
NOAA Technical Memorandum NMFS-AFSC-395

# An Evaluation of Methods Used to Predict Commercial Fishing Effort in Alaska

P. Ganz and C. Faunce

**U.S. DEPARTMENT OF COMMERCE**
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# An Evaluation of Methods Used to Predict Commercial Fishing Effort in Alaska

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## ABSTRACT

Every year, the Alaska Fisheries Science Center's Fishery Monitoring and Analysis Division and the Alaska Regional Office's Sustainable Fisheries Division produce an Annual Deployment Plan (ADP) that documents how the National Marine Fisheries Service plans to deploy observers into the partial coverage fishing fleet during the coming year. One important element of the ADP is a prediction of how much fishing effort will be carried out by the partial coverage fleet in the coming year. An accurate prediction of effort is necessary if the North Pacific Observer Program is to deploy observers at rates that keep the program within an acceptable range of its available budget, and this prediction needs to be completed prior to the end of the previous year.

Predicting fishing effort for the coming year is not a straightforward task, and a variety of methodologies have been used to predict fishing effort in past ADPs. As part of the final 2019 ADP, we developed a new approach to effort prediction with the intent that the new methodology would be more repeatable and be at least as accurate as past methodologies used. At the time of writing the final ADP, we have access to past fishing effort data through mid-October of the year prior to the year for which the ADP is being developed. We also have access to stock assessments that project Acceptable Biological Catch (ABC) through the year for which the ADP is being written. The effort prediction methodology developed for the final 2019 ADP had two steps: 1) use past trends in fishing effort to project 2018 fishing effort from mid-October to the end of 2018, and 2) use ABC to adjust projected 2018 effort into a prediction of effort to occur in 2019.

The use of ABC in predicting fishing effort assumes that there is a relationship between effort and ABC. This assumption was not formally tested as part of the final 2019 ADP but is evaluated here. In this analysis, we show that there is no statistically significant relationship between ABC and the amount of fishing effort that occurs within the fisheries that contribute most to effort by the partial coverage fishing fleet. We therefore go on to examine the implications of not adjusting effort by ABC, which we refer to as the 'do-nothing' approach. We show that there is evidence to suggest that the 'do-nothing' approach outperforms the approach that uses ABC to predict effort. Finally, we show the cost implications of 2019 fishing effort being equal to levels predicted by the 'do-nothing' approach rather than levels used to determine deployment rates in the final 2019 ADP.

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# INTRODUCTION

Fisheries monitoring is an integral part of the management structure for commercial fisheries in the United States. Data are collected by fisheries observers, and only recently through cameras and location devices commonly referred to as electronic monitoring (EM). These data are used in the catch accounting that makes the in-season enforcement of catch quotas possible. In the North Pacific, vessels that are to receive monitoring for every trip arrange for fishery observers or EM equipment through open market provider companies. Vessels that are subject to monitoring on a random subset of trips are part of the partial selection fleet and are charged an ex-vessel fee that funds future monitoring programs administered by the National Marine Fisheries Service (NMFS). Whether a vessel pays for individual fishing trips to be monitored or pays an ex-vessel landing fee, the cost of fishery monitoring in the North Pacific is borne almost entirely by the fishing industry, with NMFS supporting observer training, data quality control, and other infrastructure costs. Every year the Alaska Fisheries Science Center's Fishery Monitoring and Analysis Division and the Alaska Regional Office's Sustainable Fisheries Division are tasked with developing an Annual Deployment Plan (ADP) for its North Pacific Observer Program. The ADP details how the available funds from ex-vessel landing fees will be used to place observers on vessels and trips within the partial coverage fleet. Such a plan is not necessary for portions of the fleet that undergo complete monitoring.

The ADP separates the partial coverage fleet into several strata and is presented for consideration by the North Pacific Fishery Management Council (Council) each October as a draft. In recent years, strata have been defined by gear (trawl: TRW, longline: HAL, pot: POT)

sometimes in combination with tendering[1] activity (e.g., Tender TRW). Selection rates for strata are the focus of the final ADP that is presented to the Council in December. Selection rates within an ADP have been set in two ways. Deployment rates for observers are established from the interaction of funds available for observer deployment, the cost of deployment for a trip (the sampling unit), the resulting variance of one or a suite of metrics deemed important, and the anticipated fishing effort by the partial coverage fleet (as defined in the draft ADP) in the coming year. In contrast, deployment rates for EM are policy-driven and have been set by a working group of the Council. This document focuses on the setting of deployment rates for observers, in particular the methods used for the final 2019 ADP, although there is no preclusion towards applying the methods presented to EM in future ADPs.

Predicting future fishing effort for the calculation of fisheries monitoring selection rates for the final ADP is not straightforward. Accurate effort prediction is necessary if deployment rates are to be set at levels that keep costs within an acceptable range of the available budget – setting rates too low risks the perception that too much money has been collected to spend on fishery monitoring, whereas setting rates too high risks running out of available funds. The purpose of this work is to document the past attempts made to predict future fishing effort in the partial coverage fleet, document the method used for the 2019 ADP, and evaluate whether the most recent attempt at prediction would have performed better on past ADP fishing data than the 'do-nothing' approach where future fishing effort is assumed to be equal to the most recent year of fishing effort.

[1] Tendering is the act of providing goods and/or services to catcher vessels on the fishing grounds or elsewhere away from port. Tendered fishing trips can last longer than shore-based trips.

## METHODS

Prediction of fishing effort involves two steps. At the time of the final ADP preparation, data from the current year are only complete through mid-October, so an expansion of that data must be made to the end of the year. In order to project 2018 fishing effort to the end of the year, cumulative fishing trips were enumerated by 'fishery' defined as combinations of gear type (hook-and-line, pot, or trawl), Fishery Management Plan (FMP) area (Gulf of Alaska or Bering Sea and Aleutian Islands), and the predominant species landed on a trip (also known as the 'target' species). Four species that represent the most common targets of the partial coverage fleet were used: Pacific halibut (*Hippoglossus stenolepis,* 'halibut'), Pacific cod (*Gadus macrocephalus,* 'cod'), Walleye pollock (*Gadus chalcogrammus,* 'pollock'), and sablefish (*Anoplopoma fimbria*). Effort for other species was still predicted, but it was combined into a target labeled as "other." Trips targeting the "other" species group comprised 3.58% of trips between 2014 and 2017, which was lower than that of halibut (17.68%), Pacific cod (32.47%), pollock (30.78%) and sablefish (15.50%). Fishing effort for sablefish was combined across the Gulf of Alaska (GOA) and Bering Sea and Aleutian Islands (BSAI) since, unlike with other species, there is just one stock assessment for sablefish that covers both the GOA and the BSAI. This combined FMP for sablefish is termed AK here.

A simple ratio estimator was used to expand the fishing through mid-October (O) in the current (c) year ($Oc$) to the end of the year ($Ec'$) using the ratio of the end-of-year fishing effort in prior year(s) ($Ep$) to the fishing effort to the same date in October in prior year(s) ($Op$), or $Ec' = \frac{Ep}{Op} \cdot Oc$ . Cumulative fishing trends revealed three general groupings (Fig. 1; Table 1). Fisheries were either adjusted using the average fishing activity among years or had no

adjustment with two exceptions. For instance, to predict total effort for pot-gear (POT) caught Pacific cod in the BSAI, the cumulative number of trips through 17 October 2018 (the last day for which data were available in 2018) was multiplied by 1.33 since effort at the end of the year was, on average, 33% higher than effort through mid-October for that gear-type, FMP, and species combination (Table 1). In contrast, for hook-and-line (HAL) Pacific cod in the GOA and POT sablefish in AK, only the ratio for 2017 was used to project 2018 effort, since 2017 effort was so starkly different from other years (Fig. 1) and thought to be more representative of effort in the future. The former fishery underwent a drastic cut in available quota from 2017 to 2018 following a warm water 'blob' event and a new assessment (Barbeaux et al. 2017). The latter is a relatively new fishery in the GOA for which historical data are lacking (Hanselman et al. 2017, p.11). A ratio of 1 was applied to fisheries that were finished by 17 October, resulting in no adjustment.

Once fishing effort was projected through the end of 2018, the second step of the prediction problem is to predict effort for 2019. At the time of completing the final 2019 ADP, estimates of Acceptable Biological Catch (ABC) in 2018 and 2019 were available for Pacific cod (Barbeaux et al. 2017, Thompson 2017, Thompson and Palsson 2017), pollock (Dorn et al. 2017), and sablefish (Hanselman et al. 2017). Much like the ratios used to adjust 2018 fishing effort between 1 January and 17 October to the end of the year, we used the ratios of ABCs between 2018 and 2019 to adjust the predicted 2018 effort for Pacific cod, pollock, and sablefish to produce predicted 2019 effort for those species (Table 2). Effort (in trips) for the year of interest ($T_y$) was predicted by multiplying effort in the year prior ($T_{y-1}$) by the ratio of ABC in the current year ($ABC_y$) to ABC in the year prior ($ABC_{y-1}$), or $T_y = \frac{ABC_y}{ABC_{y-1}} \cdot T_{y-1}$. For example, the 2018 and 2019 ABCs for GOA Pacific cod, as listed in the North Pacific Fishery

Management Council's Stock Assessment and Fishery Evaluation report (published in December 2017) are 18,000 t and 17,000 t, respectively (Barbeaux et al. 2017). This represents a decrease of 5.6% from 2018 to 2019. We therefore predicted that the number of trips targeting Pacific cod in the GOA would be 5.6% fewer in 2019 than predicted in 2018 (Table 2). In order to predict how many POT and trawl (TRW) trips would be tendered, we assumed that fisheries would have the same proportion of tendered trips in 2019 as they did in 2017 (Table 2).

Halibut stocks were treated differently than other groundfish when predicting fishing effort for 2019. Stock assessments for halibut are conducted by the International Pacific Halibut Commission (IPHC) and are not published before the final ADP. In 2018 the U.S. and Canada failed to reach consensus on limits for the first time since 1990, but both countries endorsed a quota cut. With no estimate of stock sizes available for halibut for 2019, we made the *ad hoc* decision to decrease effort for halibut by 10%. However, contrary to our expectations, quotas for Pacific halibut were *increased* in all but one IPHC region off Alaska between 2018 and 2019 (IPHC 2018, IPHC 2019) after the final ADP was completed for 2019. Effort for species other than halibut, Pacific cod, pollock, and sablefish were kept the same between 2018 and 2019 (Table 2).

## RESULTS AND DISCUSSION

Predicting fishing effort for the upcoming year has been conducted in a variety of ways for past ADPs. Fishing between 1 January and mid-October was compared across the prior three years by gear for the final 2016 ADP. A linear trend in trawl gear effort between years was used to produce a model and that model prediction for 2017 was then lowered by the same percentage of the GOA pollock TAC between 2016 and 2017 (NMFS 2015, Appendix B). The number of

POT and HAL trips from 2014 were used as effort estimates for those gear types in 2016, since those gear types did not have strong trends in effort over prior years. Effort from 2015 was used as an estimate for all gear types in the final 2017 ADP (NMFS 2016, Appendix B). In the final 2018 ADP, 2018 effort was first approximated by combining partial coverage data from 1 January through 18 November 2017 to partial coverage data from 19 November to 31 December 2016. Then 2018 hook-and-line and pot effort targeting Pacific cod was reduced by 75% according to anticipated changes in Pacific cod quota in the GOA. An additional 100 trips were reduced from trawl fishing effort in the western GOA (NMFS area 610) in order to maintain the proportion of trips belonging to the TRW and TRW Tender strata. These adjustments were made following consultation with fishery managers at the Fisheries Monitoring and Analysis Division of the Alaska Fisheries Science Center and the Sustainable Fisheries Division of the Alaska Regional Office (NMFS 2017, Appendix B).

The methods used in the past to adjust future fishing effort by quota amounts assumes a strong relationship between available quota and fishing effort. To our knowledge, prior to this analysis, this relationship has not been examined. Although there is a positive relationship between ABC and effort (Fig. 2), results from the linear model $Trips = \alpha + \beta(ABC)$ suggest that ABC is not a significant predictor of effort at the 0.05 confidence level ($p = 0.21$). This relationship breaks down further when results are split by FMP and target species (Fig. 3). We decided to use ABC to predict the number of trips that will occur in the next year despite this result. Our rationale stemmed from the fact that this analysis is based on just four years of data and the fact that the decision over what p-value is sufficient is a subjective one.

With more years of data, we will be able to better understand the relationship (if any) between fishing effort and quotas.

As stated, the results of the linear model do not support the adjustment of effort by ABC. We therefore used hindcasting to test the accuracy of the 2019 effort prediction methodology against the results of the 'do-nothing' approach, which uses the previous year's effort, unadjusted, as the prediction of effort in any given year (Table 3). The 'do-nothing' approach outperformed the 2019 methodology in three out of the four years between 2014 and 2017. The number of trips realized ranged from being 8.35% higher than predicted in 2014 to 7.13% lower than predicted in 2017 when using the 2019 effort prediction methodology. The number of trips ranged from being 4.42% higher than predicted in 2014 to 11.07% lower than predicted in 2017 when using the previous year's effort as the prediction. Although not directly comparable, it is worth noting that, using past methodologies, the total number of realized days in 2016 and 2017 were 0.05% and 12.7% lower than predicted, respectively (AFSC and AKRO 2017, AFSC and AKRO 2018). This suggests that the 2019 effort prediction methodology and the 'do-nothing' approach produce estimates of fishing effort with accuracies similar to that of past methods. However, it is important to note that both methodologies were simplified in this analysis - we were able to use the exact effort from previous years in predicting effort the following year. At the time of publishing the ADP, effort from the previous year is only available through mid-October, so we would have had to use a projection of that effort in making our predictions.

Effort for the TRW gear type was the most poorly predicted, regardless of which methodology was used (Table 3). The type of trips that contributed the most to inaccurate effort prediction were pollock TRW trips in the GOA (Fig. 4). This is unsurprising, given that more trips are taken in this fishery than any other fishery within partial coverage (Fig. 5). When the

error associated with effort prediction are examined relative to the number of trips taken, however, the predictions for the GOA pollock TRW fishery are among the most accurate (Fig. 5, bottom panel). This result shows that small errors in effort prediction for the GOA pollock TRW fishery have dramatic consequences to effort predictions as a whole.

Had we used 2018 projected effort as our effort prediction for 2019, that 'do-nothing' prediction of fishing effort would have been higher than the prediction made using the methodology in the final 2019 ADP. We present the cost implications of 2019 effort being equal to 2018 projected effort in Table 4. The distributions used to calculate confidence limits were created by randomly sampling trips from 2017 and 2018 that were drawn with replacement. Due to the fact that rates were set based on the lower estimation of effort, an implication of 2019 effort being equal to 2018 projected effort is that we are more likely to exceed our budget in 2019.

This analysis highlights challenges to the effort prediction process for the partial coverage fleet in the North Pacific and ways in which these challenges might be addressed. The effort prediction methodology used for the final 2019 ADP represents the latest and most well-documented iteration of a developing, data-poor process that may be improved upon in future years if different methodology proves more accurate. As presented in this analysis, a potential improvement is to resist the temptation to adjust effort by ABC, and instead set effort equal to the projected effort of the previous year. As the quantity of data increases, this analysis can serve as the basis for making decisions about how fishing effort will be predicted in future years.

## CITATIONS

AFSC (Alaska Fisheries Science Center) and AKRO (Alaska Regional Office). 2017. North Pacific Observer Program 2016 Annual Report. AFSC Processed Rep. 2017-07, 143 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.

AFSC and AKRO. 2018. North Pacific Observer Program 2017 Annual Report. AFSC Processed Rep. 2018-02, 136 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.

Barbeaux, S., K. Aydin, B. Fissel, K. Holsman, W. Palsson, K. Shotwell, Q. Yang and S. Zador. 2017. Assessment of the Pacific cod stock in the Gulf of Alaska. Available online at: https://www.afsc.noaa.gov/REFM/Docs/2017/GOApcod.pdf.

Dorn, M., K. Aydin, B. Fissel, D. Jones, A. McCarthy, W. Palsson, and K. Spalinger. 2017. Assessment of the walleye pollock stock in the Gulf of Alaska. Available online at: https://www.afsc.noaa.gov/REFM/Docs/2017/GOApollock.pdf.

Hanselman, D.H., C.J. Rodgveller, C.R. Lunsford, and K.H. Fenske. 2017. Assessment of the sablefish stock in Alaska. Available online at: https://www.afsc.noaa.gov/REFM/Docs/2017/BSAIsablefish.pdf.

IPHC 2019. Report of the 95th Session of the IPHC Annual Meeting (AM095). Victoria, Canada, 28 January to 1 February 2019. IPHC–2019–AM095–R, 46 p.

IPHC 2018. Revised Pacific halibut catch limits for 2018 [News release]. Available online at: https://iphc.int/uploads/pdf/nr/2018/iphc-2018-nr005.pdf.

NMFS (National Marine Fisheries Service). 2018. 2019 Annual Deployment Plan for Observers in the Groundfish and Halibut Fisheries off Alaska. National Oceanic and Atmospheric Administration, 709 West 9th Street. Juneau, Alaska 99802.

NMFS. 2017. 2018 Annual Deployment Plan for Observers and Electronic Monitoring in the Groundfish and Halibut Fisheries off Alaska. National Oceanic and Atmospheric Administration, 709 West 9th Street. Juneau, Alaska 99802.

NMFS. 2016. 2017 Annual Deployment Plan for Observers in the Groundfish and Halibut Fisheries off Alaska. National Oceanic and Atmospheric Administration, 709 West 9th Street. Juneau, Alaska 99802.

NMFS. 2015. 2016 Annual Deployment Plan for Observers in the Groundfish and Halibut Fisheries off Alaska. National Oceanic and Atmospheric Administration, 709 West 9th Street. Juneau, Alaska 99802.

Thompson, G.G. 2017. Assessment of the Pacific cod stock in the eastern Bering Sea. Available online at: https://www.afsc.noaa.gov/REFM/Docs/2017/EBSpcod.pdf.

Thompson, G.G., and Palsson, W.A. 2017. Assessment of the Pacific cod stock in the Aleutian Islands. Available online at: https://www.afsc.noaa.gov/REFM/Docs/2017/aipcod.pdf.

Table 1. -- Ratio of fishing effort through December over fishing effort through mid-October by FMP, gear type, and target species. Ratios are collected into groups in which 1) an average ratio across years was used, 2) only the ratio from the most recent year of data was used, and 3) a ratio of 1 was used because fisheries were finished by mid-October.

| FMP | Gear type | Target | Dec./Oct. Ratio |
|---|---|---|---|
| **Group 1: Average ratio across years** | | | |
| BSAI | HAL | Halibut | 1.05 |
| GOA | HAL | Halibut | 1.06 |
| GOA | TRW | Other | 1.13 |
| BSAI | POT | Pacific cod | 1.33 |
| GOA | POT | Pacific cod | 1.24 |
| GOA | TRW | Pollock | 1.11 |
| AK | HAL | Sablefish | 1.06 |
| **Group 2: Most recent year ratio** | | | |
| GOA | HAL | Pacific cod | 1.08 |
| AK | POT | Sablefish | 1.11 |
| **Group 3: Ratio of 1** | | | |
| GOA | POT | Halibut | 1.00 |
| BSAI | HAL | Other | 1.00 |
| GOA | HAL | Other | 1.00 |
| GOA | POT | Other | 1.00 |
| BSAI | HAL | Pacific cod | 1.00 |
| BSAI | TRW | Pacific cod | 1.00 |
| GOA | TRW | Pacific cod | 1.00 |
| GOA | POT | Pollock | 1.00 |
| AK | TRW | Sablefish | 1.00 |

Table 2. -- Ratios of Acceptable Biological Catch (ABC) limits (2019 over 2018) and associated effort predictions. Effort predictions are made by FMP, gear type, and target species while ABCs and associated ratios are by FMP and target species. An ad hoc ratio of 0.9 was used for halibut due to the fact that the stock assessment for halibut is published after the draft Annual Deployment Plan. An ad hoc ratio of 1 was used for species other than halibut, Pacific cod, pollock, and sablefish. The number of trips listed in Table 3 will not match the number listed in previous reports, since trips have been recoded to match the stratification methodology used in 2019 (NMFS 2018, Appendix B).

| FMP | Gear | Target | 2018 ABC | 2019 ABC | Interannual ABC ratio | Number of trips in 2018 | Number of trips predicted in 2019 | Proportion of trips tendered in 2017 | Number of tendered trips predicted in 2019 |
|---|---|---|---|---|---|---|---|---|---|
| AK | HAL | Sablefish | 15380 | 15380 | 1.00 | 730 | 730 | 0.00 | 0 |
| AK | POT | Sablefish | 15380 | 15380 | 1.00 | 152 | 152 | 0.00 | 0 |
| BSAI | HAL | Halibut | | | 0.90 | 153 | 138 | 0.00 | 0 |
| BSAI | POT | Pacific cod | 194700 | 170700 | 0.88 | 376 | 330 | 0.05 | 16 |
| BSAI | TRW | Pacific cod | 194700 | 170700 | 0.88 | 221 | 194 | 0.00 | 0 |
| GOA | HAL | Halibut | | | 0.90 | 765 | 688 | 0.00 | 0 |
| GOA | HAL | Other | | | 1.00 | 2 | 2 | 0.00 | 0 |
| GOA | HAL | Pacific cod | 18000 | 17000 | 0.94 | 57 | 54 | 0.00 | 0 |
| GOA | POT | Other | | | 1.00 | 1 | 1 | 0.00 | 0 |
| GOA | POT | Pacific cod | 18000 | 17000 | 0.94 | 100 | 94 | 0.15 | 14 |
| GOA | TRW | Other | | | 1.00 | 232 | 232 | 0.00 | 0 |
| GOA | TRW | Pacific cod | 18000 | 17000 | 0.94 | 46 | 43 | 0.28 | 12 |
| GOA | TRW | Pollock | 161492 | 106568 | 0.66 | 1506 | 994 | 0.01 | 10 |

Table 3. -- Comparisons between the number of realized trips and the number of trips predicted using both the 2019 effort prediction methodology and the 'do-nothing' approach. The number of realized trips may not match previous reports because trips have been recoded to match 2019 stratification, with the exception that tendered and non-tendered trips have been grouped together for pot and trawl. The method with the lowest total percent difference each year are in bold.

| Gear | Previous year trips | Predicted trips | Realized trips | % Difference from predicted (2019 method) | % Difference from previous year trips ('do-nothing' approach) |
|---|---|---|---|---|---|
| **2014** | | | | | |
| HAL | 2628 | 2456 | 2142 | -12.79 | -18.49 |
| POT | 717 | 745 | 898 | 20.54 | 25.24 |
| TRW | 1835 | 1791 | 2369 | 32.27 | 29.10 |
| TOTAL | 5180 | 4992 | 5409 | 8.35 | **4.42** |
| **2015** | | | | | |
| HAL | 2142 | 1961 | 2184 | 11.37 | 1.96 |
| POT | 901 | 905 | 842 | -6.96 | -6.55 |
| TRW | 2369 | 2534 | 2569 | 1.38 | 8.44 |
| TOTAL | 5412 | 5400 | 5595 | 3.61 | **3.38** |
| **2016** | | | | | |
| HAL | 2184 | 1995 | 1962 | -1.65 | -10.16 |
| POT | 1234 | 1298 | 1250 | -3.70 | 1.30 |
| TRW | 2570 | 3123 | 2793 | -10.57 | 8.68 |
| TOTAL | 5988 | 6416 | 6005 | -6.41 | **0.28** |
| **2017** | | | | | |
| HAL | 1962 | 1771 | 1854 | 4.69 | -5.50 |
| POT | 1250 | 1236 | 1264 | 2.27 | 1.12 |
| TRW | 2793 | 2743 | 2222 | -18.99 | -20.44 |
| TOTAL | 6005 | 5750 | 5340 | **-7.13** | -11.07 |

Table 4. -- Estimated cost outcomes for two effort scenarios: 1) 2019 effort is as predicted in the Annual Deployment Plan and 2) 2019 effort is equal to 2018 projected effort. The distributions used to calculate confidence limits were created by randomly sampling trips from 2017 and 2018 that were drawn with replacement.

| Value | Budget - cost (dollars): 2019 effort equal to 2018 projected effort adjusted by ABC | Budget - cost (dollars): 2019 effort equal to 2018 projected effort |
|---|---|---|
| Lower 95% confidence limit | -293,532 | -1,094,573 |
| Mean | 2,380 | -786,906 |
| Upper 95% confidence limit | 289,210 | -479,618 |

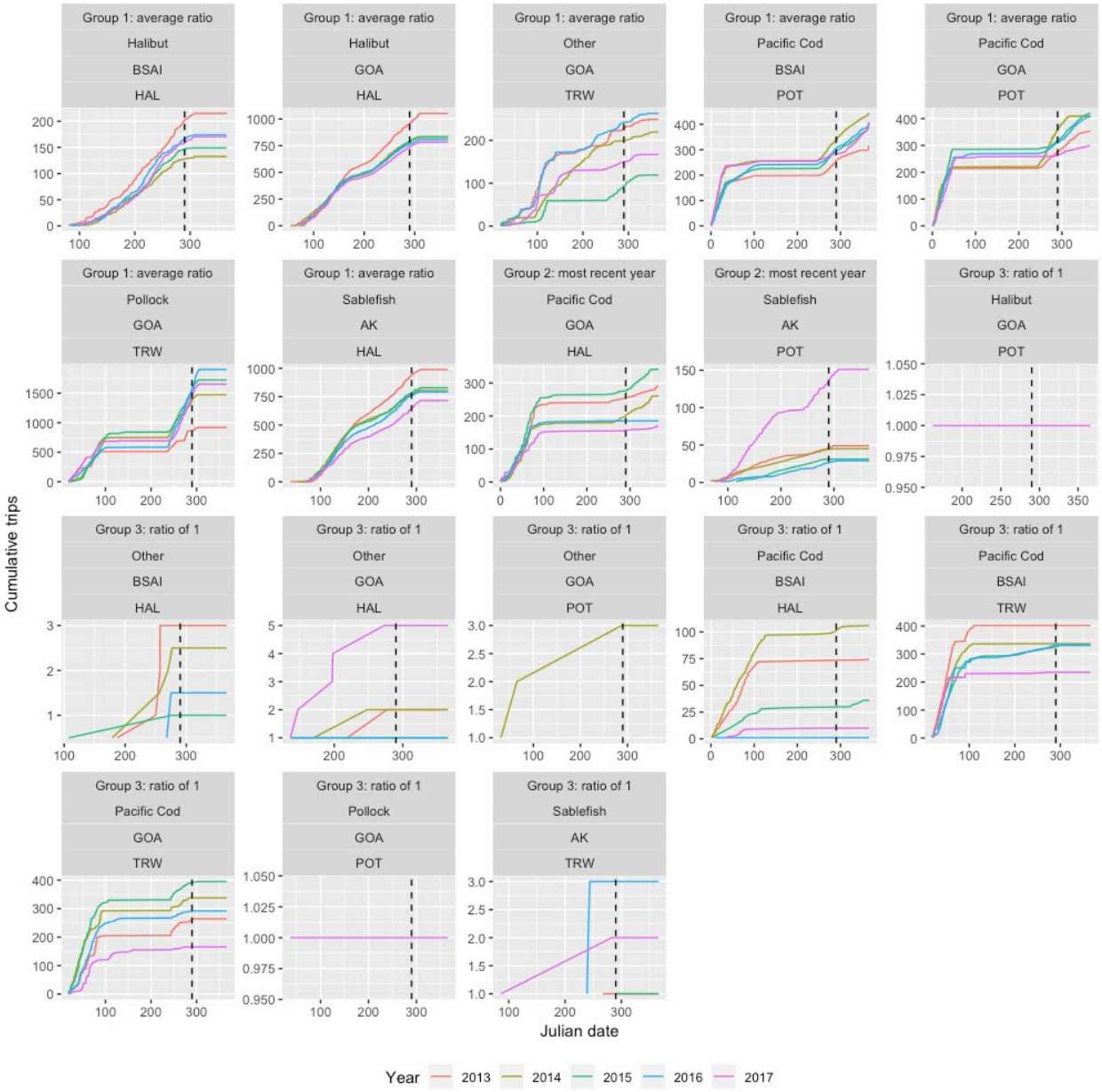


Figure 1. -- Cumulative trips taken by Julian date for each target species, FMP area, and gear type combination. Group numbers indicate whether the ratios to project effort through the end of the year were based on 1) an average ratio across years, 2) only the ratio from the most recent year of data, or 3) an ad hoc ratio of 1. The vertical dotted line marks the date in mid-October through which we have data for the year prior to the year for which the ADP is being made at the time of writing the ADP.

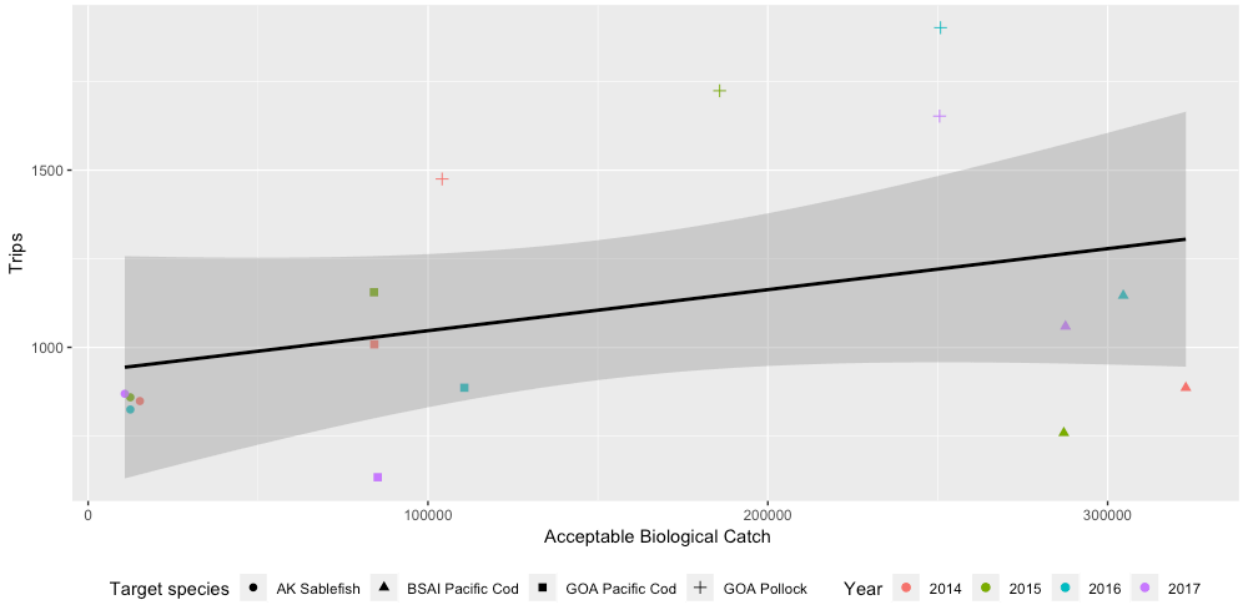


Figure 2. -- Relationship between number of trips taken and Acceptable Biological Catch.

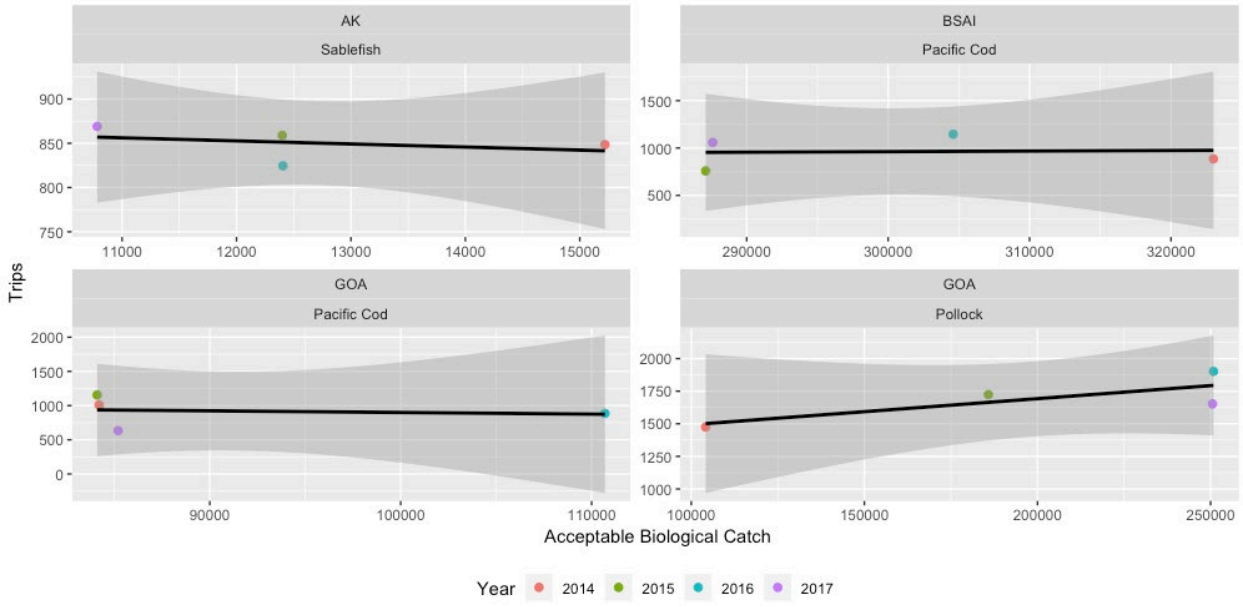


Figure 3. -- Relationship between number of trips taken and Acceptable Biological Catch by Fishery Management Plan area and species.

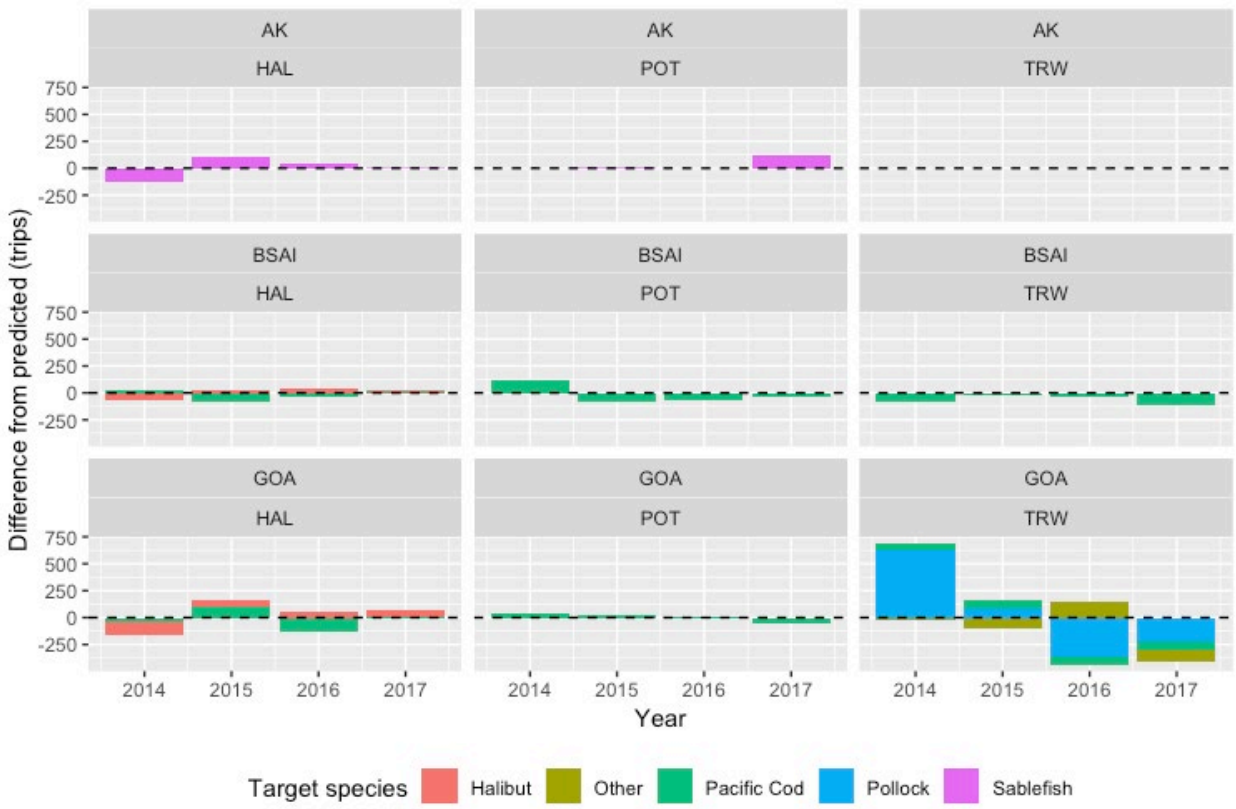


Figure 4. -- The difference between the number of trips taken and the number of trips predicted to occur by year, Fishery Management Plan area, and gear type.

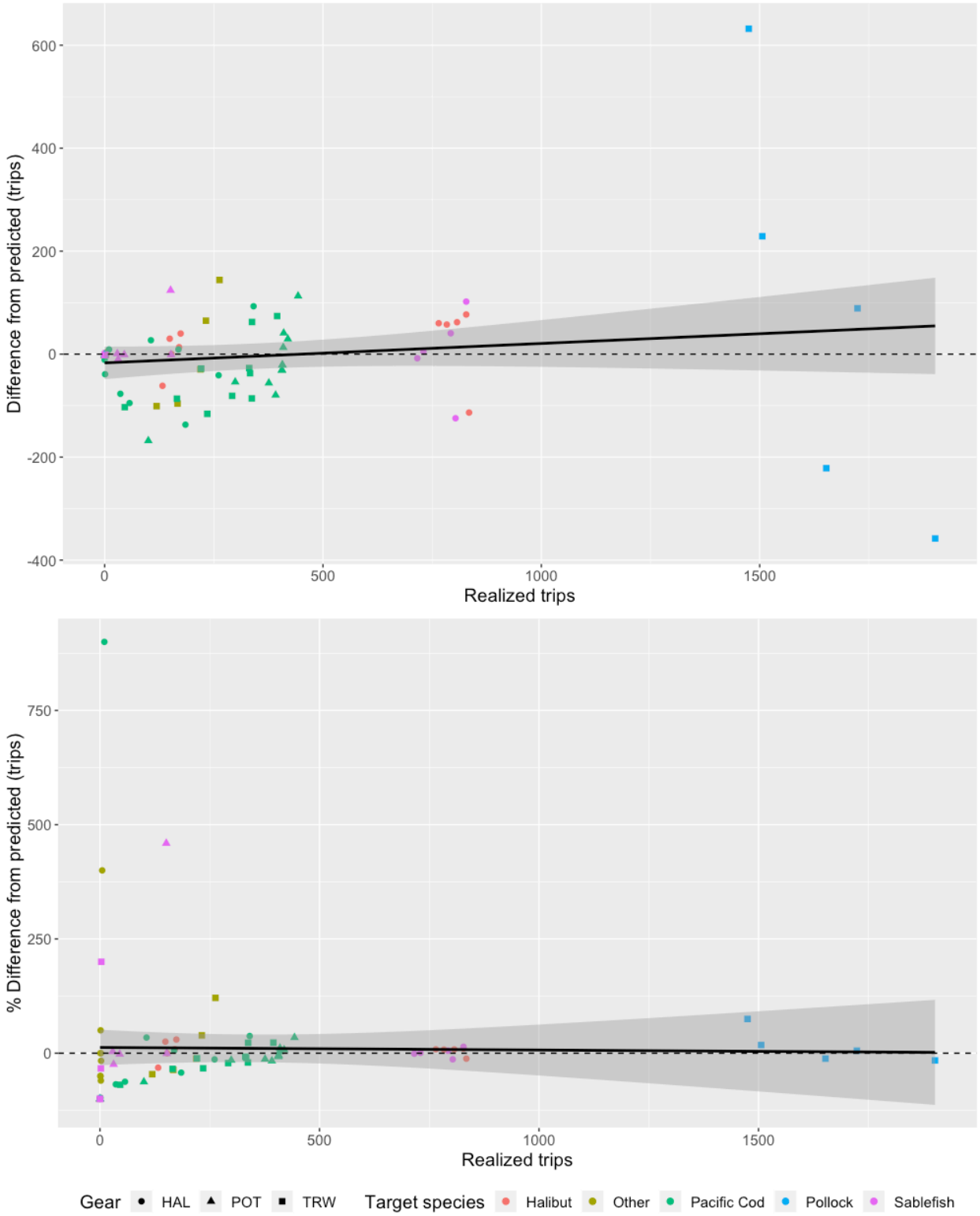


Figure 5. -- The difference between the number of trips taken and the number of trips predicted to occur, plotted against the number of trips taken.

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AFSC-

394 GANZ, P., and C. FAUNCE. 2019. Alternative sampling designs for the 2019 Annual Deployment Plan of the North Pacific Observer Program, 29 p. NTIS number pending.

393 M. M. MUTO, V. T. HELKER, R. P. ANGLISS, P. L. BOVENG, J. M. BREIWICK, M. F. CAMERON, P. J. CLAPHAM, S. P. DAHLE, M. E. DAHLHEIM, B. S. FADELY, M. C. FERGUSON, L. W. FRITZ, R. C. HOBBS, Y. V. IVASHCHENKO, A. S. KENNEDY, J. M. LONDON, S. A. MIZROCH, R. R. REAM, E. L. RICHMOND, K. E. W. SHELDEN, K. L. SWEENEY, R. G. TOWELL, P. R. WADE, J. M. WAITE, AND A. N. ZERBINI. 2019. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2012-2016, 71 p. NTIS number pending.

392 HELKER, V. T., M. M. MUTO, K. SAVAGE, S. TEERLINK, L. A. JEMISON, K. WILKINSON, and J. JANNOT. 2017. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2012-2016. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-392, 71 p. NTIS number pending.

391 GUTHRIE III, C. M., HV. T. NGUYEN, M. MARSH, J. T. WATSON, and J. R. GUYON. 2019. Genetic stock composition analysis of the Chinook salmon bycatch samples from the 2017 Bering Sea trawl fisheries, 36 p. NTIS No. PB2019-100738.

390 GUTHRIE III, C. M., Hv. T. NGUYEN, M. MARSH, and J. R. GUYON. 2019. Genetic stock composition analysis of Chinook salmon bycatch samples from the 2017 Gulf of Alaska trawl fisheries, 30 p. .

389 LINDEBERG, M. R., and S. C. LINDSTROM. 2019. Assessment and catalog of benthic marine algae from the Alaska Peninsula, May 2016, 22 p + Appendices. NTIS No .PB2019-100739.

388 KEARNEY, K. A. 2019. Freshwater Input to the Bering Sea, 1950–2017, 46 p. NTIS No. PB2019-100329.

387 FENSKE, K. H., A. M. BERGER, B. CONNORS, J.M. COPE, S. P. COX, M. A. HALTUCH, D. H. HANSELMAN, M. KAPUR, L. LACKO, C. LUNSFORD, C. RODGVELLER, and B. WILLIAMS. 2019. Report on the 2018 International Sablefish Workshop, 107 p. NTIS No. PB2019-100329.

386 LANG, C. A., J. I. RICHAR, and R. J. FOY. 2019. The 2018 eastern Bering Sea continental shelf and northern Bering Sea trawl surveys: Results for commercial crab species, 220 p. NTIS No. PB2019-100298.

385 JEFFERSON, T. A., M. E. DAHLHEIM, A. N. ZERBINI, J. M. WAITE, and A. S. KENNEDY. 2019. Abundance and seasonality of Dall's porpoise (*Phocoenoides dalli*) in Southeast Alaska, 45 p. NTIS No. PB2019-100297.