Assessment of the effects of fishing on Essential Fish Habitat in Alaska

April 2017[1]

1 Introduction

The Magnuson-Stevens Fishery Conservation and Management (MSA)[2] requires regional Fishery Management Councils to describe and identify Essential Fish Habitat (EFH) for all fishes managed under a Fishery Management Plan (FMP) and to minimize to the extent practicable the adverse effects of fishing on EFH. The North Pacific Fishery Management Council (Council) is currently evaluating updates to EFH in its FMPs, as required by MSA, that make use of new, model-based descriptions of EFH for Bering Sea (BS), Aleutian Islands (AI), and Gulf of Alaska (GOA) groundfish and crab. The update to EFH also includes an updated assessment of the adverse impacts of non-fishing and fishing activities on EFH that make use of these model-based descriptions.

In December 2016, the Council approved a three-tiered method to assess the impacts of fishing on EFH, using the Fishing Effects model that the Council also approved in December 2016. The results of the Fishing Effects model were delivered to stock assessment authors for each species in the GOA and BSAI FMPs. The authors were asked to evaluate whether the current impacts of fishing on EFH presented the potential for impacts that were more than minimal or not temporary. This discussion paper presents the results of their analysis.

2 Evaluating the Effects of Fishing

2.1 Fishing Effects Model

During the current EFH review cycle, the Council requested updates to the model to predict the impacts of fishing on EFH. The Fishing Effects (FE) model was developed to make in put parameters more intuitive and to draw on the best available data. Like the previous Long-term Effects Index (LEI) model, the Fishing Effects model is run on 5 m grid cells throughout the BS, AI, and GOA. It is based on the interaction between habitat impact and recovery, which depends on the amount of fishing effort, the types of gear used, habitat sensitivity, and substrate. The FE model updates the LEIS model in the following ways:

[1] Prepared by: Steve MacLean, Council staff, with input from Matthew Eagleton, John Olson, Megan Mackey

[2] As originally amended in 1996 and as amended through January 12, 2007

- The FE model is cast in a discrete time framework. Rates such as impact or recovery are defined over a specific time interval, compared to the LEI model which used continuous time. Using discrete time makes fishing impacts and habitat recovery more intuitive to interpret compared to continuous time.
- The FE model implements sub annual (monthly) tracking of fishing impacts and habitat disturbance. This allows for queries of habitat disturbance for any month from the start of the model run (January 2003).
- The FE model draws on the spatially explicit Catch-In-Areas (CIA) database to use the best available spatial data of fishing locations. The CIA database provides line segments representing the locations of individual tows or other bottom contact fishing activities. This provides a more accurate allocation of fishing effort among grid cells.

The FE model incorporates an extensive, global literature review from Grabowski et al. (2014) to estimate habitat susceptibility and recovery dynamics. The FE model identifies 27 unique habitat features and incorporates impact and recovery rates to predict habitat reduction and recovery over time. The FE model is also designed to be flexible to produce output based on any single habitat feature or unique combination of features.

2.2 Impact assessment methods

In December 2016, the Council approved a three-tiered method to evaluate whether there are adverse effects of fishing on EFH (Figure 1). This analysis considers impacts of commercial fishing first at the population level, then uses objective criteria to determine whether additional analysis is warranted to evaluate if habitat impacts caused by fishing are adverse and more than minimal or not temporary.

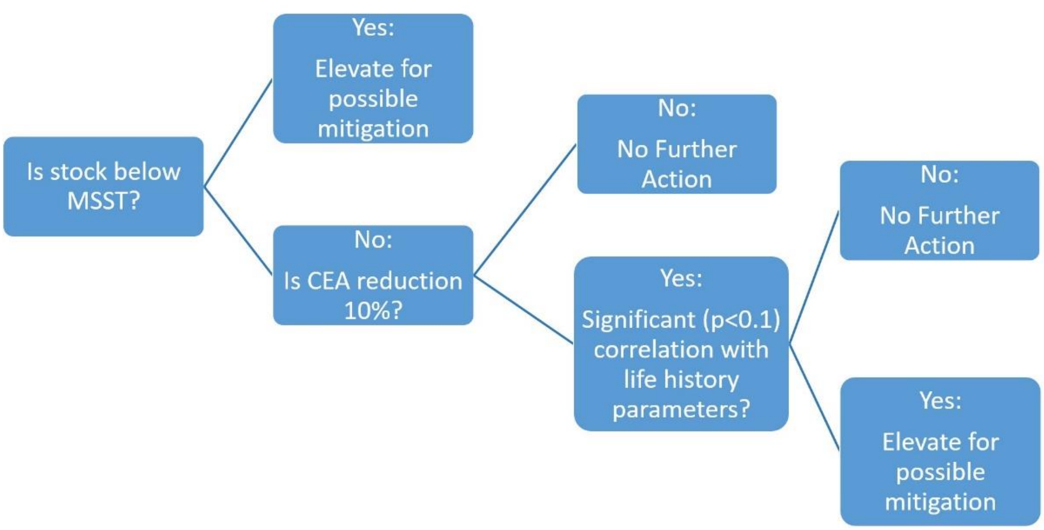

Figure 1 Three-tiered method to evaluate effects of fishing on Essential Fish Habitat in Alaska.

Because EFH is defined for populations managed by Council FMPs, stock authors first considered whether the population is above or below the Minimum Stock Size Threshold (MSST), defined as 0.5*MSY stock size, or the minimum stock size at which rebuilding to MSY would be expected to occur within 10 years if the stock were exploited at the Maximum Fishing Mortality Threshold (MFMT). Stock authors were asked to identify any stock that is below MSST for review by the Plan Teams. Mitigation measures may be recommended by the Plan Team if they concur that there is a plausible connection to reductions of EFH as the cause.

To investigate the potential relationships between fishing effects and stock production, the stock assessment authors examined trends in life history parameters and the amount of disturbed habitat in the "core EFH Area" (CEA) for each species. The CEA is identified as the predicted 50 percent quantile threshold of suitable habitat or summer abundance (Laman et al. 2015, Turner et al. 2015, Rooney et al. 2015). Stock assessment authors evaluated whether 10 percent or more of the CEA was impacted by commercial fishing in November 2016 (the end of the time series). The 10 percent threshold was selected based on the assumption that impacts to less than 10 percent of the CEA means than more than 90 percent of the CEA (top 50 percent of suitable habitat or summer abundance) was undisturbed, and therefore represented minimal disturbance. If 10 percent or more of the CEA was impacted, the stock assessment authors examined indices of growth-to-maturity, spawning success, breeding success, and feeding success to determine whether there are correlations between those parameters and the trends in the proportion of the CEA impacted by fishing. If a correlation exists, positive or negative, stock assessment authors determined whether the correlation is significant at a p-value of 0.1. If a significant correlation was found, stock assessment authors used their expert judgement to determine whether there is a plausible connection to reductions in EFH as the cause. Stock assessment authors identified the correlation, and the significance in their reports.

Reports from the stock assessment authors were collated and presented to representatives of the GOA and BSAI Groundfish Plan Teams and the Crab Plan Team. Plan Team representatives reviewed the reports on March 7 2017. Representatives concurred with the stock assessment authors determinations in all cases.

3 Results of stock assessment author evaluation

3.1 Bering Sea

3.1.1 Alaska plaice

Female adult spawning biomass is estimated to be 1.8 times above B_{MSY}, and is therefore above MSST. The majority of EFH disturbance occurs in the northern part of 513 and the southern part of 514. Overall impacts are low, with 2.2 percent of the CEA disturbed from 2003 – 2016. No changes to management are recommended at this time.

3.1.2 Alaska skate

Female adult spawning biomass is estimated to be 110,180 tons, relative to MSST of 31,598 tons. Habitat disturbance in the CEA ranged from 0.2 to 0.6 percent from 2003 – 2016 with little variation. No changes to management are recommended at this time.

3.1.3 Aleutian skate

Aleutian skate is managed as Tier 5, so MSST is undefined. Habitat disturbance in the CEA ranged from 4.4 to 8.3 percent from 2003 – 2016, with some interannual and decadal variability. Habitat reduction was consistently low throughout the CEA with the exception of a few local areas that are heavily fished. No changes to management are recommended at this time.

3.1.4 Arrowtooth flounder

Female adult spawning biomass is above $B_{35\%}$, therefore Bering Sea Arrowtooth flounder are above MSST. Areas of highest impact to Arrowtooth flounder CEA occur from north of Akutan Island to the center of Unimak Island. Habitat disturbance in the CEA averaged 6.3 percent from 2003 -2016, and did not vary seasonally. Although the 10 percent habitat disturbance threshold was not reached, a correlation analysis was conducted for age 3 recruitment, female spawning biomass, and total (feeding) biomass. None of the correlations were significant at $p<0.1$. No changes to management are recommended at this time.

3.1.5 Bering skate

Bering skate is managed as Tier 5, so MSST is undefined. Habitat disturbance in the CEA ranged from 5.8 to 9.4 percent, with moderate temporal variability. Habitat reduction was low throughout the CEA with the exception of a few localized areas at the heads of canyons that are heavily fished. No changes to management are recommended at this time.

3.1.6 Bigmouth sculpin

Bigmouth sculpin are managed as Tier 5, so MSST is undefined. Habitat disturbance in the CEA was generally 2-10 percent, but there are small regions of habitat impact 10-25 percent in areas 521, and 513. Overall, in the Bering Sea, habitat disturbance in the CEA averaged 2.5 percent, and varied seasonally with the highest impacts occurring in the late summer and early fall. Habitat impacts on bigmouth sculpin growth-to-maturity, spawning success, breeding success, and feeding success are not detectable and no changes to management are recommended at this time.

3.1.7 Dover sole

Dover sole are managed at Tier 5, so MSST is undefined. Habitat disturbance in the CEA, averaged 7.8 percent from 2003 to 2016. Impacts are less than 2 percent in the northern reaches but exceed 25 percent near Unimak Pass and in the central portion of Area 517. Effects exceed 10 percent for several months in 2007 and 2008, but declined thereafter. No changes to management are recommended at this time.

3.1.8 Flathead sole

Female spawning biomass is above $B_{35\%}$, therefore Bering Sea Flathead sole are above MSST. Habitat reduction in the Bering Sea CEA is low in most areas, with a few regions where impacts are above 25 percent. Overall, habitat reduction in the CEA did not exceed 10 percent in any month, and is decreasing in recent years. Habitat impacts to growth-to-maturity, spawning success, breeding success, and feeding success are not detectable, and no changes to management are recommended at this time.

3.1.9 Great sculpin

Great sculpin are managed as Tier 5, so MSST is undefined. Impact rates in the Bering Sea CEA are low, with a few areas impacted more than 10 percent. Three small areas north of Unimak Pass show impact rates over 50 percent where the Pacific cod and flatfish trawl fisheries occur. Overall, the CEA habitat reduction from 2010 – 2016 was 4.8 percent in the Bering Sea, habitat impacts to growth-to-maturity, spawning success, breeding success, and feeding success are not detectable, and no changes to management are recommended at this time.

3.1.10 Greenland turbot

Female spawning biomass is above $B_{35\%}$, therefore Bering Sea Greenland turbot are above MSST. Habitat reduction in the Bering Sea CEA is low, with a few small, localized areas of higher habitat reduction corresponding to fishing grounds within Bering Sea canyons. Overall impacts to the CEA are low, and averaged 4.0 percent from 2003 to 2016. Habitat reduction has been stable since 2007, and below 4 percent since 2011. Overall, habitat impacts on BS Greenland turbot growth-to-maturity, spawning success, breeding success, and feeding success are not detect able, and no changes to management are recommended at this time.

3.1.11 Kamchatka flounder

Female spawning biomass is 17 percent above B_{MSY} level, and therefore, above MSST. Habitat reduction in the BS CEA is low, and averaged 5.1 percent from 2003 – 2016. There is a declining trend in fishing impacts since 2008. No changes to management are recommended at this time.

3.1.12 Mud skate

Mud skates are managed as Tier 5, so MSST is undefined. Habitat reduction in the Bering CEA ranged from 5.1 to 9.8 percent from 2003 to 2016. Habitat reduction was consistently low throughout the CEA, with the exception of a few localized areas at the heads of canyons that are heavy targets for commercial fisheries. No changes to management are recommended at this time.

3.1.13 Northern rock sole

Female spawning biomass is 2.3 times the B_{MSY} level, and therefore, above MSST. Habitat reduction in the BS CEA is low, and averaged 3.9 percent from 2003 – 2016. There appears to be a declining trend in the proportion of northern rock sole habitat impacted by fishing. No management changes are recommended at this time.

3.1.14 Octopus

Bering Sea octopus are managed in Tier 6, so MSST is undefined. Habitat reduction in the BS CEA is less than 2 percent for most of the area, with a few areas where habitat reduction is >25 percent. Habitat reduction for the CEA as a whole averaged 5.2 percent for 2003 – 2016. There are few data available on indices for growth-to-maturity, spawning success, breeding success, and feeding success. No changes to management are recommended at this time.

3.1.15 Pacific cod

Pacific cod in the Bering Sea are above MSST. Habitat reduction in the BS CEA averaged 4.9 percent, with a range from 3-6 – 6.0 percent. No management changes are recommended at this time.

3.1.16 Pacific ocean perch

Female spawning biomass is above $B_{35\%}$, and therefore, above MSST. Habitat reduction in the BS CEA has not exceeded 10.0 percent, and averaged 7.5 percent from 2003-2016. No changes to management are recommended at this time.

3.1.17 Rex sole

Rex sole are managed as Tier 5, so MSST is undefined. Habitat reduction in the BS CEA is generally less than 2 percent in most areas, but some areas where habitat reduction > 25% occur along the outer shelf in Area 517 and in the heavily-fished region north of Unimak Island. Overall, habitat reduction in the BS CEA does not exceed 9.6 percent for any moth, and the trend is decreasing after 2008. No changes to management are recommended at this time.

3.1.18 Sablefish

Female spawning biomass is at $B_{35\%}$, therefore, BS Sablefish are above MSST. Habitat reduction in the BS CEA is generally low in most areas, but there are small, localized areas where habitat reduction is >25 percent in the southeastern part of the EBS slope. Overall, habitat reduction in the BS CEA averaged 2.2 percent from 2003 – 2016, and the trend appears to be stable. Habitat impacts on BS Sablefish growth-to-maturity, spawning success, breeding success, and feeding success are not detectable, and no changes to management are recommended at this time.

3.1.19 Shortraker rockfish

Shortraker rockfish are managed as Tier 5, so MSST is undefined. Habitat reduction in the BS CEA is low, and averaged 2.7 percent from 2003 – 2016, and is stable over time. Habitat impacts to BS shortraker rockfish growth-to-maturity, spawning success, breeding success, and feeding success are not detectable, and no changes to management are recommended at this time.

3.1.20 Shortspine thornyhead

Shortspine thornyhead are managed as Tier 5, so MSST is undefined. Habitat reduction in the BS CEA is generally low and is less than 1 percent in most areas. There are small, localized areas near Pribilof Canyon where habitat reduction is 10 – 25 percent. Overall, habitat reduction in the BS CEA averaged 5.2 percent, and does not exceed 7 percent in any month. No changes to management are recommended at this time.

3.1.21 Walleye pollock

Female spawning biomass is above B_{MSY}, therefore, BS walleye pollock are above MSST. Overall, habitat reduction in the BS CEA is low, and averaged 2.6 percent with a maximum of 3.6 percent. There are small areas where habitat reduction is >25 percent in the middle domain of the EBS shelf. No changes to management are recommended at this time.

3.1.22 Yellow Irish lord

Yellow Irish lord are assessed as a Tier 5 stock, so MSST is undefined. Habitat reduction in the BS CEA is highest in reporting areas 521, 513, 509, and 516. There are three small areas north of Unimak Island and north of the Alaska Peninsula where habitat reduction is >50 percent. Overall, habitat reduction in the CEA as a whole varies seasonally, and are lower in January and February. Overall habitat reduction averaged 7.5 percent from 2010 – 2016. Habitat impacts on Bering Sea yellow Irish lord growth-to-maturity, spawning success, breeding success, and feeding success are not detectable, no changes to management are recommended at this time.

3.1.23 Yellowfin sole

Female spawning biomass is estimated to be 1.8 times above the B_{MSY} level, therefore BS Yellowfin sole are above MSST. The majority of habitat reduction in the BS CEA occurs in the northern part of 513, and 514. Overall, habitat reduction in the BS CEA averaged 2.9 percent from 2003 – 2016, and the trend is declining. Growth-to-maturity was analyzied by conducting a correlation analysis between the estimated annual proportion of habitat disturbed and indices of growth (weight-at-age) annually available from the AFSC bottom trawl survey in the BS. For recruitment analysis, the log of average annual recruitment estimate were used for 2003 – 2011, and stock assessment model estimate of female spawning biomass were used as a proxy index for breeding success. None of the correlations resulted in a p-value ≤ 0.1. The impact of estimated fishing effects on BS yellowfin sole life-history traits is not a concern, and no changes to management are recommended at this time.

3.1.24 BS summary

None of the groundfish stocks in the Bering Sea are below MSST. There are small, localized areas where habitat impacts are greater than 10 percent for some species, but for the CEA as a whole, habitat reduction was below 10 percent for all BS groundfish species. Analyses of correlations between trends in habitat reduction and indices of growth-to-maturity, spawning success, breeding success, and feeding success were conducted for a few species, none of the correlations were significant at $p \leq 0.1$. None of the stock assessment authors concluded that habitat reduction within the CEA was affecting groundfish stocks. Representatives of the BSAI Groundfish Plan Team concurred with the authors' assessments. No changes to management measures were recommended for any BS groundfish stock.

Table 1 Summary of stock assessment author evaluations of the effects of fishing on EFH for groundfish in the Bering Sea

	Stock < MSST	Average %CEA Disturbed	Cumulative CEA Disturbed	Management Change
Alaska plaice	N	2.2	2.1	N
Alaska skate	N	0.4	0.2	N
Aleutian skate	NA	6.4	7.8	N
Arrowtooth flounder	N	6.3	4.8	N
Bering skate	NA	7.4	6.3	N
Bigmouth sculpin	NA	6.7	4.6	N
Dover sole	NA	7.8	7.9	N
Flathead sole	N	6.7	4.9	N
Great sculpin	NA	4.8	3.2	N
Greenland turbot	N	4.0	2.8	N
Kamchatka flounder	N	5.1	3.7	N
Mud skate	NA	7.4	8.0	N
Northern rock sole	N	3.9	3.2	N
Octopus	NA	5.2	5.1	N
Pacific cod	N	4.9	3.6	N
Pacific ocean perch	N	6.4	7.7	N
Rex sole	NA	6.8	6.0	N
Sablefish	N	2.9	2.2	N
Shortraker rockfish	NA	2.7	3.6	N
Shortspine thornyhead	NA	2.5	1.8	N
Walleye pollock	N	2.6	2.0	N
Yellow Irish lord	NA	7.5	4.5	N
Yellowfin sole	N	3.0	2.7	N

3.2 Aleutian Islands

3.2.1 Alaska skate

Female spawning biomass is estimated to be 110,180 tons, relative to MSST of 31,598 tons. BSAI Alaska skate is well above MSST. Habitat reduction in the AI CEA ranged from 0.7 percent to 1.7 percent, from 2003 – 2016. No changes to management are recommended at this time.

3.2.2 Aleutian skate

Aleutian skate are assessed as a Tier 5 stock, so MSST is undefined. Habitat reduction in the CEA ranged from 2.0 to 3.5 percent, with little temporal variability. No changes to management are recommended at this time.

3.2.3 Arrowtooth flounder

Female spawning biomass is above $B_{35\%}$, therefore, AI Arrowtooth flounder are above MSST. Habitat reduction in the AI CEA was typically less than 1 percent for most areas, and over the entire CEA averaged 2.1 percent from 2003 – 2016, and did not vary seasonally. Correlation analyses between trends in habitat reduction and age 3 recruitment, female spawning biomass, and total (feeding) biomass were conducted despite not reaching the 10 percent habitat reduction threshold. None of the correlation tests were significant after correction for multiple tests. In summary, the proportion of habitat reduction in the BS and AI CEA is less than 10 percent, and is decreasing. Habitat impacts on BS and AI Arrowtooth flounder growth-to-maturity, spawning success, breeding success, and feeding success are not detectable, and no changes to management are recommended at this time.

3.2.4 Atka mackerel

Female spawning biomass is above $B_{35\%}$, and therefore AI Atka mackerel are above MSST. Habitat reduction in the AI CEA are generally very low (<2 percent), although there are some small, localized areas of 25 percent habitat reduction corresponding to Atka mackerel fishing areas. Analysis of historic fishery CPUE has suggested that the fishery may create temporary localized depletions of Atka mackerel. Overall habitat reduction in the AI CEA is low, averaging 1.7 percent, and did not exceed 2.3 percent from 2003 – 2016. Habitat impacts on AI Atka mackerel growth-to-maturity, spawning success, breeding success, and feeding success are not detectable, and no changes to management are recommended at this time.

3.2.5 Bigmouth sculpin

Bigmouth sculpin are assessed as a Tier 5 stock, so MSST is undefined. Habitat reduction in the AI CEA appears to be low, the majority of fishing effects were less than 1 percent. Overall, the reduction in the AI CEA averaged 2.5 percent from 2010 – 2016, and did not vary seasonally. Habitat impacts on AI bigmouth sc8ulping growth-to-maturity, spawning success, breeding success, and feeding success are not detectable, and no changes to management are recommended at this time.

3.2.6 Blackspotted rockfish

Female spawning biomass is above $B_{35\%,}$ and therefore, AI blackspotted rockfish are above MSST. Habitat reduction in the AI CEA has not exceeded 10 percent, and averaged 1.8 percent for each year from 2003 – 2016. Data are limited for indices of growth-to-maturity, spawning success, breeding success, and feeding success, so analyses were not completed. No changes to management are recommended at this time.

3.2.7 Dover sole

Dover sole are assessed as a Tier 5 stock, so MSST is undefined. The effects of fishing in the AI CEA is typically low, with less than 2 percent habitat reduction in most areas. Small areas of >25 percent habitat reduction occur in the heavily-fished region near Unimak Pass and in Area 541 north of Yunaska Island. Habitat reduction for the AI CEA, as a whole, averaged 2.4 percent, and did not exceed 3.9 percent in any month. No changes to management are recommended at this time.

3.2.8 Dusky rockfish

Dusky rockfish are assessed as a Tier 5 stock, so MSST is undefined. The effects of fishing in the AI CEA are low, with less than 1 percent habitat reduction in most areas. Habitat reduction for the AI CEA, as a whole, is 0.7 percent. Few data are available on indices of growth-to-maturity, spawning success, breeding success, and feeding success for dusky rockfish. No changes to management are recommended at this time.

3.2.9 Flathead sole

Female spawning biomass is above $B_{35\%}$, so AI flathead sole are above MSST. The effects of fishing on AI CEA are generally very low, with less than 2 percent habitat reduction in most areas. Habitat reduction for the CEA, as a whole, was less than 4 percent in all months, and the trend is decreasing. Habitat impacts on AI flathead sole growth-to-maturity, spawning success, breeding success, and feeding success are not detectable. No changes to management are recommended at this time.

3.2.10 Great sculpin

Great sculpin are assessed as a Tier 5 stock, so MSST is undefined. The effects of fishing on the AI CEA are low, generally less than 1 percent habitat reduction in most areas. Habitat reduction for the AI CEA, as a whole, averaged 2.3 percent. Habitat impacts on AI great sculpin growth-to-maturity, spawning success, breeding success, and feeding success are not detectable. No changes to management are recommended at this time.

3.2.11 Greenland turbot

Female spawning biomass is above $B_{35\%}$, therefore, AI Greenland turbot are above MSST. The effects of fishing on AI CEA are low, generally less than 3 percent habitat reduction in most areas. Habitat reduction for the AI CEA, as a whole, averaged 2.0 percent from 2003 – 2016. Habitat impacts on AI Greenland turbot growth-to-maturity, spawning success, breeding success, and feeding success are not detectable. No changes to management are recommended at this time.

3.2.12 Harlequin rockfish

Harlequin rockfish are assessed as a Tier 5 stock, so MSST is undefined. The effects of fishing on the AI CEA are low, habitat reduction is less than 1 percent in many areas, with some areas 2-10 percent, and a few areas with more than 10 percent habitat reduction. Habitat reduction for the AI CEA, as a whole, did not exceed 5 percent for any month. No changes to management are recommended at this time.

3.2.13 Kamchatka flounder

Female spawning biomass is estimated to be 17% above B_{MSY}, therefore, AI Kamchatka flounder are above MSST. The effects of fishing on the AI CEA, as a whole, are low and averaged 2 percent from 2003 – 2016. No changes to management are recommended at this time.

3.2.14 Mud skate

Mud skate are assessed as a Tier 5 stock, so MSST is undefined. The effects of fishing on the AI CEA, as a whole ranged from 2.5 to 3.5 percent. Habitat reduction was consistently low throughout the CEA, with the exception of a few highly localized areas in the eastern AI. No changes to management are recommended at this time.

3.2.15 Northern rock sole

Female spawning biomass is estimated to be 2.3 times B_{MSY}, therefore, AI northern rock sole are above MSST. The effects of fishing on the AI CEA, as a whole, is low with a maximum habitat reduction of less than 2.5 percent from 2003 – 2016. No changes to management are recommended at this time.

3.2.16 Northern rockfish

Female spawning biomass is above $B_{35\%}$, therefore AI northern rockfish are above MSST. The effects of fishing on the AI CEA has not exceeded 3 percent from 2003 – 2016. Time series of life-history indices such as age at 50% maturity, size at ae, and recruitment are only available for a small number of years. Limited sample sizes preclude meaningful analysis of correlations between life history indices and estimates of habitat reduction. No changes to management are recommended at this time.

3.2.17 Octopus

Octopus are assessed as a Tier 6 stock, so MSST is undefined. The effects of fishing on the AI CEA, as a whole, averaged 2.4 percent from 2003 – 2016. Habitat reduction did not exdeed 3% for any month in the time series. There are very few data available on indices of growth-to-maturity, spawning success, breeding success, and feeding success for any of the octopus species in the assemblage. No changes to management are recommended at this time.

3.2.18 Pacific cod

Pacific cod in the AI are assessed as a Tier 5 stock, so MSST is undefined. Habitat reduction in the AI CEA, as a whole, averaged 1.9 percent, with a range of 1.2 to 2.7 percent. No changes to management are recommended at this time.

3.2.19 Pacific ocean perch

Female spawning biomass is larger than the estimated $B_{35\%}$, so AI Pacific ocean perch are above MSST. Habitat reduction for the AI CEA, as a whole, has not exceeded 10 percent from 2003 – 2016. Time series of life-history indices such as age at 50% maturity, size at age, and recruitment are available for only a small number of years. Limited sample sizes preclude meaningful analysis of correlations between life-history indices and estimates of habitat reduction. No changes to management are recommended at this time.

3.2.20 Rex sole

Rex sole are assessed as a Tier 5 stock, so MSST is undefined. Habitat reduction for the AI CEA, as a whole, averaged 2.1 percent from 2003 – 2016, and did not exceed 2.9 percent in any month. No changes to management are recommended at this time.

3.2.21 Rougheye rockfish

Rougheye rockfish and blackspotted rockfish are managed as a single stock complex in the BSAI. Female spawning biomass is larger than the estimated $B_{35\%}$, therefore, Rougheye and blackspotted rockfish are above MSST. The maximum average percent habitat reduction for the AI CEA for rougheye rockfish was 4.0 percent from 2003 – 2016. Time series of life history indices such as age at 50% maturity, size at age, and recruitment are generally available only for a small number of years. Limited sample sizes preclude meaningful analysis of correlations between life-history indices and estimates of habitat reduction. No changes to management are recommended at this time.

3.2.22 Sablefish

Female spawning biomass is at $B_{35\%}$, so AI sablefish are above MSST. The effects of fishing on the AI CEA are generally very low (<3 percent habitat reduction), but there are small, localized areas of higher habitat reduction (>25%) near the eastern edge of the AI. Habitat reduction for the AI CEA, as awhole, averaged 2.6 percent, with a stable time trend. Habitat impacts on AI sablefish growth-to-maturity, spawning success, breeding success, and feeding success are not detectable. No changes to management are recommended at this time.

3.2.23 Shortraker rockfish

Shortraker rockfish is assessed as a Tier 5 stock, so MSST is undefined. The effects of fishing on the AI CEA are low, in November 2016 the areas of highest impact show less than 1 percent habitat reduction. Habitat reduction for the AI CEA, as a whole, averaged 1.7 percent from 2010-2016. Habitat impacts on AI shortraker rockfish growth-to-maturity, spawning success, breeding success, and feeding success are not detectable. No changes to management are recommended at this time.

3.2.24 Shortspine thornyhead

Shortspine thornyhead is assessed in a Tier 5 “other rockfish” complex, so MSST is undefined. The effects of fishing on the AI CEA, as a whole, are low, habitat reduction averaged 2.4 percent for 2003 – 2016. There are few data available on indices of growth-to-maturity, spawning success, breeding success, and feeding success for shortspine thornyhead. No changes to management are recommended at this time.

3.2.25 Southern rock sole

Southern rock sole have been combined with northern rock sole in the BSAI stock assessments. Female spawning biomass is estimated to be 2.3 times above the B_{MSY}, therefore northern and southern rock sole are above MSST. The effects of fishing on the AI CEA, as a whole, appears to be very low with maximum habitat reduction of less than 2.5 percent from 2003 – 2016. No changes to management are recommended at this time.

3.2.26 Walleye pollock

Female spawning biomass is above $B_{35\%}$, therefore, AI walleye pollock are above MSST. The effects of fishing on the AI CEA, as a whole, is low, habitat reduction averaged 1.8 percent from 2003 – 2016, with a maximum of 2.9 percent. Habitat impacts on AI walleye pollock growth-to-maturity, spawning success, breeding success, and feeding success are not detectable. No changes to management are recommended at this time.

3.2.27 Yellow Irish lord

Yellow Irish lord is assessed as a Tier 5 stock, so MSST is undefined. The effects of fishing on the AI CEA appear to be low, habitat reduction was generally less than 1 percent, with the exception of a small region of high impact west of Atka Island. Habitat reduction for the AI CEA, as a whole, averaged 2.2 percent. Habitat impacts on AI Yellow Irish lord growth-to-maturity, spawning success, breeding success, and feeding success are not detectable. No changes to management are recommended at this time.

3.2.28 Aleutian Islands summary

None of the groundfish stocks in the Aleutian Islands are below MSST. There are small, localized areas where habitat impacts are greater than 10 percent for some species, but for the CEA as a whole, habitat reduction was below 10 percent for all AI groundfish species. Analyses of correlations between trends in habitat reduction and indices of growth-to-maturity, spawning success, breeding success, and feeding success were conducted for a few species, none of the correlations were significant at $p \leq 0.1$. None of the stock assessment authors concluded that habitat reduction within the CEA was affecting groundfish stocks. Representatives of the BSAI Groundfish Plan Team concurred with the authors' assessments. No changes to management measures were recommended for any AI groundfish stock.

Table 2 Summary of stock assessment author evaluations of the effects of fishing on EFH for groundfish in the Aleutian Islands

	Stock < MSST	Average %CEA Disturbed	Cumulative CEA Disturbed	Management Change
Alaska skate	N	1.3	0.9	N
Aleutian skate	NA	2.8	2.3	N
Arrowtooth flounder	N	2.1	1.5	N
Atka mackerel	N	1.7	1.4	N
Bigmouth sculpin	NA	2.5	2.2	N
Blackspotted rockfish	N	1.5	1.8	N
Dover sole	NA	2.4	2.0	N
Dusky rockfish	NA	0.7	0.5	N
Flathead sole	N	2.4	1.3	N
Great sculpin	NA	2.3	1.3	N
Greenland turbot	N	2.2	1.9	N
Harlequin rockfish	NA	3.8	3.0	N
Kamchatka flounder	N	1.7	2.0	N
Mud skate	NA	3.0	3.1	N
Northern rock sole	N	1.3	0.9	N
Northern rockfish	N	1.6	1.2	N
Octopus	NA	2.4	1.8	N
Pacific cod	NA	1.9	1.4	N
Pacific ocean perch	N	2.4	2.1	N
Rex sole	NA	2.1	1.5	N
Rougheye rockfish	N	3.6	4.2	N
Sablefish	N	2.4	2.6	N
Shortraker rockfish	NA	1.7	2.1	N
Shortspine thornyhead	NA	2.0	2.0	N
Southern rock sole	N	2.0	1.7	N
Walleye pollock	N	2.1	1.7	N
Yellow Irish lord	NA	2.2	1.9	N

3.3 Gulf of Alaska

3.3.1 Alaska plaice

Alaska plaice are part of the shallow-water flatfish complex that is assessed as a Tier 5 stock, so MSST is undefined. The effects of fishing on the GOA CEA is low, habitat reduction was less than 10 percent. No changes to management are recommended at this time.

3.3.2 Alaska skate

Alaska skate in the GOA is assessed as a Tier 5 stock, so MSST is undefined. Habitat reduction in the GOA CEA was consistently low, with the exception of a few localized areas in the Shumagin Islands and off the coast of Kodiak. Habitat reduction for the GOA CEA, as a whole, ranged from 1.2 to 1.9 percent from 2003 – 2016. No changes to management are recommended at this time.

3.3.3 Aleutian skate

Aleutian skate in the GOA is assessed as a Tier 5 stock, so MSST is undefined. Habitat reduction in the GOA CEA ranged from 1.0 to 1.6 percent, and was low throughout the CEA with the exception of a few localized areas in the Shumagin Islands and near Kodiak Island. No changes to management are recommended at this time.

3.3.4 Arrowtooth flounder

Female spawning biomass in the GOA is above $B_{35\%}$, so GOA Arrowtooth flounder are above MSST. Habitat reduction in the GOA CEA averaged 1.5 percent from 2003 – 2016, and did not vary seasonally. Although the 10 percent threshold was not exceeded, correlation analyses were performed for trends in habitat reduction and Arrowtooth flounder age 3 recruitment, female spawning biomass, and total (feeding) biomass. No data were available to examine growth-to-maturity. None of the correlation tests were significant. Habitat impacts on GOA Arrowtooth flounder growth-to-maturity, spawning success, breeding success, and feeding success are not detectable. No changes to management are recommended at this time.

3.3.5 Atka mackerel

Atka mackerel in the GOA are assessed as a Tier 6 stock, so MSST is undefined. The effects of fishing on the GOA CEA, as a whole, averaged 1.4 percent from 2003 – 2016, and the trend is stable. Overall habitat reduction did not exceed 2 percent in any month. Habitat impacts on GOA Atka mackerel growth-to-maturity, spawning success, breeding success, and feeding success are not detectable. No changes to management are recommended at this time.

3.3.6 Bering skate

Bering skate in the GOA are assessed as a Tier 5 stock, so MSST is undefined. Habitat reduction for the GOA CEA ranged from 1.0 to 1.8 percent and was consistently low throughout the CEA except for a few localized areas off Kodiak Island where habitat reduction exceeded 50 percent. No changes to management are recommended at this time.

3.3.7 Bigmouth sculpin

Bigmouth sculpin in the GOA are assessed as a Tier 5 stock, so MSST is undefined. Habitat reduction in the GOA CEA, as a whole, averaged 1.5 percent from 2010 – 2016 and did not vary seasonally. Habitat impacts on GOA bigmouth sculpin growth-to-maturity, spawning success, breeding success, and feeding success are not detectable. No changes to management are recommended at this time.

3.3.8 Blackspotted and rougheye rockfish

Female spawning biomass is well above $B_{35\%}$, therefore, blackspotted and rougheye rockfish in the GOA are above MSST. The effects of fishing on the GOA CEA are generally very low with less than 2 percent habitat reduction. There are small localized areas of higher habitat reduction corresponding to areas with blackspotted and rougheye rockfish bycatch. Habitat reduction for the GOA CEA, as a whole, is very low, and averaged 1.1 percent for rougheye rockfish and 1.2 percent for blackspotted rockfish. Habitat impacts on GOA blackspotted and rougheye rockfish growth-to-maturity, spawning success, breeding success, and feeding success are not detectable. No changes to management are recommended at this time.

3.3.9 Dover sole

Female spawning biomass is above $B_{35\%}$, therefore GOA Dover sole are above MSST. The effects of fishing on the GOA CEA are generally very low, overall habitat reduction was less than 2.5 percent in all months of the time series. Habitat impacts on GOA Dover sole growth-to-maturity, spawning success, breeding success, and feeding success are not detectable. No changes to management are recommended at this time.

3.3.10 Dusky rockfish

Female spawning biomass is above $B_{35\%}$, therefore GOA dusky rockfish are above MSST. The effects of fishing on the GOA CEA are generally low with less than 3 percent habitat reduction. There are small localized areas of higher habitat reduction ranging from 25 – 60 percent reduction. Habitat reduction for the GOA CEA, as a whole, did not exceed 3 percent in any month. Habitat impacts on GOA dusky rockfish growth-to-maturity, spawning success, breeding success, and feeding success are not detectable. No changes to management are recommended at this time.

3.3.11 Flathead sole

Female spawning biomass is above $B_{35\%}$, therefore GOA flathead sole are above MSST. The effects of fishing on the GOA CEA are generally very low, less than 1 percent habitat reduction in most areas, and less than 10 percent in nearly all areas. An area of greater than 50 percent habitat reduction exists off of Kodiak Island. Habitat reduction on the GOA CEA, as a whole, was less than 2.5 percent in all months. Habitat impacts on GOA flathead sole growth-to-maturity, spawning success, breeding success, and feeding success are not detectable. No changes to management are recommended at this time.

3.3.12 Great sculpin

Great sculpin is assessed as a Tier 5 stock in the GOA, so MSST is undefined. The effects of fishing on the GIO CEA is generally low, although there is an area with higher impact south of Kodiak Island. Habitat reduction on the GOA CEA, as a whole, averaged 1.1 percent from 2010 – 2016. Habitat impacts on GOA great sculpin growth-to-maturity, spawning success, breeding success, and feeding success are not detectable. No changes to management are recommended at this time.

3.3.13 GOA Other rockfish complex

The other rockfish stock complex (OR) is a mixed group of up to 25 rockfish species, depending on the GOA management area. For this analysis, ten species have enough information available to assess the impacts of fishing on EFH. Those include greenstriped, harlequin, pygmy, quillback, redbanded, redstripe, rosethorn, sharpchin, silvergray, and yelloweye rockfish (Table 3). The effects of fishing on the GOA CEA are generally very low, less than 2 percent habitat reduction although there are small, localized areas of greater than 25 percent habitat reduction. Habitat reduction on the GOA CEA, as a whole, averaged about 2.5 percent across all examined species from 2003-2016, and did not exceed 3 percent in any month for all species examined. Habitat impacts on the GOA other rockfish complex growth-to-maturity, spawning success, breeding success, and feeding success are not detectable. No changes to management are recommended at this time.

Table 3 Species in the other rockfish complex included in this analysis

Common name	Scientific name	>MSST	Disturbed CEA >10%
greenstriped rockfish	*Sebastes. elongates*	NA	No
harlequin rockfish	*S. variegatus*	NA	No
pygmy rockfish	*S. wilsoni*	NA	No
quillback rockfish[a]	*S. maliger*	NA	No
redbanded rockfish	*S. babcocki*	NA	No
redstripe rockfish	*S. proriger*	NA	No
rosethorn rockfish	*S. helvomaculatus*	NA	No
sharpchin rockfish	*S. zacentrus*	NA	No
silvergray rockfish	*S. brevispinis*	NA	No
yelloweye rockfish[a]	*S. ruberrimus*	NA	No

3.3.14 Northern rocksole

Female spawning biomass is above $B_{35\%}$, therefore GOA northern rocksole are above MSST. The effects of fishing on the GOA CEA are generally low, with less than 1 percent habitat reduction. There are small localized areas of greater than 25 percent habitat reduction corresponding to northern rocksole fishing grounds. Habitat reduction for the GOA CEA, as a whole, averaged 1 percent from 2003 – 2016 and did not exceed 1.4 percent in any month. No changes to management are recommended at this time.

3.3.15 Northern rockfish

Female spawning biomass is above $B_{35\%}$, so GOA northern rockfish are above MSST. The effects of fishing on the GOA CEA are low, habitat reduction averaged 1.4 percent from 2003 – 2016, and habitat reduction did not exceed 1.9 percent in any month. No changes to management are recommended at this time.

3.3.16 Octopus

Octopus are assessed as a Tier 6 stock, so MSST is undefined. For most of the GOA CEA, habitat reduction is less than 1 percent. Small areas of higher habitat reduction (>25 percent and >50 percent) occur on the shelf east of Kodiak Island in statistical area 630, and in the Shumagin Islands in area 610. Habitat reduction for the GOA CEA, as a whole, is 1.5 percent from 2003 – 2016, and did not exceed 2 percent in any month. There are few data available on indices of growth-to-maturity, spawning success, breeding success, or feeding success. No changes to management are recommended at this time.

3.3.17 Pacific cod

Female spawning biomass is above $B_{35\%}$, so GOA Pacific cod are above MSST. The effects of fishing on the GOA CEA is generally very low (<2 percent habitat reduction). There are small localized area of higher habitat reductions (>25 percent) corresponding to fishing grounds surrounding Kodiak Island and in the Shumagin Islands. Habitat reduction on the GOA CEA, as a whole, averaged 1.8 percent from 2003 – 2016, with a maximum of 2.2 percent. Habitat impacts on GOA Pacific cod growth-to-maturity, spawning success, breeding success, and feeding success are not detectable. No changes to management are recommended at this time.

3.3.18 Pacific ocean perch

Female spawning biomass is above $B_{35\%}$, so GOA Pacific ocean perch are above MSST. The effects of fishing on the GOA CEA is generally low. Habitat reduction in the majority of areas in the CEA is 0-1 percent. There are areas with habitat reduction up to 25 percent, and two small localized areas with habitat reduction >25 percent. Habitat reduction in the GOA CEA, as a whole, averaged 1.4 percent from 2003 – 2016, with a maximum of 1.8 percent. The time trend is stable. Although the 10 percent threshold was not reached, correlation analyses were conducted on trends of habitat reduction and average size at age (3-15), and annual Von Bertalanffy function growth parameter estimates. Spawning success in this case was defined as the recruitment (age-2) estimated from the stock assessment model that survived to join the adult population. It was assumed that total (feeding) and spawning biomass across time are proportional to spatial distribution contraction/expansion. No analysis were significant at $p<0.1$. Overall, the proportion of habitat disturbed in the GOA CEA is minimal (<5 percent), and due to low habitat impacts on GOA POP, no changes to management are recommended at this time.

3.3.19 Rex sole

Although rex sole is assessed as a Tier 5 stock, an age-structured stock assessment exists and biomass reference points are thought to be reliable. Therefore, GOA rex sole is above MSST. The effects of fishing on the GOA CEA are generally low, habitat reduction was less than 1 percent in most areas and less than 10 percent in nearly all areas. Some areas with habitat reduction of 10 – 60 percent exist near Kodiak Island. Habitat reduction in the GOA CEA, as a whole, was less than 2 percent in all months, and the 10 percent threshold was not reached. Habitat impacts on GOA Pacific ocean perch growth-to-maturity, spawning success, breeding success, and feeding success are not detectable. No changes to management are recommended at this time.

3.3.20 Sablefish

Female spawning biomass is above $B_{35\%}$, so GOA sablefish are above MSST. The effects of fishing on the GOA CEA are low, and averaged less than 1 percent habitat reduction from2003 – 2016. The trend is stable. Habitat impacts on GOA sablefish growth-to-maturity, spawning success, breeding success, and feeding success are undetectable. No changes to management are recommended at this time.

3.3.21 Shortraker rockfish

Shortraker rockfish in the GOA are assessed as a Tier 5 stock, so MSST is undefined. The effects of fishing on the GOA CEA are low with habitat reduction less than 1 percent in most areas. There are small localized areas of higher habitat reduction (10-25 percent) corresponding to areas with shortraker rockfish bycatch. Habitat reduction in the GOA CEA, as a whole, averaged less than 1 percent from 2003 – 2016, and did not exceed 1.2 percent in any month. Habitat impacts on GOA shortraker rockfish growth-to-maturity, spawning success, breeding success, and feeding success are undetectable. No changes to management are recommended at this time.

3.3.22 Shortspine thornyhead

Shortspine thornyhead in the GOA are assessed as Tier 5 stock, so MSST is undefined. The effects of fishing on the GOA CEA are generally low, with less than 1 percent habitat reduction in most areas. There are small localized areas of higher habitat reduction (10-25 percent) corresponding to areas with shortspine thornyhead bycatch. Habitat reduction in the GOA CEA, as a whole, averaged less than 1 percente from 2003 – 2016, and did not exceed 1.1 percent in any month. Habitat impacts on GOA shortspine thornyhead growth-to-maturity, spawning success, breeding success, and feeding success are undetectable. No changes to management are recommended at this time.

3.3.23 Southern rock sole

Female spawning biomass is above $B_{35\%}$, so GOA southern rock sole are above MSST. The effects of fishing on the GOA CEA are generally low, with less than 2 percent habitat reduction in most areas. There are small localized areas of higher habitat reduction (>25 percent) corresponding to southern rock sole fishing grounds. Habitat reduction on the GOA CEA, as a whole, averaged 1.3 percent from 2003 – 2016, and did not exceed 1.5 percent in any month. No changes to management are recommended at this time.

3.3.24 Walleye pollock

Female spawning biomass is above $B_{35\%}$, so GOA walleye pollock are above MSST. The effects of fishing on the GOA CEA are generally low, with less than 5 percent habitat reduction in most areas. There are small areas of higher habitat reducdtion (>25 percent) distributed throughout the GOA shelf, particularly east of Kodiak Island in Area 630 in Barnabus and Chiniak Gullies, which are important fishing grounds for the Kodiak trawl fleet. Some areas of higher habitat reduction also occur near Sand Point, suggesting that areas closer to major fishing ports may experience higher levels of habitat reduction. Habitat reduction for the GOA CEA, as a whole, averaged 1.7 percent from 2003 – 2016. The average for area 630, where trawl impacts are highest, was 3 percent, and did not exceed 4.1 percent in any month. The time trend is stable, but there was an uptick in habitat reduction in area 630 in spring 2008, which may be associated with increased effort due to the central GOA rockfish pilot program. Although the 10 percent threshold was not reached, correlation analysis was conducted for the trend in habitat reduction in areas 610-630 with the weight at age anomaly from the Shelikof Strait acousitic survey, log recruitment, and the length at 50 percent mature from the Shelikof Strait acoustic survey. Because the Shelikof Strait survey occurs in the beginning of the year, habitat impacts were correlated with the indicator from Shelikof Strait in the following year, Similarly habitat impacts were correlated with estimated recruitment in the following year. Results indicate a positive correlation between the proportion of habitat disturbed and the weight at age anomaly ($p=0.12$), but no obvious relationship for log recruitment (p=0.99), and the length at 50 percent mature (p=0.61). Interestingly, the correlation between habitat impacts and the weight at age anomaly is relatively strong and positive. However, since both time series are strongly autocorrelated, the p-value almost certainly overstates the strength of the relationship. Because none of the p-values were less than 0.1, habitat impacts on GOA pollock growth-to-maturity, spawning success, breeding success, and feeding success are not detectable. No changes management are recommended at this time.

3.3.25 Yellow Irish lord

Yellow Irish lord in the GOA are assessed as a Tier 5 stock, so MSST is undefined. The effects of fishing on the GOA CEA are generally low, with less than 2 percent habitat reduction. The area of highest impact is reporting area 630, an area of high fishing effort for wally pollock and flatfish. Habitat reduction for the GOA CEA, as a whole, averaged 1.7 percent from 2010 – 2016. Habitat impacts on GOA yellow Irish lord growth-to-maturity, spawning success, breeding success, and feeding success are not detectable. No changes to management are recommended at this time.

3.3.26 Yellowfin sole

Yellowfin sole in the GOA are part of the shallow-water flatfish complex which is assessed in Tier 5, so MSST is undefined. The effects of fishing on the GOA CEA are generally low, and averaged less than 1 percent habitat reduction from 2003 – 2016. No changes to management are recommended at this time.

3.3.27 GOA summary

None of the groundfish stocks in the Gulf of Alaska are below MSST. There are small, localized areas where habitat impacts are greater than 10 percent for some species, but for the CEA as a whole, habitat reduction was below 10 percent for all GOA groundfish species. Analyses of correlations between trends in habitat reduction and indices of growth-to-maturity, spawning success, breeding success, and feeding success were conducted for a few species, none of the correlations were significant at $p \leq 0.1$. None of the stock assessment authors concluded that habitat reduction within the CEA was affecting groundfish stocks. Representatives of the GOA Groundfish Plan Team concurred with the authors' assessments. No changes to management measures were recommended for any GOA groundfish stock.

Table 4 Summary of stock assessment author evaluations of the effects of fishing on EFH for groundfish in the Gulf of Alaska

	Stock < MSST	Average %CEA Disturbed	Cumulative %CEA Disturbed	Management Change
Alaska plaice	NA	0.4	0.3	N
Alaska skate	NA	1.5	1.2	N
Aleutian skate	NA	1.3	1.0	N
Arrowtooth flounder	N	1.5	1.1	N
Atka mackerel	NA	1.4	0.9	N
Bering skate	NA	1.4	1.0	N
Bigmouth sculpin	NA	1.5	1.1	N
Blackspotted rockfish	N	1.1	0.9	N
Dover sole	N	1.0	0.7	N
Dusky rockfish	N	2.1	1.3	N
Flathead sole	N	1.6	1.3	N
Great sculpin	NA	1.1	0.9	N
Greenstriped rockfish	NA	1.5	1.1	N
Harlequin rockfish	NA	0.6	0.5	N
Northern rock sole	N	1.0	0.7	N
Northern rockfish	N	1.4	0.9	N
Octopus	NA	1.5	1.2	N
Pacific cod	N	1.8	1.4	N
Pacific ocean perch	N	1.4	1.0	N
Pygmy rockfish	NA	1.4	1.0	N
Quillback rockfish	NA	1.3	1.0	N
Redbanded rockfish	NA	1.4	1.0	N
Redstriped rockfish	NA	1.5	1.1	N
Rex sole	N	1.3	1.0	N
Rosethorn rockfish	NA	1.4	1.1	N
Sablefish	N	1.2	0.9	N
Sharpchin rockfish	NA	1.4	1.1	N
Shortraker rockfish	NA	0.8	0.6	N
Shortspine thornyhead	NA	0.7	0.6	N
Silvergray rockfish	NA	0.2	0.2	N
Southern rock sole	N	1.3	1.0	N
Walleye pollock	N	1.5	1.1	N
Yellow Irish lord	NA	1.8	1.4	N
Yelloweye rockfish	NA	1.4	1.1	N
Yellowfin sole	NA	0.7	0.5	N

3.4 Crab

Commercial crab species in the Bering Sea and Aleutian Islands Fishery Management Plan are managed (OFL, ABC, and TAC) at a stock level, so EFH (and the CEA for this analysis) was also identified at the stock level over the assessed portion of the eastern Bering Sea. For the analysis below, stock assessment authors analyzed the crab stock relative to MSST and the CEA for each stock. For some stocks data are not available for stock biomass due to a lack of available fishery independent data. Also for some stocks fishing effects assessments on habitat are not available due to limited stock distribution or fishery data available in the region specific to the crab stock. Future EFH reviews will require additional data to adequately assess CEA habitat disturbance for those species.

3.4.1 Pribilof Island blue king crab

The mature male biomass for the Pribilof Island blue king crab stock is projected to be 233 t, while MSST is 2,058 t. Therefore, *Pribilof Island blue king crab are below MSST*. However, habitat reduction in the total CEA, as well as directly around the Pribilof Islands, appears to be, and has been less than 1 percent. Thus, it is unlikely that habitat reduction due to commercial fishing plays a role in the decline of the Pribilof Island blue king crab stock. Additionally, the Pribilof Islands Habitat Conservation Zone is closed to fishing with either non-pelagic trawl gear or Pacific cod gear. Therefore, no changes to management are recommended at this time.

3.4.2 St. Mathew Island blue king crab

The mature male biomass for the St. Matthew Island blue king crab is estimated to be 2,230 t in 2017, while the proxy for MSST is 1,840 t. Therefore, the St. Matthew Island blue king crab stock is above MSST. Habitat reduction due to commercial fishing in the St. Matthew blue king crab CEA did not exceed 1 percent from 2003 – 2016. No changes to management of essential fish habitat are recommended at this time.

3.4.3 Bristol Bay red king crab

The mature male biomass for Bristol Bay red king crab was estimated to be 24,000 t in 2017, while the proxy for MSST was 12,890 t. Therefore, the Bristol Bay red king crab stock is above MSST. Habitat reduction due to commercial fishing in the Bristol Bay red king crab CEA, did not exceed 5 percent from 2003 – 2016. However, the most critical area for Bristol Bay red king cab spawning is in southern Bristol Bay, where habitat reduction exceeded 10 percent. The stock assessment author suggests that additional analysis is required for Bristol Bay red king crab to adequately assess potential changes needed for this stock.

3.4.4 Pribilof Islands red king crab

The mature male biomass for Pribilof Islands red king crab was estimated to be 6,980 t in 2017, while the proxy for MSST was 2,760 t. Therefore, the Pribilof Islands red king crab stock is above MSST. Habitat reduction due to commercial fishing in the Pribilof Islands red king crab CEA, did not exceed 5 percent from 2003 – 2016. The Pribilof Islands Habitat Conservation Zone is closed to fishing with either non-pelagic trawl gear or Pacific cod gear. Therefore, no changes to management of essential fish habitat are recommended at this time.

3.4.5 Bering Sea snow crab

The current male mature biomass for Bering Sea snow crab was estimated to be 91,600 t, while MSST was 75,800 t. Therefore, Bering Sea snow crab are above MSST. Habitat reduction for the Bering Sea snow crab CEA has not exceeded 5 percent from 2003 – 2016. No changes to management are recommended at this time.

3.4.6 Norton Sound red king crab

The mature male biomass for Norton Sound red king crab was estimated to be 2,660 t in 2017, while the proxy for MSST was 1,090 t. Therefore, the Norton Sound red king crab stock is above MSST. An assessment of habitat reduction due to commercial fishing is not available for Norton Sound red king crab because of limited data available on fishing effort. No changes to management of essential fish habitat are recommended at this time but it is recommended that stock authors and analysist work to identify fishing data that may complete a future analysis on the effects of fishing on Norton red king crab habitat.

3.4.7 Western Aleutian Islands red king crab

The mature male biomass and MSST for Western Aleutian Islands red king crab are unknown and only historical catch data are available for status of the stock. An assessment of habitat reduction due to commercial fishing is not available for Western Aleutian Islands red king crab because of limited data available on fishing effort. No changes to management of essential fish habitat are recommended at this time but it is recommended that stock authors and analysist work to identify fishing data that may complete a future analysis on the effects of fishing on Western Aleutian Islands red king crab habitat.

3.4.8 Aleutian Islands golden king crab

The mature male biomass and MSST for Pribilof Islands golden king crab are unknown and only historical catch data are available for status of the stock. Habitat reduction in the Aleutian Islands golden king crab CEA did not exceed 5 percent from 2003 – 2016. No changes to management of essential fish habitat are recommended at this time.

3.4.9 Pribilof Islands golden king crab

The mature male biomass and MSST for Pribilof Islands golden king crab are unknown and only historical catch data are available for status of the stock. An assessment of habitat reduction due to commercial fishing is not available for Pribilof Islands golden king crab because of limited data available on fishing effort. No changes to management of essential fish habitat are recommended at this time but it is recommended that stock authors and analysist work to identify fishing data that may complete a future analysis on the effects of fishing on Pribilof Islands golden king crab habitat.

3.4.10 Bering Sea snow crab

The mature male biomass for Bering Sea snow crab was estimated to be 96,100 t in 2017, while the proxy for MSST was 75,800 t. Therefore, the Bering Sea snow crab stock is above MSST. Habitat reduction for the Bering Sea snow crab CEA did not exceed 5 percent from 2003 – 2016. No changes to management of essential fish habitat are recommended at this time.

3.4.11 Bering Sea Tanner crab

The current mature male biomass for Bering Sea Tanner crab was estimated to be 45,340 tons in 2017, while the proxy for MSST was 12,825 t. Therefore, the Bering Sea Tanner crab stock is above MSST. Habitat reduction for the Bering Sea Tanner crab CEA did not exceed 9 percent from 2003 – 2016. Because habitat reduction did not exceed 10 percent in the CEA, no changes to management of essential fish habitat are recommended at this time.

3.4.12 Crab summary

Pribilof Islands blue king crab is the only stock below MSST at this time. None of the crab stocks habitat reduction within the CEA was greater than 10% when appropriate data was available to make the assessment. Representatives of the BSAI Crab Plan Team concurred with the authors’ assessments and no changes to management of essential fish habitat were recommended for any fisheries. However, the BSAI Crab Plan Team noted that future efforts need to assess the importance of smaller local habitat scales on overall stock health especially when you have areas showing >50% habitat reduction even though the overall habitat reduction average is <10% (e.g. southwest Bristol Bay).

Table 5 Summary of stock assessment author evaluations of the effects of fishing on EFH for crabs in the Bering Sea and Aleutian Islands

	Stock < MSST	Average % CEA Disturbed	% CEA Disturbed Nov 2016	Management Change
Pribilof Islands blue king crab	Y	<1.0	0.7	N
St. Matthew blue king crab	N	<1.0	0.2	N
Bristol Bay red king crab	N	<5.0	2.9	N
Pribilof Islands red king crab	N	<1.0	0.4	N
Norton Sound red king crab	N	NA	NA	N*
Western Aleutian Islands red king crab	NA	NA	NA	N*
Aleutian Islands golden king crab	NA	<5.0	2.1	N
Pribilof Islands golden king crab	NA	NA	NA	N*
Snow crab	N	<5.0	0.8	N
Tanner crab	N	<9.0	5.1	N

* Recommend future work with analysts to identify data available for GAM and FE analysis

4 Conclusion

The MSA requires regional Fishery Management Councils to describe and identify EFH for all species managed under a FMP, and to minimize to the extent practicable the adverse effects of fishing on EFH. This paper presents the results of the stock assessment authors' review of the effects of fishing on EFH for their species of interest. None of the stock assessment authors concluded that habitat reduction within the CEA for their species was affecting their stocks in ways that were more than minimal or not temporary. None of the authors recommended any change in management with regards to fishing within EFH.

5 Document preparation

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Review of BSAI and GOA groundfish EFH

Coordinated by Sandra Lowe, Dan Ito, Phil Rigby, Jon Heifetz
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Review of BSAI king and Tanner crab EFH
Coordinated by Robert Foy and Karla Bush

Reviews by Matt Eagleton, Robert Foy, Chris Long, Doug Pengilly, Lou Rugolo, William Stockhausen, Kathy Swiney, Jack Turnock, Jie Zheng

Preparation of Fishing Effects model

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