F_{MSY}, and year-to-year catch variability. The study found that the chosen control rule's performance mattered more, in term of the variables being evaluated, under poor future conditions such as high natural mortality, low recruitment and overestimates of stock size.

Given the biological consequences of the different control rules, Council members expressed additional interest in the economic trade-offs among control rules or other ways in which economic considerations could be accounted for in harvest control rules. At that time, two of the authors (i.e., Hutniczak and Lipton) were working with Wiedenmann on an economic analysis of the timing of stock assessment updates and data management lags building on another MSE study (Wiedenmann et al. 2017). That study (Hutniczak et al. 2018), used a suite of economic models built around the summer flounder fishery, to demonstrate that annually updating the summer flounder stock assessment produced summer flounder economic benefits greater than the cost of updating. We found that the difference between a two year stock assessment update interval with a data lag of one year (base scenario), and a five year update interval with a two year data lag is only 10,000 metric tons of summer flounder harvested over a 27 year period. Our analysis estimates, however, that the difference in economic benefits between the two scenarios is about $102.7 million which is more than the added cost of updating every two years. We offered to the Council that, at least for summer flounder, we could modify the harvest control rules in our base scenario to match the simulations in the Wiedenmann (2018) report, and determine the differences in economic benefits from the fishery for the scenarios analyzed in that report.

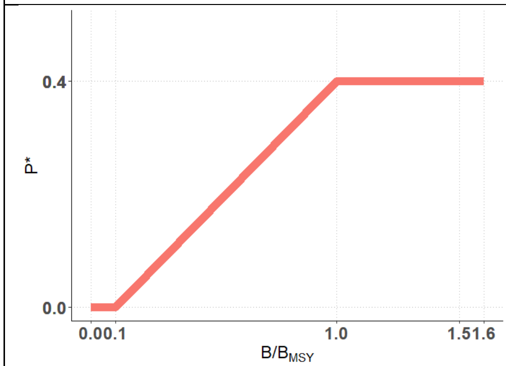
Results of that economic analysis were presented to the Council in its December 2018 meeting and summarized in the report "Economic Trade-offs of Alternative ABC Control Rules for Summer Flounder", dated December 10, 2018. The analysis found that the current policy (Alternative 1 in this study) was the most conservative and leads to the lowest economic welfare, while the 2-step policy (Alternative 3 in this study) performed the best. The gap in performance between these two control rules increased with time. In the beginning of the period, when B/B_{MSY} of the summer flounder resource is below one, the current policy restricted harvest which resulted in its underperformance. In later years, the 2-step policy was better able to take advantage of the increased biomass, again resulting in the underperformance fo the current policy.

Subsequent to the December 2018 report Risk Policy Working Group identified three additional control rules for evaluation (hereafter referred to as Alternatives 6, Alternative 7, and Alternative 8). In addition to these newly proposed control rules, another development also necessitated the re-evaluation of economic performances of alternative control rules. In July 2018, the Marine Recreational Information Program (MRIP) replaced the existing estimates of recreational catch of summer flounder with a calibrated 1982-2017 times series that corresponds to new survey methods that were fully implemented in 2018. Additionally, a benchmark stock assessment incorporating the new MRIP estimates was implemented. The new MRIP estimates resulted in significant increases in estimated recreational summer flounder catch and overall biomass. As a result, we expect economic welfare to increase significantly overall and for the recreational sector.

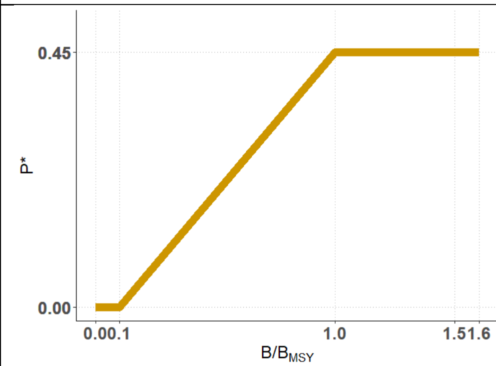
As part of this re-evaluation, additional MSE simulations were performed by John Wiedenmann under five control rules previously considered (Alternatives 1 through 5) as well as under the three new proposed control rule alternatives (Alternatives 6 through 8). Table 1 shows the control rule alternatives. Corresponding economic welfare analysis were performed on the MSE outputs according to the methods outlined in the next section.

Table 1. Control Rule Alternatives

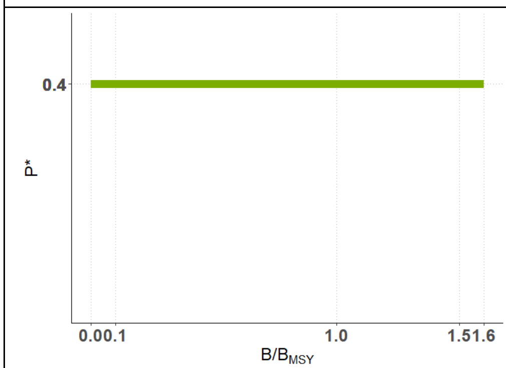
Alternative 1



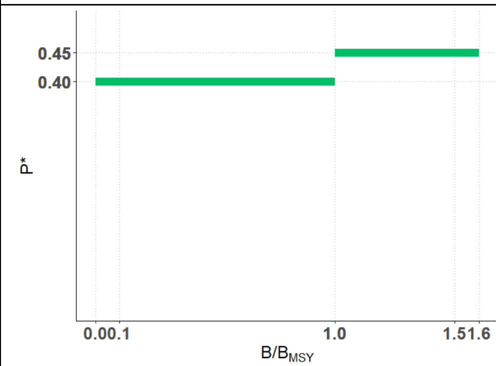
Alternative 2



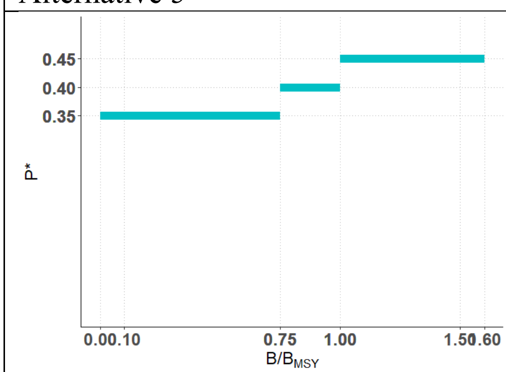
Alternative 3



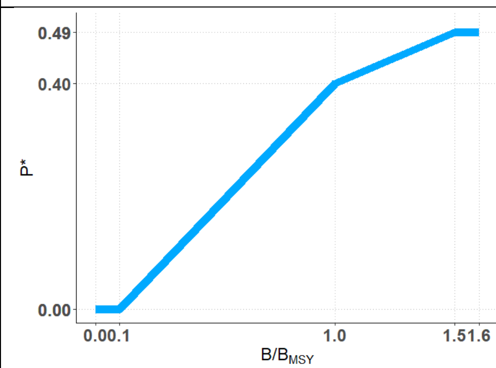
Alternative 4



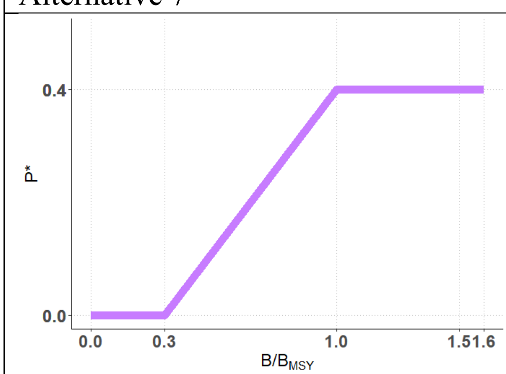
Alternative 5



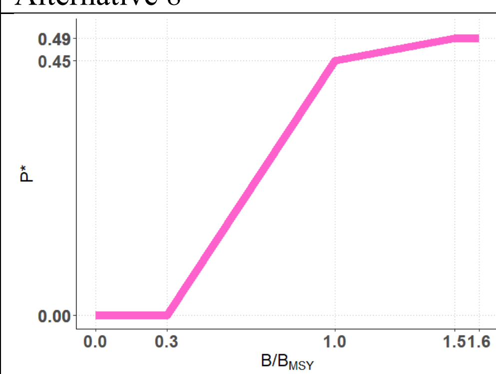
Alternative 6



Alternative 7



Alternative 8



Methods

Figure 1 shows the conceptual framework by which the catch projections and spawning stock biomass (SSB) estimates from Wiedenmann's MSE serve as inputs to three economic submodels to calculate total economic benefits from the fishery. Details of the economic models are available in Hutniczak et al 2018.

The economic estimates are generated from estimating models for summer flounder price from an inverse demand model, summer flounder net fishing revenue from a model that relates multispecies days at sea to changes in the total allowable catch and stock biomass, and a summer flounder recreational fishing valuation model.

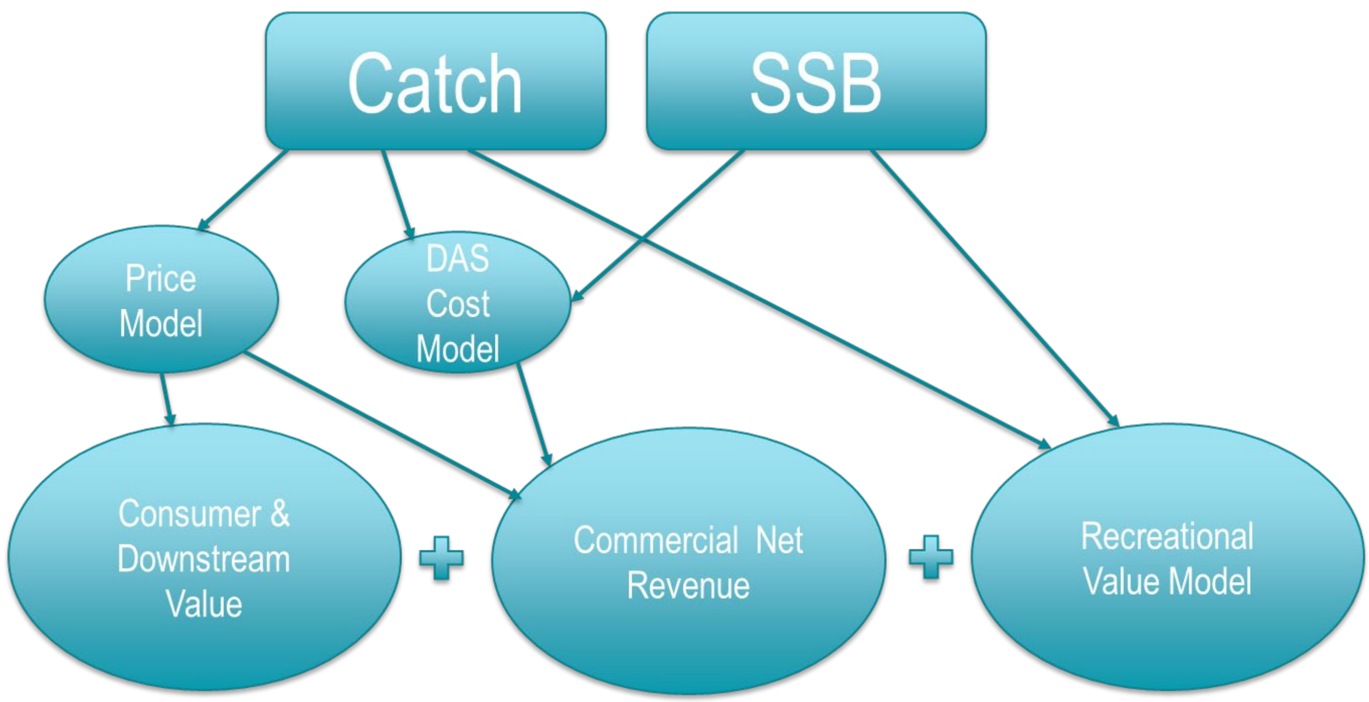


Figure 1. Conceptual approach showing how catch and spawning stock biomass from MSE feed into economic submodels (DAS=days at sea). For details of economic models, see Hutniczak et al. 2018).

The scenarios analyzed follow those in Wiedenman's MSE outputs which contain 500 simulated catch and biomass projections over 30 years for each of the eight control rule alternatives. In addition to the base scenario of average summer flounder fishery productivity, there are two additional scenarios corresponding to higher than average recruitment and lower than average natural mortality (good productivity scenario) and to lower than average recruitment and higher than average natural mortality (poor productivity scenario). Additionally, economic welfare comparisons were performed for each of the three scenarios for the initial five years as well as for the final 20 years of projections. This is to distinguish between periods in which summer flounder relative biomass is below target (initial 5 years) and above target (final 20 years). All scenarios assume a coefficient of variation (CV) of 1.0.

Results – 30 Year Projections

Figures 2 shows the summer flounder estimated SSB from the MSE for the average productivity scenario over 30 years. Conservative control rule Alternatives 1 and 7 results in the highest SSB levels for the entire projection period. Alternative 6, which is identical to Alternative 1 when B/B_{MSY} is below one, performs well in the initial five years but underperforms at higher B/B_{MSY} where it is less conservative. The non-ramped Alternatives 3 through 5 performs the worst in the initial five years. However, Alternative 3, with a conservative constant P* of 0.4 even at B/B_{MSY} > 1, has the third highest SSB level over the 30-year projection period.

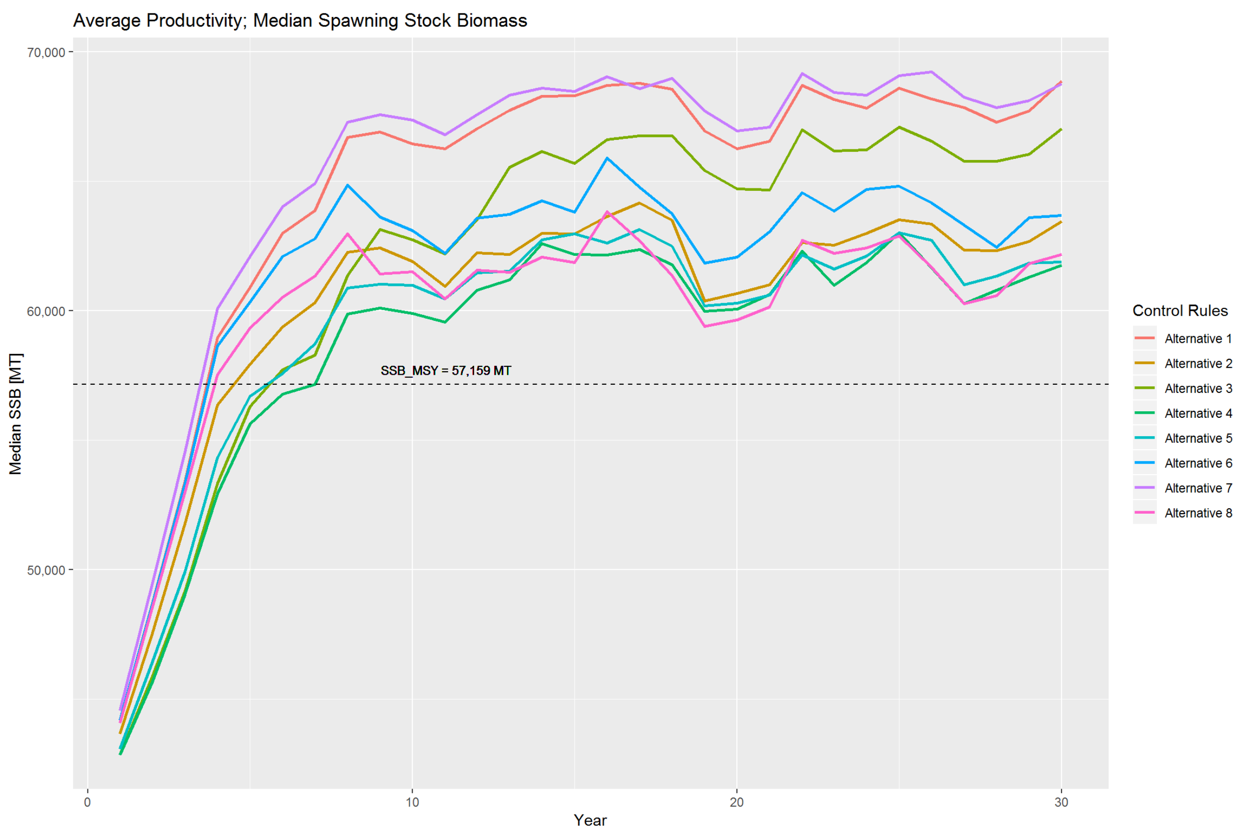
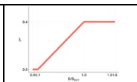
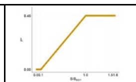
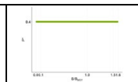
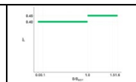
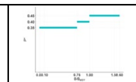
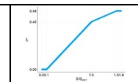
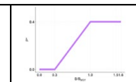
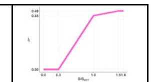


Figure 2. Simulated summer flounder median spawning stock biomass used as input for the average productivity scenario as input to the economic submodels.

In our initial set of projections, we run the economic models using the full 30-year dataset of projections of catches and SSB. In addition to the average productivity scenario, we present the economic projections for the good and poor productivity scenarios. Table 2 shows the mean cumulative total economic welfare under the three productivity scenarios for each of the control rule alternatives, as well as the increases relative to Alternative 1, and the rankings.

Table 2. Mean Cumulative 30-Year Total Economic Welfare (Millions, 3% PV) / Increase over Alternative 1 / Rank

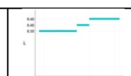
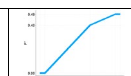
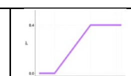
Control Rule								
Average Productivity	4,312	4,390	4,380	4,427	4,414	4,352	4,295	4,379
	0	78	68	115	102	40	-17	67
	7	3	4	1	2	6	8	5
Good Productivity	7,434	7,670	7,476	7,693	7,685	7,723	7,423	7,768
	0	236	42	259	251	289	-11	334
	7	5	6	3	4	2	8	1
Poor Productivity	2,515	2,544	2,632	2,632	2,606	2,513	2,478	2,503
	0	29	117	117	91	-2	-37	-12
	5	4	1	1	3	6	8	7

Discussion

Table 2 shows that Alternatives 4 and 5, the stepped control rules, perform well under all productivity scenarios, ranking no worse than third and fourth, respectively, among all alternatives. Alternative 7 is the worst performer, ranking last in all three productivity scenarios. Alternatives 8 and 6, which have maximum P* of 0.45 at 1.5 B/B_{MSY}, perform relatively well under the good productivity scenario, ranking first and second, respectively. However, both perform poorly under the poor productivity scenario, ranking seventh and sixth, respectively. Alternative 3, the constant 0.4 P* control rule performs the best under poor productivity scenario but ranks sixth under the good productivity scenario. Alternative 1, the status quo, ranks no better than fifth, and is second to last in the average and good productivity scenarios.

To see how the various control rule alternatives may affect the welfares of consumers, commercial fishermen, and recreational fishermen differently, we broke out the three measures of economic welfare for the average productivity scenario in Table 3. It shows that the alternatives with the most positive impacts on consumer and recreational welfare tend to have the most negative impacts on producer welfare, and vice versa.

Table 3. Mean Cumulative 30-Year Economic Welfares (Millions, 3% PV) / Increase over Alternative 1

Control Rule								
Producer Welfare	421	399	410	392	395	403	423	393
	0	-22	-11	-29	-26	-18	2	-28
Consumer Welfare	1,044	1,075	1,076	1,096	1,089	1,059	1,036	1,068
	0	31	32	52	45	15	-8	24
Recreational Welfare	2,846	2,916	2,894	2,939	2,930	2,891	2,836	2,918
	0	70	48	93	84	45	-10	72
Total Welfare	4,312	4,390	4,380	4,427	4,414	4,352	4,295	4,379
	0	78	68	115	102	40	-17	67

Figures 3 shows the distribution of the present value of total economic welfare over 30 years of the 500 simulated runs under the poor productivity scenario. It shows that Alternatives 3 through 5, the control rules with piecewise constant P*, have lower variability in total economic welfare compared to control rules with ramped P* under poor productivity conditions. This pattern is not as pronounced in either the average or the good productivity scenarios.

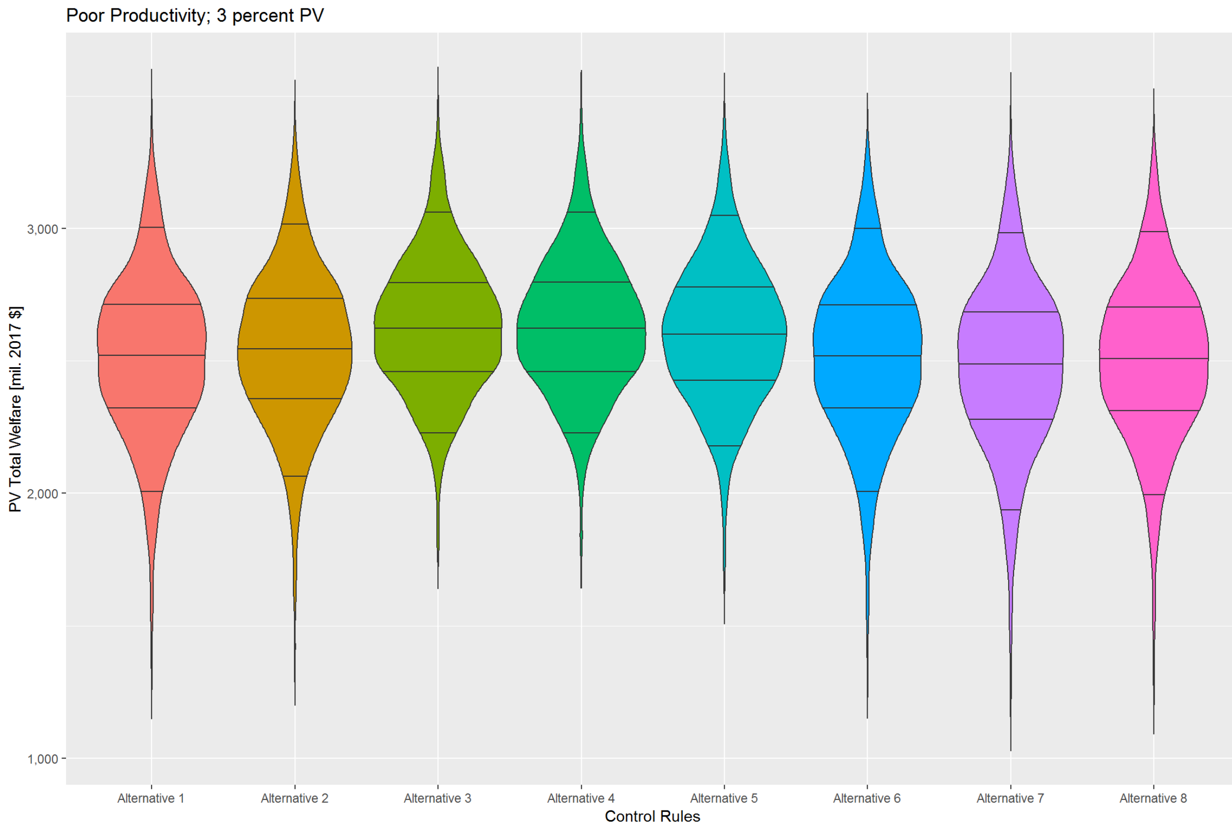
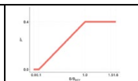
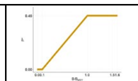
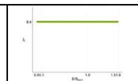
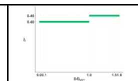
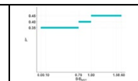
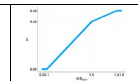
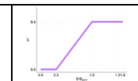
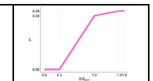


Figure 3. Violin plots of model runs showing the 5%, 25%, 50%, 75%, and 95% quantiles of the present value of total economic welfare over 30 years for the poor productivity scenario.

Results – Initial 5 Years Projections

The economic performance of the various control rule alternatives in the initial five years is summarized in Table 4.

Table 4. Mean Cumulative Initial 5-Year Total Economic Welfare (Millions, 3% PV) / Increase over Alternative 1 / Rank

Control Rule								
Average Productivity	758	794	830	840	825	765	738	774
	0	36	72	82	67	7	-20	16
	7	4	2	1	3	6	8	5
Good Productivity	892	937	966	983	968	908	872	922
	0	45	74	91	76	16	-20	30
	7	4	3	1	2	6	8	5
Poor Productivity	638	665	706	711	696	641	619	644
	0	27	68	73	58	3	-19	6
	7	4	2	1	3	6	8	5

Discussion

It is rather simple to rank the performance of the alternative control rules in the initial five-year period: Alternative 4 is the best in all productivity scenarios. Alternatives 3 and 5 ranks either second or third. The bottom five rankings remain constant in all productivity scenarios with Alternative 2 in fourth, Alternative 8 in fifth, Alternative 6 in sixth, Alternative 1 in seventh, and Alternative 7 in last place.

Figures 4 shows the distribution of the present value of total economic welfare over the initial five years of the 500 simulated runs under the average productivity scenario. It shows that Alternatives 3 through 5, the control rules with piecewise constant P*, have lower variability in total economic welfare compared to control rules with ramped P*. This pattern is also observed under both good and poor productivity scenarios.

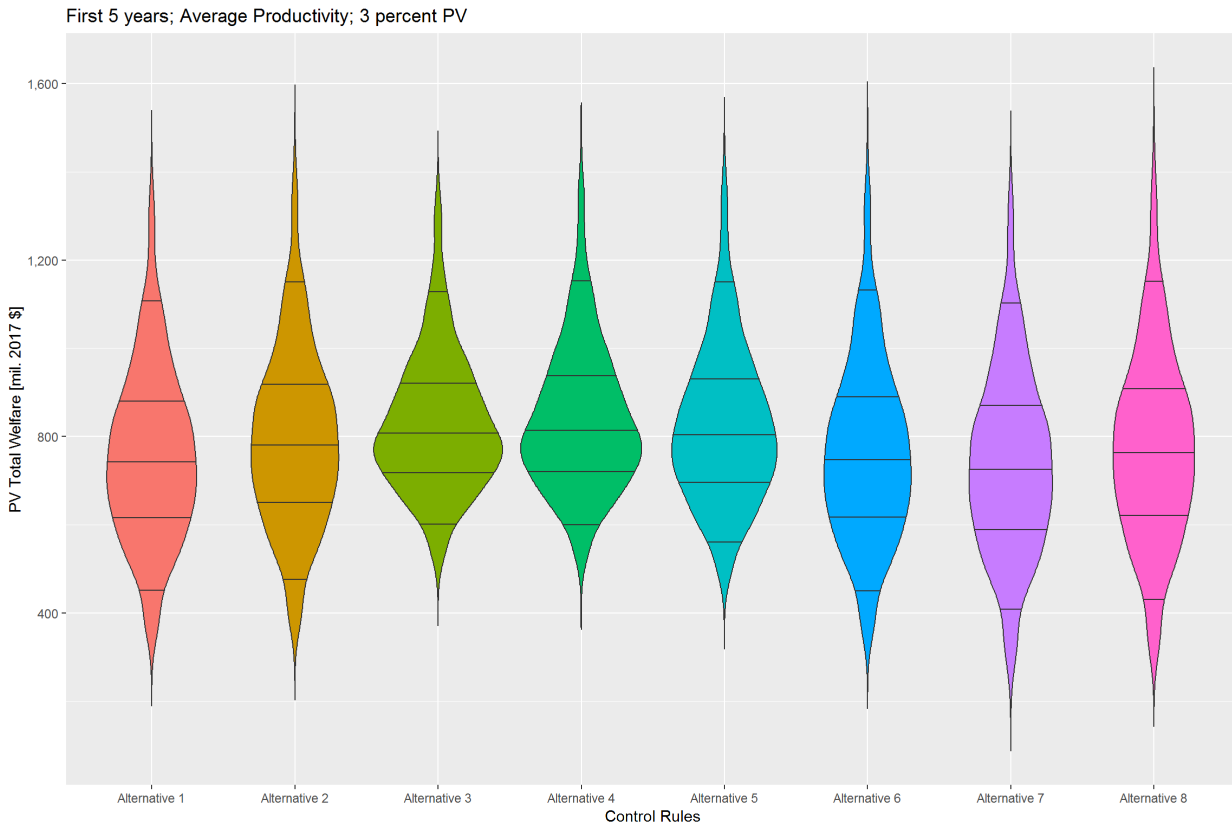
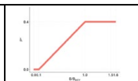
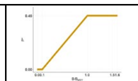
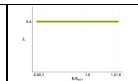
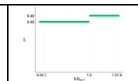
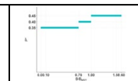
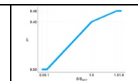
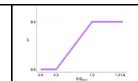
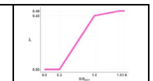


Figure 4. Violin plots of model runs showing the 5%, 25%, 50%, 75%, and 95% quantiles of the present value of total economic welfare over the initial 5 years for the average productivity scenario.

Results – Final 20 Years Projections

The economic performance of the various control rule alternatives in the final 20 years is summarized in Table 5.

Table 5. Mean Cumulative Final 20-Year Total Economic Welfare (Millions, 3% PV) / Increase over Alternative 1 / Rank

Control Rule								
Average Productivity	1,147	1,154	1,153	1,158	1,156	1,147	1,146	1,150
	0	7	6	11	9	0	-1	3
	6	3	4	1	2	6	8	5
Good Productivity	2,265	2,315	2,265	2,314	2,315	2,308	2,266	2,324
	0	50	0	49	50	43	1	59
	7	2	7	4	2	5	6	1
Poor Productivity	578	581	592	591	590	576	574	575
	0	3	14	13	12	-2	-4	-3
	5	4	1	2	3	6	8	7

Discussion

Table 5 shows that there is relatively little difference among the control rule alternatives in the final 20 years when B/B_{MSY} is greater than one. The rankings in Table 5 are similar to those in Table 2. They show that Alternatives 2, 4, and 5 perform well under all productivity scenarios, ranking no worse than fourth, fourth, and third, respectively, among all alternatives. Alternative 7 is the worse performer, ranking sixth in the good productivity scenario but last in the remaining two scenarios. Alternatives 8 ranks first under the good productivity scenario but second to last under the poor productivity scenario. Alternative 3, the constant 0.4 P* control rule performs the best under poor productivity scenario but ranks seventh under the good productivity scenario. Alternative 1, the status quo, ranks no better than fifth, and ranks second to last in the good productivity scenario.

Figures 5 shows the distribution of the present value of total economic welfare over the final 20 years of the 500 simulated runs under the poor productivity scenario. It shows that Alternatives 3 through 5, the control rules with piecewise constant P*, have lower variability in total economic welfare compared to control rules with ramped P* under poor productivity conditions. This pattern is not as pronounced in either the average or the good productivity scenarios.

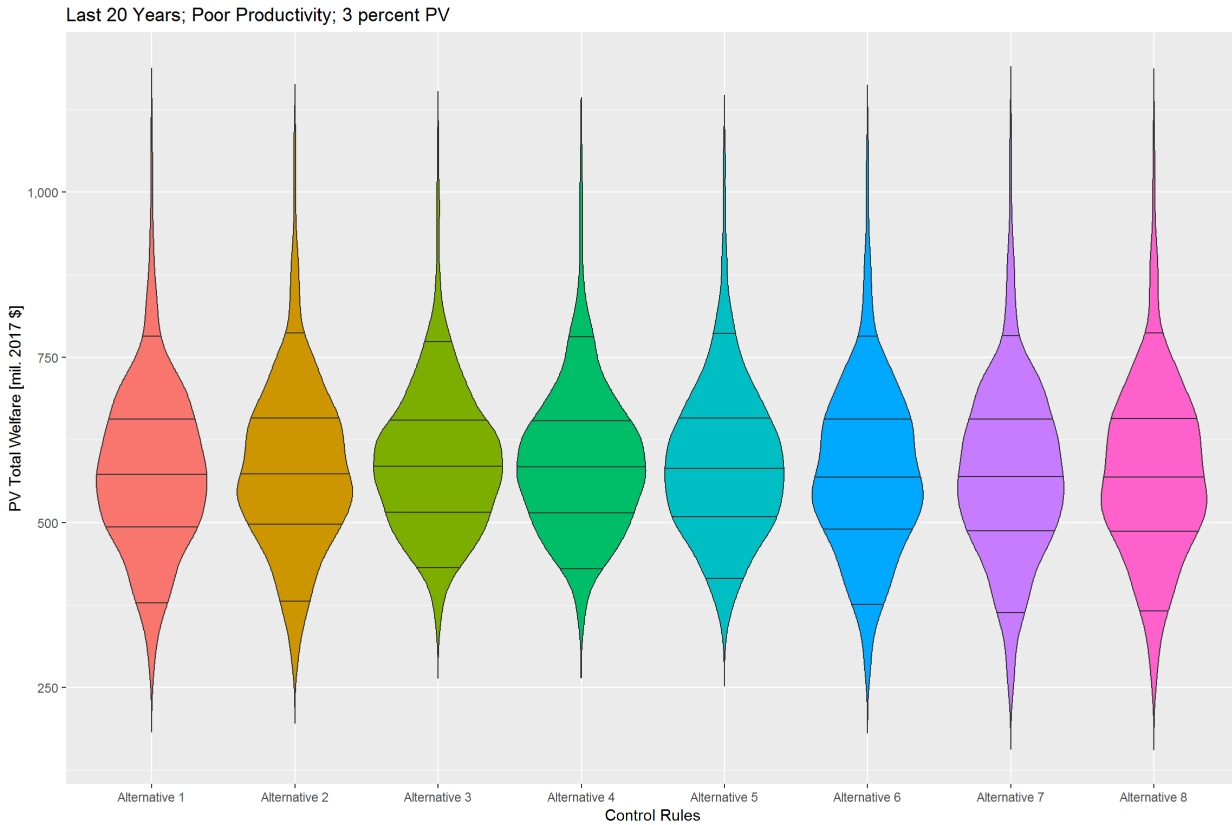


Figure 5. Violin plots of model runs showing the 5%, 25%, 50%, 75%, and 95% quantiles of the present value of total economic welfare over the final 20 years for the poor productivity scenario.

Discussion

Similar to results from the December 2018 report, we found that total economic welfare correlates strongly with allowable catch. Alternatives 4 and 5, which are less conservative when B/B_{MSY} is below one, perform the best under average and poor productivity scenarios, and in the initial five years when the summer flounder resource has below target biomass. Their relative performance is not as strong under good productivity scenarios. The current policy, Alternative 1, and its close variant, Alternative 7, which are most conservative under all B/B_{MSY} levels, perform rather poorly, often ranking in the bottom two. Alternative 3, with a constant 0.4 P* performs relatively well under poor productivity scenarios and in the initial five years, but relatively poorly under good productivity scenarios. In contrast, Alternative 8 performs relatively well under good productivity scenarios but relatively poorly under poor productivity scenarios and in the initial five years. Our results also show that Alternatives 3 through 5, the least restrictive alternatives under low B/B_{MSY} levels, produce the lowest variability in economic welfare, particularly under poor productivity scenarios, and in the initial five years.

A Note About Other Species Economic Impacts of Harvest Control Rules

Since we do not have quantitative economic models developed for the other two species, scup and butterfish, analyzed in the Wiedenmann study, we looked at factors indicative of how these species might deviate from summer flounder in their economic performance relative to the different harvest control rules analyzed.

Recreational Value

The presence of a major recreational fishery for summer flounder and scup increases the overall magnitude of the economic impact of the harvest control rules compared to fisheries without a recreational sector (i.e., butterfish). According to revised MRIP estimates, directed trips for scup (trips for which the individual indicated they were targeting scup as their first or second choice) averaged 1.3 million trips per year from 2009-2018 compared to an average of just over 1.0 million trips per year for summer flounder (Figure 1).

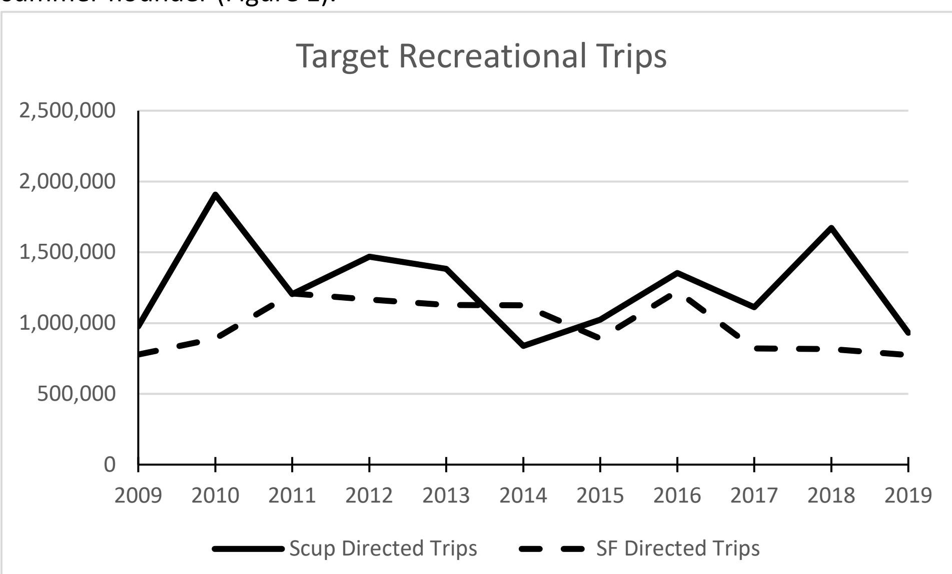


Figure 3. Trips targeting scup and summer flounder.

In our detailed summer flounder analysis, the harvest control rules affect both the value of a trip (due to catch rate changes related to biomass) and the number of trips taken (due to changes in the recreational quota). We do not have estimates of the value (willingness-to-pay) for scup trips to compare with summer flounder trips. Evidence would suggest, however, that the number of scup trips taken is not as sensitive to the quota level as it is for summer flounder. Figure 2 shows the relationship between TAC and the number of directed trips for scup and summer flounder. As expected, there is a positive relationship ($r^2 = 0.225$) between trips and TAC for summer flounder, but no relationship ($r^2 = 0.001$) for scup.

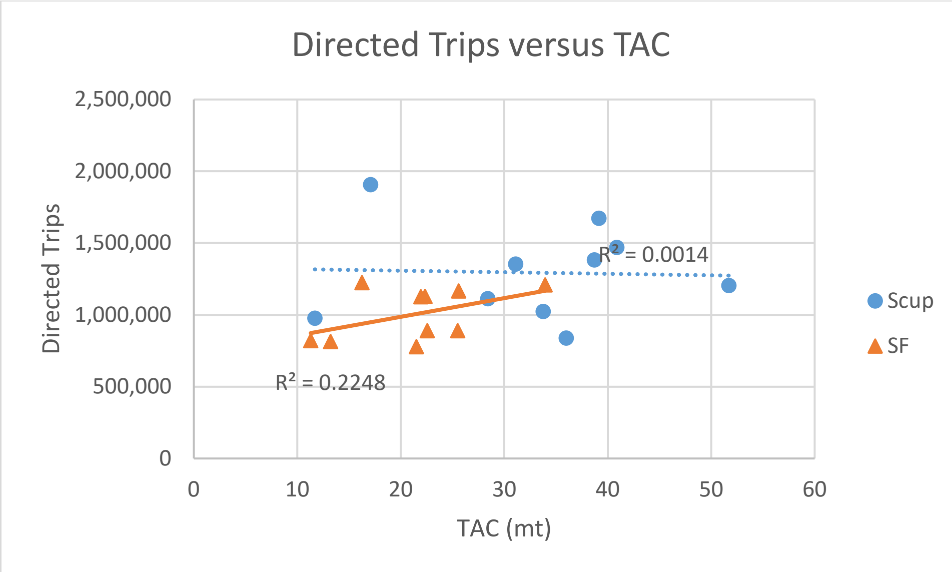


Figure 4. Relationship between scup and summer flounder directed trips and quota

Given the lack of sensitivity of directed trips for scup to the quota, it is expected that the recreational economic impacts of the different harvest control rules considered will be significantly less than the impacts for the summer flounder fishery. However, if scup biomass, and thus TAC, attains extremely low values, this might lead to sharp reductions in trips taken, and thus a more significant economic impact could ensue. The implication for the harvest control rule performance for scup recreational value is that due to the trip to quota relationship, the rules that avoid extremely low quota are more beneficial; whereas, there is little increased recreational benefit from control rules that lead to significantly higher than average quotas.

Commercial Value

We looked at commercial landings and price data from 2009-2017 for scup and butterfish in comparison to summer flounder (Figure 3) in order to examine qualitatively how commercial fishing value analyses for these species diverge from the summer flounder model presented elsewhere. Over the period examined, average summer flounder ex-vessel price is over 4 times that of scup and butterfish.

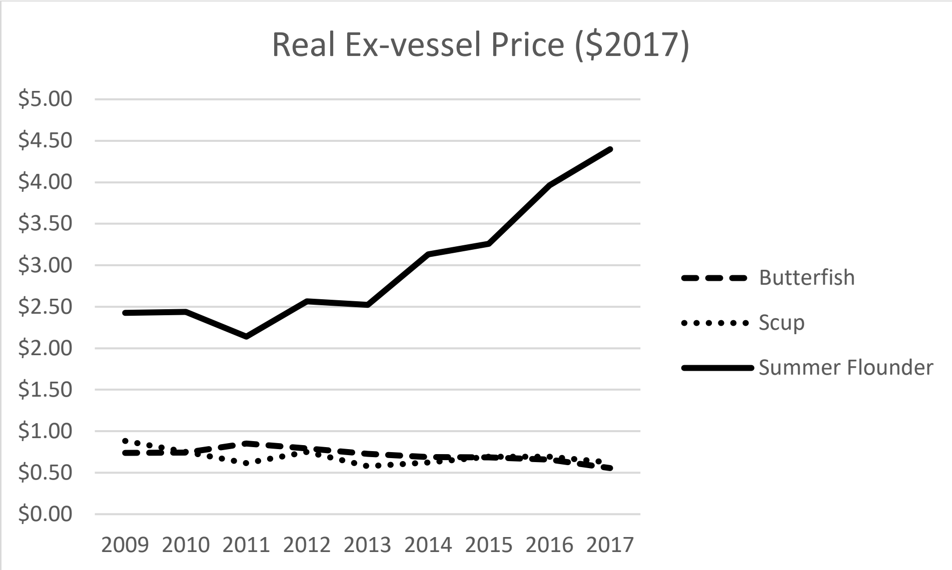


Figure 5. Real (2017 dollars) ex-vessel price for butterfish, scup and summer flounder.

Figures 4, 5 and 6 provide simple price-quantity relationships for summer flounder, scup and butterfish, respectively. The summer flounder model in our detailed harvest control rule analysis contains a more sophisticated summer flounder inverse demand model, but for comparison purposes, we are using the simplified relationships for all three species here.

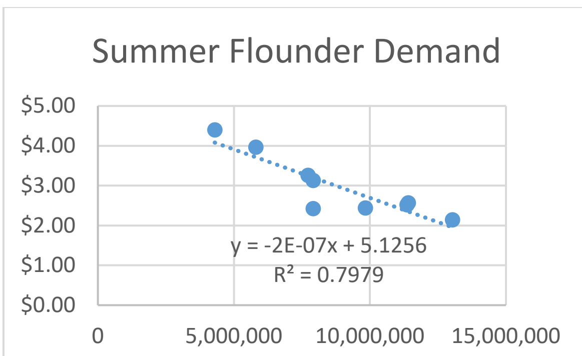


Figure 6. Simple summer flounder demand relationship.

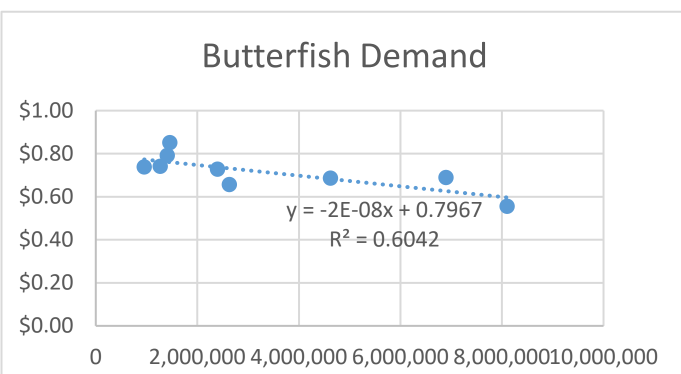


Figure 7. Simple butterfish demand relationship.

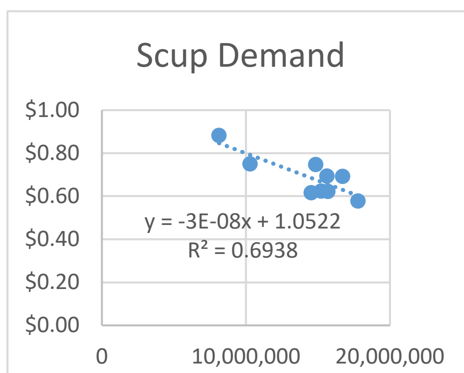


Figure 6. Simple scup demand relationship.

The demand relationship affects the performance of the harvest control rules in two significant ways. First, the price flexibilities[1], will impact the total commercial revenue of the fishing fleet. The calculated flexibility at the mean of summer flounder quantity and prices is 0.59, 0.62 for scup and 0.09 for butterfish. Since all three flexibilities are less than 1.0, at the mean, fleet total revenues will decline when the quota is lowered from the mean and revenues will rise when the quota is raised (assuming all quota is landed). Given our linear demand estimation, as one moves down the demand curve due to higher quotas and landings, prices become more flexible. At high quotas and landings, a reduction in quota is compensated for by a higher price, but an increase in quota means that prices decrease at a greater percentage than landings increase and total revenue declines. For summer flounder and scup, the price flexibilities calculated at the highest level of landings over the sample period –during 2011 for summer flounder and 2013 for scup, were both greater than 1.0. This means that had quotas and landings been set any higher, revenues would have fallen. This price effect dampens the benefits from control rules that allow significantly higher catch for these species. This effect is captured in the more detailed summer flounder analysis. Butterfish, on the other hand, exhibits low price flexibility, even at maximum catch, compared with scup and summer flounder. Industry total revenues, will thus, follow more closely the trends in predicted biologically driven results from the Wiedenmann model.

In the detailed summer flounder model, we also use the summer flounder demand curve estimation to calculate consumer surplus, the net economic welfare from downstream effects of summer flounder as it reaches the final consumer. The greater the slope of the demand curve, the greater the consumer surplus. Since the butterfish demand curve is relatively flat (near horizontal), the differences between harvest control rules leading to changes in quota setting will have a muted impact on the net benefit estimation. Consumer surplus for scup will vary similarly to summer flounder in direction, but will be significantly lower for scup due to the overall lower demand for that species.

Conclusion

From the above qualitative analysis, it can be expected that if we had conducted a comprehensive analysis of the scup fishery, similar to our analysis of summer flounder, the differences between harvest control rules would be similar to those found for summer flounder. However, the absolute magnitude of the impacts would be significantly lower due to its lower market price and the lack of sensitivity of recreational trips to the quota level. Butterfish, lacking a recreational fishery and having low price flexibility, would have a different economic response than summer flounder or scup. For butterfish, the difference in performance of the harvest control rules in terms of allowable catch and biomass as derived from the Wiedenmann study, should serve as an indicator of economic performance.

---

[1] Price flexibility is defined as the percentage change in price for a 1% change in quantity. This is the inverse of price elasticity and are used in fisheries models because often the quantity supplied to the market is fixed by a quota or environmental factors and we are interested in how the price adjusts. A flexibility > 1 means that total revenue will increase with a decrease in quantity supplied. In a linear demand relationship, the flexibility will vary along the point on the demand curve where it is calculated. The usual practice is to provide the value at the sample mean of prices and quantity.

References

Hutniczak, B., Lipton, D., Wiedenmann, J. and Wilberg, M. 2018. Valuing changes in fish stock assessments. Canadian Journal of Aquatic and Fisheries Sciences. Published on the web 10 November 2018, https://doi.org/10.1139/cjfas-2018-0130.

Wiedenmann, J., M. Wilberg, A. Sylvia, and T. Miller. 2017. An evaluation of acceptable biological catch (ABC) harvest control rules designed to limit overfishing. Canadian Journal of Fisheries and Aquatic Sciences. doi: 10.1139/cjfas-2016-038

Wiedenmann, J. 2018. Evaluation of alternative harvest control rules for Mid-Atlantic fisheries. Report to the Mid-Atlantic Fisheries Management Council. March 12, 2018.