7. Assessment of the arrowtooth flounder stock in the Gulf of Alaska

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November 2020

Executive Summary

The scheduled frequency for some stock assessments was recently changed in response to the National Stock Assessment Prioritization effort (Methot 2015; Hollowed et al. 2016). In previous years, all Gulf of Alaska (GOA) rockfish stocks were assessed on a biennial stock assessment schedule to coincide with the availability of new survey data. There was no change in this schedule for the arrowtooth flounder stock. For this off-cycle (even) year, we present a partial assessment consisting of an executive summary with recent fishery catch and survey trends as well as recommend harvest levels for the next two years. In on-cycle (odd) years, we will present a full stock assessment document with updated assessment and projection model results to recommend harvest levels for the next two years. Please refer to last year's full stock assessment and fishery evaluation (SAFE) report for further information regarding the stock assessment (Spies et al., 2019, available online at (https://apps-afsc.fisheries.noaa.gov/refm/docs/2019/GOAatf.pdf).

We use a statistical age-structured model as the primary assessment tool for the Gulf of Alaska (GOA) arrowtooth flounder (ATF, *Atheresthes stomias*) stock which qualifies as a Tier 3 stock. This assessment consists of a population model, which uses survey and fishery data to generate a historical time series of population estimates, and a projection model, which uses results from the population model to predict future population estimates and recommended harvest levels. The data sets used in this assessment include total catch biomass, fishery size compositions, bottom trawl survey abundance estimates, bottom trawl survey age compositions, and bottom trawl survey size compositions when age compositions are not available. For an off-cycle year, we do not re-run the assessment model, but do update the projection model with new catch information. This incorporates the most current catch information without re-estimating model parameters and biological reference points. As with last year, we use the full assessment base model from 2017 (Model 17.b).

Summary of Changes in Assessment Inputs

Changes in the input data:

There were no changes made to the assessment model inputs since this was an off-cycle year. New data added to the projection model included an updated 2019 catch estimate of 24,584 t and new catch estimates for 2020-2022. We estimated the 2020 catch by increasing the official catch as of October 21, 2020, by an expansion factor of 1.11, which represents the average fraction of catch taken after October 21 in the last five complete years (2015-2019). This resulted in an estimated catch for 2020 of 23,224 t. To estimate future catches, we updated the yield ratio to 0.23, which was the average of the ratio of catch to TAC for the last five complete catch years (2015-2019). This yield ratio was multiplied by the projected ABCs from the updated projection model to generate catches of 18,662 t in 2021.

Changes in the assessment methodology:

There were no changes to the assessment methodology since this was an off-cycle year.

Summary of Results

Based on the projection model results, recommended ABCs for 2021 and 2022 are 126,970 t and 123,445 t, respectively, and the OFLs are 151,723 t and 147,515 t. The new ABC and OFL recommendations for 2021 are similar to the 2020 ABCs and OFL developed using the 2017 full assessment model. The stock is not overfished, and is not approaching a condition of being overfished. Reference values are presented in the following table.

Quantity	As estimated or *specified last* year for:		*As estimated or *recommended this* year for:	
	2020	2021	2021	2022
M (natural mortality rate)**	0.35, 0.2	0.35, 0.2	0.35, 0.2	0.35, 0.2
Tier	3a	3a	3a	3a
Projected total (age 1+) biomass (t)	1,325,867	1,321,075	1,321,700	1,318,860
Projected Female spawning	756,100	718,325	752,703	724,288
$B_{100\%}$	1,028,329	1,028,329	1,028,330	1,028,330
$B_{40\%}$	411,332	411,332	411,331	411,331
$B_{35\%}$	359,915	359,915	359,915	359,915
F_{OFL}	0.234	0.234	0.234	0.234
$maxF_{ABC}$	0.193	0.193	0.192	0.192
F_{ABC}	0.193	0.193	0.192	0.192
OFL (t)	153,017	127,773	151,723	147,515
maxABC (t)	128,060	124,357	126,970	123,445
ABC (t)	128,060	124,357	126,970	123,445
Status	As determined *last* year for:		As determined *this* year for:	
	2018	2019	2019	2020
Overfishing	no	n/a	no	n/a
Overfished	n/a	no	n/a	No
Approaching overfished	n/a	no	n/a	No

*Projections are based on estimated catches of 23,224 t for 2020 and 18,662 t for 2021.
**Natural mortality rate is 0.35 for males, 0.2 for males.

The stock is not being subject to overfishing, is not currently overfished, nor is it approaching a condition of being overfished. The tests for evaluating these three statements on status determination require examining the official total catch from the most recent complete year and the current model projections of spawning biomass relative to $B_{35\%}$ for 2020 and 2022. The official total catch for 2019 is 24,584 t, which is less than the 2019 OFL of 174,598 t; therefore, the stock is not being subjected to overfishing. The estimates of spawning biomass for 2020 and 2022 from the current year (2020) projection model are 779,358 t and 724,288 t, respectively. Both estimates are well above the estimate of B35% at 359,915 t and, therefore, the stock is not currently overfished nor approaching an overfished condition.

Fishery Trends

Updated catch data (t) for arrowtooth flounder in the Gulf of Alaska as of October 21, 2020 (NMFS Alaska Regional Office Catch Accounting System via the Alaska Fisheries Information Network (AKFIN) database, http://www.akfin.org) are summarized in the following table:

Year	Western	Central	West Yakutat	East Yakutat/SE	Gulfwide Total	Gulfwide ABC	Gulfwide TAC
2019	684	23,784	88	28	24,584	145,841	99,295
2020	279	20,511	47	28	20,865	128,060	96,969

Catch of arrowtooth flounder decreased in all areas in 2020 compared to 2019 but remains within the range of the time series. About 80% of the catch is in the arrowtooth trawl fishery, with 10% in the pollock bottom trawl fishery, and the remainder mainly in the rockfish and shallow water flatfish fisheries. Currently, "off year" assessments are required to present a catch to biomass ratio, which is calculated as the catch divided by the total age 1+ biomass from the assessment model and 2020 total biomass from the projection model (Spies et al. 2019). The catch to biomass ratio for 1991-2020 has ranged from 0.006 in 1991 to 0.024 in 2014 (Table 7.1, Figure 7.1). The arrowtooth flounder catch/biomass ratio has been steadily increasing since 1991 (Figure 7.1). The catch to biomass ratio in 2020 was 0.017, and was 0.018 in 2019.

Area Allocation of Harvests

The following table shows recommended area apportionments for 2021 and 2022, based on the proportion of survey biomass projected for each area using the survey averaging random effects model developed by the survey averaging working group. The recommended area apportionment percentages are found in the last full assessment (https://apps-afsc.fisheries.noaa.gov/refm/docs/2019/GOAatf.pdf).

	Western	Central	West Yakutat	East Yakutat/SE	Total
2019 Area Apportionment	25.5%	54.4%	6.6%	13.5%	100%
2021 ABC (t)	32,377	69,072	8,380	17,141	126,970
2022 ABC (t)	31,479	67,154	8,147	16,665	123,445

Summaries for Plan Team

Species	Year	Biomass[1]	OFL	ABC	TAC	Catch[2]
Arrowtooth Flounder	2019	1,391,460	174,598	145,841	99,295	24,584
	2020	1,367,620	153,017	128,060	96,696	20,865
	2021	1,321,700	151,723	126,970		
	2022	1,318,860	147,515	123,445		

Stock	Area	2020				2021		2022	
		OFL	ABC	TAC	Catch[2]	OFL	ABC	OFL	ABC
Arrowtooth Flounder	W		31,455	14,500	279		32,377		31,479
	C		68,669	68,669	20,511		69,072		67,154
	WY		10,242	6,900	47		8,380		8,147
	EY		17,694	6,900	28		17,141		16,665
	Total	153,017	128,060	96,969	20,865	151,723	126,970	147,515	123,445

[1]Results from age-structured projection model for age 1+
[2]Catch as of October 21, 2020.

Responses to SSC and Plan Team Comments on Assessments in General

"*The SSC recommends that one additional column be added to include concerns related to fishery/resource-use performance…*" (SSC, December 2018)

"*The SSC recommends the authors complete the risk table and note important concerns or issues associated with completing the table.*" (SSC, October 2019)

"*The SSC recommends dropping the overall risk scores in the tables as these provided no additional information relative to ABC-setting and seemed to cause confusion*"

"*The SSC requests that the table explanations be included in all the assessments which include a risk table for completeness.*"

 (SSC, December 2019)

The comments that pertain to the risk table have been grouped together. We provided a risk table in the last full assessment and will drop the overall score in the next full assessment. Since this is a partial assessment year, we do not provide a risk table as recommended by the SSC.

"*For Tiers 1-3 partial assessments should include catch/biomass ratios for all species in addition to rerunning the projection model with updated catch information, and also including updated survey biomass trends when available (note that partial assessments for Tiers 1-3 do not involve re-running the assessment model; only the projection model). Partial assessments for Tiers 4-5 should include catch/biomass ratios, and re-running the random effects model only if there is a new survey data point available. Partial assessments for Tier 6 should include catch trends for all stocks.*"

"*For Tiers 1-3 on a 2-year cycle when only the projection model is run with updated catch and the new survey estimate is not included in model output, the Team recommended using apportionment percentages determined in the last full assessment. The rationale for this is to update apportionment values when survey data is used in biomass and ABC/OFL calculations (Tiers 4-5) but not when projection models are run that don't use new biomass estimates to inform reference points (Tiers 1-3). The AFSC will revise and clarify the partial assessment guidance in the annual assignment memo to include apportionment, and will address the issue of Tier 3 stocks on a 4-year cycle.*"

(GOA Plan Team, 2019)

We follow the GOA Plan Team recommendations regarding partial assessments for Tiers 1-3.

"*The SSC recommends thinking beyond the current (2020) situation to develop methods for making stock assessment analyses more robust to possible future survey reductions/loss. These may include:*

- *Renewed investigation of data conflicts in the assessment models, perhaps addressed through data weighting and/or identification of un-modelled processes, or occasional anomalous data points.*
- *Model-based survey time series (e.g., vector-autoregressive spatio-temporal (VAST) models) that can accommodate incomplete data, changes in survey design, or alternative survey platforms and still produce indices of abundance with statistical variance estimates. These may be particularly helpful for stocks (e.g., Tier 4 crab and Tier 5 groundfish) where harvest levels are informed directly by trends in survey data rather than solely by the results of the stock assessment.*
- *Exploration of harvest control rules that are explicitly linked to survey and assessment uncertainty and the lag between surveys and assessments.*"

(SSC, October 2020)

We plan to explore the utility of model-based survey time series (e.g., VAST model) as a way to integrate potential alternative surveys in the GOA arrowtooth flounder model in the future.

Responses to SSC and Plan Team Comments Specific to this Assessment

"There appears to be a shift to lower recruitment in recent years, beginning in 2006 (i.e., the 2005 year class). The Team recommends investigating whether these lower recruitments are related to environmental conditions in the GOA.
"The Team noted that the decrease in biomass began before the recent heatwaves in the north Pacific and is similar to drops observed in other flatfish during this time and may be potentially linked to extended poor recruitment during cold pattern in 2006-2007." (GOA Plan Team, November 2019)

We plan to investigate these lower recruitment trends through the ESP framework in future assessments. The ESP provides a unique opportunity to explore unaccounted for uncertainty through an ecosystem and socioeconomic approach to fisheries management.

"The Team also noted the potential of using AFSC longline survey data for arrowtooth flounder as they are caught in significant numbers on that survey."
"The assessment contains survey length-frequency data from 1985, 1986, and 1989 that were collected opportunistically. Because these data were not part of standard NMFS GOA bottom trawl surveys and the methodology for their collection is unclear, the Team recommends investigating whether they should be removed from the assessment." (GOA Plan Team, November 2019)
"The SSC supports the GPT recommendations to evaluate whether opportunistically collected length frequency data should be removed from the model. The SSC requests the authors investigate including IPHC survey data in this assessment, and whether fishery catch-at-age information is available for inclusion in the model." (SSC, December 2019)

We have grouped the GOA Plan Team and SSC comments regarding alternate surveys and survey length frequency data together because they pertain to the same recommendation. We plan to investigate the potential for using the AFSC longline survey and IPHC data as an auxiliary indices of arrowtooth flounder in the next full assessment. We may also explore the utility of combining this survey with the bottom trawl survey using model-based methods (e.g., VAST) when possible. We will also investigate the opportunistically collected length frequency data and determine if it should remain in the model in the next full assessment.

Literature cited

Hollowed, A.B., K. Aydin, K. Blackhart, M. Dorn, D. Hanselman, J. Heifetz, S. Kasperski, S. Lowe, and K. Shotwell. 2016. Discussion paper stock assessment prioritization for the North Pacific Fishery Management Council: Methods and Scenarios. Report to NPFMC Groundfish Plan Teams. September 2016. https://www.npfmc.org/wp-content/PDFdocuments/meetings/AFSC-HQ_Discussion_Paper.pdf.

Methot Jr., Richard D. (editor). 2015. Prioritizing fish stock assessments. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/SPO-152, 31 p.

Spies, I., Ianelli, J., Kingham, A., Narita, R. and Palsson,W. 2017. Assessment of the arrowtooth flounder stock in the Gulf of Alaska. North Pacific Fishery Management Council, P. O. Box 103136, Anchorage, AK 99510.
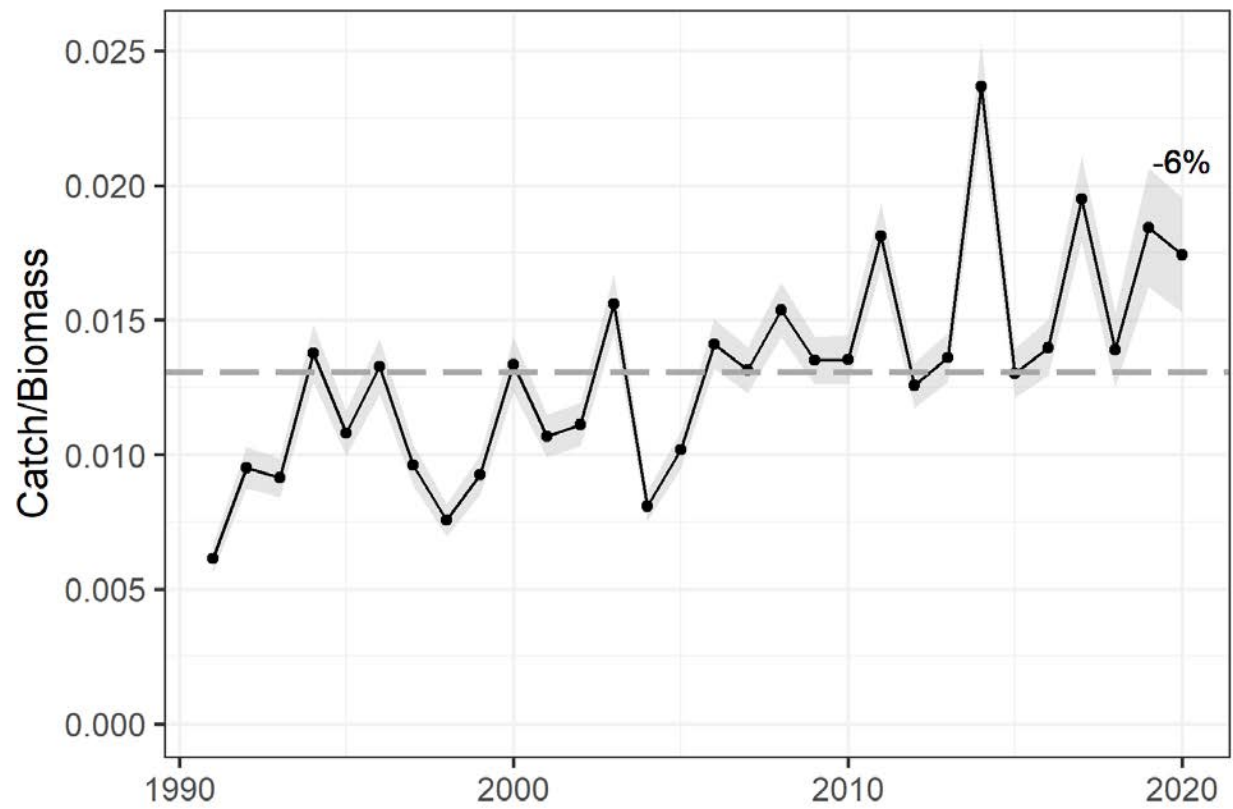
Figure 7.1 Catch to biomass ratio for Gulf of Alaska arrowtooth flounder from 1991-2020. Values for 2020 are based on projected estimates.

Table 7.1 Biomass estimates from the 2019 full assessment model, except for 2020, which was generated by the single species projection model. *Catch data is from the NMFS AKRO BLEND/Catch Accounting System, except for 2020 which is an estimate based on the catch as of October 21, 2020 extrapolated to Dec. 31, 2020 based on average catches from 2015-2019.

Year	Biomass	Catch	Catch/Biomass Ratio
1991	1,634,500	10,034	0.006
1992	1,678,600	15,970	0.010
1993	1,700,600	15,559	0.009
1994	1,711,600	23,560	0.014
1995	1,707,000	18,428	0.011
1996	1,701,300	22,583	0.013
1997	1,696,300	16,319	0.010
1998	1,714,800	12,975	0.008
1999	1,753,200	16,207	0.009
2000	1,818,300	24,252	0.013
2001	1,865,500	19,926	0.011
2002	1,908,900	21,213	0.011
2003	1,937,600	30,254	0.016
2004	1,947,300	15,758	0.008
2005	1,964,800	19,989	0.010
2006	1,966,600	27,739	0.014
2007	1,940,800	25,508	0.013
2008	1,903,900	29,270	0.015
2009	1,844,400	24,912	0.014
2010	1,776,800	24,060	0.014
2011	1,708,900	30,957	0.018
2012	1,639,300	20,617	0.013
2013	1,586,700	21,580	0.014
2014	1,533,000	36,300	0.024
2015	1,463,300	19,056	0.013
2016	1,418,800	19,835	0.014
2017	1,378,100	26,866	0.019
2018	1,358,200	18,873	0.014
2019	1,333,500	24,584	0.018
2020	1,333,540	23,224	0.017