

To: Central Bering Sea Fishermen's Association

From: Dr. Sara Sutherland

Date: October 2021

Re: Economic impact analysis of changes in halibut directed fishery catch and review of Draft Environmental Impact Statement (DEIS) for the Bering Sea and Aleutian Islands (BSAI) Halibut Abundance-Based Management (ABM) of Amendment 80 Prohibited Species Catch (PSC) Limit September 2021

The North Pacific Fishery Management Council and the National Marine Fisheries Service are considering an abundance-based management (ABM) system for the Amendment 80 sector of the Bering Sea/Aleutian Islands (BSAI) groundfish fishery. Under the ABM system, variable halibut bycatch limits (PSC limits) would be established based on the abundance of halibut, as determined by fishery-independent indices.

As requested, I have evaluated the economic impacts to St. Paul and other Area 4 communities resulting from changes in directed halibut fishery catch associated with low halibut abundance and/or halibut mortality resulting from PSC. I have also reviewed the economic impacts analysis utilized in the September 2021 Draft Environmental Impact Statement (DEIS) for the Bering Sea and Aleutian Islands (BSAI) Halibut Abundance-Based Management (ABM) of Amendment 80 Prohibited Species Catch (PSC) Limit. This memorandum summarizes my findings.

Executive Summary

This memorandum reports the result of economic analysis performed to understand the proposed management measure to link the Pacific halibut prohibited species catch (PSC) limit for the Amendment 80 commercial groundfish trawl fleet in the Bering Sea and Aleutian Islands (BSAI) groundfish fisheries to halibut abundance. The report is focused on the September 2021 Draft Environmental Impact Statement for the BSAI Halibut ABM of Amendment 80 PSC Limit (hereafter DEIS). The analysis is divided into four parts: Economic Impact Analysis of Halibut in Area 4; Amendment 80 Fleet Revenue Analysis; Economic Analysis of Past and Future Bycatch Reduction Methods; and Analysis of Benefits to the Nation. Key Findings include the following:

Economic Impact Analysis

Economic analysis underscores the importance of the halibut industry on St Paul Island and in Area 4. Key conclusions include:

- The directed halibut fishery is a cornerstone of the economy of St. Paul Island:
 - Fishing employs over one-third of all employed residents

- Employment in the halibut fishery is directly related to the total halibut allocation in the directed fishery
- Through direct and indirect effects, the \$2.25 million decline in resident halibut landings over the past decade has resulted in a \$3.465 million reduction in total resident income
- Halibut harvesting and processing are key industries in Area 4 communities where reductions in directed harvest have already led to significant economic impacts:
 - This region is both one of the most remote and racially diverse in the United States
 - Declines in the directed halibut fishery have resulted in a yearly decline in GDP in the region of \$43M
 - Declines in halibut catch and landings have led to a loss of 649 jobs
 - Halibut processors and harvesters still represent around a \$30M per year contribution to regional GDP, which is at risk if directed halibut catch is further reduced.
- A comparison of wholesale revenue demonstrates that halibut is one of the highest revenue and most impactful species harvested in the BSAI/Area 4
 - In 2010-11, estimated wholesale revenues of halibut (in Area 4) exceeded those of all A80 target species except Yellowfin Sole and Atka Mackerel
 - Estimated halibut wholesale revenues have subsequently declined by over \$28M, while many A80 target species have increased and aggregate revenues have remained stable
 - The lost value of halibut killed as bycatch by the A80 fleet still exceeds the revenue generated by three Amendment 80 target species: Arrowtooth Flounder, Alaska Plaice, or Arrowtooth Sole
- The economic impact of changes in halibut catch in Area 4 is not fully documented in the DEIS
 - The DEIS fails to acknowledge the ongoing economic impact of declining directed fishery catch in Area 4
 - The DEIS incorrectly asserts that CDQ groundfish catch is threatened by the current regulatory action

Revenue Projection Analysis

In contrast to underemphasized halibut impacts, an analysis of the Amendment 80 fleet revenue projections under the proposed PSC limits suggests fleet impacts are overemphasized in the DEIS.

- The use of revenue as the key metric for measuring impacts, which is not the correct measure to use according to economic theory, is never justified in the DEIS.

- The model uses Amendment 80 harvesting data from periods where PSC limits were high and bycatch avoidance practices were very different from current practices and predicts halibut bycatch at levels exceeding any actual bycatch observations in the past 5 years.
- No model accuracy or test data is provided to gauge its accuracy or relevance, despite the failure of the 2015 revenue projections to accurately predict impacts.

Bycatch Analysis

The regulatory environment in which the fleet operates determines their willingness to innovate to reduce bycatch. The DEIS fails to emphasize how rational economic behavior has led to past innovation to reduce bycatch and the ongoing margins for cost-effective adjustment.

- In years where PSC limits are binding, the random draw methodology precludes the possibility of the cost-minimizing response, constraining firms to irrational high-cost behavior
- Continued bycatch reductions rely on stricter regulations: past reductions in bycatch and adoption of existing and proven bycatch avoidance technologies has only occurred after bycatch limits were lowered
- Viable margins of adjustment for bycatch avoidance include benchmarking and the adoption of industry best-practices in avoidance behavior and risk-sharing, the use of the cooperative to align firm and captain incentives with overall goals of reducing bycatch, additional information sharing across firms, and experimentation with new technology

Economic Benefits to the Nation

The assertion that the new PSC limits will reduce the benefits to the nation is not justified based on the analysis included in the DEIS.

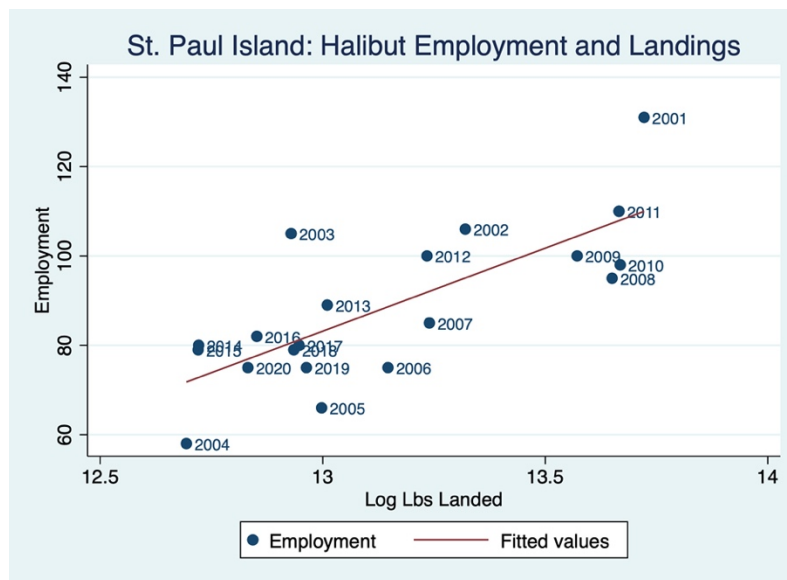
Part 1: Economic Impact to St. Paul Island and Area 4

St. Paul Island

The fishing industry is the primary source of economic activity on St. Paul Island. With fishing employing over one-third of all employed residents, the decline in halibut landings has had both direct and indirect impacts on the economy. The direct effects include reductions in wages and employment in the fishing and processing sectors, decreases in value added by the processing sector, and losses in sales tax revenue for St. Paul's municipal government. Additionally, the local commercial fleet plays an important role in the subsistence fishery, as subsistence catch is often caught on resident commercial vessels (Unger et al., 2006).

Although crab harvest and processing is the largest sector in terms of landings and revenue, the viability of the locally owned vessel fleet is linked to the directed halibut fishery. Unlike crab, halibut can be harvested directly by residents of St. Paul using smaller long-line vessels. The locally owned fleet is almost entirely composed of halibut fishermen and has been for the last three decades. Jobs in processing the landed halibut and the multiplier effects of landings (like vessels services) on the local economy are strongest for resident-owned catch. Most of the crab is harvested by non-resident vessel owners, making halibut key to retaining income locally.

Figure 1: Employment in the Directed Halibut Fishery and Halibut Landings on St. Paul Island



On average, the fish harvesting sector employs 88 residents each year and most, if not all, of these individuals are involved in the halibut industry. Over the past two decades, reductions in landings have been accompanied by a reduction in active vessels, and associated employment. As demonstrated in figure 1, employment in the halibut fishery is strongly linked with total halibut landings, with years of high landings having a higher number of individuals employed.

We can estimate the impact of reduced halibut landings on St. Paul Island using results from Watson et al. (2021). A decrease of \$1 million in resident catch results in a reduction of 3.4 local crew hires and 9 less processing jobs. Between 2010 and 2019, resident income on St. Paul Island from Halibut landings decreased by approximately \$2.25 million, which translates to a reduction in 7.65 local crew hires. Watson et al. (2021) also estimate a reduction in catch of one million dollars results in 7.2 less jobs via indirect effects, including changes in vessel support industries (gear, bait, repair maintenance), and seafood wholesalers and retailers.

Local firms supply goods and services to individuals earning income directly and indirectly from the halibut fishery. Watson et al. (2021) estimate that each additional

dollar in resident catch results in a decrease of 1.54 dollars of adjustable gross income for the respective city. This implies that a \$2.25 million reduction in halibut landings translates to \$3.465 million reduction in total income for the Island of St. Paul. Table 1 summarizes estimates of employment and local income effects of a reduction in resident halibut revenues over the past decade.

Table 1: Estimated impacts of reduced resident halibut revenue (2010-2019)

Category	Impact
Direct Employment: Crew	7.65 jobs
Indirect Employment	16.2 jobs
Local Income	\$3.465M

The halibut fishery has generated on average \$2.46 million per year in ex-vessel revenue over the past decade. There is a clear link between the patterns of halibut landings and the population and sales tax income of small remote Alaska communities (Sutherland and Edwards, 2021). As of 2017, nearly a third of St. Paul’s population was under twenty, with a thinned population between the ages of twenty and forty. The population distribution suggests that working-age individuals are leaving St. Paul to find work, a trend that will be exacerbated with further declines in the directed halibut catch.

Figure 2: Halibut Landings and Sales Tax Revenue

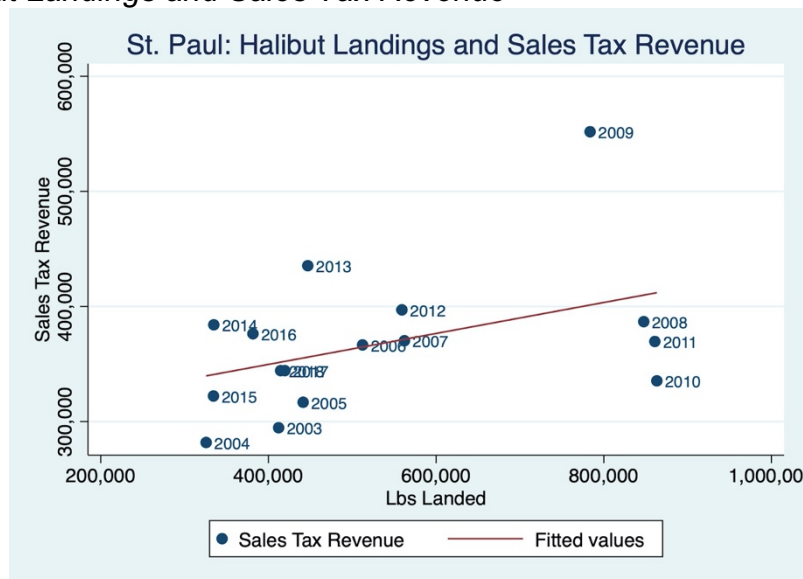


Figure 2 shows the positive relationship between sales tax revenue and halibut landings. Lower sales tax revenue in years of lower halibut landings may be caused by reductions in vessel services of the local fleet or lower income of local fishermen. Thus, at the same time the residents of St. Paul Island see declines in employment

opportunities, their local government sees declines in revenue to provide the services these citizens require.

Area 4

The reliance of Alaskan communities on the halibut fishery for local employment is not limited to St. Paul Island. The economic impact of the halibut fishery on area 4, where the Amendment 80 fleet operates, is large. Table 2 provides a revenue comparison of the many species targeted by the Amendment 80 fleet relative to halibut. In 2010, area 4 halibut had wholesale revenues estimated to be larger than all but two of the fisheries targeted by the A80 fleet. That same year, A80 bycatch of halibut would have had a market wholesale value estimated at \$24.69 million. Because these fish are killed and discarded by the Amendment 80 fleet, their potential economic impact is lost. The value of halibut to the region makes sense, given the 2010-2019 average price of halibut, as shown in the table, is approximately 7 times that of any other target species.

The last 10 years have seen a massive decline in halibut revenue. By 2019, directed halibut revenue had declined by \$28 million, with revenue falling below that of pollock and Pacific Cod, and similar to that of Pacific Ocean Perch, a fish worth only \$1.16 per pound. In the same period, the revenue from Yellowfin Sole increased by almost \$23 million. Overall Amendment 80 groundfish revenues stayed constant or increased over the same period.

Table 2: Area 4 Targeted Species Wholesale Revenues

Fishery	Average Revenue (\$M)			Average 2010-19
	2010	2019	Change	Price (per lb)
Yellowfin Sole	72.73	95.45	22.73	0.60
Atka Mackerel	71.21	74.24	3.03	1.15
Northern Rock Sole	41.92	19.70	-22.22	0.70
Pacific Cod	39.90	34.34	-5.56	1.23
Pollock	24.75	29.80	5.05	0.63
Pacific Ocean Perch	22.73	24.75	2.02	1.16
Arrowtooth Flounder	20.71	7.58	-13.13	0.81
Flathead Sole	12.63	13.64	1.01	0.81
Other	11.62	24.24	12.63	
Alaska Plaice	3.54	10.10	6.57	0.55
Directed Halibut (Area 4)	56.19	27.99	-28.19	7.33
A80 Halibut Bycatch (Lost Revenue)	-24.69	-15.34	9.35	7.33

The decline in halibut revenues has a large impact on Area 4 communities reliant on the harvesting and processing jobs the industry provides. This region is one of the most remote and racially diverse in the United States and halibut is a key economic contributor to regional GDP. Table 3 estimates the economic impact of halibut harvesting and processing in area 4, and critically the change from average 2010-11 to average 2018-19 impacts (we use two-year averages to reduce effect of any anomalous high or low revenue years).

The top panel of table 3 estimates the economic impact on the economy of Area 4 using data on the directed fishery (IFQ+CDQ) ex-vessel revenue from DEIS table 4-9. Estimation of economic impacts is complicated by the nature of fishing, i.e. an out-of-region harvester can fish in a region and then leave the region without affecting the regional economy. For this reason, we use ex-vessel landing revenue in Area 4, the middle panel of table 3 taken from table 18 of the Social Impact Assessment, to estimate the economic impact of the harvesting sector. We use total harvesting revenue as an estimate of value-added economic impact, as discussed in Edwards et al. (2021). Value-added economic impact estimates the contribution of an activity to regional GDP and avoids the double-counting involved in estimating total sales impacts.

Using NOAA EIA multipliers, we can translate ex-vessel sales into total jobs. From 2010-11 to 2018-19, Area 4 saw declines in directed halibut catch worth \$28.9M, and reduced halibut deliveries to local processing facilities of \$28M, a 70% decline. Using the middle panel estimates of Area 4 deliveries, these reductions in directed halibut catch led to an estimated loss of 348 jobs. Currently, the harvesting sector is still a critical part of the region's economy, contributing \$12M to GDP and 150 jobs.

The bottom panel of table 3 shows the economic impact of reductions in directed fishery catch on the harvesting sector of Area 4. The contribution of the processing sector to GDP is estimated using ex-vessel revenue estimates, a ratio of ex-vessel revenue to wholesale revenue, and a value-added multiplier from NOAA. Total processing regional GDP contributions by the halibut processing sector fell 45% from around \$33M in 2010-11. This represented a yearly loss of over \$14M in regional GDP and 290 jobs. Today the processing sector in Area 4 is estimated to contribute 364 jobs \$18M to the regional economy.

As a result of the declining allocation of halibut to the directed fishery, regional GDP has declined since 2010-11 by over \$42M. The corresponding estimate of job losses was 650. The impact of declining directed halibut catch in Area 4 on the regional economy since 2010 is not emphasized in the current DEIS. Amendment 80 revenue loss estimates from lower PSC limits (which are inflated, as discussed below) are considerable smaller in many cases than the losses already experienced by the directed halibut fishery.

The Amendment 80 fleet provides no contribution to GDP in the direct economic impact categories estimated here. Groundfish are not caught by local vessels or processed in local facilities, so any impacts of the fleet to the region is indirect or through

contributions in fish-tax revenue. The DEIS does not provide the full context for these relative economic impacts and the ongoing risk of further economic impact with continuing declines in directed halibut landings. The 2018-19 impact of halibut to the regional economy, impact at-risk without reduced PSC limits, exceeds \$30M.

Impact on BSAI Groundfish CDQ

The DEIS discusses potential economic impacts on local communities engaged in halibut (p. 250-1), stating that although halibut may be one important species to the region's communities, "CDQ entities and their constituent communities would be vulnerable to potential decreases in CDQ groundfish revenues during low abundance halibut conditions." This statement is not supported by evidence and does not appear to justify the lack of economic impact analysis performed on regional communities.

While CDQ communities hold groundfish quota fished by the Amendment 80 fleet, this quota is not currently subject to the proposed PSC action. Current bycatch allocation rules suggest that CDQ quota would become more, not less valuable under lower PSC limits. When fishing standard quota and CDQ, a boat has two hours after sorting to assign the tow. Because CDQ bycatch limits are to remain at current limits, and the proposed action will increase the opportunity cost of assigning a high bycatch tow to Amendment 80 quota, the value of the CDQ groundfish quota will increase due to its ability to absorb halibut bycatch.

Table 3: The Economic Impact of Declining Directed Fishery Allocation in the BSAI Halibut Fishery in Area 4

<u>Harvesting Sector (by Catch Location)</u>			<u>Ex-Vessel Sales (GDP)</u>			<u>Harvesting Sector Jobs</u>		
Area	2010-11	2018-19	Change	2010-11	2018-19	Change		
4A	14,730,678	5,886,137	-8,844,541	183	73	-110		
4B	11,539,189	4,478,989	-7,060,200	143	56	-88		
4C	4,575,548	2,079,811	-2,495,737	57	26	-31		
4D	13,247,041	4,209,844	-9,037,197	164	52	-112		
4E	1,998,024	535,450	-1,462,574	25	7	-18		
Area 4 Harvesting Total	46,090,477	17,190,230	-28,900,248	572	213	-359		
<u>Harvesting Sector (by Landing Location)</u>			<u>Ex-Vessel Sales (GDP)</u>			<u>Harvesting Sector Jobs</u>		
Area	2010-11	2018-19	Change	2010-11	2018-19	Change		
Akutan/Unalaska/Dutch Harbor	23,600,000	7,920,000	-15,680,000	293	98	-195		
Adak/Atka/False Pass/St Paul	14,700,000	3,435,000	-11,265,000	182	43	-140		
Chefornak/Kipnuk/Toksook Bay	535,000	0	-535,000	7	0	-7		
Hooper Bay/Mekoryuk/Tununak	465,000	0	-465,000	6	0	-6		
Nome/Savoonga/Togiak/Twin Hills	770,000	705,000	-65,000	10	9	-1		
Area 4 Harvesting Total	40,070,000	12,060,000	-28,010,000	497	150	-348		
<u>Processing Sector (by Landing Location)</u>			<u>Processing Value-Added (GDP)</u>			<u>Processing Sector Jobs</u>		
Communities	2010-11	2018-19	Change	2010-11	2018-19	Change		
Akutan/Unalaska/Dutch Harbor	19,152,738	11,880,000	-7,272,738	385	239	-146		
Adak/Atka/False Pass/St Paul	11,929,883	5,152,500	-6,777,383	240	104	-136		
Chefornak/Kipnuk/Toksook Bay	434,183	0	-434,183	9	0	-9		
Hooper Bay/Mekoryuk/Tununak	377,374	0	-377,374	8	0	-8		
Nome/Savoonga/Togiak/Twin Hills	624,899	1,057,500	432,601	13	21	9		
Area 4 Processing Total	32,519,077	18,090,000	-14,429,077	654	364	-290		
Area 4 Total (by Landing Location)	72,589,077	30,150,000	-42,439,077	1,226	577	-649		

Notes: GDP contribution estimates are ex-vessel sales from the harvesting sector and value-added from the processing sector. All numbers taken from DEIS unless otherwise noted. Economic multipliers are backed out from the NOAA Alaska EIA. Processing numbers start from ex-vessel value and add a 1.47 markup to arrive at wholesale revenue, which is from the DEIS page 234. False Pass is included as an Area 4 City due to its proximity and our inability to separate it out in the data from the DEIS.

Part 2: Analysis of Amendment 80 Fleet Revenue Projections

To analyze the potential impact on the Amendment 80 fleet of linking PSC catch to halibut abundance, the Council has undertaken an analysis of Amendment 80 revenue impacts. Using a model that randomly draws from every haul the fleet undertook in prior years, the approach simulates yearly fishing seasons under PSC catch limits defined in three potential alternative policies. In this summary, I identify several issues with this analysis which suggest it provides limited insight into the potential changes that would occur in the harvesting patterns of the Amendment 80 fleet. I argue that these issues, taken together, suggest a model that overstates the potential costs of the proposed measures on the Amendment 80 fleet. The key issues are as follows:

- The use of revenue as the key metric, which is not the correct measure to use according to economic theory, is not justified in the DEIS.
- The model is unable to incorporate key margins of fishing adaptation available to the Amendment 80 fleet.
- The model uses Amendment 80 harvesting data from periods where PSC limits were high and bycatch avoidance practices were very different from current practices.
- In years where PSC limits are binding, the random draw methodology precludes the possibility of the cost-minimizing response, constraining firms to irrational high-cost behavior.
- No model accuracy or test data is provided to gauge its accuracy or relevance for answering the questions asked of it.
- Revenue outcomes are provided according to hypothetical states of the world without associated likelihoods.

Total surplus, not revenue, is the relevant economic measure of impact.

Economic theory suggests that the economic impact of changes to constraints on the harvesting behavior of the Amendment 80 fleet should be measured in terms of surplus—in this case producer surplus. The DEIS does not appear to discuss why revenue was chosen as the key measure instead of total surplus, although we can infer it is because cost data was not available. Because the choice of revenue as the key measure is never discussed, the relationship between changing revenue and changing surplus is not made clear. Typically, if a fishing fleet has an increasing marginal cost function, a unit reduction in harvest will result in relatively smaller reductions in producer surplus. As harvest decreases, the same unit of revenue decrease will result in a larger decline in surplus. To quantify this relationship, the cost function of the fleet must be understood. The DEIS does not acknowledge the incomplete nature of a revenue-only impact analysis and in its analysis of the economic benefits to the nation (discussed subsequently in detail) makes the incorrect assumption that revenue declines correspond to losses in surplus.

The model relies on past fishing behavior to implicitly model cost and therefore fails to include key margins of adaptation.

There are many potential avenues the Amendment 80 fleet can undertake to reduce bycatch. These methods and their relevance to the current fleet are discussed separately in a separate section. The model uses the choices of fishing behavior in the past to simulate future outcomes. Yet this necessarily limits the potential ability to reduce bycatch to the adaptations that have already been made. For instance, the model does not include the use of groundfish CDQ, which does not see changes in PSC limits, as a bycatch risk reduction mechanism. Operators with CDQ on board can assign high bycatch hauls to CDQ catch after the realization of bycatch levels. Nor does the model allow for changes in the allocation or pooling of bycatch quota as is observed in fisheries with stringent PSC limits. Current practice of the cooperative is to assign catch via historical values, and transfers have been limited. The use of such transfers to equalize the marginal cost of abating halibut bycatch would be expected under more stringent limits. While the authors of the DEIS make clear that new margins of adaptation are not modeled, the discussion of how outdated modes of harvest enter directly into the current model is less clear.

The use of haul data from the 2010-2014 period brings outdated fishing behavior from a period of higher PSC limits into revenue projections, deflating catches and increasing the apparent revenue declines.

Revenue estimates based on the observed behavior at a lower bycatch limit, the 2016-2019 period, demonstrate that revenue losses are limited or non-existent for PSC limits ranging from 1396-2007. (As noted in point 1, this does not mean total surplus did not decrease.) The revenue projections using 2010-14 data are problematic and make revenue loss estimates appear deceptively high because they occurred during a period where the PSC limit was around 2,400mt. For instance, by 2019 deck sorting is near 100%. In 2014, no deck sorting was undertaken (see DEIS figure 3-43). It is highly unrealistic to think the fleet will return to a state without deck sorting and including this as an equal potential revenue projection is deceptive. This point is acknowledged in the DEIS (p. 206): “Given recent mortality patterns and substantial changes in fleet operation, including widespread adoption of deck sorting, it seems unlikely that future years will be similar to those before 2015.” Yet there is no justification for the continued use of hauls during this period to estimate revenue outcomes going forward.

The “low” bycatch period in the data saw a PSC limit of 1,745mt, and the analysis applies the Amendment 80 fleet behavior of this historic period to a world where bycatch limits are more constrained: PSC limits of 960, 1047, 1222, 1309, 1396, 1483, and 1571. When PSC limits are lowered to these levels in the modeling exercises, there are not analogous events to observe the behavior of the Amendment 80 fleet and no modeling changes are made to account for continued modification of the Amendment 80 fleet’s production choices. Although we do not observe Amendment 80 fleet behavior under low PSC limits, the divergence in model outcomes when based on 2010-2014 versus 2016-2019 are illustrative. At the PSC level of 1,745, which was the level in the analogous “low” observed behavior period, the simulation models suggest large divergences in revenue estimates between the model runs from 2010-2014 (\$257.73M under the high groundfish scenario) and those from 2016-2019 (\$309.99M) (table 5-3).

Similarly, we might expect estimates for PSC limits below 1745 based on Amendment 80 behavior from the 2016-2019 period to provide similarly low, out-of-sample revenue estimates.

The model also constrains economically rational behavior on the part of the Amendment 80 fleet by preventing the choice to reduce catch in species with low revenue to bycatch ratios.

Assuming the model is correct and strict PSC limits lead to less ground fish catch and not adaptation, the lowest cost method of reducing catch to comply with a PSC limit is one where the first catch foregone is that with the lowest marginal benefit per unit of halibut bycatch. DEIS table 3-33 suggests that in a given year there is some uncertainty of the precise revenue-to-bycatch ratio, due to uncertainties in price of groundfish and the location of halibut. Still, two species, Pacific Ocean Perch and Atka Mackerel, always tend to have high revenue-to-bycatch ratios. It would make sense that in years where Amendment 80 operators knew PSC would be low, they would ensure the full harvest of these species. The random draw approach does not account for this behavior. This 'dumb harvester' model underestimates the revenue in low PSC limit years and overestimates the revenue losses. As discussed subsequently, the analysis in the 2015 PSC limit discussion NPFMC (2015 p. 280)) utilizes an approach consistent with economic theory which is not undertaken in the DEIS.

Apparent model inconsistencies suggest some test of model performance on real data is warranted, but no simulation runs are compared to actual outcomes.

There is no academic justification provided for the accuracy of this type of simulation model in representing revenue outcomes. In the absence of a clear methodological approach, the DEIS authors should provide some test of the model's performance. One such test would be to plot simulation outcomes relative to PSC limits and PSC use on DEIS figure 5-1, with error bars. There is reason to suspect that the approach leads (perhaps often) to a sampling method that shuts down the fishery (or leads to a level of catch above the PSC limit) even when in reality that year did not reach the PSC limit. For instance, the runs using 2010-14 and 2010-2019 data exceed the 2007 and 1745 catch limits in the random draw exercise (Table 5-4) when, in reality, the fishery did not exceed these catch limits for the relevant years.

The display of the revenue outcome tables provides a distorted view of the likelihood of potentially low-probability PSC limits.

The model itself is run to provide definitive results for each potential state of the world. For instance, if the model is run with a PSC limit of 50mt, it would provide a revenue estimate. This does not mean a 50mt state has an equal likelihood of occurring as a 1745mt PSC limit. The model and DEIS do not provide any estimates for the likelihood of being in each state the model runs. Further, the inclusion of model runs from years with high bycatch (2010-14) further creates tables with a majority of large revenue loss estimates. Without providing explicit likelihood estimates, the tables organized this way

provide a deceptive picture of the results by allowing the reader to infer the potential probabilities of outcome from the physical layout of the chart.

Part 3: Past and Future Bycatch Reduction

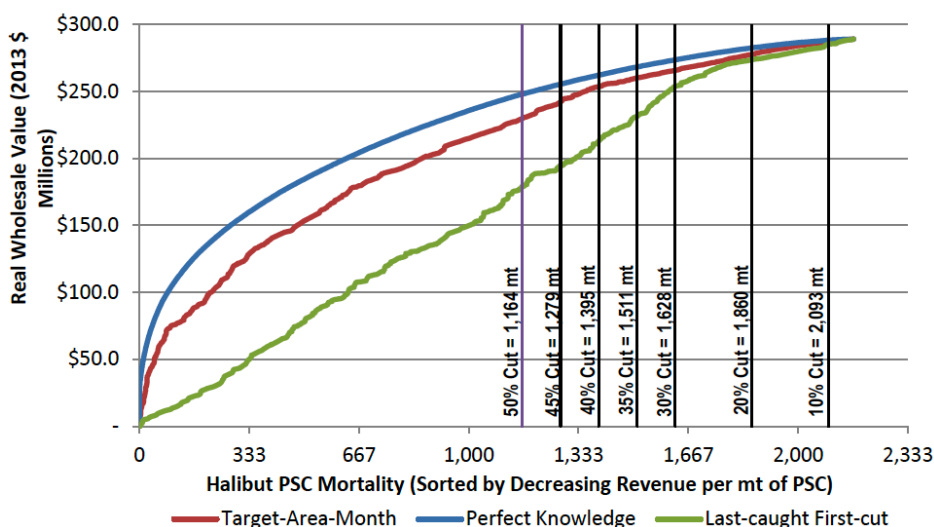
In 2015 a proposed Amendment 80 PSC reduction action was evaluated using a similar revenue estimation methodology as provided in the current DEIS. This approach dramatically underestimated the ability of the Amendment 80 fleet to adapt to lower PSC limits. After 2015, the fleet began using approaches and technology long available to it to meet the new restrictions. This history suggests reviewing current Amendment 80 fleet bycatch reduction strategies and assessing the potential for additional reductions is required to assess potential impacts. Methods of reducing bycatch and meeting more stringent PSC limits remain available to Amendment 80 operators. The analysis contained in the DEIS is again at risk of over-estimating revenue losses to the Amendment 80 fleet.

2015 Revenue Estimates

Prior use of a similar revenue impact analysis provides substantial evidence that projected revenue losses for the Amendment 80 fleet were consistently higher than observed in reality. In May of 2015, the Council provided an economic assessment of a proposal to reduce Amendment 80 PSC bycatch (and that of other sectors) by up to 50%. A revenue impact analysis for the Amendment 80 fleet was performed in this document with striking similarities to the methodology used in the present DEIS. Using monthly aggregated catch for each species from the period 2008-2013, each target species-month was scored in terms of revenue per PSC. Then, starting with the highest revenue per PSC month, the fleet was assumed to capture target species based on three scenarios shown in figure 4-69: (a) highest marginal revenue targets with perfect information (blue); (b) lowest target-area-month species going unfished first (red); or (c) fish as usual until the quota target is reached (green). It appears the random sampling approach of the DEIS is similar to the “Last-caught, First-cut” approach in green.

Figure 3: 2015 estimate of Amendment 80 Revenue Declines by Three Methods

Figure 4-69 Proposed Scenario A PSC Limit Reduction for A80-CPs, 2013



Cuts on the order of 25%, leading to a PSC limit of 1,745mt, were selected under the 2015 action. Under the preferred estimation method (b, red line). At the time, the analysis suggested annual revenue losses of \$5.7-15.5M under the low revenue loss scenario A and \$16.7-35.2M under the revenue loss scenario B, relative to 2008-2014 revenues (see table 4-127 in NPFMC (2015)). The model most analogous to that used in the 2021 DEIS is the last-caught first-cut, which predicted even larger revenue losses to the A-80 fleet.

Looking at the actual revenue results of the Amendment 80 fleet in DEIS table 5-1 suggests no apparent losses in fleet revenue from 2016-2019. This outcome was predicted in a 2015 CBSFA comment letter stating “vessel operators will seek to maximize their catch while minimizing bycatch to the extent necessary to meet any bycatch limits. To the extent that the halibut encounter rate can be reduced, the bycatch can also be reduced without necessarily reducing the groundfish harvest.” The fleet likely bore some costs to make this happen, but here we focus on the revenue numbers as provided in the DEIS. The 2015 revenue estimation approach dramatically underestimated the ability of the Amendment 80 fleet to adapt to more stringent PSC limits.

Amendment 80 Bycatch Reduction: History and Current Practices

The Amendment 80 trawl fleet reduces and avoids halibut bycatch in a variety of ways utilizing methods that have been adopted over time exclusively in response to changing regulations. For instance, prior to 2015 the fleet faced a PSC limit at 2,325 mt and bycatch exceeded 2,000 mt in three of the five years leading to the changing in PSC limit. After the PSC limit was lowered to 1,745 mt in 2015, the fleet’s bycatch never exceeded 1,500mt in any of the subsequent five years.

The evolution of regulatory response over time is consistent with the fleet adjusting its fishing practices in response to regulation and only reducing bycatch by the minimum amount required by the regulatory regime. Measures available to the fleet to reduce bycatch were available prior to the implementation of Amendment 80 but were not undertaken until the institutional change occurred and a PSC limit was implemented. One of the most striking examples of this is the adoption of excluder technology. Excluder technology was developed in the late 1990s but was not widely utilized until after Amendment 80 in 2008 (Gauvin and Rose 2000; Rose and Gauvin 2000).

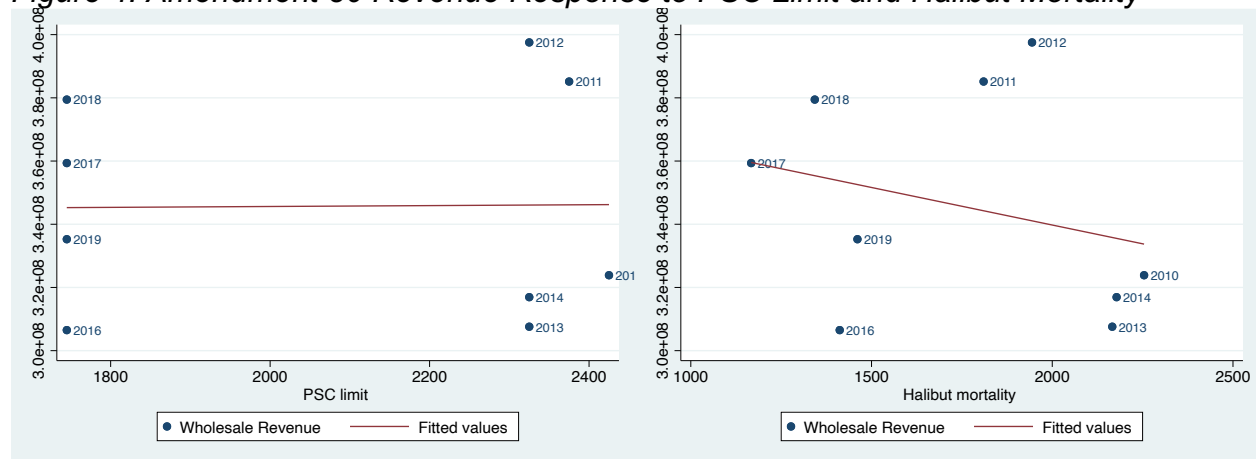
After the passage of Amendment 80, factory trawlers formed cooperatives and allocated bycatch amongst firms and vessels. Vessels were able to take advantage of the spatiotemporal heterogeneity of relative catchabilities and species distribution to utilize three different behavior modifications to reduce halibut PSC: (1) adjusting fishing ground selection; (2) making short term movements away from ephemeral bycatch hot spots; and (3) reducing night fishing (Abbott et al. 2015). Since the adoption of Amendment 80, the cooperative has succeeded in never surpassing the halibut PSC allocation. Abbott et al (2015) found that Amendment 80’s share of halibut PSC became more consistent through the year, except during the last 25% of the season. Interviews

with fishermen suggested that halibut avoidance was important during the beginning of the year to ensure the fishery would not be shut down before participating in the yellowfin sole fishery at the end of the year. Once it became clear that there would be sufficient bycatch, patterns of fishing again resembled pre-Amendment 80 conditions.

Based in part on the aforementioned research by Abbott et al. (2015) and other indicators that there was slack in late-season bycatch limits, PSC catch limits were lowered and the fleet implemented the Halibut Avoidance Plan (HAP).

As previously addressed, the environmental assessment from 2015 suggested that PSC reductions would lead to large losses in revenue, but these predictions have not been realized through 2020. In fact, it is not clear that there is a link between bycatch limits and Amendment 80 fleet revenues. Figure 4 left panel shows there was no clear decrease in revenues even when PSC limits are decreased 25%, from 2,325 to 1,745.

Figure 4: Amendment 80 Revenue Response to PSC Limit and Halibut Mortality



Between 2016 and 2019, the Amendment 80 fleet has largely converted to deck sorting as a result of the HAP (table 3.43) which has reduced bycatch mortality. This decrease in bycatch mortality has not led to a decrease in revenue, as shown in figure 4, right panel.

The Amendment 80 fleet can also be seen to be learning to avoid bycatch only up to the PSC regulatory limit. The first year where the majority of the fleet was deck sorting, 2017, looked very similar in tons of PSC catch to 2016, and 2016 and 2017 represent the lowest PSC catch years. In 2017 with deck sorting *and* low PSC catch, the fleet achieves its lowest ever PSC mortality rate of 1,167mt. The following year, however, learning the effectiveness of deck sorting, they increased their PSC catch by over 25%. Deck sorting's effectiveness became a substitute for fishing practices that avoid bycatch. It is reasonable to believe that re-adoption of these practices is practicable for the Amendment 80 fleet given their success of doing both in 2017.

Bycatch limits must be adopted under law by the Amendment 80 fleet if they are practicable. The Amendment 80 fleet cost data is confidential, so it is difficult to assess costs directly. However, there are several potential margins for additional PSC mortality and catch reductions:

- Better measuring and benchmarking avoidance behaviors and technology performance. Currently, “[m]etrics for effectiveness are not well measured. For example, fishery participants and managers can only speculate about whether excluders might be less effective when encountering a higher proportion of small size halibut. (DEIS page 147)”
- Simultaneously implementing halibut avoidance behavior and deck sorting, as described above and as was done in 2017, leading to the lowest ever level of PSC mortality.
- Adoption of industry best-practices in cooperative bycatch allocation and risk sharing.
- Additional information sharing across firms within the cooperative on areas with low/high halibut bycatch.
- Discontinuing the use of a single PSC limit which reduces the incentives for innovation in PSC reduction through novel fishing practices and the adoption of new fishing technology or information systems.

In addition to the above opportunities for reducing catch and mortality, the Amendment 80 fleet could use the cooperative structure to which its boats belong to lower the cost of reducing bycatch. Cooperation on bycatch reduction is currently limited when certain target species constrain catch: “While sharing of information is a valuable tool in halibut avoidance, captains and firms have greater incentives to share information on fishing locations that allow the vessel to harvest more target catch under a cooperative program relative to the open access or when certain species constrain catch. (DEIS p. 215)”

Informal or formal PSC markets or pooling and insurance (as in the Pacific whiting fishery) are options for covering the risk of a disastrous halibut haul. Such measures have the added bonus of creating incentives for innovation and adoption of new methods because they create an economic regulatory environment. The lack of a method for equalizing the marginal costs of PSC avoidance suggests the fleet is not at its cost-minimizing allocation of avoidance behaviors (i.e. marginal costs of abatement are not equalized across boats/firms). Captains are generally not incentivized to keep bycatch as low as possible, instead only required to keep bycatch “within the standard bycatch rates established under the HAP. (DEIS p. 214)” As the use of bycatch reduction measures are generally left to the captain’s discretion, economic theory suggests their incentives must be aligned to achieve lowest cost PSC reductions.

The principal PSC catch reduction strategies are changing fishing time and location; use of halibut excluders; and deck sorting. Fishing time and location decisions can be greatly aided by inter and intra-firm communication. However, current cooperative practices limit the incentives to adopt this type of information sharing: “In the Amendment 80 sector a firm may be less willing to share information when they find an

area with low halibut bycatch in the yellowfin sole fishery, if they are concerned about taking their entire PSC limit...The longer the vessel is able to fish the area without competition, the more yellowfin sole it could harvest at relatively low bycatch rates. This strategy is beneficial to the firm with a set halibut and yellowfin sole limit, but it is not beneficial to reducing halibut mortality relative to CPUE for the sector as a whole. This behavior is not unique to the Amendment 80 sector as, for example, it has been noted in other cooperative fisheries in Alaska as well as the West Coast cooperative fisheries when rockfish have been a constraining species. (DEIS p. 215)”

When halibut stocks are low, the marginal cost of halibut bycatch increases. Consistent with economic theory, reducing PSC limits in these times provides the Amendment 80 fleet with an incentive to adjust their cost functions, spending more to reduce bycatch. PSC reducing innovations should accelerate as the PSC catch limit declines, and these practices and technologies can then be adopted to reduce bycatch at lower costs in later years.

This effect is illustrated through the adoption of excluder technology, which is inconsistent across the fleet “The use of deck sorting in conjunction with excluder devices varies by firm. Some firms utilize both measures on almost all tows...Other firms tend not to utilize excluders in their nets and deck sort on tows that provide the greatest benefit. Other firms fall in-between these strategies, based on their own experiences utilizing the bycatch reduction tools. (DEIS p. 219)” During year of low halibut abundance, firms have incentives to use new technologies to reduce bycatch. One potential approach is the use of precision seafood harvesting technology (such as biochemical sensors and fish handling systems) when fishing select target species during times of potentially high bycatch. Learning through these select trials would eventually lead to innovations that are widely adopted during times of low PSC limits, as occurred with excluders.

Part 4: Benefits to the Nation

Net benefits to the Nation, as defined in the DEIS, are the sum of the producer and consumer surplus occurring in the entire U.S. economy. Although the DEIS asserts that net benefits to the nation of abundance-based management are negative, there is no actual calculation or attempt at calculation of producer or consumer surplus. The DEIS also states that “producer surplus is expected to be negative because the expected catch reductions in the Amendment 80 sector are not offset by equivalent catch increases in the directed halibut fisheries.” This statement is based on the assumption that groundfish catch will need to be reduced to reach lower PSC limits. However, the economic analysis in this document suggests there are further margins by which PSC can be avoided or mortality decreased while maintaining revenue.

Thus, without cost data it is impossible to calculate changes in producer surplus for the Amendment 80 fleet. Likewise, the benefits from reduced halibut bycatch are not estimated in the DEIS, instead many scenarios are presented. Given the current lack of analysis of increased Amendment 80 costs under the adjusted PSC limits, the only way to justify that the net benefits are negative is by assuming that reducing halibut bycatch creates no additional catch of the directed fishery.

The relevant legal definition of “benefit to the Nation” from 50 CFR 600.310(e)(3)(iii)(A):

(A) Determining the greatest benefit to the Nation. In determining the greatest benefit to the Nation, the values that should be weighed and receive serious attention when considering the economic, social, or ecological factors used in reducing MSY, or its proxy, to obtain OY are:

(1) The benefits of food production derived from providing seafood to consumers; maintaining an economically viable fishery together with its attendant contributions to the national, regional, and local economies; and utilizing the capacity of the Nation's fishery resources to meet nutritional needs.

(2) The benefits of recreational opportunities reflect the quality of both the recreational fishing experience and non-consumptive fishery uses such as ecotourism, fish watching, and recreational diving. Benefits also include the contribution of recreational fishing to the national, regional, and local economies and food supplies.

(3) The benefits of protection afforded to marine ecosystems are those resulting from maintaining viable populations (including those of unexploited species), maintaining adequate forage for all components of the ecosystem, maintaining evolutionary and ecological processes (e.g., disturbance regimes, hydrological processes, nutrient cycles), maintaining productive habitat, maintaining the evolutionary potential of species and ecosystems, and accommodating human use.

The legal definition of benefits to the nation suggests the calculation of total surplus should account for “[t]he benefits of food production derived from providing seafood to consumers;” and benefits to the national, regional and local economies and food supplies. From the perspective of US seafood consumers, any policy that increases

halibut supply in US markets creates consumer surplus. Given the lack of attention paid to consumer surplus in the DEIS and the failure to estimate Amendment 80 producer surpluses, the DEIS should make no determination on benefits to the nation.

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