Chapter 1A: Assessment of the pollock stock in the Aleutian Islands

Steve Barbeaux, James Ianelli, Ivonne Ortiz, and Ned Laman

Alaska Fisheries Science Center, National Marine Fisheries Service
National Oceanic and Atmospheric Administration
7600 Sand Point Way NE., Seattle, WA 98115-6349

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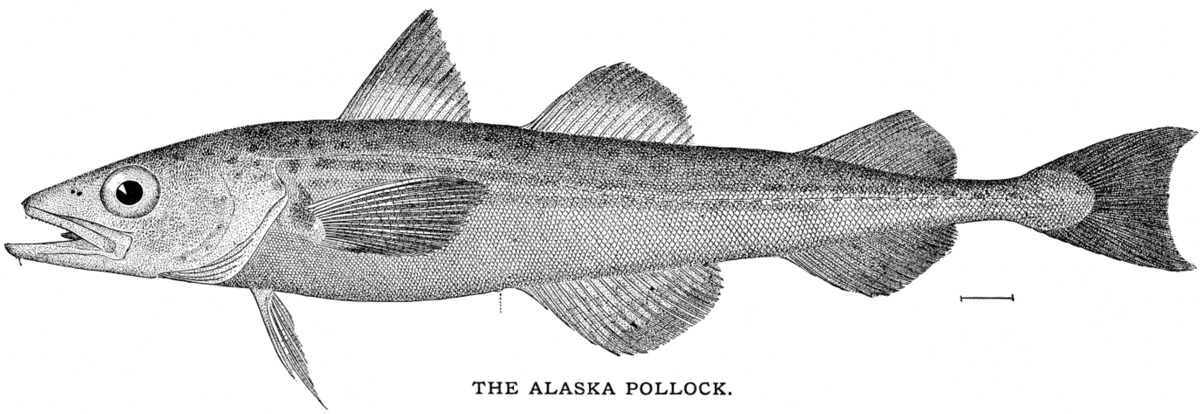


THE ALASKA POLLOCK.

Executive Summary

Model 15.1 (same as the 2015 accepted model) is presented for ABC/OFL advice. The 2021 Aleutian Islands bottom trawl survey index value, 2020-2021 fishery age composition, and updated 2021 and 2022 fishery catch estimates comprised the new data for this year's assessment. Total 2021 catch in the AI was 1,839 t, and as of September 27 the 2022 catch was at 2,709 t.

Summary of Changes in Assessment Inputs

Relative to last year's assessment, the following changes have been made in the current assessment:

Summary of changes in assessment inputs

- Catches for 1978 to 2022 were updated to latest estimates from the catch accounting system (CAS). There were no significant changes except the addition of the 2022 estimate at 3,000 t. 2022 AI bottom trawl survey index estimate was added.
- 2019 and 2020 fishery age composition data were added.
- All survey age composition data prior to 1991 were removed from the model to be consistent with the use of Aleutian Islands bottom trawl survey data prior to 1991.

Summary changes in the assessment model

- There were no changes to the recommended model for ABC/OFL advice. However, for comparison Model 15.2 configuration was again presented which allows for differential natural mortality (*M*) with age. In this configuration, natural mortality for ages 1, 2, and 15 were modeled as deviations from the natural mortality for ages 3-14 fit with a log normal prior on *M* with a mean of 0.2 and CV of 0.2.

Summary of Results

Quantity	As estimated or *specified last* year for: 2022	2023	As estimated or *recommended this* year for: 2023	2024*
M (natural mortality rate)	0.21		0.21	
Tier	3a		3a	
Total (age 1+) biomass (t)	308,525	330,375	264,173	281,618
Female spawning biomass (t)				
Projected	89,516	87,650	78,628	80,432
$B_{100\%}$	185,475		174,218	
$B_{40\%}$	74,190		69,687	
$B_{35\%}$	64,916		60,976	
F_{OFL}	0.390	0.390	0.380	0.380
$maxF_{ABC}$	0.313	0.313	0.305	0.305
F_{ABC}	0.313	0.313	0.305	0.305
OFL (t)	61,264	61,379	52,383	52,043
maxABC (t)	50,752	50,825	43,413	43,092
ABC (t)	50,752	50,825	43,413	43,092
Status	As determined *this* year for: 2020	2021	As determined *this* year for: 2021	2022
Overfishing	no	no	no	n/a
Overfished	n/a	n/a	n/a	no
Approaching overfished	n/a	n/a	n/a	no

* Projection based on estimated catches of 3,000 t for 2022 and 1,670 t for 2023, the five-year average *F* (2017-2021) of 0.026, used in place of maximum permissible ABC .

** Long-term equilibrium F_{OFL} and F_{ABC} were 0.380 and 0.305, respectively.

The stock is not being subject to overfishing, is not currently overfished, nor is it approaching a condition of being overfished. The tests for evaluating these three statements on status determination require examining the official total catch from the most recent complete year and the current model projections of spawning biomass relative to $B_{35\%}$ for 2021 and 2022. The official total catch for 2021 was 1,840 t which is a small fraction of the 2021 OFL of 61,856 t; therefore, the stock is not being subjected to overfishing. The estimates of spawning biomass for 2023 and 2024 from the current year (2022) projection model are 78,628 t and 80,432 t, respectively. The 2023 estimate is above $B_{35\%}$ at 60,976 t and the 2024 estimate is above ½ $B_{35\%}$ and the stock is expected to be above $B_{35\%}$ in 2034 under projection Scenario 7, therefore, the stock is not currently overfished nor approaching an overfished condition.

Responses to SSC and Plan Team Comments on Assessments in General

December 2021 SSC

Assessment authors should evaluate the risk of the ABC exceeding the true (but unknown) OFL and whether a reduction from maximum ABC is warranted, even if past TACs or exploitation rates are low.

That has been and will continue to be the consideration of the authors for AI pollock.

The SSC recommends that groundfish, crab and scallop assessment authors do not change recommendations in documents between the Plan Team and the SSC meetings.

No changes will be made to the recommendations in the document prior to the SSC meeting.

Response to SSC and Plan Team comments specific to this assessment

- There were no SSC or Plan Team comments specific to the AI pollock stock assessment.

Introduction

Walleye pollock (*Gadus chalcogrammus;* Coulson *et al.* 2006; Carr and Marshall 2008; here after pollock) are distributed throughout the Aleutian Islands (AI) with concentrations in areas and depths dependent on diel and seasonal migration. Although the population of pollock in the AI decreased in abundance from the mid-1980s to the mid-1990s (1986 bottom trawl survey estimate of 444,000 t to a 1994 bottom trawl survey estimate of 78,000 t). Since 1994 the abundance point estimate has been variable with substantial fluctuations in the population (Fig 1A.1). The 2012 survey abundance was a record low at 44,281 t. The 2014 survey abundance estimate at 85,316 t nearly doubled the 2012 estimate. The 2016 biomass estimate was similar to 2014 at 83,070 t, but the 2018 survey biomass estimate was double that of the previous survey at 165,747 t. The low 2012 estimate is thought to be anomalous due to the very low temperatures in the region affecting availability of the species to the bottom trawl survey. Due to COVID 19 restrictions there was no bottom trawl survey in 2020. The 2022 survey showed a decrease to 110,000t, however given the relatively high uncertainty of the estimates from this survey, the estimates have been relatively stable since 2014(CV between 0.24 and 0.47 since 2014). The precipitous decline between 1986 and 1991 may be in part due to undocumented fishing by foreign vessels claiming catch from the Central Bering Sea (CBS), as the documented fishing levels alone cannot account for the decline (Table 1A.1). A number of foreign fishing vessels were observed fishing in the AI during this time period (Egan 1988a; Egan 1988b) while claiming catch from the CBS. Since 2004 surveys show that the AI pollock population has been predominantly concentrated in the eastern portion of the Aleutian Island chain, closer to the Eastern Bering Sea shelf. Surveys from the 1980's and 1990's estimated higher proportions of pollock biomass in the central and western Aleutians (Table 1A.1). This spatial change in population abundance may reflect a spatial contraction of the stock in the Eastern Bering Sea after the collapse of the Central Bering Sea population in the early 1990's, low AI pollock recruitments since the mid 1980's, documented higher exploitation rate of the AI pollock in the mid- to late 1990's, and possibly a high undocumented exploitation rate in the late 1980's by foreign fishers.

The relationship between Aleutian Islands pollock and pollock from neighboring areas is poorly understood. Bailey *et al.* (1999) presented a review of the meta-population structure of pollock throughout the north Pacific region identifying possible meta-populations in the Eastern Bering Sea. At the time of that study, samples from the Aleutian Islands region were unavailable. Recent genetic studies, which includes samples from the Aleutian Islands near Adak Island, have shown a lack of genetic heterogeneity among Northeast Pacific and Bering Sea pollock samples (Grant *et al.* 2010). Grant *et al.* (2006) found and later confirmed (Grant *et al.* 2010) the greatest genetic differences occurred between samples from Asia and the Eastern North Pacific with mirror-image haplogroup clines between them. Grant *et al.* (2010) interpreted that the genetic differences across the Pacific Ocean and mirror-image haplogroup clines likely reflect divergence during ice-age isolations and subsequent expansion into the central North Pacific on each side with gene flow across the contact zone. The pollock in the AI therefore are most likely a mixed population from both Asian and North American and the result of re-colonization from both sides of the Pacific post ice-age.

Although the genetics evidence points to a mixed population, other evidence suggests that the AI pollock are separated from the EBS stock at smaller temporal time scales than current genetic techniques can identify, including disparate size at age and asynchrony in high recruitment events. It appears that the AI pollock are much more similar to the Gulf of Alaska (GOA) pollock than the EBS pollock in size at age, with the GOA pollock being significantly larger than the EBS fish and AI pollock being significantly larger than the GOA pollock (Figure 1A.2 from Barbeaux *et al.* 2016). This may be a latitudinal effect with the more southern AI pollock encountering a longer summer growing period. Similar latitudinal differences have been observed in both Pacific and Atlantic cod (Gadus *macrocephalus* and *morhua*; Ormseth and Norcross 2009). Although the AI and EBS shared some larger-than-the-mean (normalized at post-1979) recruitment events (1977, 1978, 1982, 1989, 2000, and 2011/2012) the AI shared more with the GOA (1976, 1977, 1978, 1985, 1989, 2000, and 2011/2012). All three regions shared five of these higher recruitment events (1977, 1978, 1989, 2000, and 2011/2012). In addition, the AI had unique high recruitment events in 1981, 1983, 1986, and 1987. Although the evidence is rather weak and not by any means conclusive, the size at age and asynchronous recruitments suggest some degree of separation between the EBS and the pollock of these three regions. In the stock structure presentation (Barbeaux et *al.* 2014) to the Council on Aleutian Islands pollock the Plan Team determined that the current management practices were of “little concern”.

For management purposes, the pollock population in the Eastern Bering Sea and Aleutian Islands (BSAI) has been split into three stocks. These stocks are: Eastern Bering Sea (EBS) pollock occupying the eastern Bering Sea shelf from Unimak Pass to the U.S.-Russia Convention line, Aleutian Islands (AI) pollock encompassing the pollock in the Aleutian Islands shelf region from 170°W to the U.S.-Russia Convention line; and the Central Bering Sea-Bogoslof Island (CBS-BI) pollock. These three management stocks probably have some degree of exchange. The CBS-BI stock is a group that forms a distinct spawning aggregation that has some connection with the deep water region of the Aleutian Basin. This stock assessment concentrates on the pollock of the Aleutian Islands and assumes that these fish are distinct enough from the CBS-BI and EBS meta-populations to model their dynamics separately.

Previously, Ianelli *et al.* (1997) developed a model for Aleutian Islands pollock and concluded that the spatial overlap and the nature of the fisheries precluded a clearly defined “stock” since much of the catch was removed very close to the eastern edge of the region and appeared continuous with catch further to the east. In some years, a large portion of the pollock removed in the Aleutian Islands Region was from deep-water regions and appeared to be most aptly assigned as CBS-BI pollock. Since 2003 these deep-water catches have been excluded from the stock assessment data and only the area designated as the Near-Rat-Andreanof Islands area (NRA) or the area closest to the Aleutian Islands have been used in the stock assessment (Fig 1A.2). In 2003 through 2007 the authors’ preferred stock assessment model excluded the fishery dependent data from east of 174°W longitude in the NRA. In 2007 a CIE review deemed the east-west data split as inappropriate and the authors’ preferred model has since included all fisheries dependent data from the entire NRA region.

Fishery

General description

The nature of the pollock fishery in the Aleutian Islands Region has varied considerably since 1977 due to changes in the fleet makeup and in regulations. During the late 1970s through the 1980s the fishing fleet was primarily foreign and joint venture (JV) where US catcher vessels delivered to foreign motherships. The last JV delivery was conducted in 1989 when the domestic fleet began operating in earnest. The distribution of observed catch differed between the foreign and JV fishery (1977-1989; Fig. 1A.3) and the domestic fishery (1989-2009). The JV and foreign fishery operated in the deep basin area extending westward to Bowers Ridge and in the eastern most portions of the Aleutian Islands. Some operations took place out to the west but observer coverage was limited. In the early domestic period (1991-1998) the fishery was more dispersed along the Aleutian Islands chain with no observed catches along Bowers Ridge and fewer operations in the deep basin area. The majority of catch in the beginning of the domestic fishery came from the eastern areas along the 170°W longitude line, and around Seguam Island in both Seguam and Amukta passes (Fig. 1A.3). As the fishery progressed more pollock were removed from the north side of Atka Island around 174°W and later near 177°W northwest of Adak Island inside Bobrof Island. While the overall catch level was relatively low, the domestic fishery moved far to the west near Buldir Island in 1998 (Table 1A.2). In 1999 the North Pacific Fishery Management Council (NPFMC) closed the Aleutian Islands region to directed pollock fishing due to concerns for Steller sea lion recovery.

Recent fishery performance

In 2003 the AI pollock quota was allocated to the Aleut Corporation and in 2005 the directed fishery was reopened. The fishery was still restricted to areas outside of 20 nm of Steller sea lion rookeries and haulouts, limiting fishing to two small areas with commercial concentrations of pollock within easy delivery distance to Adak Island. One area is a 4 mile stretch of shelf break located northwest of Atka Island between Koniuji Island and North Cape of Atka Island, the other is a 7 mile stretch located east of Nazan Bay in an area referred to as Atka flats. Bycatch of Pacific ocean perch (POP) can be very high in both these areas and it appears that pollock and POP share these areas intermittently; depending on time of day, season, and tide. Although there may be other areas further west that may have commercial concentrations of pollock, to date there have been no attempts by the reopened directed fishery to explore these areas.

Two catcher processor vessels attempted directed fishing for pollock in February 2005, but failed to find commercially harvestable quantities outside of Steller sea lion critical habitat closure areas and in the end removed less than 200 t of pollock. In addition, bycatch rates of POP were prohibitively high in areas where pollock aggregations were observed. The 2005 fishery is thought to have resulted in a net loss of revenue for participating vessels. Data on specific bycatch and discard rates for the 2005 fishery are not presented due to issues of data confidentiality.

In 2006 and 2007 the Aleut Corporation, in partnership with the Alaska Fisheries Science Center (AFSC), Adak Fisheries LLC and the owners and operators of the F/V Muir Milach, conducted the Aleutian Islands Cooperative Acoustic Survey Study (AICASS) to test the technical feasibility of conducting acoustic surveys of pollock in the Aleutian Islands using small (<32 m) commercial fishing vessels (Barbeaux and Fraser 2009). This work was supported under an exempted fishing permit that allowed directed pollock fishing within Steller sea lion critical habitat. A total of 932 t and 1,100 t of pollock were harvested during these studies in 2006 and 2007 respectively, and biological data collected during the studies were treated in the stock assessment as fishery data. In 2008, additional surveys of Aleutian Islands region pollock in the same area were conducted on board the R/V Oscar Dyson and in cooperation with the F/V Muir Milach; the work was funded through a North Pacific Research Board grant and less than 10 t of groundfish were taken for the study. In 2009 the directed pollock fishery in the Aleutian Islands region took 403 t, and 1,326 t were taken as bycatch in other fisheries, predominantly the Pacific cod and rockfish fisheries. In 2010 through 2012, financial problems with the Adak processing plant greatly hindered the directed fishery. In 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, and 2018 catches of 295 t, 0 t, 0 t, 145 t, 0 t, 54 t, 70 t, 0 t , and 235 t (respectively), were harvested in the directed fishery. In 2019 and 2020 an exempted fishing permit (EFP) allowed fishers to take up to 500 t of POP for the entirety of the fishing season instead of a 5% maximum per delivery. This allowed additional flexibility in 2019 the fishery was hindered by weather and the directed fishery catch remained low at 70 t, but in 2020 the fishery was more successful and 711 t was taken in the directed fishery. There was no directed pollock fishery in 2021 and as of October 11 there has been 217t of catch in the 2022 AI pollock fishery. Since 2005, except for years with EFPs (2006-2008, 2020) the majority of catch has been harvested in other fisheries, primarily the rockfish fisheries, but also Atka mackerel, flatfish, and Pacific cod fisheries (Table 1A.8). From 2000 to 2006 the most bycatch was in the Pacific cod fishery, in 2007 this switched to rockfish fisheries. An increase in catch in 2013 and 2014 was primarily in the arrowtooth flounder fishery. This fishery changed fishing tactics to fish more shallow than in previous years to avoid Greenland turbot bycatch. Table 1A.3 provides a history of ABC, OFL, TAC, and catch for Aleutian Islands pollock since 1991. Since 2005 the TAC has been constrained to 19,000 t or the ABC, whichever is lower, by statute.

Estimates of pollock discard levels have been available since 1990. During the years when directed fishing was allowed pollock discards represented a small fraction of the total catch (Table 1A.7).

Fishery proportion at age

From 1983 through 1987 the 1978 year class was predominant in the fishery (Fig. 1A.4). It wasn't until 1990s that the 1989 year class made up a larger proportion of the fishery catch at age data than the 1978 year class. Although the 1981 and 1983 year classes were large in comparison to recent recruitments, they were dwarfed by the 1978 recruitment event. There were insufficient age data collected from the fishery between 1988 and 1993, 1997, between 1999 and 2005, from 2009 to 2017 and 2019 onward to construct an age distribution.

The age data collected during the 2006-2008 AICASS (Barbeaux *et. al.* 2011) revealed that the 1999 and 2000 year class made up a large portion of the adult population and were relatively large recruitment events for all three study years compared to more recent recruitments for this stock. In 2008, the 1998 year class appeared to be larger than previous years, but this may be due to a high level of aging error as the agreement between age readers was only between 20.5% and 43.6% for this study. The low level of agreement between age readers compared to Bering Sea pollock was due to the high number of older fish in this stock and the low definition of the otolith annuli in the AI pollock. This has been a consistent problem for the AICASS data with aging agreement averaging less than 50% across all years of data. In 2018 there were 121 pollock otoliths collected and aged, this collection shows no substantially overly dominant year class, however the 2012 year class is the most prevalent cohort followed by the 2013 and 2009 cohorts (Fig. 1A.4A).

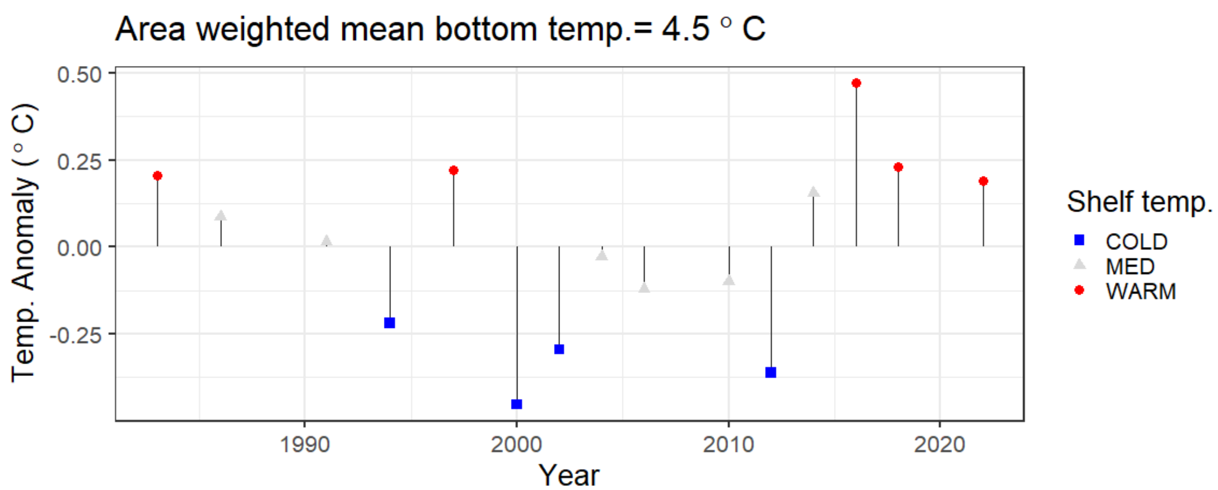
Surveys

Bottom trawl surveys

The National Marine Fisheries Service in conjunction with the Fisheries Agency of Japan conducted bottom trawl surveys in the Aleutian Islands region (from ~165°W to ~170°E) in 1980, 1983, and 1986. The Alaska Fisheries Science Center's Resource Assessment and Conservation Engineering Division (RACE) conducted bottom trawl surveys in this region in 1991, 1994, 1997, 2000, 2002, 2004, 2006, 2010, 2012, 2014, and 2016. The Aleutian Islands bottom trawl survey planned for 2008 was canceled due to budgetary constraints. The earlier cooperative survey biomass estimates are not comparable with biomass estimates obtained from the RACE trawl surveys because of differences in the nets, fishing power of the vessels, and sampling design. In the early surveys, biomass estimates were computed using relative fishing power coefficients (RFPC) and were based on the most efficient trawl during each survey. Such methods result in pollock biomass estimates that are higher than those obtained using the standard methods employed in the RACE surveys. In the NRA area, the early survey (1980-1986) abundance ranged from 267 to 440 thousand tons and the later surveys (1991-2014) ranged from 44 to 175 thousand tons (Table 1A.4) with a peak in survey abundance in 2002. Plots of CPUE by tow show the relative distribution of pollock to be variable between years and areas (Fig. 1A.1 and Fig. 1A.5) but with an obvious decreasing trend in the Western and Central AI.

The RACE Aleutian Islands bottom trawl (AIBT) surveys prior to 2004 indicated that most of the pollock biomass was distributed roughly equally between the Eastern (541) and Central Aleutian Islands area (542). Since 2004 there has been a shifting of the center of abundance to the east (Barbeaux *et al.* 2016) The 2012, 2014, 2016, and 2018 surveys again show little pollock in the NRA. The general trend for the 2002 through 2022 pollock distribution is a low level of pollock abundance in the Central and Western Aleutians with a more abundant, but patchy distribution of pollock in the Eastern Aleutians resulting in highly imprecise survey estimates. Although the largest proportion of the pollock biomass in the 2012 through 2016 surveys were observed in the Eastern Aleutians (Area 541), the surveys did not find large concentrations of pollock in the east as it had in the previous three surveys. The 2018 survey saw a more than doubling of pollock biomass in the Eastern Aleutians from 59,119 t in 2016 to 122,291 t in 2018 and dropped somewhat in 2022 to 90,473t. The central Aleutian Islands areas also saw a large increase from 9,404 t to 27,553 t from 2016 to 2018. The Western Aleutians also saw a slight increase from 14,787 t to 15,902 t. The overall 2018 survey estimate was 165,747 t, a 99.5% increase from 2016 (Fig. 1A.1). The increase in biomass was not proportional for all areas with the central Aleutians showing the highest proportional increase in biomass a 193% increase. Due to COVID 19 restrictions in 2020 there was no AI bottom trawl survey. The 2022 bottom trawl survey observed a decrease in pollock biomass in all three regions with an overall decrease of 34% down to 110,110 t. The decrease in the west was proportionally the greatest at -63%, next in the central at -50%. and the east at -26%.

Bottom temperatures increased from 2014 to 2016, with 2016 having the highest overall temperature in the time series. 2018 and 2022 temperatures decreased slightly, but remained warm for the time series. The bottom temperature anomaly for AI bottom trawl survey 1980-2022 with temperatures weighted by size of AI survey strata are shown below. In this figure "warm" is greater than and "cold" is less than 1 standard deviation from the mean. The warming started in 2014 peaked in 2016 and continues to be warm through 2022.



Survey proportion at age and length frequencies

The survey age composition data from 1991 through 1997 are inconsistent. The 1991 survey age data have high 1988 and 1987 year classes, the 1994 and 1997 surveys however have a large 1989 year class. The 1993 year class is large in the 1994 and 1997 surveys, The 1997 through 2004 surveys don't show any consistent dominant year class, while the 2006 through 2012 survey age data show the 1999 and 2000 year classes as dominant (Fig. 1A.4 and Table 1A.5). The 2010 survey had a large age-1 mode (2009 year class. The 2012 survey had a dominant age-1 mode (2011 year class) and a smaller age-6 mode (2006 year class). The age-1 mode continued into 2014 as a dominant age-3 mode, and the age-6 mode (2006 year class) appears to have split into a pair of high age-7 and age-8 modes (2006 and 2007 year class). This is likely due to aging error either with age-6s in 2012 or the 7 and 8s in 2014. The 2016 age composition data shows a large 2012 year class, the 2015 year class at age-1 also appears to be large. In 2018 the 2012 cohort was dominant and matches that observed in the fishery. The AIBTS weight-at-age data are presented in Table 1A.6. The 1991 survey age data is questionable since most of the age data were collected in only a few survey hauls in the Western Aleutians area. For this reason the 1991 age composition data have been down-weighted in the stock assessment model.

The length data for the 1980 through 2018 surveys are shown in Figure 1A.6. The 2010, 2012, and 2016 size composition show a higher proportion of fish < 20 cm than has been typical for the Aleutian Islands area. The 2014 survey had a very large mode between 20 and 40 cm which appears to correlate with a large 2011 year class at age 3. This mode continues into the 2016 data, but at much lower proportion and now appears to be assigned to the 2012 year class. The 2016 survey has four separate modes in the length data with the 2006 year class as fish between 50 and 70 cm, a 2012 year class at between 40 and 50 cm, and another large model between 10 and 20 cm which would correlated with a 2015 year class. The 2018 survey length composition shows few fish less than 40cm, but with the main mode being at between 45 and 65 cm, indicative of the 2012 year class also identified in the 2016 survey data and 2018 fishery data.

Note that although otoliths were collected in the 2022 survey, these have not yet been analyzed.

Other Surveys

In addition to the bottom trawl survey there has been one echo integration-trawl survey in a portion of the NRA. The R/V Kaiyo Maru conducted a survey between 170°W and 178°W longitude in the winter of 2002 after completing a survey of the Bogoslof region (Nishimura *et al.* 2002). Due to difficulties in operating their large mid-water trawl on the steep slope area, they determined that their biological sampling in this area were insufficient for accurate species identification and biomass estimation.

In 2006 and 2007, acoustic survey studies were completed in the central Aleutian Islands region aboard a 32m commercial trawler (F/V Muir Milach) equipped with a 38 kHz SIMRAD ES-60 acoustic system. The Aleutian Islands Cooperative Acoustic Survey Study (AICASS) was conducted to assess the feasibility of using a small commercial fishing vessel to estimate the abundance of pollock in waters off the central Aleutian Islands. In 2008 this survey was expanded to include the R/V Oscar Dyson to survey the same area as the F/V Muir Milach. The results of the 2006 survey are presented in an AFSC Technical Memorandum (Barbeaux and Fraser 2009) and the 2007 survey results were described in the 2009 Aleutian Islands pollock stock assessment (Barbeaux *et al.* 2009). In summary, both surveys were able to conduct scientific quality acoustic surveys in the Aleutian Islands during the winter months using commercially available echosounders and a commercial fishing vessel. In 2006 there was a high degree of variability between surveys due to the small area being surveyed, pollock movement, and potential overlap with the fishery being conducted during the survey period. In 2007 the spatial distribution of pollock varied between surveys with pollock abundance decreasing in an area inside Boborof Island near Ship Rock and in an area north of Atka Island known as the Knoll and increasing elsewhere in the study area.

The 2008 AICASS was conducted to investigate whether cooperative biomass assessments and surveys could be an effective way to manage fisheries at the local scales that are important to predators such as Steller sea lions. The study included two acoustic surveys one conducted by the R/V Oscar Dyson and the other by the F/V Muir Milach. The first acoustic survey conducted 16-29 February by the R/V Oscar Dyson between 173° W and 178° W resulted in a pollock biomass estimate of 36,135 t for the surveyed area. The second survey conducted 23-27 March between 174.17°W and 178° W resulted in a biomass estimate of 29,041 t. For the same area the R/V Oscar Dyson survey had a biomass estimate of 27,128 t, each of the estimates for the smaller area are within the margin of error of the other. The later F/V Muir Milach survey showed fewer pollock in the Tanaga area and more pollock in the Knoll area. The size of the pollock from the two 2008 surveys were consistent with each other with a mode between 60 and 65 cm, but were larger than the pollock observed in the 2006 and 2007 surveys (See Fig. 1A.9 in Barbeaux *et al.* 2013).

Data

This section describes data used in the current assessment. It does not attempt to summarize all available data pertaining to walleye pollock in the Aleutian Islands. Descriptions of the trends in these data were provided above in the pertinent sections.

Source	Data	Years
NMFS AI Bottom Trawl Survey (AI.BIOMASS_INPFC)	Survey Biomass	1991, 1994, 1997, 2000, 2002, 2004, 2006, 2010, 2012, 2014, 2016, 2018, 2022
NMFS AI Bottom Trawl Survey (RACEBASE.SPECIMEN)	Survey Age Data	1991, 1994, 1997, 2000, 2002, 2004, 2006, 2010, 2012, 2014, 2016, 2018,
AKFIN Domestic Blend (COUNCIL.COMPREHENSIVE_BLEND_CA)	Total Catch	1991-2022
Ianelli *et al.* 2001	Total Catch	1978-1990
Observer Program (OBSINT.DEBRIEFED_AGE)	Fishery Age Data	1978-1987, 1994-1996, 1998, 2018
AICASS	Fishery Age Data	2006 - 2008

Fishery

Catch estimates

Estimates of pollock catch in the Aleutian Islands Region are derived from a variety of data sources (Table 1A.1). The foreign-reported database (held at AFSC) is the main source of information for the early period catches, and was used to derive the official catch statistics until about 1980 when the observer data were introduced to provide more reliable estimates. The foreign and joint-venture (JV) blend data take into account observer data and reported catches and formed the basis of the official catch statistics until 1990. The NMFS Observer data are the raw observed catch estimates and provide an indication of the amount of catch observed relative to the current estimates from the blend data. The foreign reported catch database was used to partition catches among areas for the period 1977-1984, and the observer data were used to apportion catches from 1985-1990 These proportions were then expanded to match the total catch. The Alaska Fisheries Information Network (AKFIN) provides the Domestic Blend data for 1991-2020. Estimates of pollock discard levels have been available since 1990. During the years when directed fishing was allowed pollock discards represented a small fraction of the total catch (Table 1A.7). The majority of catch in the last 11 years has been as bycatch in other target fisheries (Table 1A.8).

Fishery age composition

Otoliths, weight, and length samples were collected through shore-side sampling and by at-sea observers. The number of age samples and length samples were highly variable (Table 1A.9 and Table 1A.10) and sampling effort in the directed fishery was very low after 1998 through 2017. The age composition data collected in the 2006, 2007, and 2008 AICASS were used as fishery data. Estimates of the catch-age compositions used in this assessment are shown in Table 1A.11. Fishery average weights-at-ages are provided in Table 1A.12.

Surveys

NMFS Aleutian Islands Bottom Trawl Survey

Abundance Estimates

Design-based, area-swept estimates of total biomass (tons) used in the assessment models examined this year are shown in Table 1A.4 and Fig. 1A.1, together with their respective coefficients of variation. Note that the surveys prior to 1991 were not used in this assessment.

Age Composition

Design-based estimates of the age compositions up to age 15+ from the bottom trawl surveys for the years 1983-2022 are shown in Table 1A.5. Note that survey age composition data prior to 1991 were not used in this assessment.

Analytic Approach

The 2022 Aleutian Islands walleye pollock stock assessment uses the same modeling approach since 2015; implemented through the Assessment Model for Alaska (here referred to as AMAK). AMAK is a variation of the "Stock Assessment Toolbox" model presented to the Plan Team in the 2002 Atka mackerel stock assessment (Lowe *et al.* 2002), with some small adjustments to the model and a user-friendly graphic interface.

The abundance, mortality, recruitment, and selectivity of the Aleutian Islands pollock were assessed with a stock assessment model constructed with AMAK as implemented using the ADMB software. The ADMB is a C++ software language extension and automatic differentiation library. It allows for estimation of large numbers of parameters in non-linear models using automatic differentiation software developed into C++ libraries (Fournier 1998). The optimizer in ADMB is a quasi-Newton routine (Press *et al.* 1992). The model is determined to have converged when the maximum parameter gradient is less than a small constant (set to 1×10^{-7}). A feature of ADMB and AMAK is that it includes post-convergence routines to calculate standard errors (or likelihood profiles) for quantities of interest.

Model structure

AMAK models catch-at-age with the standard Baranov catch equation. The population dynamics follows numbers-at-age over the period of catch history with natural and age-specific fishing mortality occurring throughout the age groups that are modeled (ages 1-15+). Age-1 recruitment in each year is estimated as deviations from a mean value expected from an underlying stock-recruitment curve. Model 15.1 estimates natural mortality across all ages. Model 15.2 estimates natural mortality as a vector of deviations from the mean (see *Natural Mortality* in the Parameters Estimated Inside the Assessment Model section below for more detail). For all models, deviations between observations and expected values are quantified with a specified error model and cast in terms of a penalized log-likelihood. This overall log-likelihood (L) is the weighted sum of the calculated log-likelihoods for each data component and model penalties. The component weights are inversely proportional to the specified (or in some cases, estimated) variances. Appendix A Tables 1–3 provide a description of the variables used, and the basic equations describing the population dynamics of Aleutian Islands pollock and likelihood equations. The models presented have remained the same since 2015and described in Barbeaux *et al.* (2015).

The quasi[1] likelihood components and the distribution assumption of the error structure are given below:

Likelihood Component	Distribution Assumption
Catch biomass	Lognormal
Catch age composition	Multinomial
Survey catch biomass	Lognormal
Survey catch age composition	Multinomial
Recruitment deviations	Lognormal
Stock recruitment curve	Lognormal
Selectivity smoothness (in age-coefficients, survey and fishery)	Lognormal
Selectivity change over time (fishery only)	Lognormal
Priors (where applicable)	Lognormal

The age-composition components are heavily influenced by the sample size assumptions specified for the multinomial likelihood. In this year's model the multinomial sample sizes for the fishery were calculated as the minimum of the number of sampled hauls or 100 plus the number of sampled hauls divided by the mean number of sampled hauls. A value of 100 was specified for survey catch-at-age data.

Fishery data*	Year	1978	1979	1980	1981	1982	1983	1984	1985	1986
	$\dot{N}_{i,\bullet}$	100	33	100	100	101	101	104	102	101
	Year	1987	1988	1991	1992	1993	1994	1995	1996	1997
	$\dot{N}_{i,\bullet}$	101	101	101	103	103	103	103	103	101
	Year	1998	2006	2007	2008	2018				
	$\dot{N}_{i,\bullet}$	101	100	100	100	100				
Survey data	Year	1991	1994	1997	2000	2002	2004	2006		
	$\dot{N}_{i,\bullet}$	1**	100	100	100	100	100	100		
	Year	2010	2012	2014	2016	2018				
	$\dot{N}_{i,\bullet}$	100	100	100	100	100				

*2006, 2007, and 2008 effective sample sizes were set at 100 for this assessment

**The 1991 values were down-weighted because the samples collected in these years were not representative of the region considered.

Parameters Estimated Outside the Assessment Model

Weight-at-age

We estimated weight-at-age separately for the survey and fishery. We obtained survey estimates from AIBT surveys and computed fishery estimates from observer data and the 2006-2008 AICASS. The fishery weight-at-age values from 1978 to 2022 are given in Table 1A.9 and the survey weight-at-age values are given in Table 1A.12 and Table 1A.13. All weight-at-age by year values were estimated using generalized additive models with time and age as the independent variables (Barbeaux *et al.* 2011). For the time component, five periods were defined (F1 = 1978-1984, F2= 1985-1989, D1=1990-1994, D2=1995-1998, D3=1999-2022). These periods correspond to the following fisheries: early foreign (F1), late foreign and joint venture (F2), early domestic (D1) late domestic (D2), and the recent period of

[1] The likelihood is *quasi* because model penalties (e.g., non-parametric smoothers) are included.

mainly pollock as bycatch (D3). Weight-at-age values are important since they convert model estimated catch-at-age (in numbers) to estimated total annual harvests (by weight) and hence affect the measure of fishery impacts.

Maturity at Age

Prior to 2008, the maturity schedule developed for the Bering Sea by Wespestad and Terry (1984; Table 1A.14) was used. The CIE panel (at the 2007 Review) commented that given the differences in size-at-age there likely is a difference in maturity-at-age between the Bering Sea and Aleutian Islands. Since Aleutian Islands pollock size at age is more similar to that observed in the Gulf of Alaska (GOA) than in the Bering Sea and population density shares characteristics between these areas (steep slope, relatively narrow shelf areas) the maturity schedule from the GOA was adopted (Dorn *et al.* 2013). The difference is that maturation occurs at slightly older ages with 50% maturity at 4 - 5 years while the Bering Sea pollock reach 50% maturity at 3 - 4 years (Table 1A.15 and Fig. 1A.7).

Recruitment

We used an area-parameterized form of the Beverton-Holt stock recruitment relationship based on Francis (1992). Values for the stock recruitment function parameters α and β are calculated from the values of R_0 (the number of 0-year-olds in the absence of exploitation and recruitment variability) and the "steepness" (h) of the stock-recruit relationship. The "steepness" parameter is the fraction of R_0 to be expected (in the absence of recruitment variability) when the mature biomass is reduced to 20% of its pristine level (Francis 1992). As an example, a value of h = 0.7 implies that at 20% of the unfished spawning stock size will result in an expected value of 70% of the unfished recruitment level. The steepness parameter (h) was fixed at 0.7 and the recruitment variance (σ_R^2) was fixed at a value of 0.6 for both model runs. Since recruitment estimates arise from available age composition data, alternative values of h have little effect on historical estimates.

Parameters Estimated Inside the Assessment Model

Deviations between the observations and the expected values are quantified with a specified error structure. Lognormal error is assumed for estimates of survey and fishery catch, and a multinomial error structure is assumed for analysis of the survey and fishery age compositions. These error structures are used to estimate the following parameters conditionally within the model.

Fishing Mortality

Fishing mortality in all models was parameterized to be separable with both an age component (selectivity) and a year component. In all models selectivity is conditioned so that the mean value over all ages will be equal to one. To provide regularity in the age component, a smoothness penalty was imposed on abrupt changes in selectivity between ages using the sum of squared second differences. In addition, the age component parameters are assumed constant for the last 8 age groups (ages 8-15). Selectivity was allowed to change in temporal blocks for 1978-1989, 1990-1998, and 1999-2007, and 2008-2022. The 1990 change was selected for the change from a foreign to a domestic fishery, in 1999 the directed fishery for pollock was closed, and in 2005 the data were from the AICASS experimental fishery. Another change was implemented for 2008 when the arrowtooth flounder fishery increased and affected pollock bycatch patterns. However, age data are unavailable for pollock from these fisheries.

Survey Selectivity and Catchability

In both models presented for the bottom trawl survey, survey selectivity-at-age follows the parameterization similar to the fishery selectivity-at-age presented above but is time invariant. The selectivity-at-age relationship is modeled with a smoothed non-parametric relationship that can take on any shape (with penalties controlling the degree of change and curvature specified by the user) similar to how the fishery selected is modeled. As noted above, the model allows specification of the age-range over which the catchability parameter is applied. For Aleutian Islands pollock, ages 5-12 were selected to have the average catchability (factoring selectivity components) equal to the catchability parameter value.

In the 2004 Aleutian Islands pollock stock assessment, the focus of our analysis was to evaluate a key model assumption: the extent to which the NMFS summer bottom trawl survey catchability should be estimated by the available data (resulting in very high stock sizes), or constrained to be close to a value of 1.0 (implying that the area-swept survey method during the summer months reasonably applies to a fishery that will likely occur during the winter). Based on the dynamics and the lack of informative data to “anchor” the biomass estimates, (i.e., there is relatively little “depletion” of recent cohorts to inform historical stock size) the assumption of catchability equals 1.0 was retained.

Natural Mortality

For Model 15.1 natural mortality was estimated using a prior with a mean of 0.2 with a *CV* of 0.2. Results of previous assessments (Barbeaux *et al.* 2007) suggested that Aleutian Islands pollock are less productive than the Eastern Bering Sea stock and model fits suggest that *M* should be closer to 0.2 than the value of 0.3 used in the Eastern Bering Sea and Gulf of Alaska pollock assessments (Ianelli *et al.* 2009; Dorn *et al.* 2009). In Model 15.1 we assume a prior value of $M = 0.2$ based on the studies of Wespestad and Terry (1984) for the Central Bering Sea (Table 1A.14). Natural mortality can be reasonably estimated using the AICASS age data because steepness (*h*), the recruitment variance (σ_R^2), and survey catchability (*q*) are assumed to be known. Model 15.2 allows for age-specific natural mortality rates. An age-specific natural mortality has been used by Ianelli *et al.* (2013) for the Eastern Bering Sea pollock with a higher natural mortality rate for age 1 and 2. In this model we allowed different natural mortality for ages 1, 2, and 15. These were fit as lognormal offsets from natural mortality for ages 3 through 14. In Model 15.2 we fixed the shape of the natural mortality vector iteratively by running the model with different values for 1, 2, and 15, and evaluating the likelihood of each iteration. The best fit model had the lowest –log likelihood.

Results

Model Evaluation

Both Model 15.1 and Model 15.2 remain the same in structure since 2015. The only change this year was to remove the survey age composition data for the pre-1991 surveys.

Both models were configured with a survey catchability of 1.0 for ages 5-12, a stock recruitment steepness parameter (*h*) of 0.7 and recruitment variance (σ_R^2) of 0.6. Natural mortality for Model 15.1 was estimated using a prior with a mean of 0.2 and *CV* of 0.2. For Model 15.2 natural mortality was age-specific and fit for ages 1, 2, and 15 as deviations from the mean value fit for ages 3-14. For both models the aging error component of the models was configured as described by Ianelli *et al.* (2003) in the 2003 Bering Sea pollock stock assessment (Table 1A.16).

Model fit criteria results are shown in Table 1A.17 and key results are presented in Table 1A.18 and Figure 1A.9, Figure 1A.10, Figure 1A.11, Figure 1A.12, Figure 1A.13, and Figure 1A.14. Model 15.1 and Model 15.2 can be compared directly using likelihood methods (Table 1A.17 and Table 1A.18). Model 15.2 does not provide an improvement in fit, except a marginal improvement in recruitment. Similar to previous years, the model fit to the survey index was poor for all models (Fig. 1A.9), particularly for the 1991, 1994, and 2012 survey values. This is not surprising given the high level of variance in the survey point estimates, the high intra-annual variability of the estimates, and the fact that the survey estimates are from the summer while the fishery is conducted in the winter. Both models fit the 2018 survey estimate well. Neither model predicts the drop in biomass for 2022 observed in the survey, this is likely due to the high 2018 survey and relatively large uncertainty in the 2022 survey (CV= 0.47).

The fit to the survey age composition data was good for both models, except for the data prior to 1993 which, for sampling reasons, were given less weight than the following years (Fig. 1A.11). The fishery age-composition data (Fig. 1A.11) were not fit as well as the survey catch-at-age data, but the fits were still relatively good. Observed and model derived mean ages matched well for both models, except for the 1995 and 2006 fishery data and 1994 survey data (Fig. 1A.12). Fishery age data were highly variable which probably reflects the diversity in sampling locations for the fishery in different years. There doesn't appear to be any obvious or consistent patterns in the residuals for either the fishery or survey catch-at-age fits (Fig. 1A.13) for any of the models explored.

The mean natural mortality across all ages was similar for both models; 0.21 for Model 15.1 and 0.26 for Model 15.2. The iterative approach used for Model 15.2 resulted in a relatively flat fit with high M of 0.34 for age 1, 0.26 for age 2 through 14 and 0.14 for the 15+ age group (Table 1A.14). Selectivity curves for both models (Fig. 1A.14) were similar for both the survey and the fishery. There is an apparent shift in fishery selectivity from Model 15.1 to Model 15.2 with higher selectivity for fish between ages 4 and 7. A shift in the survey selectivity is also apparent from Model 15.1 to Model 15.2 with an increase in selectivity for ages 3 to 8. The increase in natural mortality and decrease in natural mortality for ages 15+ would explain the model fitting higher selectivity for the age-4 to age-7 pollock for both the fishery and survey.

Because Model 15.2 provides a marginally worse fit to the data and gives qualitatively similar results to Model 15.1, Model 15.1 is recommended for consistency and will be used for evaluating stock status in the sections to follow.

Time Series Results

Abundance and exploitation trends

As indicated in the 2004 stock assessment (Barbeaux *et al.* 2004), the abundance trend is highly conditioned on the assumptions made about the area-swept survey trawl catchability. Even with catchability fixed at 1.0, the uncertainty in the abundance trend and level is very high. Bearing in mind the high degree of uncertainty, total biomass estimates (Table 1A.19, Fig. 1A.15, and Fig. 1A.16) in the 1980's for the Aleutian Islands area reached a peak of 897,764 t in 1982 primarily due to the 1978 year class which was well above average (Table 1A.20 and Table 1A.21, Fig. 1A.18, Fig. 1A.19, Fig. 1A.20). The model shows a large decline in the stock since its 1982 peak, hitting a low biomass levels in 2001 at 149,556 t. Total age 1+ biomass increased from 2001 to 2003 after cessation of directed fishing in the area. The increasing trend leveled off after 2003 and decreased through 2008 due to poor recruitment after 2000. Average recruitments for 1990-1999 (72 million) and 2000-2009 (41 million) were well below the average for 1978-1989 (303 million). Biomass increased from 2011 onward due to low fishing pressure and the more prominent year classes in the recent survey age data with the 2007-2018 average recruitment at 64 million age-1 fish. Estimated pollock catch at age in numbers from 1978 to 2016 are given in Table 1A.22.

Female Spawning Stock Biomass (SSB) rose to a peak of 285,257 t in 1984 from 147,787 t in 1978 due to the large 1978 year class (Fig.1A.15 and Fig. 1A.16). SSB remained high in the late 1980's as the larger than average 1981, 1983 and 1987 year classes matured. Even though there was a higher than average 1989 year class the SSB began to drop in the early 1990s in response to heavy fishing pressure and dipped to 47,804 t in 2010 ($B_{27\%}$ or 17% of the 1988 value) after a high fishing in the late 1990s and decades of poor recruitments. The highest full selection fishing mortality occurred in 1995 (F_{full} = 0.23 and Catch/biomass = 0.33) when the fishery harvested more than 82% of the 1994 survey biomass estimate (Fig. 1A.17 and Fig.1A.18). The authors' preferred Model 15.1 shows higher exploitation rates beginning in 1990 continuing through 1998 (F_{avg} = 0.17; Table 1A.23). The early 1990s fishery appeared to concentrate on the older fish, particularly the 1978 year class, this is consistent with a switch in the domestic fishery to concentrating on spawning aggregations for roe (Fig. 1A.18, and Fig. 1A.19). The status of AI pollock in 2021and 2022 was assessed to be well above $B_{20\%}$ and had low exploitation rates (Fig. 1A.21).

There was a steep decline in pollock abundance in the Aleutian Islands as the 1978 year class diminished with age and relatively high fishery removals. Estimates of exploitation rates suggest they were below F_{OFL}, during this period. However, given poor recruitment, catches near the 1990s level were unsustainable. To examine the role of the 1978 year class, estimated recruitment was projected forward from that year but in the absence of fishing mortality (to estimate "dynamic B_0"). This showed that a significant decline occurred simply due to changes in recruitment. The "no fishing" projection suggests that the 2022 female spawning stock biomass would be at 89% of what it would have been without fishing (with a low point in 1997 at 31% of the unfished stock). Since the cessation of directed fishing in 1999 and very low removal levels since 2005, the stock has stabilized and increased (Fig.1A.22).

Recruitment

Recruitment variance (σ_R^2) was specified to be 0.6 yet the actual recruitment variability was 0.24. The 1978 year-class is the largest (1.553 billion age-1 recruits; Table 1A.24 and Fig. 1A.20) and is highly influential with a large part of the fishery removals being composed of this year class (Fig. 1A.18 and Fig. 1A.19). The years 1976-1986 had several large year classes in comparison to more recent recruitment. The mean recruitment of age-1 pollock for 1978-1989 was 316 million, while the mean recruitment at age-1 between 1998 and 2008 was 41 million fish, with no year classes since the 1989 year class exceeding the overall 1978-2018 mean recruitment of 131 million age-1 recruits. Since the start of the domestic fishery in 1990, the three largest year classes have been the 1989 year class at 256 million age-1 recruits, the 1993 year class at 127 million age-1 recruits and the 2000 year class with 92 million age-1 recruits. The 2011 and 2012 year classes were also relatively large at 93 and 127 million age-1 recruits. Given our limited time series we are unable to determine whether the larger year classes in the late 1970's and early 1980's were anomalous or whether they are part of a larger cycle. The bottom line is that pollock year class strength has been much lower in the 1990 through the 2010's than in the previous decade leading to lower abundance of pollock in the Aleutian Islands, even without substantial local fishing pressure over the previous 23 years.

The 1978 year class in particular was highly influential. The mean recruitment for 1978 - 2018 without the 1978 year class was 73% (96 million) of the mean recruitment with the 1978 year class (131 million). If the 1978 year class is anomalous, it may be inflating the biological reference points and may be causing an overestimation of the expected productivity of this system, particularly if the 1978 year class originated elsewhere. Whether AI pollock recruitment is synchronous with other areas is an open question (e.g., the 1978, 1989, 2000, and 2012 year classes are also strong in the EBS region, Ianelli *et al.* 2005). The AI recruitment appears to be just as, or even more, correlated with the Gulf of Alaska (GOA) stock (Fig. 1A.3 in Barbeaux *et al.* 2009) and the extent to which these adjacent stocks interact is an active area of research.

There is some conflict in the data with respect to the 2011 and 2012 year classes. Both the Gulf of Alaska and Bering Sea have observed a very high 2012 year class, however the 2012 and 2014 survey age data indicate that the dominant year class was 2011. The 2016 AI bottom trawl survey age composition data indicate a high 2012 year class, however due to the high uncertainty introduced through the aging error matrix, the model identifies these as 2011 year class fish as there are data from two previous surveys identifying this strong year class as 2011. Given the large 2012 year class in surrounding areas, the model could be misidentifying this year class. Given the steep maturity schedule for this stock, this likely has little impact on current spawning stock biomass estimates.

Retrospective analysis

We systematically removed each year's data from the model for 10 years to evaluate the retrospective pattern in the preferred model's performance. There is a trend in the more recent estimates which are consistently higher than the current model estimates (Fig. 1A.23). The performance of the Aleutian Islands pollock preferred model was reasonable given the unexpectedly low estimates of abundance in the bottom trawl survey estimates for 2012 through 2016 and then quick increase in 2018. Mohn's rho for the authors' preferred Model 15.1 was estimated at 0.156, Woods Hole rho was 0.088, and retrospective RMSE was 0.118.

Projections and harvest alternatives

For management purposes we use the yield projections estimated from the 2022 authors' preferred Model 15.1. We used the estimated terminal (2008-2022) fishery selectivity at age (Table 1A.20 and Fig. 1A.14) for all projections.

Reference fishing mortality rates and yields

Amendment 56 to the BSAI Groundfish Fishery Management Plan (FMP) defines "overfishing level" (OFL), the fishing mortality rate used to set OFL (F_{OFL}), the maximum permissible ABC, and the fishing mortality rate used to set the maximum permissible ABC (*max* F_{ABC}). The fishing mortality rate used to set ABC (F_{ABC}) may be less than or equal to this maximum permissible level. The overfishing and maximum allowable ABC fishing mortality rates are given in terms of percentages of unfished female spawning biomass ($F_{SPR\%}$), on fully selected age groups. The associated long-term average female spawning biomass that would be expected under average estimated recruitment from 1978-2020 for the authors' preferred model (128.4 million age 1 fish) and F equal to $F_{40\%}$ and $F_{35\%}$ are denoted $B_{40\%}$ and $B_{35\%}$, respectively. The Tiers require reference point estimates for biomass level determinations. We present the following reference points for NRA pollock for Tier 3 of Amendment 56. For our analyses, we estimated the following values from the authors' preferred model:

Female spawning biomass	Model 15.1
$B_{100\%}$	174,218 t
$B_{40\%}$	69,687 t
$B_{35\%}$	60,976 t
B_{2022}	82,810 t

Specification of OFL and Maximum Permissible ABC

For the authors' preferred Model 15.1, the projected year 2023 female spawning biomass (SB_{23}) is estimated to be 75,328 t, above the $B_{40\%}$ value of 69,687 t placing NRA pollock in Tier 3a. The maximum permissible ABC and OFL values under Tier 3a for 2023 are:

Harvest Strategy	FSPR%	Fishing Mortality Rate	2023 Projected yield (t)
max F_{ABC}	$F_{40\%}$	0.31	43,413 t
F_{OFL}	$F_{35\%}$	0.38	52,384 t

If the estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ were deemed not reliable, then under Tier 5 with estimated natural mortality of 0.20 and the 2023 AIBT survey biomass, the 2023 ABC would be 16,517 t (110,110 t x 0.75 x 0.20 = 16,517 t) and under Tier 5 with an assumed natural mortality of 0.3 the 2023 ABC would be 24,775 t.

ABC Considerations and Recommendation

ABC Considerations

There remains considerable uncertainty in the Aleutian Islands pollock assessment. We've noted some concerns below:

1) The level of interaction between the Aleutian stock and the Eastern Bering Sea stock is unknown. It is evident that some interaction does occur and that the abundance and composition of the eastern portion of the Aleutian Islands stock is highly confounded with that of the Eastern Bering Sea stock. How this interacts with the current warming trend is also not fully understood. Overestimation of the Aleutian Islands pollock stock productivity due to an influx of Eastern Bering Sea stock is a significant risk.

2) As indicated in the 2004 AI pollock stock assessment (Barbeaux *et al.* 2004), AIBT survey catchability is probably less than 1.0, but we have no data to concretely anchor the value at anywhere less than 1.0. We therefore employ a default value for catchability of 1.00. This provides a conservative total biomass estimate.

3) Recent (1991 through 2022) AI bottom trawl surveys are highly uncertain with an average *CV* of 0.4375. The 2002, 2004, 2006, 2010, 2012, 2014, 2016, 2018, and 2022 estimates of *CV* are 0.38, 0.78, 0.48, 0.33, 0.55, 0.24, 0.33, 0.41, and 0.47 respectively. This results in considerable uncertainty in the model results.

4) Aging error is a significant concern for this stock with aging comparisons for the 2006 through 2008 age data at between 20% and 47% agreement.

5) If the 1978 year class is anomalous, it may be inflating the biological reference points, and in turn may be causing an overestimation of the expected productivity of this system, particularly if the 1978 year class originated elsewhere. At this point given more than two decades without substantial fishing a new baseline might be considered.

6) The low 2012 through 2016 bottom trawl survey estimates can't be explained by estimated natural mortality or catch. The availability of pollock to the survey may not be static and therefore the index could be unreliable. Migration of pollock outside the survey area could also explain this decline. The sudden increase in biomass in 2018 is commensurate with a steep increase in temperature on the Bering Sea shelf, although this increase is now consistent with the model, there still appears to be an availability issue not addressed in this modeling framework.

7) Due to COVID 19 restrictions, there was no 2020 survey.

8) With little fishing occurring there are also little age composition data collected. This results in little information for the stock assessment. Future assessments should consider using length composition data to offset this limitation.

ABC Recommendations

The pollock spawning stock biomass and total age 1+ biomass in the NRA appears to have reached an asymptote or slightly decreasing since 2018. The projected total age 1+ biomass for 2023 is 264,173 t. Assuming the five year average F of 0.026, the estimated female spawning biomass projected for 2023 is 75,328 t. Under this scenario the maximum permissible Tier 3a 2023 ABC (F_{maxABC} = 0.305) is 43,413 t and OFL (F_{OFL} = 0.380) is 52,384 t and the 2024 ABC (F_{maxABC} = 0.305) is 43,092 t and OFL (F_{OFL} = 0.380) is 52,044 t which are the authors' recommended ABC and OFLs.

Risk Table and ABC Recommendation

The following template is used to complete the risk table:

	Assessment-related considerations	*Population dynamics considerations*	*Environmental/ecosystem considerations*	*Fishery Performance*
Level 1: Normal	Typical to moderately increased uncertainty/minor unresolved issues in assessment.	Stock trends are typical for the stock; recent recruitment is within normal range.	No apparent environmental/ecosystem concerns	No apparent fishery/resource-use performance and/or behavior concerns
Level 2: Substantially increased concerns	Substantially increased assessment uncertainty/ unresolved issues.	Stock trends are unusual; abundance increasing or decreasing faster than has been seen recently, or recruitment pattern is atypical.	Some indicators showing adverse signals relevant to the stock but the pattern is not consistent across all indicators.	Some indicators showing adverse signals but the pattern is not consistent across all indicators
Level 3: Major Concern	Major problems with the stock assessment; very poor fits to data; high level of uncertainty; strong retrospective bias.	Stock trends are highly unusual; very rapid changes in stock abundance, or highly atypical recruitment patterns.	Multiple indicators showing consistent adverse signals a) across the same trophic level as the stock, and/or b) up or down trophic levels (i.e., predators and prey of the stock)	Multiple indicators showing consistent adverse signals a) across different sectors, and/or b) different gear types
Level 4: Extreme concern	Severe problems with the stock assessment; severe retrospective bias. Assessment considered unreliable.	Stock trends are unprecedented; More rapid changes in stock abundance than have ever been seen previously, or a very long stretch of poor recruitment compared to previous patterns.	Extreme anomalies in multiple ecosystem indicators that are highly likely to impact the stock; Potential for cascading effects on other ecosystem components	Extreme anomalies in multiple performance indicators that are highly likely to impact the stock

"The table is applied by evaluating the severity of four types of considerations that could be used to support a scientific recommendation to reduce the ABC from the maximum permissible. These considerations are stock assessment considerations, population dynamics considerations, environmental/ecosystem considerations, and fishery performance. Examples of the types of concerns that might be relevant include the following:

1. “Assessment considerations—data-inputs: biased ages, skipped surveys, lack of fishery-independent trend data; model fits: poor fits to fits to fishery or survey data, inability to simultaneously fit multiple data inputs; model performance: poor model convergence, multiple minima in the likelihood surface, parameters hitting bounds; estimation uncertainty: poorly-estimated but influential year classes; retrospective bias in biomass estimates.

2. “Population dynamics considerations—decreasing biomass trend, poor recent recruitment, inability of the stock to rebuild, abrupt increase or decrease in stock abundance.

3. “Environmental/ecosystem considerations—adverse trends in environmental/ecosystem indicators, ecosystem model results, decreases in ecosystem productivity, decreases in prey abundance or availability, increases or increases in predator abundance or productivity.

4. “Fishery performance—fishery CPUE is showing a contrasting pattern from the stock biomass trend, unusual spatial pattern of fishing, changes in the percent of TAC taken, changes in the duration of fishery openings.”

Assessment considerations. The AI pollock assessment does not show a strong retrospective bias, and fits to the age composition data well. There is however a lack of recent fishery and survey age composition data in the model leading to a larger degree of uncertainty in the model performance.

Population dynamics considerations. Female spawning biomass is currently estimated to be at $B_{47\%}$ and given low exploitation expected to continue to increase even at lower than average recruitment. The authors have no concerns with this stock concerning population dynamics.

Environmental/Ecosystem considerations.

Environment: The average bottom temperature from the Aleutian Islands bottom trawl survey (AIBTS, (165°W – 172°E, 30-500 m) was ~4.4◦C, similar to 2018 and cooler than the highest observed in 2016 but still above the long term mean, as have the last four surveys (2014 onwards). Mid-depth (100-300m) and water column temperature (surface to bottom) from the longline survey (164°W to 180°W) and bottom trawl survey, respectively show a similar pattern, with warmer temperatures throughout the water column starting 2014. Surface temperature both from the AIBTS, as well as satellite, show an increasing trend in temperatures, during both summer and winter with 2022 being one of the warmest years in summer throughout the Aleutians and in wintertime for the western and central Aleutians. Most of the year through August has been under some level of heatwave in the central and western Aleutians, less so in the eastern Aleutians where the majority of the pollock is distributed. This area also has a mean long term peak summer temperature ~ 9.2°C during late September (Bond et al 2022).

Pollock spawns in March through June, their larvae stay in surface waters (top 40 m) before they shift to deeper waters (Smart et al., 2013). In the NMFS area 541 Aleutians, where most of the pollock biomass is, this period has lower intensity marine heatwaves (MHW) compared to summer.

Prey: Although we don’t have direct abundance estimates of copepods, which comprise juvenile (<20cm) pollock diet, along with euphausiids and pelagic gelatinous filter feeders, we can infer that copepods experienced lower predation pressure based on the biannual cycle and record abundance of Kamchatka pink salmon during 2021. The biannual cycle and cascading effects of pink salmon predation on copepods has been documented before by Springer and van Vliet (2014), Batten et al. (2018), and Matta et al. (2020). Time-series of either young ages or total population do not show alternate years of high number of pollock. Based on the Kamchatka pink-salmon – copepods relationship, we assume that copepod prey availability to pollock in 2022 would be higher than in odd years when pink salmon abundance is high (Ruggerone, 2022). Other inferences we can make about zooplankton prey availability are from the reproductive success of planktivorous auklets nesting on Buldir Island. All auklet colonies While the colony was not surveyed in 2020, they had good reproductive success 2016-2019, suggesting that zooplankton were sufficiently abundant during these years to support successful production of chicks and possibly indicative of abundant zooplankton prey in that area. Reproductive success in Aiktak (eastern Aluetians) of Leach's storm petrels, which feed on zooplankton and invertebrates, and piscivorous murres and tufted puffins was above average, indicating forage fish prey was also widely available (Rojek et al, 2022). Data from the Continuous Plankton Recorders that sample near the Aleutian chain show average size anomalously small copepod taxa from 2016-2018, increasing in size in 2019 and 2021 (Bond et al., 2022), which may indicate a recent increase in the quality of zooplankton prey available to pollock.

Recent condition indices (2014 onwards, even years) taken during surveys have been lower than the long-term survey mean, but improved overall above the men in 2022, driven by the Central Aleutians. Condition improved in all regions except for the western Aleutians (O'Leary and Rohan, 2022). The recent higher water temperatures increasing consumption, along with higher competition and increasing biomass of POP, may jointly explain the negative body condition observed in the past years in walleye pollock. – Pacific ocean perch and northern rockfish which were heavily fished by the foreign fishery in the 1960s and 1970s and have subsequently been increasing since the 1980s to its peak biomass (age 3+) in 2011-2012. Since then POP have decreased but remain at a high biomass and along with northern rockfish dominate over Atka mackerel and pollock within the pelagic foragers guild. Pollock and Atka mackerel were the dominant species 9based on survey data) in the early 1990s.

Competitors and predators: Both Pacific ocean perch (particularly juvenile POP <20 cm), Kamchatka pink salmon, and Atka mackerel are primary consumers of copepods, with the first two showing biannual signals in their abundance. Both the western and central Aleutians have shown decreased survey biomass estimates of pollock not observed in the eastern Aleutians. The increased consumption of copepods by the increasing POP population and high abundance years of Kamchatka pink salmon might be limiting the availability of prey for pollock through competitive pressure.

Walleye pollock are a key prey for Steller sea lions, Pacific cod, arrowtooth flounder, and Pacific Halibut (AFSC Groundfish Food Habits database), they are also consumed by harbor seals. Recent data suggest that Steller sea lion populations are increasing in the eastern Aleutians (Sweeney and Gelatt, 2020) where most of the pollock is distributed.), suggesting that their predatory impact on pollock may increase in this region. Offsetting this potential increase in predation, Pacific cod decreased compared to 2018, as did arrowtooth flounder based on AI survey biomass estimates. These trends suggest no large changes in predation pressure on AI pollock.

Taken together, these indicators suggest that the current level of concern is level 1—no apparent environmental/ecosystem concerns.

We note that the sustained high biomass of POP which may be outcompeting or displacing pollock is a return to conditions before POP was heavily fished by the foreign fleet. The trends in fish condition and seabird reproductive success would seem to support prey is available and it is only in the western Aleutians where historically pollock was not very abundant, that pollock condition did not improve.

Fishery Performance. There hasn't been a substantial pollock fishery in the Aleutian Islands since 1998. From 2005 to the present catch in the AI has been less than 3,500 t. Although an experimental fishing permit was developed for the 2019 and 2020 fishery, the catch remained below 3,500 t. There is no consistent metric available to assess fishery performance for this fishery. The TAC for this stock is limited to 19,000 t, less than half of the annual ABC. We have no concerns about fishery performance that would suggest a drop in ABC would be required.

We consider the concern level to be 1 – normal.

These results are summarized in the table below:

Assessment-related considerations	Population dynamics considerations	Environmental/ecosystem considerations	Fishery Performance
Level 1: Normal	Level 1: Normal	Level 1: Normal	Level 1: Normal

The authors suggest that setting the ABC below the maximum permissible is not warranted at this time.

Standard Harvest Scenarios and Projection Methodology

A standard set of projections is required for each stock managed under Tiers 1, 2, or 3, of Amendment 56. This set of projections encompasses eight harvest scenarios designed to satisfy the requirements of Amendment 56, the National Environmental Policy Act, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA).

For each scenario, the projections begin with the vector of 2022 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2023 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total (year-end) catch for 2022 of 3,000 t. For 2023 the five-year average F (2017-2021) of 0.026, used in place of maximum permissible ABC resulting in a catch estimate of 1,670 t. In each subsequent year, the fishing mortality rate is prescribed on the basis of the spawning biomass in that year and the respective harvest scenario. In each year, recruitment is drawn from an inverse Gaussian distribution whose parameters consist of maximum likelihood estimates determined from recruitments estimated in the assessment. Spawning biomass is computed in each year based on the time of peak spawning and the maturity and weight schedules described in the assessment. Total catch is assumed to equal the catch associated with the respective harvest scenario in all years. This projection scheme is run 1000 times to obtain distributions of possible future stock sizes, fishing mortality rates, and catches.

Five of the seven standard scenarios are sometimes used in an Environmental Assessment prepared in conjunction with the final SAFE. These five scenarios, which are designed to provide a range of harvest alternatives that are likely to bracket the final TAC for 2023 and 2024, are as follows (a "*max* F_{ABC}" refers to the maximum permissible value of F_{ABC} under Amendment 56):

Scenario 1: In all future years, F is set equal to *max* F_{ABC}. (Rationale: Historically, TAC has been constrained by ABC, so this scenario provides a likely upper limit on future TACs.)

Scenario 2: In all future years, F is set equal to a constant fraction ("author's F") of max F_{ABC}, where this fraction is equal to the ratio of the F_{ABC} value for 2023 recommended in the assessment to the max F_{ABC} for 2023, and where catches for 2023 and 2024 are estimated at their most likely values given the 2023 and 2024 recommended ABCs under this scenario. (Rationale: When F_{ABC} is set at a value below max F_{ABC}, it is often set at the value recommended in the stock assessment; also, catch tends not to equal ABC exactly.)

Scenario 3: In all future years, F is set equal to the 2017-2021 average F. (Rationale: For some stocks, TAC can be well below ABC, and recent average F may provide a better indicator of F_{TAC} than F_{ABC}.)

Scenario 4: In all future years, F is set equal to $F_{75\%}$. (Rationale: This scenario represents a very conservative harvest rate and was requested by the Alaska Regional Office based on public comment.)

Scenario 5: In all future years, F is set equal to zero. (Rationale: In extreme cases, TAC may be set at a level close to zero.)

Two other scenarios are needed to satisfy the MSFCMA's requirement to determine whether a stock is currently in an overfished condition or is approaching an overfished condition. These two scenarios are as follow (for Tier 3 stocks, the MSY level is defined as $B_{35\%}$):

Scenario 6: In all future years, F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is overfished. If the stock is expected to be 1) above its MSY level in 2022 or 2) above 1/2 of its MSY level in 2022 and above its MSY level in 2032 under this scenario, then the stock is not overfished.)

Scenario 7: In 2023 and 2024, F is set equal to *max* F_{ABC}, and in all subsequent years, F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is approaching an overfished condition. If the stock is expected to be above its MSY level in 2034 under this scenario, then the stock is not approaching an overfished condition.)

The author included one more scenario in order to take into consideration the congressionally mandated TAC cap on pollock harvest from the Aleutian Islands area.

Scenario 8: In 2023 through 2035 the TAC is increased to 19,000 t or *max* F_{ABC} whichever is lower. (Rationale: 19,000 is the AI pollock cap set by Congressional mandate).

Projections and status determination

Is the stock currently overfished? This depends on the stock's estimated spawning biomass in 2022:

a. If spawning biomass for 2022 is estimated to be below ½ $B_{35\%}$, the stock is below its MSST.
b. If spawning biomass for 2022 is estimated to be above $B_{35\%}$ the stock is above its MSST.
c. If spawning biomass for 2022 is estimated to be above ½ $B_{35\%}$ but below $B_{35\%}$, the stock's status relative to MSST is determined by referring to harvest Scenario #6. If the mean spawning biomass for 2032 is below $B_{35\%}$, the stock is below its MSST. Otherwise, the stock is above its MSST.

Is the stock approaching an overfished condition? This is determined by referring to harvest Scenario #7:

a. If the mean spawning biomass for 2022 is below 1/2 $B_{35\%}$, the stock is approaching an overfished condition.
b. If the mean spawning biomass for 2022 is above $B_{35\%}$, the stock is not approaching an overfished condition.
c. If the mean spawning biomass for 2022 is above 1/2 $B_{35\%}$ but below $B_{35\%}$, the determination depends on the mean spawning biomass for 2034. If the mean spawning biomass for 2034 is below $B_{35\%}$, the stock is approaching an overfished condition. Otherwise, the stock is not approaching an overfished condition.

The projected yields, female spawning biomass, and the associated fishing mortality rates for the eight harvest strategies for the authors' preferred model are shown in Table 1A.25. In the authors' preferred model under a Tier 3a harvest strategy of $F_{40\%}$ (Scenario 1), female spawning biomass is projected to be above $B_{35\%}$ through 2024, be below $B_{40\%}$ from 2025 through 2028, then be above $B_{40\%}$ for the remainder of the projection (Fig.1A.24 and Fig.1A.25). Female spawning biomass is projected be above $B_{35\%}$ except for 2025 through 2027 when fishing at F_{OFL} (Fig.1A.26) in Scenario 7. The female spawning biomass is projected to be above $B_{35\%}$ from 2028 through the end of the projection for both Scenario 6 and Scenario 7. Please note again that the fishing mortality rates are prescribed on the basis of the harvest scenario and the spawning biomass in each year. Thus, fishing mortality rates may not be constant within the projection if spawning biomass drops below $B_{40\%}$ in any run due to the harvest control rules.

The associated long-term average female spawning biomass that would be expected under average estimated recruitment from 1978-2020 (128.4 million age 1 fish) and $F = F_{35\%}$, denoted $B_{35\%}$ is estimated to be 60,976 t. This value ($B_{35\%}$), is used in the status determination criteria. Female spawning biomass for 2022 (82,810 t) is projected to be above 1/2 $B_{35\%}$ thus, the NRA pollock stock is *above* its minimum stock size threshold (MSST) and is *not overfished*. Female spawning biomass for 2035 is projected to be above $B_{35\%}$ in Scenario 7, and is expected to be above $B_{35\%}$ in 2032 in Scenario 6, therefore the NRA pollock stock is *not* expected to fall below its MSST in two years and is *not approaching an overfished condition*.

Projections under Scenario 8 (Fig.1A.24, Fig.1A.25, and Table 1A.25), show that the stock could support a constant catch of 19,000 t. The stock is currently at $B_{47\%}$ and the long-term expected yield at $B_{40\%}$ is 40,465 t and at $B_{35\%}$.is 42,776 t, well above the 19,000 t cap.

The 2022 OFL given this year's model would have produced a sum of apical F of 0.4416.

Ecosystem Considerations

Pollock is a commercially important species. It is also important as prey to other fish, birds, and marine mammals, and has been the focus of substantial research in Alaskan ecosystems, especially in the Gulf of Alaska (GOA; Hollowed *et al.* 2000). To determine the ecosystem relationships of juvenile and adult pollock in the Aleutian Islands (AI), we first examined the diet data collected for pollock. Diet data are collected aboard NMFS bottom trawl surveys in the AI ecosystem during the summer (May – August). In the AI, a total of 1,458 pollock stomachs were collected from the 1991 and 1994 bottom trawl surveys (n=688 and 770, respectively) and used in this analysis. The diet compositions reported here reflect the size and spatial distribution of pollock in each survey (see Appendix A, "Diet calculations" for detailed methods from Barbeaux *et al.* 2006). Juvenile pollock were defined as fish less than 20 cm in length, which roughly corresponds to 0 and 1 year old fish, and adult pollock were defined as fish 20 cm in length or greater, roughly corresponding to age 2+ fish.

In the AI, pollock diet data reflects a closer connection with open oceanic environments than in either the Eastern Bering Sea (EBS) or the GOA. Similar to the other ecosystems, euphausiids and copepods together make up the largest proportion of AI adult pollock diet (29% and 19%, respectively); however, it is only in the AI that adult pollock rely on mesopelagic forage fish in the family Myctophidae for 24% of their diet, and AI juvenile pollock have a lower proportion of euphausiids and a higher proportion of gelatinous filter feeders than in the GOA or EBS (Fig.1A. 27, left panels). We took this diet composition information and convert it to broad ranges of tons consumed annually by pollock in the AI using the Sense routine (Aydin *et al.* 1997), which incorporates information on pollock consumption derived from the stock assessment (see Appendix A from Barbeaux *et al.* 2006, "ration calculations" for detailed methods), as well as uncertainty in all other food web model parameters. As estimated by the Sense routine, AI adult pollock consumed between 100 and 900 thousand metric tons of euphausiids annually during the early 1990s, with similar ranges of myctophid and copepod consumption. Juvenile AI pollock consumed an additional estimated 100 to 900 thousand tons of copepods per year (Fig.1A.27, right panels).

Using diet data for all predators of pollock and consumption estimates for those predators, as well as fishery catch data, we next estimated the sources of pollock mortality in the AI. Sources of mortality were compared against the total production of pollock as estimated in the AI pollock stock assessment model. In the AI, integration of this single species information with predation within the food web model suggests that most adult pollock mortality was caused by the pollock trawl fishery during the early 1990s (48%; Fig.1A.28, left panels). Fishery catch of pollock in the AI has subsequently declined to less than half the early 1990s catch by the late 1990s, and the directed fishery was closed in 1999 (Ianelli *et al.* 2005). Therefore, AI pollock likely now experience predation mortality exceeding fishing mortality as in the EBS and GOA ecosystems.) The major predators of AI adult pollock are Pacific cod, Steller sea lions, pollock themselves, halibut, and skates. In the AI, juvenile pollock have a very different set of predators from adult pollock; Atka mackerel cause most juvenile pollock mortality (71%). Estimates of the tonnage of adult pollock consumed by predators from the Sense routines (Aydin *et al.*1997) ranged from 8 to 27 thousand tons consumed by Pacific cod annually during the early 1990s, while Atka mackerel were estimated to consume between 75 and 410 thousand tons of juvenile pollock annually in the AI ecosystem (Fig.1A.28, right panels).

After reviewing the diet compositions and mortality sources of pollock in the AI, we shifted focus slightly to view pollock and the pollock fishery within the context of the larger AI food web. When viewed within the AI food web, the pollock trawl fishery (in red; Fig.1A.29) is a relatively high trophic level (TL) predator which interacts mostly with adult pollock (Fig. 1A.30), but also with many other species (in green; Fig. 1A.31). The diverse pollock fishery bycatch ranges from high TL predators such as salmon sharks, sleeper sharks, and arrowtooth flounder, to mid TL pelagic forage fish and squid, to low TL benthic invertebrates such as crabs and shrimp, but all of these catches represent extremely small flows. Because the pollock trawl fishery contributes significant fishery offal and discards back into each ecosystem, these flows to fishery detritus groups are represented as the only "predator consumption" flows from the fishery; the biomass of retained catch represents a permanent removal from the system.

In the AI food web model, we included detailed information on bycatch for each fishery. This data was collected in the early 1990s when the AI pollock fishery was much larger than it is at present. During the early 1990's, the pollock trawl fishery was extremely species-specific in the AI ecosystem, with pollock representing over 90% of its total catch by weight (Fig.1A. 30). No single bycatch species accounted for more than 1% of the catch. Although these catches are small in terms of percentage, the high volume pollock fisheries still account for the majority of bycatch of pelagic species in the BSAI management areas, including smelts, salmon sharks, and squids (Gaichas *et al.* 2004).

Pollock is also a very important prey species in the wider AI food web. When both adult and juvenile pollock food web relationships are included, over two thirds of all species groups turn out to be directly linked to pollock either as predators or prey in the food web model (Fig.1A.31). In the AI, the significant predators of pollock (blue boxes joined by blue lines) include halibut, cod, Alaska skates, Steller sea lions, and the pollock trawl fishery. Significant prey of pollock (green boxes joined by green lines) are myctophids, euphausiids, copepods, benthic shrimps, and amphipods, with juveniles preying on the euphausiids and copepods.

We investigated whether these differences in pollock diet, mortality, and relationships between the EBS and AI might suggest different ecosystem roles for pollock in these areas. We used the diet and mortality results integrated with information on uncertainty in the food web using the Sense routines (Aydin et al in review) and a perturbation analysis with each model food web to explore the ecosystem relationships of pollock further. Two questions are important in determining the ecosystem role of pollock: which species groups are pollock important to, and which species groups are important to pollock?

First, the importance of pollock to other groups within the AI ecosystem was assessed using a model simulation analysis where pollock survival was decreased (mortality was increased) by a small amount, 10%, over 30 years to determine the potential effects on other living groups. This analysis also incorporated the uncertainty in model parameters using the Sense routines, resulting in ranges of possible outcomes. Figure 1A.32 shows the resulting percent change in the biomass of each species after 30 years for 50% of feasible ecosystems with 95% confidence intervals (error bars in Figure1A.32. Species showing the largest median changes from baseline conditions are presented in descending order from left to right. Therefore, the largest change resulting from a 10% decrease in pollock survival in both ecosystems is a decrease in adult pollock biomass, as might have been expected from such a perturbation. However, the decrease in pollock biomass resulting from the 10% survival reduction is uncertain in AI: the 50% intervals range from a 5-37% decrease in the AI (Fig.1A.32, upper panel). Along with the decrease in pollock biomass predicted in this simulation is a decrease in pollock fishery catch. The next largest median effect is on juvenile pollock, which are predicted to decrease in 50% of feasible ecosystems, but the 95% interval includes zero, suggesting that the decrease is uncertain. The simulation further suggests the possibility that herring, Atka mackerel, and other miscellaneous deep water fish might increase slightly as a result of a decrease in pollock survival; however, for all of these species groups the 95% intervals cross zero, so the direction of change is uncertain. Therefore, this analysis suggests that in the AI ecosystem during the early 1990's, pollock were most important to themselves, and to the pollock fishery.

To determine which groups were most important to pollock in each ecosystem, we conducted the inverse of the analysis presented above. In this simulation, each species group in the ecosystem had survival reduced by 10% and the system was allowed to adjust over 30 years. The strongest median effects on AI adult pollock are presented in Fig. 1A.32 (lower panel). The largest effect on adult pollock was the reduction in biomass resulting from the reduced survival of juvenile pollock, although the 95% intervals include zero change, indicating considerable uncertainty in this result. (The same caution applies to the interpretation of all of the results of this simulation as all of the 95% intervals contain zero). It is interesting, however, that reduced survival of juvenile Atka mackerel had a larger median effect on adult pollock biomass than the direct effect of reduced adult pollock survival itself (Fig. 1A.32, lower panel), and that the effect is positive. Adult Atka mackerel show the same pattern, which is likely explained by the amount of mortality caused by Atka mackerel on juvenile pollock in the AI food web model (see Fig. 1A.28, lower panels). Reduced survival of Atka mackerel adults or juveniles apparently relieves considerable mortality on juvenile pollock in this model, accounting for the increases in pollock biomass predicted (which is similar in magnitude to the increase predicted from reducing the pollock fishery catch by 10%). Although this result is uncertain, it does indicate an important interaction between two commercially important species in the AI ecosystem which might be further investigated.

Ecosystem effects on Aleutian Islands Walleye Pollock

The following ecosystem considerations are summarized in Table 1A.26.

Prey availability/abundance trends

Adult walleye pollock in the Aleutian Islands consume a variety of prey, primarily large zooplankton, copepods, and myctophids. Figure 1A.31 highlights the trophic level of pollock in relation to its prey and predators. No time series of information is available on Aleutian Islands for large zooplankton, copepod, or myctophid abundance.

Predator population trends

The abundance trend of Aleutian Islands Pacific cod is decreasing, and the trend for Aleutian Islands arrowtooth flounder is relatively stable. Northern fur seals and Steller sea lions west of 178°W longitude are showing declines, while Steller sea lions east of 178°W longitude have shown some slight increases. Declining trends in predator abundance could lead to possible decreases in walleye pollock mortality. The population trends of seabirds are mixed, some increases, some decreases, and others stable. Seabird population trends could affect young-of-the-year mortality.

Changes in habitat quality

Water temperature in the Aleutian Islands is variable among survey years particularly for bottom depth at the preferred depth range of pollock (Fig. 1A.33 and Fig. 1A.34). The 2012 Aleutian Islands summer bottom temperatures indicated that water temperatures were substantially cooler than the 2004-2010 surveys (Lowe *et al.* 2012). Bottom temperatures could possibly affect fish distribution. The 2014 through 2018 AI bottom trawl surveys show a swing of bottom and surface temperature values to above the means for the entire time series (1991-2018) and higher than the 2004-2010 bottom temperatures.

AI pollock fishery effects on the ecosystem

AI pollock fishery contribution to bycatch

Prior to 1998, levels of bycatch in the pollock fishery of prohibited species, forage, HAPC biota, marine mammals and birds, and other sensitive non-target species was very low compared to other fisheries in the region. The AI pollock fishery opening in 2005 was limited to only four hauls, within these four hauls the bycatch level of POP was very high (~50%). In addition to the lack of commercially harvestable levels of pollock, the high levels of POP bycatch convinced fishers to discontinue the fishery in 2005. The 2006 and 2007 AI pollock fisheries were conducted in conjunction with the AICASS, Pacific ocean perch was the most substantial bycatch species and made up 3% of the catch in 2006 and 11% in 2007. The 2008 directed pollock fishery had an observed bycatch rate of 1% with 97% of this being POP. In 2009 there was no observer coverage of the directed fishery and in 2010 there was less than 1% bycatch in the directed fishery which caught less than 50 tons of pollock. There was no directed pollock fishery in the Aleutians in 2011 through 2014, a limited fishery of 62 t in 2015, no directed fishery in 2016 and 2017. The directed fishery in 2018 was limited to 188 t from two hauls from a single vessel. The 2019 and 2020 directed fishery was conducted under an experimental fishing permit that allowed up to 500 t of Pacific ocean perch bycatch. Bycatch in the 2019 targeted AI pollock fishery resulted in 42 t of Pacific ocean perch bycatch with 70 t of pollock catch and the 2020 targeted AI pollock fishery resulted in 78t of Pacific ocean perch bycatch with 712 t of pollock. In 2021 there was no directed pollock fishery in the AI and in 2022 there was 217 of pollock caught in a directed fishery with 22 t of POP bycatch, Table 1A.27.

Concentration of AI pollock catches in time and space

For 2023 amd 2024 the level of catch of pollock is not expected to be large and will be much lower than the 19,000 t cap, there is not expected to be a localized impact of this fishery.

AI pollock fishery effects on amount of large size walleye pollock

The AI pollock fishery in the Aleutian Islands was closed between 1999 and 2005. There was only a very limited fishery in 2005 (< 200t), 2006 (932 t), 2007 (1,300 t), 2008 (382 t), 2009 (400 t), 2010 (50 t), 2011 (0 t), 2012 (0 t), 2013 (0 t), 2014 (0 t), 2015 (62 t), 2016 (0 t), 2017 (0 t) and 2018 (188 t). In 2019 and 2020 there was an EFP which allowed up to 500t of POP bycatch, the directed fishery in 2019 and 2020 was 72 t in 2019 and 712 t in 2020, the most since the 2007 acoustic project EFP. In 2021 there were no directed fishery catch of pollock however in 2022 to date there has been 217t caught as of October 9, 2022. Year to year differences observed in the previous decade cannot be attributed to the fishery and must be attributed to natural fluctuations in recruitment. Fishers have indicated that the larger pollock in the Aleutian Islands will be targeted. But the low level of fishing mortality is not expected to greatly affect the size distribution of pollock in the AI.

AI pollock fishery contribution to discards and offal production

The 2023 Aleutian Islands pollock fishery, if pursued, is expected to be conducted by catcher vessels delivering unsorted catch to a processing plant in Adak, and therefore very little discard or offal production is expected from this fishery.

AI Pollock fishery effects on AI pollock age-at-maturity and fecundity

The effects of the fishery on the age-at-maturity and fecundity of AI pollock are unknown. No studies on AI pollock age-at-maturity or fecundity have been conducted. Studies are needed to determine if there have been changes over time and whether changes could be attributed to the fishery. Little impact is expected if the fishery continues to be conducted in the limited capacity it has been over recent years.

Data gaps and research priorities

Very little is known about the AI pollock stock structure and their relation to Western Bering Sea, Eastern Bering Sea, Gulf of Alaska, Bogoslof and Central Bering Sea pollock. Studies on the migration of pollock in the North Pacific should be explored in order to obtain an understanding of how the stocks relate spatially and temporally and how neighboring fisheries affect local abundances. Time series data sets on prey species abundance in the Aleutian Islands would be useful for a more clear understanding of ecosystem affects. Studies to determine the impacts of environmental indicators such as temperature regime on AI Aleutian pollock are needed. Currently, we rely on studies from the eastern Bering Sea and Gulf of Alaska for our estimates of life history parameters (e.g. maturity-at-age, fecundity, and natural mortality) for the NRA pollock. Studies specific to the NRA to determine whether there are any differences from the eastern Bering Sea and Gulf of Alaska stocks and whether there have been any changes in life history parameters over time would be informative.

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Tables

Table 1A.1. Estimates of walleye pollock catches from the entire Aleutian Islands Region by source, 1977-2022. Units are in metric tons.

Year	Official Foreign & JV Blend	Domestic Blend	Foreign Reported	NMFS Observed Catch*	Total Best Estimates
1977	7,367		7,827	5	7,367
1978	6,283		6,283	234	6,283
1979	9,446		9,505	58	9,446
1980	58,157		58,477	883	58,157
1981	55,517		57,056	2,679	31,258
1982	57,753		62,624	11,847	50,322
1983	59,021		44,544	12,429	44,442
1984	77,595		67,103	48,538	42,901
1985	58,147		48,733	43,844	47,070
1986	45,439		14,392	29,464	23,810
1987	28,471			17,944	26,257
1988	41,203			21,987	36,864
1989	10,569			5,316	10,569
1990		79,025		59,935	79,025
1991		98,604		53,647	98,604
1992		52,352		36,581	52,352
1993		57,132		44,552	57,132
1994		58,659		43,430	58,659
1995		64,925		53,647	64,925
1996		29,062		23,482	29,062
1997		25,940		19,623	25,940
1998		23,798		21,032	23,798
1999		1,010		492	1,010
2000		1,244		573	1,244
2001		1,010		477	1,010
2002		1,177		519	1,177
2003		1,649		1,562	1,649
2004		1,158		1,074	1,158
2005		1,621		1,359	1,621
2006		1,745		540	1,745
2007		2,519		1,182	2,519
2008		1,278		996	1,278
2009		1,662		1,409	1,662
2010		1,285		1,261	1,285
2011		1,208		1,198	1,208
2012		975		927	975
2013		2,964		2,953	2,964
2014		2,375		2,369	2,375
2015		915		914	915
2016		1,257		1,251	1,257
2017		1,507		1,505	1,507
2018		1,860		1,827	1,860
2019		1,663		1,660	1,663
2020		3,202		3,080	3,202
2021		1,840		1,762	1,840
2022**		2,726		1,960	2,726

*Extrapolated catch from observed fishing not a total catch estimate. ** as of October 9, 2022

Table 1A.2. Estimates of Aleutian Islands Region walleye pollock catch by the three management sub-areas. Units are in metric tons.

Year	East 541	Central 542	West 543	Total	Year	East 541	Central 542	West 543	Total
1977	4,402	0	2,965	7,367	2000	615	461	169	1,244
1978	5,267	712	305	6,283	2001	333	387	105	1,010
1979	1,488	1,756	6,203	9,446	2002	862	182	133	1,177
1980	28,284	7,097	22,775	58,157	2003	565	758	326	1,649
1981	43,461	10,074	1,982	55,517	2004	397	513	248	1,158
1982	54,173	1,205	2,376	57,753	2005	689	415	517	1,621
1983	56,577	1,250	1,194	59,021	2006	1,036	488	220	1,745
1984	64,172	5,760	7,663	77,595	2007	1,919	476	124	2,519
1985	19,885	38,163	100	58,147	2008	872	293	112	1,278
1986	38,361	7,078	0	45,439	2009	1,020	400	243	1,662
1987	28,086	386	0	28,471	2010	754	382	150	1,285
1988	40,685	517	0	41,203	2011	695	447	66	1,208
1989	10,569	0	0	10,569	2012	503	427	45	975
1990	69,170	9,425	430	79,025	2013	2,342	309	313	2,964
1991	98,032	561	11	98,604	2014	2,088	176	111	2,375
1992	52,140	206	6	52,352	2015	565	264	87	916
1993	54,512	2,536	83	57,132	2016	899	195	162	1,257
1994	58,091	554	15	58,659	2017	688	517	302	1,507
1995	28,109	36,714	102	64,925	2018	1,060	546	254	1,860
1996	9,226	19,574	261	29,062	2019	1,000	415	248	1,663
1997	8,110	16,799	1,031	25,940	2020	2,166	671	365	3,202
1998	1,374	2,603	19,821	23,798	2021	1,322	273	245	1,840
1999	484	420	105	1,010	2022*	1,899	317	510	2,726

*as of October 9, 2022

Table 1A.3. Time series of ABC, TAC, OFL, and total catch for Aleutian Islands Region walleye pollock fisheries 1994-2022. Units are in metric tons.

YEAR	ABC	TAC	OFL	CATCH	CATCH/TAC
1995	56,600	56,600	60,400	64,925	115%
1996	35,600	35,600	47,000	29,062	82%
1997	28,000	28,000	38,000	25,940	93%
1998	23,800	23,800	31,700	23,798	100%
1999	23,800	2,000	31,700	1,010	51%
2000	23,800	2,000	31,700	1,244	62%
2001	23,800	2,000	31,700	825	41%
2002	23,800	1,000	31,700	1,177	116%
2003	39,400	1,000	52,600	1,649	167%
2004	39,400	1,000	52,600	1,158	116%
2005	29,400	19,000	39,100	1,621	9%
2006	29,400	19,000	39,100	1,745	9%
2007	44,500	19,000	54,500	2,519	13%
2008	28,160	19,000	34,040	1,278	7%
2009	26,873	19,000	32,553	1,662	9%
2010	33,100	19,000	40,000	1,285	7%
2011	36,700	19,000	44,500	1,208	6%
2012	32,500	19,000	39,600	975	5%
2013	37,300	19,000	45,600	2,964	16%
2014	35,048	19,000	42,811	2,375	13%
2015	29,659	19,000	36,005	915	5%
2016	32,227	19,000	39,075	1,257	7%
2017	36,061	19,000	43,650	1,507	8%
2018	40,788	19,000	49,289	1,860	10%
2019	52,887	19,000	64,240	1,663	9%
2020	55,120	19,000	66,973	3,202	17%
2021	51,241	19,000	61,856	1,840	10%
2022	50,752	19,000	61,264	2,726	14%

* as of Otober 9, 2022

Table 1A.4. Pollock biomass estimates (t) from the Aleutian Islands Groundfish Survey, 1980-2022.

	Eastern Area 541	Central Area 542	Western Area 543	Unalaska-Umnak Area (~165W-170W)	NRA 170W - 170E Biomass	CV
1980	80,242	180,227	6,884	6,770	267,353	0.34
1983	164,286	183,542	118,234	104,515	466,063	0.17
1986	211,589	175,886	55,732	40,059	443,208	0.23
1991	60,932	50,259	26,701	51,644	137,891	0.19
1994	37,355	27,174	14,213	39,696	78,741	0.19
1997	38,541	36,764	18,115	65,400	93,420	0.22
2000	56,084	42,969	6,870	22,462	105,922	0.28
2002	54,634	108,179	13,140	181,334	175,953	0.38
2004	112,040	11,763	6,605	235,658	130,408	0.78
2006	69,996	18,002	6,514	18,006	94,512	0.48
2010	104,320	28,675	7,938	110,986	140,932	0.33
2012	31,488	7,433	5,360	13,237	44,281	0.55
2014	63,723	6,807	14,787	69,168	85,316	0.24
2016	59,119	9,404	14,547	10,047	83,070	0.33
2018	122,291	27,553	15,902	31,435	165,747	0.41
2022	90,473	13,753	5,885	53,696	110,110	0.47

Table 1A.5. Aleutian Islands bottom trawl survey pollock proportion-at-age used in authors' preferred model (top panel). Shaded cells are the highest proportion for the year. Aleutian Islands bottom trawl survey pollock proportion-at-age sample sizes (bottom panel).

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1983	0	0.064	0.033	0.022	0.482	0.178	0.065	0.062	0.051	0.026	0.009	0.005	0.001	0	0
1986	0	0.088	0.418	0.027	0.115	0.048	0.06	0.126	0.077	0.017	0.013	0.009	0.001	0	0
1991	0.058	0.044	0.101	0.262	0.125	0.03	0.035	0.023	0.069	0.036	0.066	0.027	0.054	0.039	0.032
1994	0.411	0.025	0.045	0.086	0.123	0.061	0.034	0.038	0.022	0.047	0.047	0.029	0.008	0.006	0.02
1997	0.033	0.035	0.041	0.115	0.127	0.08	0.06	0.111	0.083	0.041	0.075	0.049	0.056	0.04	0.055
2000	0.192	0.012	0.034	0.096	0.122	0.1	0.091	0.072	0.03	0.033	0.066	0.042	0.037	0.058	0.016
2002	0.022	0.021	0.045	0.058	0.059	0.075	0.101	0.071	0.077	0.093	0.073	0.079	0.065	0.061	0.101
2004	0.058	0.004	0.03	0.091	0.103	0.094	0.071	0.062	0.074	0.039	0.079	0.073	0.083	0.064	0.074
2006	0.024	0.001	0.043	0.057	0.079	0.193	0.133	0.091	0.036	0.045	0.048	0.045	0.044	0.074	0.086
2010	0.289	0.001	0.023	0.08	0.086	0.028	0.028	0.049	0.071	0.075	0.116	0.051	0.04	0.005	0.057
2012	0.26	0.014	0.035	0.01	0.043	0.159	0.076	0.024	0.013	0.038	0.048	0.13	0.079	0.052	0.02
2014	0.089	0.077	0.182	0.027	0.069	0.015	0.159	0.157	0.057	0.017	0.002	0.007	0.024	0.04	0.08
2016	0.237	0.056	0.081	0.115	0.091	0.064	0.083	0.044	0.07	0.073	0.043	0.017	0.006	0.004	0.018
2018	0.021	0.057	0.009	0.028	0.083	0.257	0.125	0.092	0.085	0.035	0.051	0.088	0.033	0.009	0.026

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1983	11	663	173	668	2892	1107	345	228	171	78	36	16	4	1	0
1986	31	130	729	88	344	152	185	376	194	50	14	16	6	0	0
1991	0	25	60	198	93	26	38	23	60	28	41	15	52	34	14
1994	162	112	125	91	127	62	50	41	25	61	51	33	17	10	7
1997	97	106	114	118	105	75	58	112	69	39	49	38	33	23	22
2000	107	59	60	84	88	78	77	58	29	37	70	39	33	29	9
2002	119	116	183	122	75	104	103	77	81	74	61	54	75	34	24
2004	43	7	26	134	65	51	29	42	32	21	29	39	19	22	10
2006	41	4	26	33	48	121	72	45	17	29	27	22	23	34	20
2010	39	5	37	80	66	20	8	20	27	39	38	18	13	2	8
2012	82	8	13	16	42	138	58	14	11	31	29	53	34	19	5
2014	85	100	94	14	42	33	93	115	52	16	2	8	14	21	28
2016	48	51	71	110	69	50	82	50	57	84	36	14	9	7	18
2018	54	108	14	22	72	341	84	60	51	23	20	29	13	5	8

Table 1A.6. Aleutian Islands bottom trawl survey pollock average weight-at-age in kilograms used in authors' preferred model.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1978	0.064	0.168	0.42	0.671	0.703	0.786	0.926	0.903	0.944	1.125	1.058	0.996	1.51	2.149	1.593
1979	0.064	0.168	0.42	0.671	0.703	0.786	0.926	0.903	0.944	1.125	1.058	0.996	1.51	2.149	1.593
1980	0.064	0.168	0.42	0.671	0.703	0.786	0.926	0.903	0.944	1.125	1.058	0.996	1.51	2.149	1.593
1981	0.064	0.168	0.42	0.671	0.703	0.786	0.926	0.903	0.944	1.125	1.058	0.996	1.51	2.149	1.593
1982	0.064	0.168	0.42	0.671	0.703	0.786	0.926	0.903	0.944	1.125	1.058	0.996	1.51	2.149	1.593
1983	0.064	0.163	0.448	0.649	0.709	0.803	0.857	0.988	0.923	1.034	1.225	0.937	1.284	2.744	1.444
1984	0.064	0.168	0.42	0.671	0.703	0.786	0.926	0.903	0.944	1.125	1.058	0.996	1.51	2.149	1.593
1985	0.064	0.168	0.42	0.671	0.703	0.786	0.926	0.903	0.944	1.125	1.058	0.996	1.51	2.149	1.593
1986	0.055	0.197	0.458	0.587	0.705	0.771	0.836	0.911	0.981	1.041	1.032	0.927	1.102	1.186	1.273
1987	0.065	0.18	0.39	0.599	0.726	0.797	0.854	0.915	0.976	1.009	1.006	1.012	1.072	1.171	1.275
1988	0.065	0.18	0.39	0.599	0.726	0.797	0.854	0.915	0.976	1.009	1.006	1.012	1.072	1.171	1.275
1989	0.065	0.18	0.39	0.599	0.726	0.797	0.854	0.915	0.976	1.009	1.006	1.012	1.072	1.171	1.275
1990	0.065	0.18	0.39	0.599	0.726	0.797	0.854	0.915	0.976	1.009	1.006	1.012	1.072	1.171	1.275
1991	0.112	0.2	0.527	0.756	0.833	0.963	1.049	1.147	1.169	1.129	1.162	0.981	1.238	1.085	1.007
1992	0.079	0.205	0.446	0.736	0.945	1.061	1.155	1.243	1.285	1.278	1.282	1.338	1.393	1.35	1.211
1993	0.079	0.205	0.446	0.736	0.945	1.061	1.155	1.243	1.285	1.278	1.282	1.338	1.393	1.35	1.211
1994	0.049	0.204	0.462	0.821	0.954	1.116	1.267	1.278	1.559	1.443	1.367	1.385	2.463	1.377	1.462
1995	0.079	0.205	0.446	0.736	0.945	1.061	1.155	1.243	1.285	1.278	1.282	1.338	1.393	1.35	1.211
1996	0.044	0.161	0.417	0.704	0.906	1.045	1.161	1.261	1.321	1.351	1.383	1.398	1.372	1.373	1.451
1997	0.051	0.211	0.382	0.709	0.897	0.999	1.144	1.253	1.25	1.315	1.335	1.298	1.313	1.267	1.4
1998	0.044	0.161	0.417	0.704	0.906	1.045	1.161	1.261	1.321	1.351	1.383	1.398	1.372	1.373	1.451
1999	0.044	0.161	0.417	0.704	0.906	1.045	1.161	1.261	1.321	1.351	1.383	1.398	1.372	1.373	1.451
2000	0.03	0.166	0.451	0.725	0.925	0.961	1.201	1.34	1.362	1.314	1.541	1.468	1.478	1.383	1.563
2001	0.041	0.189	0.481	0.716	0.913	1.107	1.231	1.354	1.512	1.608	1.644	1.666	1.636	1.578	1.554
2002	0.037	0.225	0.464	0.701	1.036	1.18	1.343	1.3	1.625	1.762	1.658	1.793	1.577	1.57	1.578
2003	0.041	0.189	0.481	0.716	0.913	1.107	1.231	1.354	1.512	1.608	1.644	1.666	1.636	1.578	1.554
2004	0.031	0.214	0.487	0.801	0.94	1.014	1.329	1.322	1.735	1.585	1.688	1.583	1.445	1.567	1.479
2005	0.041	0.189	0.481	0.716	0.913	1.107	1.231	1.354	1.512	1.608	1.644	1.666	1.636	1.578	1.554
2006	0.047	0.198	0.474	0.628	0.966	1.224	1.249	1.332	1.481	1.745	1.546	1.526	1.629	1.608	1.47
2007	0.041	0.189	0.481	0.716	0.913	1.107	1.231	1.354	1.512	1.608	1.644	1.666	1.636	1.578	1.554
2008	0.041	0.189	0.481	0.716	0.913	1.107	1.231	1.354	1.512	1.608	1.644	1.666	1.636	1.578	1.554
2009	0.041	0.189	0.481	0.716	0.913	1.107	1.231	1.354	1.512	1.608	1.644	1.666	1.636	1.578	1.554
2010	0.046	0.225	0.451	0.728	0.961	1.025	1.489	1.55	1.518	1.69	1.862	1.911	1.726	1.72	1.723
2011	0.041	0.189	0.481	0.716	0.913	1.107	1.231	1.354	1.512	1.608	1.644	1.666	1.636	1.578	1.554
2012	0.035	0.167	0.459	0.788	1.043	1.166	1.379	1.958	1.743	1.603	1.773	1.943	1.732	1.677	1.671
2013	0.041	0.189	0.481	0.716	0.913	1.107	1.231	1.354	1.512	1.608	1.644	1.666	1.636	1.578	1.554
2014	0.04	0.207	0.447	0.59	0.878	1.096	1.354	1.457	1.535	1.797	1.962	1.541	1.439	1.645	1.686
2015	0.041	0.189	0.481	0.716	0.913	1.107	1.231	1.354	1.512	1.608	1.644	1.666	1.636	1.578	1.554
2016	0.041	0.191	0.477	0.645	0.923	0.874	0.961	1.074	1.354	1.486	1.529	1.644	1.921	1.486	1.464
2017	0.041	0.189	0.481	0.716	0.913	1.107	1.231	1.354	1.512	1.608	1.644	1.666	1.636	1.578	1.554
2018	0.04	0.241	0.424	0.803	0.926	0.867	1.084	1.058	1.138	1.17	1.428	1.47	1.375	1.688	1.298
2019	0.041	0.189	0.481	0.716	0.913	1.107	1.231	1.354	1.512	1.608	1.644	1.666	1.636	1.578	1.554
2020	0.041	0.189	0.481	0.716	0.913	1.107	1.231	1.354	1.512	1.608	1.644	1.666	1.636	1.578	1.554
2021	0.041	0.189	0.481	0.716	0.913	1.107	1.231	1.354	1.512	1.608	1.644	1.666	1.636	1.578	1.554
2022	0.041	0.189	0.481	0.716	0.913	1.107	1.231	1.354	1.512	1.608	1.644	1.666	1.636	1.578	1.554

Table 1A.7. Estimated walleye pollock catch discarded and retained for the Aleutian Islands Region based on NMFS blend data, 1997-2022.

Year	Catch Retained	Discard	Total	Discard Percentage
1997	25,323	618	25,940	2%
1998	23,636	162	23,798	1%
1999	529	480	1,010	48%
2000	455	790	1,244	63%
2001	445	380	825	46%
2002	398	779	1,177	66%
2003	1,181	468	1,649	28%
2004	871	287	1,158	25%
2005	1,297	324	1,621	20%
2006	1,434	311	1,745	18%
2007	2,094	425	2,519	17%
2008	1,197	81	1,278	6%
2009	1,268	395	1,662	24%
2010	1,143	142	1,285	11%
2011	1,133	75	1,208	6%
2012	880	95	975	10%
2013	2,856	107	2,964	4%
2014	2,237	138	2,375	6%
2015	896	19	915	2%
2016	1,198	59	1,257	5%
2017	1,488	18	1,507	1%
2018	1,644	216	1,860	12%
2019	1,598	65	1,663	4%
2020	2,954	245	3,202	8%
2021	1,595	244	1,840	13%
2022*	2,423	303	2,726	11%

* As of October 9, 2022

Table 1A.8. Catch of pollock in the Aleutian Islands for other target fisheries 2018-2022. 2022 data are through October 9, 2022

Target Fishery	2018	2019	2020	2021	2022	Total
Arrowtooth Flounder	0	0.13	88.65	42.32	4.70	135.80
Atka Mackerel	773.00	533.11	462.83	404.03	685.12	2858.09
Greenland Turbot - BSAI	0	0	0	0	0	0.00
Halibut	0.11	0.10	0.23	0.37	0.02	0.83
Kamchatka Flounder - BSAI	84.23	96.49	534.08	409.32	1126.12	2250.24
Pacific Cod	6.05	8.33	75.75	58.79	43.82	192.74
Rockfish	761.66	954.18	1,329.00	925.00	649.00	4618.84
Sablefish	0	0.01	0.20	0.26	0.03	0.50
Total	1625.05	1592.35	2490.74	1840.09	2508.81	

Table 1A.9. Sampling levels in Aleutian Islands Region sub-regions based on foreign, J.V., and domestic walleye pollock observer data 1978 - 2022

	NRA Area			Aleutian Islands Area Basin		
Year	Fish Measured	Hauls Sampled	Vessels Sampled	Fish Measured	Hauls Sampled	Vessels Sampled
1978	6,229	112	11	0	0	0
1979	2,294	33	6	0	0	0
1980	6,779	116	10	0	0	0
1981	11,143	94	13	1,913	15	3
1982	36,932	331	25	11,151	84	7
1983	27,474	240	21	20,744	174	21
1984	54,980	527	35	157,388	1,223	81
1985	29,185	228	25	68,923	460	58
1986	22,918	193	15	39,875	268	48
1987	47,138	352	26	2,665	26	8
1988	23,376	192	18	4,528	37	14
1989	7,431	57	7	0	0	0
1990	67,280	582	35	55	35	11
1991	3,957	34	13	24,025	396	24
1992	22,120	185	40	26,525	234	26
1993	23,559	214	30	26,218	225	31
1994	20,838	203	41	19,524	205	35
1995	31,082	350	34	340	32	16
1996	18,745	194	40	90	1	1
1997	17,722	190	31	77	1	1
1998	10,494	123	15	93	1	1
1999	135	6	4	0	0	0
2000	186	10	5	0	0	0
2001	119	6	3	0	0	0
2002	112	4	4	0	0	0
2003	544	25	7	21	1	1
2004	331	15	4	34	2	1
2005	559	27	8	10	1	1
2006	59	3	3	30	2	1
2007	830	21	10	330	12	1
2008	129	7	4	0	0	0
2009	647	29	11	0	0	0
2010	529	17	8	0	0	0
2011	697	63	6	0	0	0
2012	154	13	5	0	0	0
2013	930	42	9	0	0	0
2014	527	26	6	0	0	0
2015	811	31	5	0	0	0
2016	183	5	3	0	0	0
2017	332	9	6	0	0	0
2018	914	20	8	0	0	0
2019	659	22	8	0	0	0
2020	2,737	83	9	0	0	0
2021	1,697	44	6	0	0	0
2022	2,243	45	7	0	0	0

Table 1A.10. Number of aged and weighed fish in the NRA pollock fishery used to estimate fishery age composition. Age data from the AICASS used in the model for 2006, 2007, and 2008 are in bold.

	Number Aged			Number Weighed		
Year	Males	Females	Total	Males	Females	Total
1978	167	273	440	187	294	481
1979	124	178	302	126	183	309
1980	93	167	260	188	291	479
1981	117	143	260	246	270	516
1982	464	519	983	572	642	1214
1983	60	63	123	278	308	586
1984	80	65	145	139	151	290
1985	77	113	190	295	355	650
1986	140	147	287	323	324	647
1987	131	142	273	136	147	283
1988	34	33	67	66	65	131
1989	0	0	0	112	147	259
1990	46	49	95	340	410	750
1991	80	77	157	20	30	50
1992	110	121	231	34	45	79
1993	81	82	163	48	56	104
1994	157	151	308	102	106	208
1995	74	106	180	147	158	305
1996	95	84	179	93	83	176
1997	15	15	30	15	15	30
1998	144	170	314	126	145	271
1999	0	0	0	0	0	0
2000	0	1	1	3	17	20
2001	0	1	1	12	7	19
2002	0	0	0	1	1	2
2003	1	0	1	33	31	64
2004	0	0	0	4	15	19
2005	2	2	4	21	9	30
2006	**150**/1	**183**/0	**333**/0	**1,315**/0	**1,630**/0	**2,945**/0
2007	**542**/0	**526**/0	**1,068**/0	**701**/71	**605**/58	**1,306**/129
2008	**366**/0	**359**/0	**725**/0	**1,142**/1	**1,031**/1	**2,173**/2
2009	10	5	15	50	40	90
2010	0	0	0	29	38	67
2011	0	0	0	37	37	74
2012	0	0	0	8	9	17
2013	0	0	0	57	87	144
2014	0	0	0	18	41	59
2015	0	0	0	57	84	141
2016	5	7	12	7	13	20
2017	14	10	24	21	19	30
2018	43	78	121	45	85	130
2019	10	27	37	23	74	97
2020	0	0	0	166	230	396
2021	0	0	0	103	169	272
2022	0	0	0	98	213	311

Table 1A.11. Estimates of catch-age composition from the Aleutian Islands commercial fishery 1978-1987, 1994-1996, 1998, 2018, and the Aleutian Islands cooperative acoustic surveys for 2006-2008. Shaded cells are the highest proportion for the year.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1978	0.014	0	0.02	0.091	0.052	0.326	0.082	0.099	0.115	0.098	0.072	0.018	0.007	0.001	0.004
1979	0.01	0.004	0.117	0.138	0.133	0.179	0.148	0.078	0.079	0.045	0.031	0.028	0.003	0.001	0.006
1980	0	0.127	0.06	0.049	0.09	0.194	0.146	0.144	0.08	0.07	0.024	0.008	0.004	0.004	0.001
1981	0.031	0	0.113	0.091	0.064	0.093	0.156	0.152	0.113	0.093	0.036	0.027	0.015	0.013	0.003
1982	0.001	0	0.001	0.685	0.095	0.019	0.028	0.051	0.054	0.034	0.014	0.007	0.005	0.003	0.002
1983	0.06	0	0	0	0.534	0.112	0.069	0.053	0.074	0.059	0.034	0	0	0.005	0
1984	0.071	0.002	0.087	0	0.038	0.506	0.12	0.1	0.058	0.016	0.001	0	0.001	0	0
1985	0.002	0.005	0.016	0.225	0.051	0.128	0.426	0.082	0.038	0.021	0.003	0.003	0	0.001	0
1986	0.002	0	0.087	0.006	0.131	0.018	0.095	0.332	0.134	0.056	0.094	0.018	0.026	0	0
1987	0.011	0	0	0.245	0.068	0.068	0.01	0.033	0.423	0.04	0.042	0.002	0.022	0.015	0.018
1994	0.006	0	0	0.018	0.282	0.057	0.102	0.107	0.067	0.054	0.032	0.08	0.034	0.02	0.141
1995	0.006	0	0.018	0.049	0	0.267	0.014	0.11	0.111	0.022	0.065	0.046	0.086	0.02	0.187
1996	0.03	0	0	0.013	0.055	0.071	0.274	0.126	0.099	0.085	0.037	0.033	0.013	0.057	0.106
1998	0.004	0	0.015	0.003	0.266	0.085	0.055	0.038	0.074	0.063	0.052	0.144	0.062	0.07	0.07
2006	0.023	0	0.01	0	0.021	0.357	0.146	0.026	0.01	0.044	0.047	0.042	0.029	0.089	0.156
2007	0.001	0	0.004	0.009	0.007	0.045	0.272	0.25	0.075	0.041	0.039	0.064	0.022	0.04	0.13
2008	0.003	0	0.001	0.004	0.008	0.02	0.038	0.199	0.215	0.103	0.02	0.072	0.072	0.065	0.179
2018	0.014	0	0	0.117	0.164	0.255	0.06	0.112	0.142	0.004	0.043	0.059	0.018	0	0.012

Table 1A.12. NRA pollock fishery average weight-at-age in kilograms used in authors' preferred model.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1978	0.160	0.122	0.358	0.568	0.675	0.753	0.856	0.986	1.106	1.187	1.249	1.341	1.467	1.497	1.243
1979	0.160	0.146	0.383	0.555	0.620	0.663	0.731	0.825	0.912	0.963	0.991	1.045	1.145	1.196	1.025
1980	0.160	0.197	0.510	0.762	0.878	0.937	0.999	1.088	1.183	1.244	1.262	1.285	1.348	1.374	1.196
1981	0.160	0.126	0.335	0.546	0.681	0.744	0.773	0.812	0.873	0.924	0.929	0.905	0.894	0.879	0.787
1982	0.160	0.125	0.316	0.535	0.717	0.817	0.845	0.871	0.934	0.997	0.989	0.917	0.867	0.866	0.864
1983	0.160	0.149	0.318	0.508	0.698	0.829	0.879	0.911	0.981	1.048	1.016	0.899	0.851	0.933	1.133
1984	0.160	0.215	0.380	0.534	0.698	0.845	0.932	0.993	1.080	1.146	1.092	0.961	0.939	1.157	1.752
1985	0.160	0.319	0.512	0.616	0.735	0.877	0.996	1.098	1.209	1.278	1.211	1.075	1.082	1.403	2.453
1986	0.160	0.248	0.493	0.579	0.636	0.720	0.807	0.895	0.994	1.066	1.033	0.927	0.907	1.158	1.734
1987	0.160	0.096	0.430	0.697	0.817	0.870	0.886	0.912	0.991	1.111	1.194	1.180	1.126	1.105	1.060
1988	0.160	0.253	0.395	0.564	0.704	0.791	0.855	0.926	1.000	1.049	1.065	1.060	1.045	1.011	0.950
1989	0.160	0.253	0.395	0.564	0.704	0.791	0.855	0.926	1.000	1.049	1.065	1.060	1.045	1.011	0.950
1990	0.160	0.253	0.395	0.564	0.704	0.791	0.855	0.926	1.000	1.049	1.065	1.060	1.045	1.011	0.950
1991	0.416	0.494	0.588	0.706	0.855	1.029	1.202	1.340	1.423	1.457	1.465	1.463	1.453	1.431	1.396
1992	0.416	0.494	0.588	0.706	0.855	1.029	1.202	1.340	1.423	1.457	1.465	1.463	1.453	1.431	1.396
1993	0.416	0.494	0.588	0.706	0.855	1.029	1.202	1.340	1.423	1.457	1.465	1.463	1.453	1.431	1.396
1994	0.416	0.508	0.583	0.683	0.813	0.962	1.107	1.221	1.290	1.317	1.319	1.309	1.295	1.275	1.247
1995	0.416	0.602	0.691	0.813	0.976	1.165	1.351	1.495	1.578	1.607	1.606	1.594	1.579	1.557	1.525
1996	0.179	0.177	0.248	0.405	0.649	0.954	1.219	1.372	1.441	1.471	1.467	1.420	1.346	1.293	1.299
1997	0.179	0.256	0.371	0.558	0.859	1.238	1.540	1.652	1.650	1.670	1.748	1.827	1.840	1.791	1.740
1998	0.179	0.277	0.383	0.552	0.774	0.995	1.157	1.253	1.312	1.362	1.400	1.413	1.400	1.385	1.397
1999	0.179	0.256	0.371	0.558	0.859	1.238	1.540	1.652	1.650	1.670	1.748	1.827	1.840	1.791	1.740
2000	0.179	0.256	0.371	0.558	0.859	1.238	1.540	1.652	1.650	1.670	1.748	1.827	1.840	1.791	1.740
2001	0.179	0.256	0.371	0.558	0.859	1.238	1.540	1.652	1.650	1.670	1.748	1.827	1.840	1.791	1.740
2002	0.179	0.256	0.371	0.558	0.859	1.238	1.540	1.652	1.650	1.670	1.748	1.827	1.840	1.791	1.740
2003	0.179	0.256	0.371	0.558	0.859	1.238	1.540	1.652	1.650	1.670	1.748	1.827	1.840	1.791	1.740
2004	0.179	0.256	0.371	0.558	0.859	1.238	1.540	1.652	1.650	1.670	1.748	1.827	1.840	1.791	1.740
2005	0.179	0.256	0.371	0.558	0.859	1.238	1.540	1.652	1.650	1.670	1.748	1.827	1.840	1.791	1.740
2006	0.179	0.319	0.459	0.705	1.048	1.392	1.621	1.722	1.772	1.844	1.951	2.052	2.085	2.021	1.893
2007	0.179	0.251	0.375	0.610	0.963	1.327	1.561	1.643	1.665	1.710	1.801	1.898	1.939	1.892	1.784
2008	0.179	0.223	0.345	0.575	0.930	1.316	1.589	1.706	1.744	1.789	1.869	1.958	2.003	1.974	1.890
2009	0.179	0.256	0.371	0.558	0.859	1.238	1.540	1.652	1.650	1.670	1.748	1.827	1.840	1.791	1.740
2010	0.179	0.256	0.371	0.558	0.859	1.238	1.540	1.652	1.650	1.670	1.748	1.827	1.840	1.791	1.740
2011	0.179	0.256	0.371	0.558	0.859	1.238	1.540	1.652	1.650	1.670	1.748	1.827	1.840	1.791	1.740
2012	0.179	0.256	0.371	0.558	0.859	1.238	1.540	1.652	1.650	1.670	1.748	1.827	1.840	1.791	1.740
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2016	0.179	0.256	0.371	0.558	0.859	1.238	1.540	1.652	1.650	1.670	1.748	1.827	1.840	1.791	1.740
2017	0.179	0.256	0.371	0.558	0.859	1.238	1.540	1.652	1.650	1.670	1.748	1.827	1.840	1.791	1.740
2018	0.179	0.256	0.371	0.558	0.859	1.238	1.540	1.652	1.650	1.670	1.748	1.827	1.840	1.791	1.740
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2020	0.179	0.256	0.371	0.558	0.859	1.238	1.540	1.652	1.650	1.670	1.748	1.827	1.840	1.791	1.740
2021	0.179	0.256	0.371	0.558	0.859	1.238	1.540	1.652	1.650	1.670	1.748	1.827	1.840	1.791	1.740
2022	0.179	0.256	0.371	0.558	0.859	1.238	1.540	1.652	1.650	1.670	1.748	1.827	1.840	1.791	1.740

Table 1A.13. Estimated von Bertalanffy growth curve parameters and length-weight regression parameters for walleye pollock sampled during the U.S.-Japan 1980, 1983, and 1986 groundfish surveys and the 1991, 1994, 1997, 2000, 2002, 2006, 2010, 2012, 2014, 2016, 2018, and 2022 RACE groundfish surveys. *Age data are not yet available for 2022.

	L_{inf}	K	t_0	a	b
1980	52.97	0.420	-0.495	0.0132	2.858
1983	53.91	0.362	-0.128	0.0233	2.696
1986	53.32	0.362	-0.454	0.0136	2.842
1991	54.48	0.407	-0.200	0.0089	2.955
1994	62.24	0.315	-0.130	0.0065	3.032
1997	61.40	0.273	-0.410	0.0071	3.006
2000	62.27	0.315	0.006	0.0062	3.032
2002	64.88	0.285	-0.122	0.0060	3.041
2004	61.81	0.331	0.009	0.0066	3.024
2006	64.43	0.271	-0.271	0.0074	2.990
2010	65.01	0.267	-0.279	0.0082	2.979
2012	66.70	0.260	-0.144	0.0070	3.004
2014	65.55	0.257	-0.284	0.0071	2.997
2016	63.24	0.257	-0.445	0.0075	2.983
2018	59.80	0.271	-0.527	0.0072	3.003
2022*	-	-	-	0.0053	3.1804

Table 1A.14. Percentage mature females at age from Wespestad and Terry (1984) for the BSAI and mean percentage of mature females at age for the Gulf of Alaska from Dorn *et al.* (2009) for 1983-2006 (GOA).

Age	1	2	3	4	5	6	7	8	9	10	11	12	13-15
BSAI	0.0	0.8	28.9	64.1	84.2	90.1	94.7	96.3	97.0	97.8	98.4	99.0	100
GOA	0.0	0.1	2.1	26.9	56.5	81.3	89.9	95.9	98.4	99.0	100	100	100

Table 1A.15. Estimated instantaneous natural mortality rates (M) by age from Wespestad and Terry (1984) for the Bering Sea and natural mortality rates in Model 15.1 (M1) and Model 15.2 (M2).

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
M	0.85	0.45	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5
M1	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
M2	0.34	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.14

Table 1A.16. Aging error matrix used in the authors' preferred model developed from aging validation tests for 2006-2008.

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1	0.9744	0.0256	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0256	0.9488	0.0256	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0389	0.9222	0.0389	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0537	0.8927	0.0537	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000	0.0692	0.8615	0.0692	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6	0.0000	0.0000	0.0000	0.0000	0.0851	0.8299	0.0851	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
7	0.0000	0.0000	0.0000	0.0000	0.0001	0.1007	0.7985	0.1007	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.1159	0.7678	0.1159	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004	0.1305	0.7383	0.1305	0.0004	0.0000	0.0000	0.0000	0.0000
10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0007	0.1442	0.7100	0.1442	0.0007	0.0000	0.0000	0.0000
11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0013	0.1571	0.6832	0.1571	0.0013	0.0000	0.0000
12	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0022	0.1689	0.6577	0.1689	0.0022	0.0000
13	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0034	0.1798	0.6337	0.1798	0.0034
14	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0049	0.1896	0.6110	0.1945
15+	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0068	0.1985	0.7948

Table 1A.17. Evaluation of 2016 Aleutian Islands pollock models.

	Model 15.1	Model 15.2
Number of Parameters	154	154
Survey Catchability	1.00	1.00
Fishery Average Effective *N*	48.24	48.46
Survey Average Effective *N*	54.37	48.43
RMSE Survey	65.86	70.31
-Log Likelihoods		
Survey Index	25.83	28.16
Fishery Age Comp	281.95	285.49
Survey Age Comp	146.11	159.08
Catch	0.81	0.84
Sub Total	454.69	473.55
-log Penalties		
Recruitment	30.98	30.38
Selectivity Constraints		
Survey	12.35	13.95
Fishery	14.64	16.08
Prior	0.002	0.002
Fpen	0.07	0.17
Residual	512.76	559.53
Total	25.83	28.16

Table 1A.18. Key results for the evaluations of Aleutian Islands pollock models.

	Model 15.1	Model 15.2
Model Conditions		
Survey Catchability	1.00	1.00
Mean Natural Mortality	0.21	0.26
Fishing Mortalities		
Max $F_{1978-2022}$	0.227	0.214
F_{2019}	0.011	0.012
Stock Abundance		
Initial Biomass (1978; thousands of tons)	466.21	637.58
CV	10%	11%
2022Total Biomass 1+ (thousands of tons)	217.17	235.85
CV	15%	16%
2022 Female SSB (thousands of tons)	79.83	78.26
CV	14%	14%
1978 Year Class (billions at age 1)	1.55	2.84
	11%	13%
Recruitment Variability (1978-2010)	0.28	0.51
Recruitment variance (σ_R^2)	0.60	0.60
Steepness (*h*)	0.70	0.70

Table 1A.19. The 2020 and 2022 authors' preferred model estimates of pollock biomass with 2022 Model 15.1 approximate lower (LCI) and upper (UCI) 95% confidence bounds for age 1+ biomass and female spawning stock biomass (SSB) estimates.

	Total Biomass (Age 1+)				Female SSB			
Year	2020 Model		LCI	UCI	2020 Model		LCI	UCI
1978	544,321	466,214	381,699	569,443	161,198	147,787	120,183	181,731
1979	621,480	483,868	399,509	586,041	174,463	159,925	131,129	195,045
1980	800,141	490,883	406,823	592,311	179,495	163,998	134,558	199,880
1981	981,105	883,524	735,343	1,061,566	168,931	152,428	122,919	189,021
1982	1,012,610	897,765	749,104	1,075,927	226,571	204,278	168,030	248,346
1983	975,680	822,585	684,696	988,245	285,435	257,347	212,730	311,321
1984	967,627	838,749	701,363	1,003,047	316,278	285,257	236,112	344,630
1985	945,474	776,372	651,190	925,620	301,170	272,039	225,913	327,583
1986	951,384	862,922	738,302	1,008,576	295,384	268,076	223,919	320,940
1987	936,706	851,240	738,468	981,234	312,537	287,343	244,842	337,220
1988	886,204	791,909	695,561	901,604	310,548	289,116	251,122	332,859
1989	823,181	759,286	676,322	852,427	298,500	280,749	247,179	318,879
1990	783,588	729,445	659,400	806,930	280,351	265,908	237,864	297,258
1991	645,210	576,538	519,938	639,299	226,308	215,361	192,941	240,386
1992	539,605	507,029	454,108	566,117	183,105	174,633	156,084	195,386
1993	467,937	435,168	389,533	486,149	160,974	153,681	137,551	171,703
1994	393,919	362,031	321,858	407,218	137,071	130,711	116,367	146,821
1995	324,048	286,674	250,656	327,867	110,967	105,355	92,275	120,289
1996	266,708	244,154	207,252	287,626	85,648	80,609	68,931	94,265
1997	233,796	208,235	173,869	249,393	76,406	71,423	59,939	85,107
1998	210,675	189,537	155,791	230,592	70,515	65,483	53,927	79,517
1999	179,910	160,809	129,136	200,250	63,954	58,956	47,499	73,177
2000	174,917	154,018	124,610	190,366	63,786	59,025	47,915	72,711
2001	178,040	149,556	121,755	183,706	63,231	58,729	47,977	71,891
2002	188,025	159,379	130,264	195,001	61,247	57,076	46,903	69,454
2003	193,229	175,731	143,980	214,483	60,753	56,702	46,789	68,715
2004	187,223	170,806	140,391	207,810	64,055	59,801	49,467	72,295
2005	176,147	160,786	132,609	194,950	66,642	62,246	51,558	75,150
2006	161,893	147,904	122,244	178,951	65,049	60,812	50,385	73,396
2007	151,588	133,639	110,625	161,440	60,393	56,539	46,848	68,236
2008	151,714	126,227	104,304	152,758	55,679	52,192	43,181	63,083
2009	158,414	139,675	115,405	169,047	51,752	48,556	40,147	58,726
2010	160,007	143,881	118,689	174,420	50,981	47,805	39,558	57,770
2011	161,266	136,749	112,542	166,162	52,965	49,631	41,023	60,045
2012	168,128	147,481	120,664	180,257	53,971	50,585	41,630	61,467
2013	178,127	145,832	118,762	179,071	54,365	50,908	41,706	62,141
2014	198,795	161,137	129,717	200,167	55,193	51,587	41,918	63,486
2015	223,489	192,153	152,414	242,254	59,911	55,838	44,985	69,310
2016	239,584	207,019	162,694	263,421	67,638	62,839	50,197	78,664
2017	250,881	216,553	168,687	278,002	76,984	71,319	56,298	90,347
2018	256,899	226,622	174,753	293,887	84,033	77,741	60,670	99,616
2019	255,323	224,425	171,605	293,504	87,725	81,021	62,573	104,909
2020	257,233	214,988	163,172	283,256	90,106	82,981	63,402	108,607
2021	292,967	213,339	159,993	284,472	86,049	82,121	62,051	108,683
2022		217,171	162,514	290,210		79,828	59,990	106,225
2023		226,795	166,032	309,795		78,671	58,873	105,127

Table 1A.20 Model 15.1 estimate of 2022 fishery and 2022 survey selectivity-at-age used in projections.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
Survey	0.266	0.199	0.201	0.265	0.403	0.616	0.828	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Fishery	0.013	0.031	0.075	0.187	0.384	0.612	0.798	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table 1A.21. Authors' preferred Model 15.1 estimates of pollock numbers at age in billions (10^9).

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	% of 15+
1978	0.15	0.13	0.10	0.12	0.07	0.10	0.03	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.02	0.80	2.2%
1979	1.55	0.13	0.11	0.08	0.10	0.05	0.08	0.02	0.02	0.02	0.01	0.01	0.00	0.00	0.02	2.20	0.7%
1980	0.04	1.26	0.10	0.09	0.07	0.08	0.04	0.06	0.02	0.02	0.01	0.01	0.01	0.00	0.01	1.82	0.8%
1981	0.06	0.04	1.02	0.08	0.07	0.05	0.06	0.03	0.04	0.01	0.01	0.01	0.01	0.00	0.01	1.49	0.7%
1982	0.39	0.05	0.03	0.82	0.06	0.05	0.04	0.04	0.02	0.03	0.01	0.01	0.01	0.00	0.01	1.56	0.7%
1983	0.15	0.32	0.04	0.02	0.63	0.05	0.04	0.03	0.03	0.01	0.02	0.00	0.00	0.00	0.01	1.35	0.7%
1984	0.59	0.12	0.26	0.03	0.02	0.48	0.04	0.03	0.02	0.02	0.01	0.01	0.00	0.00	0.01	1.64	0.6%
1985	0.12	0.48	0.10	0.21	0.02	0.01	0.37	0.03	0.02	0.01	0.01	0.01	0.01	0.00	0.01	1.41	0.6%
1986	0.11	0.10	0.39	0.08	0.16	0.02	0.01	0.27	0.02	0.01	0.01	0.01	0.00	0.01	0.01	1.21	0.7%
1987	0.26	0.09	0.08	0.32	0.06	0.13	0.01	0.01	0.21	0.01	0.01	0.01	0.01	0.00	0.01	1.23	0.9%
1988	0.13	0.21	0.07	0.06	0.25	0.05	0.10	0.01	0.01	0.16	0.01	0.01	0.01	0.01	0.01	1.11	1.0%
1989	0.06	0.11	0.17	0.06	0.05	0.20	0.04	0.08	0.01	0.00	0.12	0.01	0.01	0.00	0.01	0.93	1.4%
1990	0.26	0.05	0.09	0.14	0.05	0.04	0.16	0.03	0.06	0.01	0.00	0.09	0.01	0.00	0.01	1.00	1.3%
1991	0.04	0.21	0.04	0.07	0.11	0.04	0.03	0.10	0.02	0.04	0.00	0.00	0.06	0.00	0.01	0.78	1.4%
1992	0.07	0.03	0.17	0.03	0.05	0.08	0.02	0.02	0.06	0.01	0.02	0.00	0.00	0.04	0.01	0.63	1.5%
1993	0.06	0.05	0.03	0.13	0.03	0.04	0.06	0.02	0.01	0.04	0.01	0.02	0.00	0.00	0.03	0.53	5.9%
1994	0.13	0.05	0.04	0.02	0.10	0.02	0.03	0.04	0.01	0.01	0.03	0.01	0.01	0.00	0.02	0.52	4.1%
1995	0.03	0.10	0.04	0.03	0.02	0.08	0.01	0.02	0.02	0.01	0.00	0.02	0.00	0.01	0.01	0.40	3.3%
1996	0.06	0.02	0.08	0.03	0.03	0.01	0.05	0.01	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.34	3.4%
1997	0.03	0.05	0.02	0.07	0.02	0.02	0.01	0.03	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.29	3.0%
1998	0.03	0.03	0.04	0.01	0.05	0.02	0.01	0.01	0.02	0.00	0.00	0.01	0.00	0.00	0.01	0.24	4.3%
1999	0.03	0.02	0.02	0.03	0.01	0.04	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.21	3.6%
2000	0.08	0.03	0.02	0.02	0.02	0.01	0.03	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.25	2.8%
2001	0.09	0.06	0.02	0.01	0.01	0.02	0.01	0.03	0.01	0.01	0.00	0.01	0.00	0.00	0.01	0.29	2.8%
2002	0.02	0.08	0.05	0.02	0.01	0.01	0.02	0.01	0.02	0.01	0.00	0.00	0.01	0.00	0.01	0.26	3.2%
2003	0.02	0.02	0.06	0.04	0.01	0.01	0.01	0.01	0.00	0.02	0.01	0.00	0.00	0.01	0.01	0.22	3.4%
2004	0.02	0.01	0.01	0.05	0.03	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.20	5.6%
2005	0.01	0.01	0.01	0.01	0.04	0.03	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.01	0.17	5.8%
2006	0.03	0.01	0.01	0.01	0.01	0.03	0.02	0.01	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.17	6.0%
2007	0.09	0.02	0.01	0.01	0.01	0.01	0.03	0.02	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.22	4.6%
2008	0.05	0.07	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.23	6.0%
2009	0.01	0.04	0.06	0.02	0.01	0.01	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.20	6.2%
2010	0.08	0.01	0.03	0.05	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.24	5.3%
2011	0.03	0.06	0.01	0.03	0.04	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.23	5.2%
2012	0.09	0.03	0.05	0.01	0.02	0.03	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.28	3.9%
2013	0.13	0.08	0.02	0.04	0.01	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.35	2.9%
2014	0.07	0.10	0.06	0.02	0.03	0.00	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.35	3.3%
2015	0.07	0.06	0.08	0.05	0.01	0.03	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.35	3.9%
2016	0.08	0.05	0.05	0.07	0.04	0.01	0.02	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.36	3.3%
2017	0.05	0.06	0.04	0.04	0.06	0.03	0.01	0.02	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.34	3.1%
2018	0.03	0.04	0.05	0.04	0.03	0.05	0.03	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.31	3.0%
2019	0.06	0.02	0.03	0.04	0.03	0.03	0.04	0.02	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.31	2.6%
2020	0.08	0.05	0.02	0.03	0.03	0.02	0.02	0.03	0.02	0.00	0.01	0.00	0.00	0.01	0.01	0.33	2.4%
2021	0.09	0.06	0.04	0.02	0.02	0.03	0.02	0.02	0.02	0.01	0.00	0.01	0.00	0.00	0.01	0.36	3.0%
2022	0.09	0.07	0.05	0.03	0.01	0.02	0.02	0.02	0.01	0.02	0.01	0.00	0.01	0.00	0.01	0.38	2.9%

Table 1A.22. Authors' preferred Model 15.1 estimated NRA region pollock catch at age in millions (10^6). 2022 catch numbers estimated with the 2022 total year end catch estimate of 2,709 t.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
1978	0.07	0.13	0.26	0.91	0.82	1.77	0.59	0.74	0.57	0.41	0.28	0.13	0.10	0.08	0.50	7.36
1979	1.11	0.19	0.43	0.97	1.93	1.50	2.93	0.91	0.92	0.71	0.51	0.34	0.17	0.12	0.72	13.46
1980	0.15	8.86	1.89	4.66	5.87	9.78	6.78	12.07	3.01	3.05	2.33	1.70	1.14	0.55	2.80	64.64
1981	0.14	0.18	13.35	3.08	4.19	4.37	6.42	4.01	5.63	1.40	1.42	1.09	0.79	0.53	1.56	48.16
1982	1.10	0.28	0.46	37.06	4.74	5.36	4.96	6.58	3.26	4.58	1.14	1.16	0.89	0.65	1.70	73.92
1983	0.31	1.37	0.44	0.77	34.93	3.73	3.73	3.13	3.29	1.63	2.29	0.57	0.58	0.44	1.17	58.38
1984	1.00	0.43	2.41	0.83	0.82	31.19	2.97	2.72	1.81	1.90	0.94	1.33	0.33	0.34	0.94	49.96
1985	0.19	1.60	0.87	5.28	1.02	0.85	28.97	2.53	1.85	1.23	1.29	0.64	0.90	0.23	0.86	48.31
1986	0.10	0.19	2.00	1.19	4.06	0.67	0.50	15.65	1.09	0.80	0.53	0.56	0.28	0.39	0.47	28.48
1987	0.25	0.18	0.42	4.90	1.65	4.78	0.71	0.49	12.38	0.86	0.63	0.42	0.44	0.22	0.68	29.01
1988	0.20	0.65	0.60	1.49	9.84	2.82	7.34	1.00	0.56	14.06	0.98	0.72	0.48	0.50	1.02	42.26
1989	0.03	0.10	0.41	0.41	0.58	3.28	0.85	2.04	0.22	0.12	3.13	0.22	0.16	0.11	0.34	12.00
1990	0.83	0.38	1.53	6.04	4.37	5.50	27.16	6.08	11.82	1.29	0.72	18.11	1.26	0.92	2.58	88.59
1991	0.15	1.64	0.80	3.37	10.88	5.26	5.29	22.42	4.23	8.21	0.90	0.50	12.59	0.88	2.43	79.55
1992	0.15	0.17	2.05	1.04	3.60	7.83	3.04	2.63	9.38	1.77	3.44	0.38	0.21	5.27	1.39	42.35
1993	0.17	0.34	0.43	5.26	2.20	5.16	9.07	3.06	2.24	7.98	1.51	2.92	0.32	0.18	5.66	46.50
1994	0.50	0.40	0.89	1.15	11.42	3.19	5.98	9.04	2.57	1.88	6.71	1.27	2.46	0.27	4.91	52.64
1995	0.11	1.00	0.85	1.96	2.05	13.44	2.96	4.73	5.99	1.70	1.25	4.44	0.84	1.63	3.43	46.38
1996	0.16	0.14	1.27	1.12	2.11	1.47	7.63	1.44	1.91	2.43	0.69	0.51	1.80	0.34	2.05	25.07
1997	0.08	0.24	0.22	2.11	1.53	1.96	1.10	4.96	0.79	1.05	1.33	0.38	0.28	0.99	1.31	18.33
1998	0.08	0.19	0.61	0.57	4.55	2.24	2.31	1.13	4.30	0.68	0.91	1.15	0.33	0.24	1.99	21.28
1999	0.00	0.01	0.01	0.04	0.03	0.20	0.08	0.07	0.03	0.11	0.02	0.02	0.03	0.01	0.06	0.72
2000	0.01	0.01	0.01	0.03	0.08	0.05	0.25	0.09	0.07	0.03	0.10	0.02	0.02	0.03	0.06	0.86
2001	0.01	0.01	0.01	0.01	0.03	0.08	0.04	0.15	0.05	0.04	0.01	0.06	0.01	0.01	0.05	0.57
2002	0.00	0.02	0.03	0.03	0.04	0.07	0.12	0.05	0.18	0.05	0.04	0.02	0.07	0.01	0.07	0.80
2003	0.00	0.01	0.06	0.10	0.07	0.08	0.11	0.16	0.06	0.21	0.06	0.05	0.02	0.08	0.10	1.17
2004	0.00	0.00	0.01	0.08	0.12	0.07	0.06	0.07	0.09	0.03	0.12	0.04	0.03	0.01	0.10	0.83
2005	0.00	0.01	0.01	0.02	0.19	0.22	0.09	0.07	0.07	0.10	0.04	0.13	0.04	0.03	0.12	1.14
2006	0.00	0.00	0.01	0.02	0.04	0.25	0.22	0.08	0.05	0.06	0.07	0.03	0.09	0.03	0.11	1.06
2007	0.02	0.01	0.01	0.03	0.05	0.08	0.41	0.31	0.10	0.07	0.07	0.09	0.03	0.12	0.18	1.58
2008	0.01	0.02	0.01	0.01	0.03	0.03	0.04	0.20	0.13	0.04	0.03	0.03	0.04	0.01	0.13	0.76
2009	0.00	0.02	0.06	0.04	0.03	0.06	0.05	0.06	0.25	0.17	0.05	0.04	0.04	0.05	0.18	1.10
2010	0.01	0.00	0.03	0.11	0.06	0.03	0.05	0.04	0.04	0.17	0.11	0.04	0.02	0.03	0.15	0.89
2011	0.01	0.02	0.01	0.06	0.17	0.07	0.03	0.05	0.03	0.03	0.13	0.09	0.03	0.02	0.14	0.89
2012	0.01	0.01	0.04	0.01	0.07	0.17	0.06	0.02	0.03	0.02	0.02	0.08	0.05	0.02	0.10	0.71
2013	0.04	0.06	0.04	0.20	0.06	0.27	0.51	0.17	0.06	0.07	0.05	0.05	0.18	0.12	0.26	2.14
2014	0.02	0.06	0.09	0.07	0.26	0.06	0.22	0.39	0.10	0.04	0.04	0.03	0.03	0.11	0.23	1.75
2015	0.01	0.01	0.05	0.07	0.04	0.13	0.02	0.08	0.12	0.03	0.01	0.01	0.01	0.01	0.10	0.70
2016	0.01	0.02	0.03	0.12	0.15	0.07	0.17	0.03	0.08	0.12	0.03	0.01	0.01	0.01	0.11	0.97
2017	0.01	0.02	0.03	0.07	0.21	0.20	0.08	0.18	0.02	0.07	0.10	0.03	0.01	0.01	0.10	1.14
2018	0.00	0.01	0.04	0.07	0.13	0.30	0.23	0.08	0.16	0.02	0.06	0.09	0.02	0.01	0.10	1.32
2019	0.01	0.01	0.02	0.07	0.10	0.14	0.26	0.19	0.06	0.11	0.01	0.04	0.06	0.02	0.07	1.17
2020	0.02	0.03	0.02	0.08	0.22	0.24	0.27	0.49	0.29	0.08	0.16	0.02	0.06	0.09	0.13	2.20
2021	0.01	0.02	0.03	0.03	0.08	0.16	0.15	0.16	0.23	0.13	0.04	0.07	0.01	0.03	0.10	1.25
2022	0.02	0.03	0.06	0.09	0.07	0.15	0.26	0.22	0.19	0.28	0.16	0.05	0.09	0.01	0.16	1.84

Table 1A.23. Authors' preferred Model 15.1 estimates of full-selection fishing mortality and exploitation rates for NRA pollock.

Year	F[a]	Catch/Biomass Rate[b]
1978	0.022	0.032
1979	0.035	0.051
1980	0.163	0.239
1981	0.115	0.168
1982	0.138	0.202
1983	0.101	0.148
1984	0.082	0.121
1985	0.077	0.113
1986	0.045	0.066
1987	0.047	0.068
1988	0.071	0.104
1989	0.021	0.030
1990	0.168	0.246
1991	0.186	0.272
1992	0.120	0.175
1993	0.153	0.223
1994	0.204	0.298
1995	0.227	0.332
1996	0.150	0.219
1997	0.123	0.180
1998	0.161	0.236
1999	0.006	0.008
2000	0.007	0.010
2001	0.004	0.007
2002	0.007	0.010
2003	0.010	0.014
2004	0.007	0.010
2005	0.009	0.013
2006	0.008	0.012
2007	0.013	0.020
2008	0.007	0.011
2009	0.011	0.016
2010	0.009	0.014
2011	0.009	0.013
2012	0.007	0.010
2013	0.019	0.029
2014	0.015	0.022
2015	0.006	0.008
2016	0.007	0.011
2017	0.007	0.011
2018	0.008	0.012
2019	0.007	0.010
2020	0.013	0.019
2021	0.007	0.011
2022*	0.018	0.011

[a] Average fishing mortality rates over all ages
[b] Catch/biomass rate is the ratio of catch to beginning year age 1+ biomass.
* Assuming catch of 3,000t

Table 1A.24. Authors' preferred model estimates of age 1 pollock recruitment (in millions) for 2020 and 2022 authors' preferred models.

2020 Authors' Preferred Model			2022 Model 15.1		
Year	**Index at age 1**	**St. Dev.**	**Year**	**Index at age 1**	**St. Dev.**
1978	172.1	42.0	1978	154.6	38.4
1979	1,711.5	194.3	1979	1553.1	186.6
1980	48.0	21.7	1980	44.1	20.0
1981	62.8	23.0	1981	57.9	21.4
1982	411.4	73.1	1982	389.4	69.4
1983	156.4	50.9	1983	150.5	49.2
1984	604.6	98.6	1984	591.7	95.6
1985	122.6	50.0	1985	118.8	49.7
1986	113.8	44.0	1986	112.0	43.9
1987	270.1	50.5	1987	262.8	49.1
1988	140.5	30.9	1988	134.9	29.8
1989	67.5	19.7	1989	64.5	18.8
1990	270.1	35.0	1990	256.3	33.1
1991	44.9	12.4	1991	42.3	11.7
1992	70.2	14.4	1992	65.3	13.5
1993	60.7	13.5	1993	56.3	12.5
1994	138.7	22.1	1994	127.5	20.3
1995	29.1	8.4	1995	26.3	7.6
1996	61.6	12.3	1996	56.3	11.3
1997	36.4	8.3	1997	33.6	7.6
1998	27.8	7.1	1998	25.2	6.5
1999	33.8	7.9	1999	30.9	7.2
2000	84.7	14.3	2000	76.6	13.0
2001	101.4	16.3	2001	92.2	14.9
2002	20.7	5.4	2002	18.6	4.9
2003	17.4	4.7	2003	15.6	4.3
2004	18.6	4.7	2004	17.1	4.3
2005	13.4	4.3	2005	12.1	3.9
2006	31.9	8.0	2006	28.5	7.2
2007	94.6	17.8	2007	86.5	16.2
2008	52.7	12.2	2008	47.8	11.0
2009	14.6	5.2	2009	13.3	4.7
2010	86.8	15.6	2010	78.3	14.0
2011	36.6	10.4	2011	33.1	9.3
2012	103.9	19.8	2012	92.9	17.5
2013	141.4	28.6	2013	127.0	25.3
2014	79.4	18.7	2014	70.8	16.4
2015	73.3	20.9	2015	65.7	18.4
2016	87.3	22.7	2016	76.7	19.7
2017	53.7	20.5	2017	47.4	17.8
2018	42.9	14.0	2018	28.0	11.1
2019	100.0	63.5	2019	61.1	37.0
2020	100.0	63.5	2020	75.6	33.8
2021			2021	91.7	58.1
2022			2022	92.4	58.8
Ave 78-16	139.8		Ave 78-20	128.4	
Med 78-16	73.3		Med 78-20	65.3	

Table 1A.25. Projections of Authors' preferred Model 15.1 female spawning biomass (in thousands of t), fishing mortality (*F*), and catch (in thousands of t) for NRA pollock for the 8 scenarios. Fishing mortality rates given are based on the *average* fishing mortality over all ages *(B_0=185.48 kt, B_{40}=74.19 kt, B_{35}=64.92 kt, and ½ B_{35}=32.46 kt).*

Sp.Biomass	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8
2022	79.81	79.81	79.81	79.81	79.81	79.81	79.81	79.81
2023	75.33	75.33	78.45	77.22	78.75	74.52	75.33	77.34
2024	62.36	62.36	79.46	72.10	81.37	58.73	62.36	72.65
2025	56.80	56.80	81.72	69.75	85.01	52.74	56.39	69.95
2026	56.91	56.91	86.70	71.08	91.20	52.84	54.72	70.72
2027	60.17	60.17	94.27	75.38	99.94	56.01	56.94	74.68
2028	64.71	64.71	103.34	81.32	110.17	60.19	60.62	80.74
2029	68.68	68.68	112.34	87.16	120.36	63.62	63.80	87.28
2030	71.65	71.65	120.86	92.39	130.13	65.94	66.00	93.77
2031	73.41	73.41	128.22	96.46	138.77	67.10	67.11	99.63
2032	74.22	74.22	134.08	99.30	145.86	67.45	67.45	104.51
2033	74.38	74.38	138.64	101.15	151.57	67.32	67.31	108.44
2034	74.30	74.30	142.20	102.36	156.17	67.06	67.05	111.64
2035	73.82	73.82	144.51	102.75	159.40	66.51	66.50	113.79
F								
2022	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
2023	0.31	0.31	0.03	0.13	0.00	0.38	0.31	0.12
2024	0.27	0.27	0.03	0.13	0.00	0.32	0.27	0.14
2025	0.25	0.25	0.03	0.13	0.00	0.28	0.30	0.15
2026	0.24	0.24	0.03	0.13	0.00	0.28	0.29	0.14
2027	0.25	0.25	0.03	0.13	0.00	0.29	0.29	0.14
2028	0.25	0.25	0.03	0.13	0.00	0.29	0.30	0.14
2029	0.26	0.26	0.03	0.13	0.00	0.30	0.30	0.13
2030	0.26	0.26	0.03	0.13	0.00	0.31	0.31	0.13
2031	0.26	0.26	0.03	0.13	0.00	0.31	0.31	0.13
2032	0.26	0.26	0.03	0.13	0.00	0.31	0.31	0.12
2033	0.26	0.26	0.03	0.13	0.00	0.31	0.31	0.12
2034	0.26	0.26	0.03	0.13	0.00	0.31	0.31	0.12
2035	0.26	0.26	0.03	0.13	0.00	0.31	0.31	0.12
Catch								
2022	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
2023	43.41	43.41	4.20	20.55	0.00	52.38	43.41	19.00
2024	30.82	30.82	4.10	18.43	0.00	33.39	30.82	19.00
2025	25.13	25.13	4.17	17.58	0.00	26.44	30.37	19.00
2026	24.90	24.90	4.44	17.89	0.00	26.31	28.26	19.00
2027	26.76	26.76	4.82	18.86	0.00	28.69	29.62	19.00
2028	29.75	29.75	5.29	20.34	0.00	32.26	32.67	19.00
2029	32.77	32.77	5.79	21.99	0.00	35.62	35.77	19.00
2030	35.04	35.04	6.31	23.61	0.00	37.90	37.95	19.00
2031	36.37	36.37	6.73	24.80	0.00	39.04	39.04	19.00
2032	37.13	37.13	7.06	25.62	0.00	39.55	39.54	19.00
2033	37.27	37.27	7.31	26.10	0.00	39.50	39.49	19.00
2034	37.17	37.17	7.50	26.40	0.00	39.27	39.26	19.00
2035	36.93	36.93	7.63	26.56	0.00	38.82	38.82	19.00

Table 1A.26. Ecosystem effects on AI walleye pollock

Indicator	Observation	Interpretation	Evaluation
Prey availability or abundance trends			
Zooplankton	Stomach contents, ichthyoplankton surveys	None	Unknown
Predator population trends			
Marine mammals	Fur seals declining, Steller sea lions increasing slightly in central, decreasing in West.	Possibly lower mortality on walleye pollock	No concern
Birds	Stable, some increasing some decreasing	May affect young-of-year mortality	Unknown
Fish (Pacific cod, arrowtooth flounder)	Pacific cod—increasing, arrowtooth--stable	Possible increases to walleye pollock mortality	No concern
Changes in habitat quality			
Temperature regime	The 2014-2018 AI summer bottom temperature was warmer than average	warming could affect apparent distribution.	Unknown

The AI walleye pollock effects on ecosystem

Indicator	Observation	Interpretation	Evaluation
Fishery contribution to bycatch			
Prohibited species	Expected to be heavily monitored	Likely to be a minor contribution to mortality	No concern
Forage (including herring, Atka mackerel, cod, and pollock)	Expected to be heavily monitored.	Bycatch levels should be low.	Unknown
HAPC biota (seapens/whips, corals, sponges, anemones)	Very low bycatch levels of seapens/whips, sponge and coral catches expected in the pelagic fishery	Bycatch levels and destruction of benthic habitat expected to be minor given the pelagic fishery.	No concern
Marine mammals and birds	Very minor direct-take expected	Likely to be very minor contribution to mortality	No concern
Sensitive non-target species	Expected to be heavily monitored	Unknown given that this fishery was closed between 1999 and 2005. The 2006 AICASS had 3% POP bycatch, the only significant bycatch. The 2005-2009 fishery had high bycatch of POP, but bycatch of other species was very low in fishery prior to 1999.	No concern
Other non-target species	Very little bycatch.	Unknown	No concern
Fishery concentration in space and time	Newly opened areas should spread the fishery out more than under previous SSL protection measures.	Depending on concentration of pollock outside of critical habitat could have an effect.	Possible concern
Fishery effects on amount of large size target fish	Depends on highly variable year-class strength	Natural fluctuation	Possible Concern
Fishery contribution to discards and offal production	Offal production—unknown. 2021 fishery not expected to be significant.	Unknown	Unknown
Fishery effects on age-at-maturity and fecundity	Unknown	Unknown	Unknown

Table 1A.27 Catch and bycatch in the targeted Aleutian Islands walleye pollock fishery 2016-2022*. The 2022 catch is through October 10, 2022. There were no directed pollock fisheries in the Aleutian Islands in 2017 or 2021.

	2016	2018	2019	2020	2022	Total
pollock, walleye	70.5	235.0	70.2	711.5	216.7	1303.9
perch, Pacific ocean	62.6	65.7	42.0	77.7	22.5	270.5
Kamchatka flounder	0.3	16.7		3.5	133.3	153.8
flounder, arrowtooth	7.5	2.8		7.5	37.5	55.3
greenling, atka mackerel		8.7			44.9	53.6
sablefish (blackcod)		2.0		4.4	32.0	38.4
skate, other		0.1		0.1	8.5	8.7
turbot, Greenland					6.8	6.8
cod, Pacific (gray)	1.1	1.6		0.4	0.9	4.0
rockfish, rougheye		0.3		0.0	1.8	2.1
sculpin, bigmouth		2.0				2.0
skate, Whiteblotched		1.0				1.0
rockfish, northern	0.1	0.6			0.2	0.9
Pacific sleeper shark					0.9	0.9
sculpin, yellow irish lord		0.3		0.4		0.7
sole, flathead	0.6					0.6
sculpin, general		0.2		0.1		0.4
rockfish, thornyhead (idiots)	0.0	0.1			0.2	0.4
rockfish, shortraker		0.2		0.0	0.1	0.3
rockfish, dusky					0.2	0.2
squid, majestic		0.1				0.1
sole, rock	0.0				0.0	0.1
sculpin, other large		0.1				0.1
sole, dover					0.1	0.1
flounder, starry				0.1		0.1
octopus, North Pacific				0.1		0.1
rockfish, harlequin		0.0				0.0
sole, rex					0.0	0.0

Figures

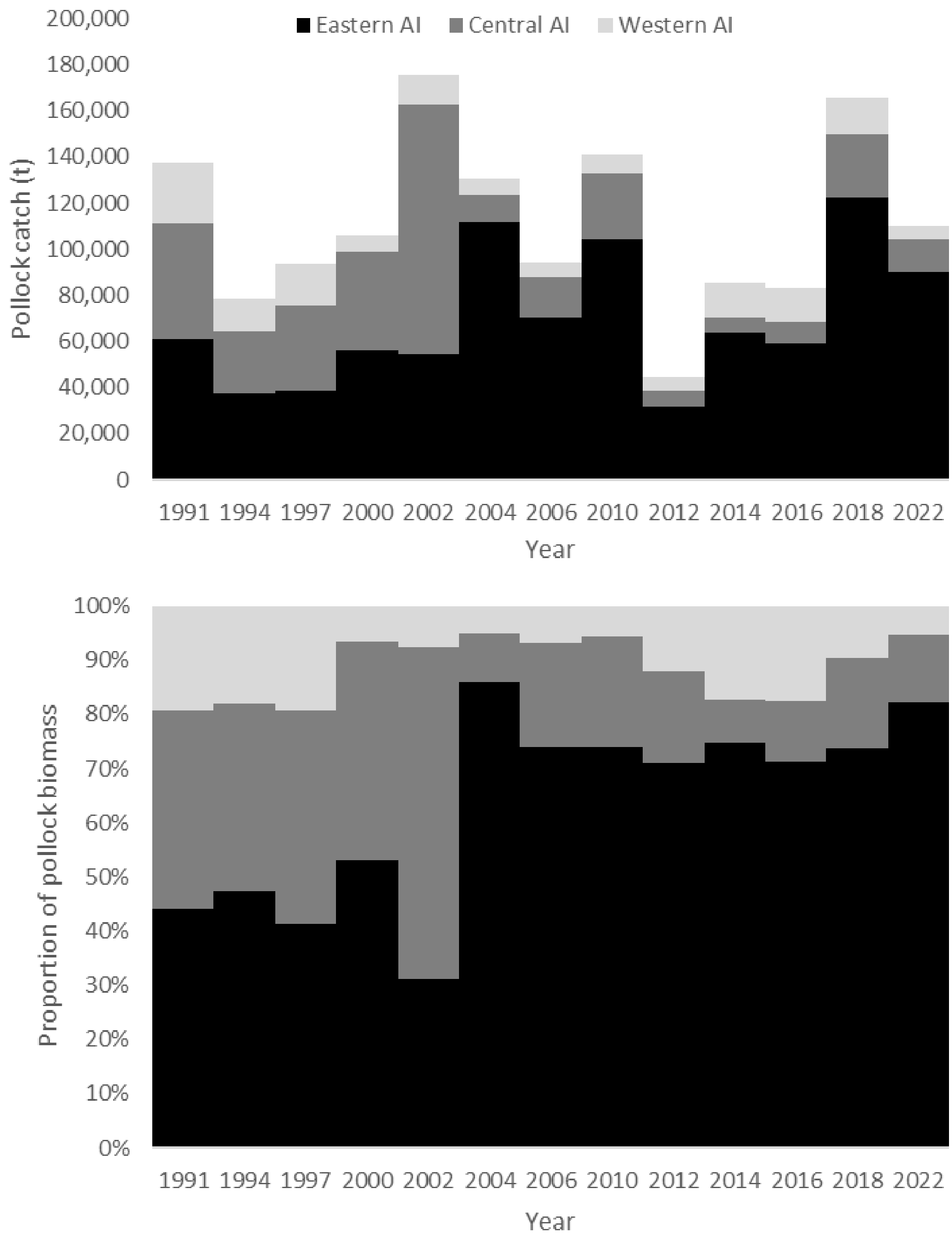


Figure 1A.1 Aleutian Islands bottom trawl survey pollock biomass (top) and proportion of biomass (bottom) for the three Aleutian Island management regions.

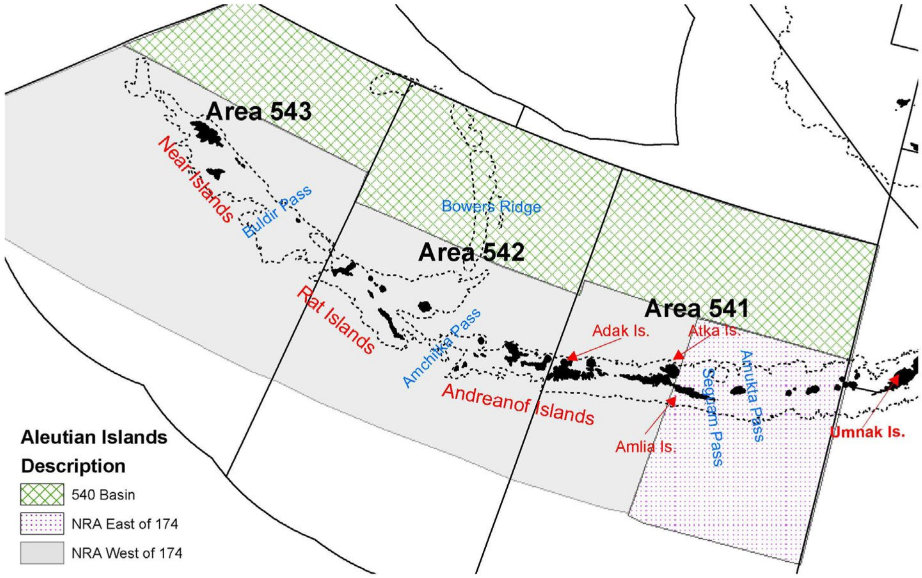


Figure 1A. 2. Regions defined for consideration of alternative data partitions for Aleutian Islands Region pollock. The abbreviation "NRA" represents the Near, Rat, and Andreanof Island group. There are no models for 2018 that consider the NRA east-west partition at 174° W.

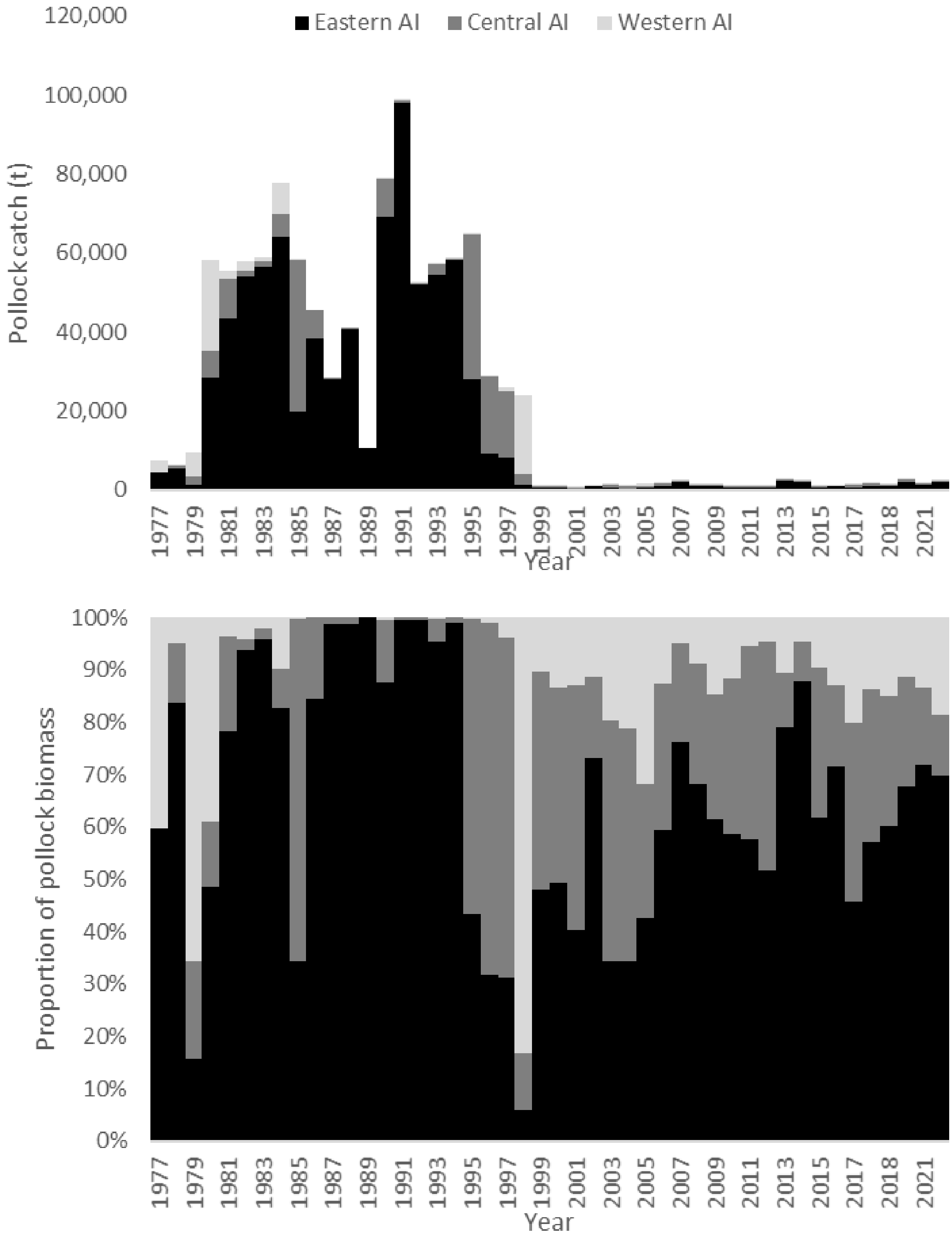


Figure 1A.3. Pollock catch by NMFS reporting area for 1977- 2022 by total catch (top) and percentage of catch by area (bottom).

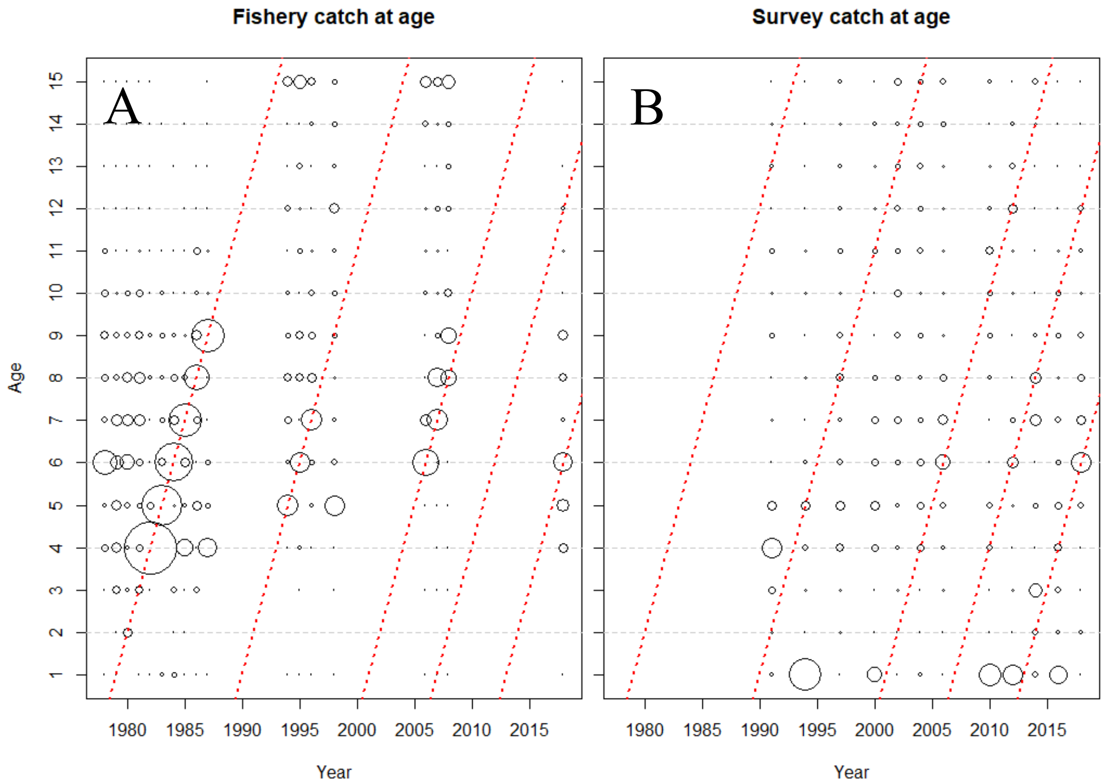


Figure 1A.4. Age distributions for 1978-2018 Aleutian Islands pollock fishery (A; left) and 1991 - 2018 Aleutian Islands Bottom Trawl surveys (B; right). The 1978, 1989, 2000, 2006, and 2012 year classes are indicated by the diagonal dashed lines.

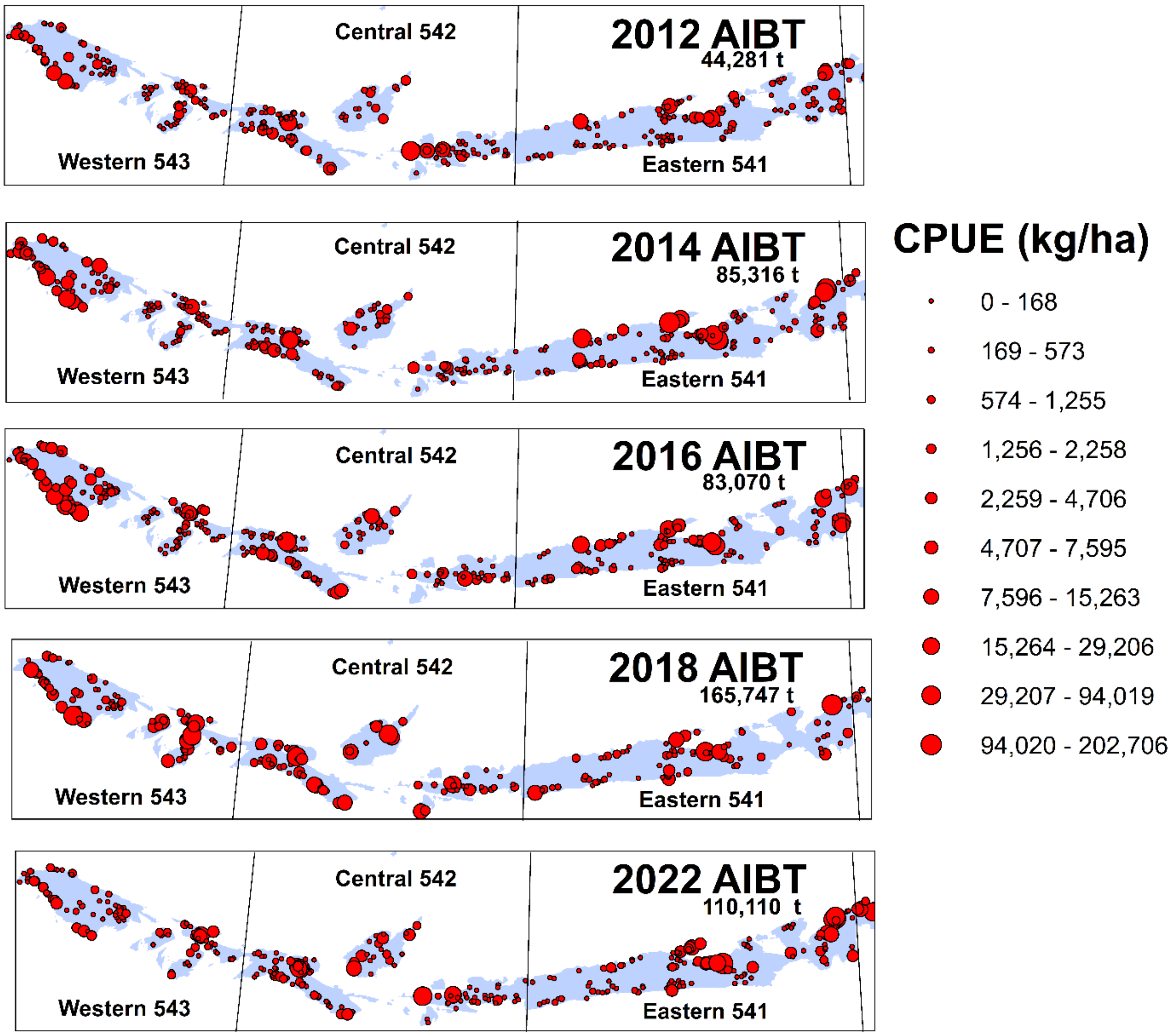


Figure 1A.5. Catch per unit effort ($kgha^{-1}$) for surveys of pollock in the Aleutian Islands Region, 2012-2022. The shaded area is the Aleutian Islands shelf area less than 300m depth.

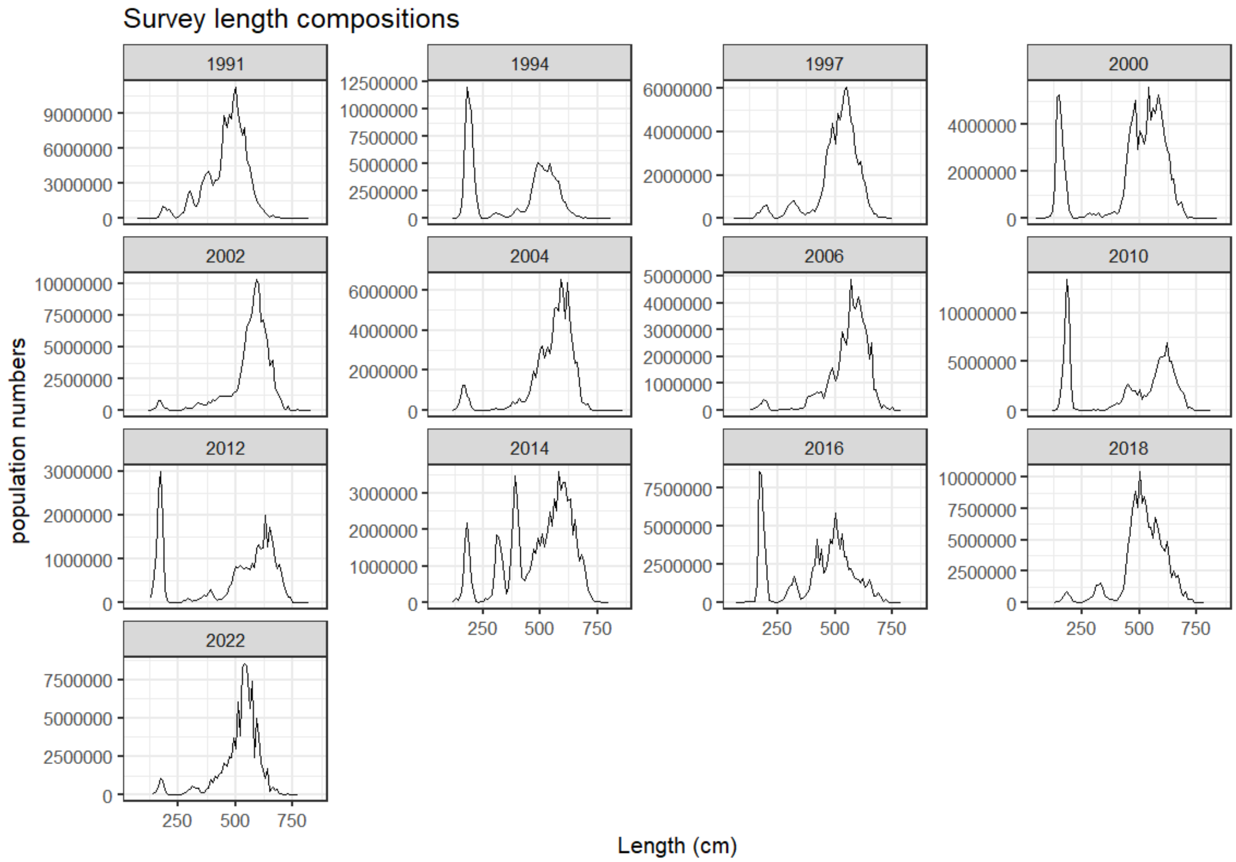


Figure 1A.6. Distribution by length for 1991-2022 Aleutian Islands bottom trawl surveys.

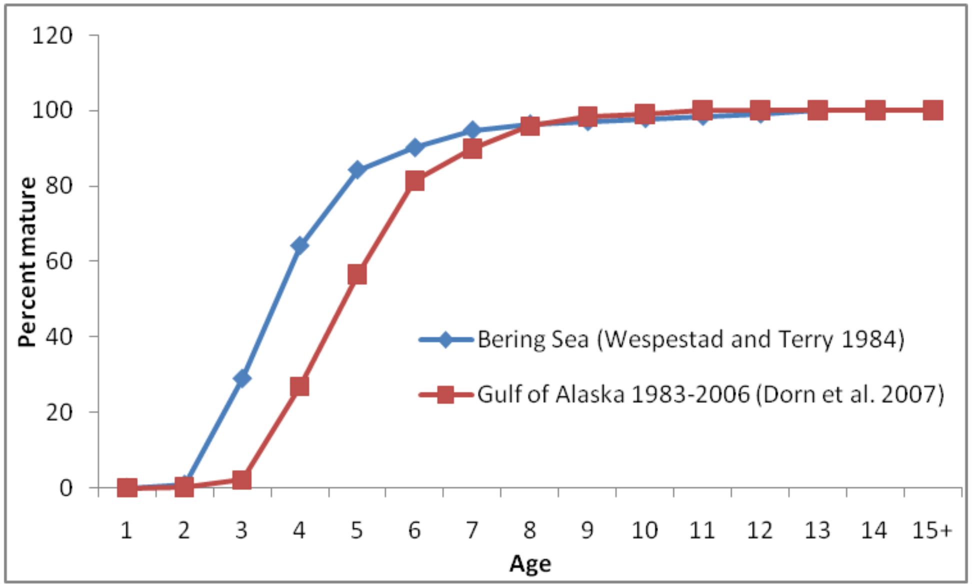


Figure 1A.7. Percent mature at age for Bering Sea pollock (Wespestad and Terry 1984) and the mean percent mature at age for 1983-2006 for Gulf of Alaska pollock (Dorn *et al.* 2007).

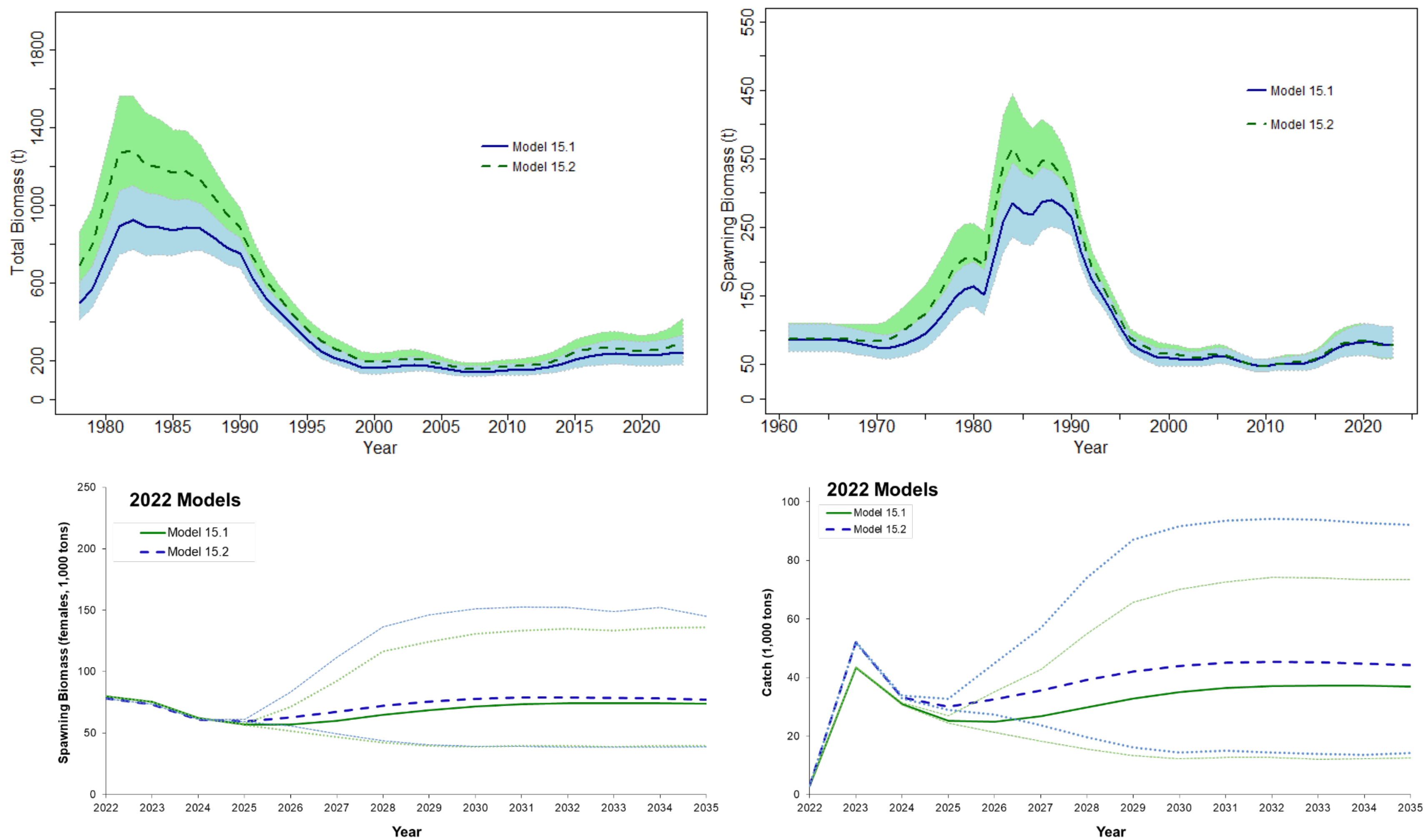


Figure 1A.8. Total biomass (top left), spawning biomass (top right), and spawning biomass projection (bottom left) and catch projection (bottom right) from Model 15.1. and Model 15.2.

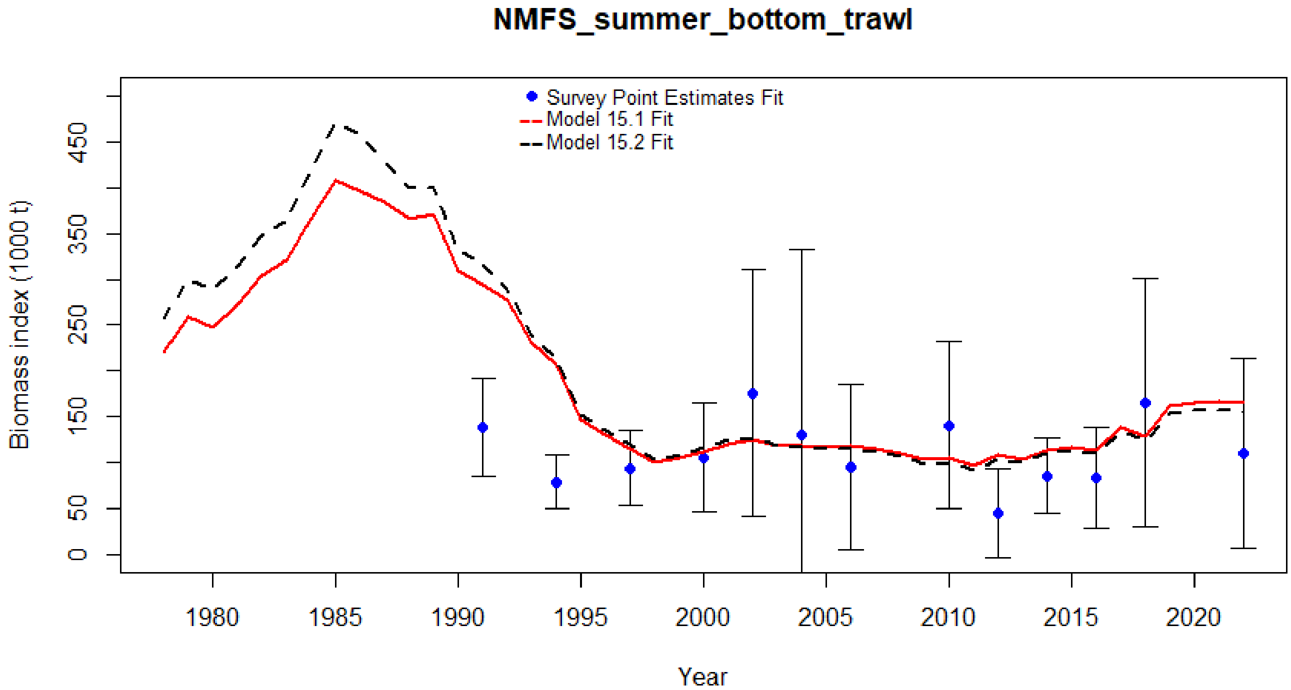


Figure 1A.9. Model fits to NMFS summer bottom trawl survey.

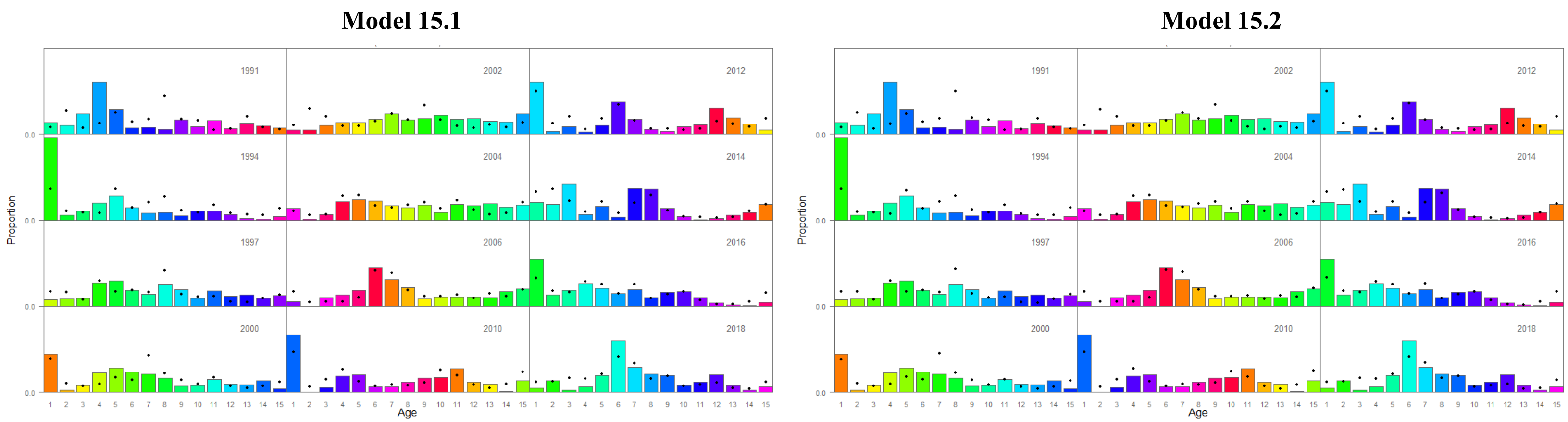


Figure 1A.10. Aleutian Islands pollock Model 15.1 and Model 15.2 fit to NMFS summer bottom trawl survey age composition data. The "•" symbol are the model predictions and columns are the observed proportions at age (with colors corresponding to cohorts).

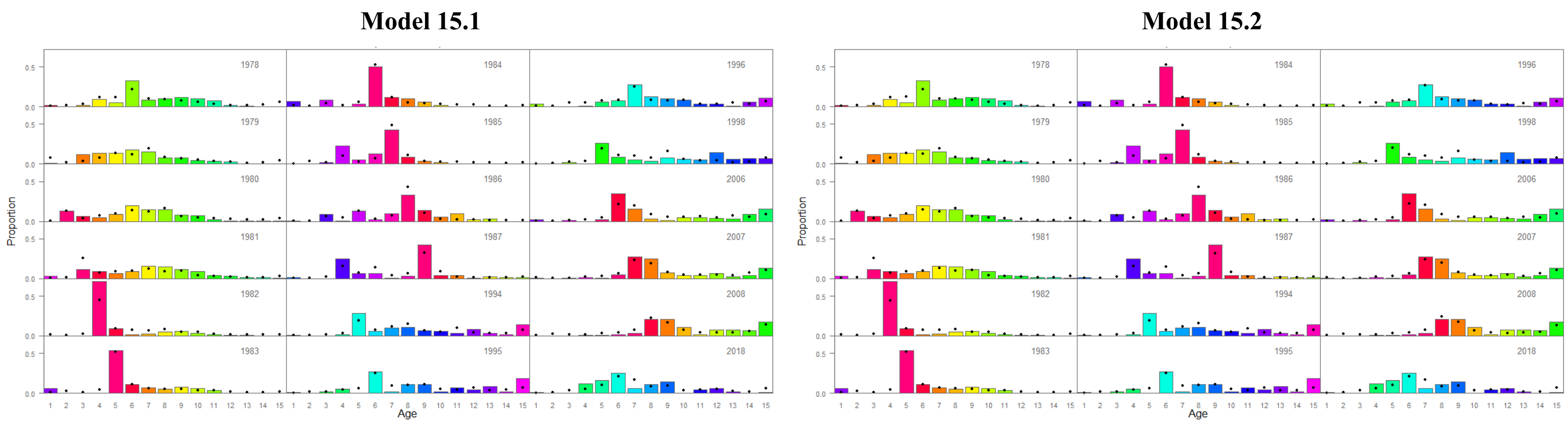


Figure 1A.11. Model 15.1 and Model 15.2. fits to fishery age composition data for Aleutian Islands pollock. The "•" symbol are the model predictions and columns are the observed proportions at age (with colors corresponding to cohorts).

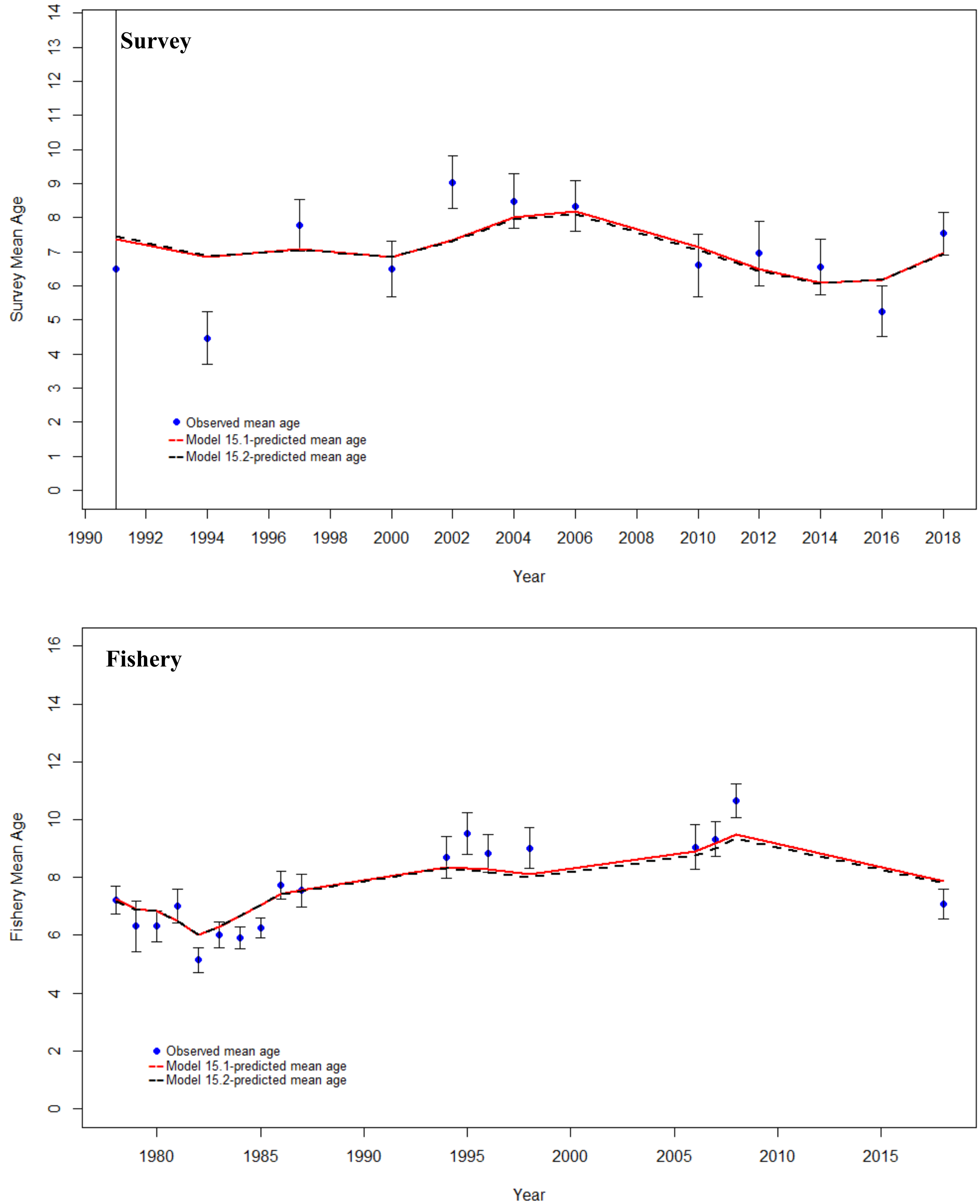


Figure 1A.12. Observed mean age and model derived mean age from the AIBTS (top) and fishery catch at age data (bottom) for Model 15.1 and Model 15.2. The confidence intervals are adjusted by the multinomial sample sizes used in the models.

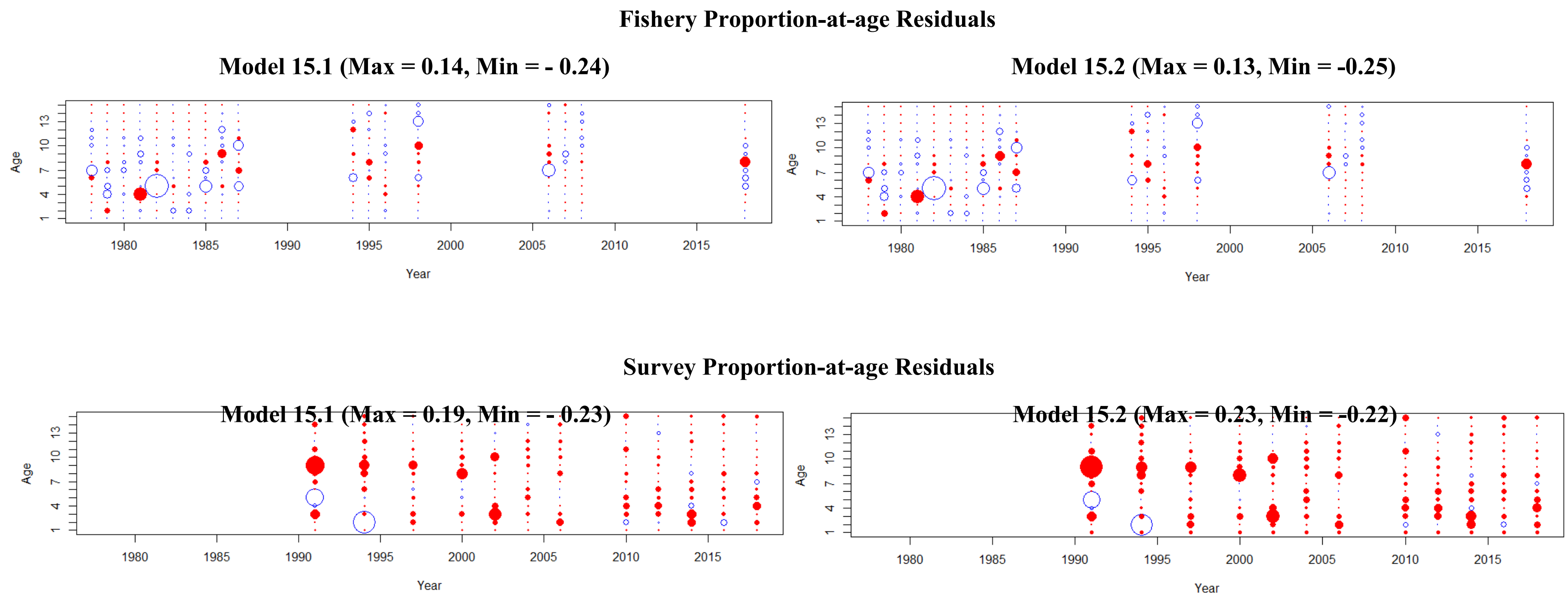


Figure 1A.13. Standardized residuals for fits to the fishery (top) and survey (bottom) proportion-at-age data for AI pollock Model 15.1 and Model 15.2. Red indicating positive residuals and blue negative residuals.

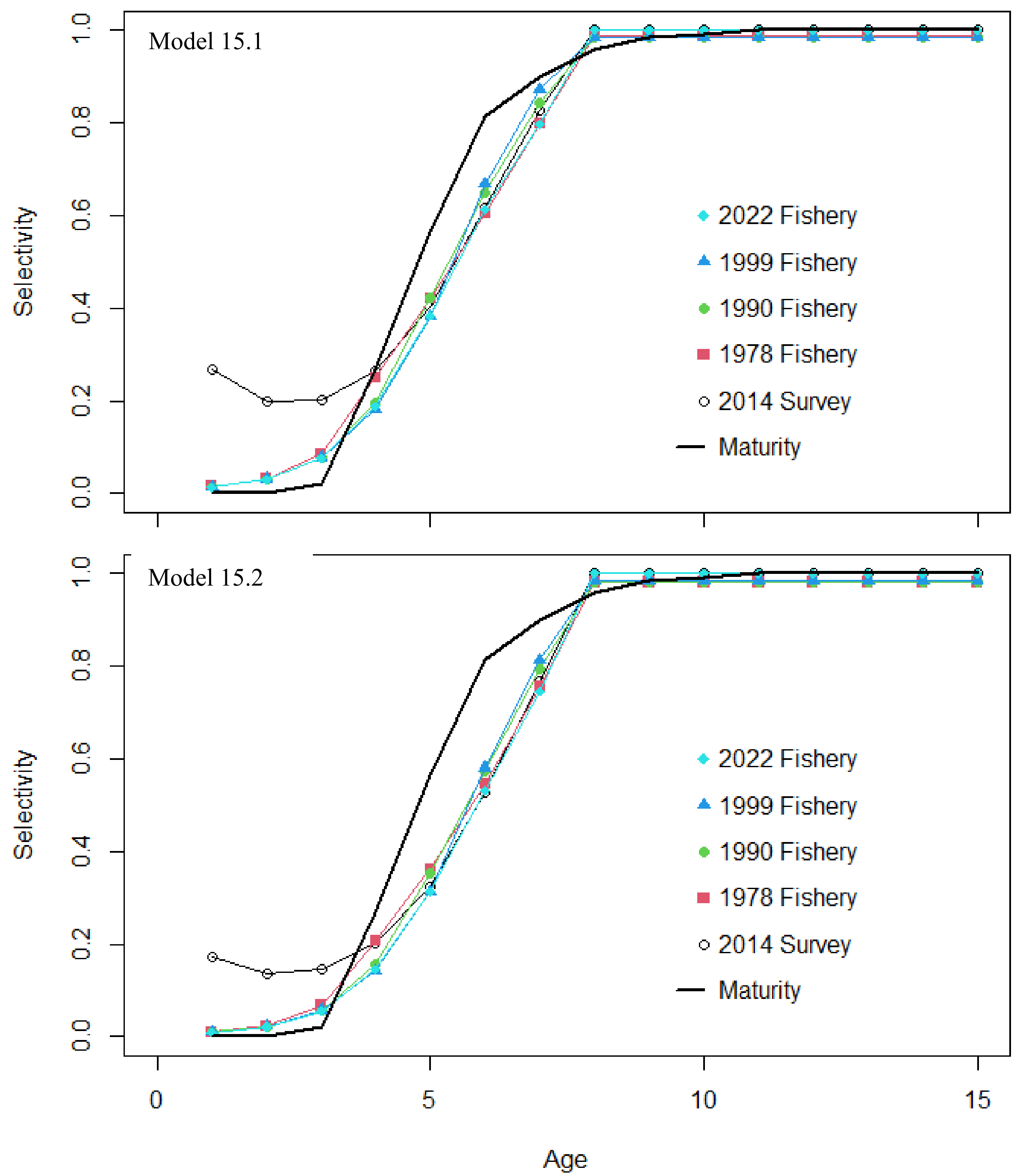
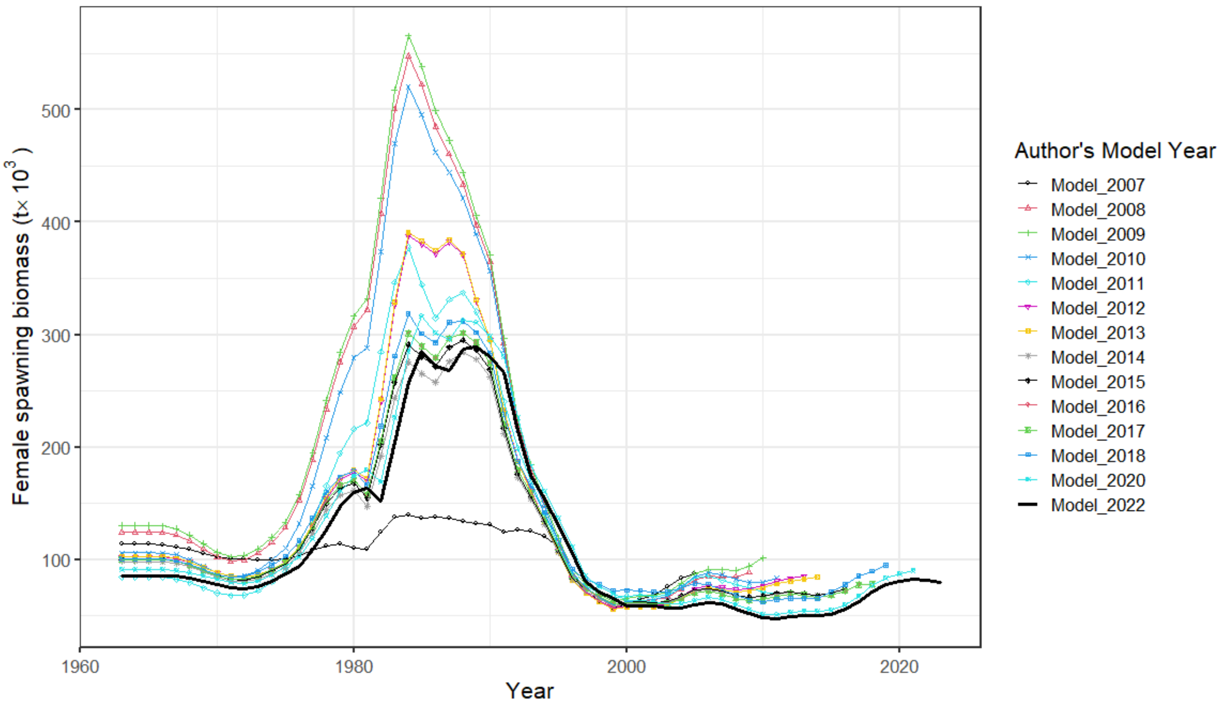


Figure 1A.14. Fishery and survey selectivity estimates with maturity at age for Aleutian Islands pollock models.



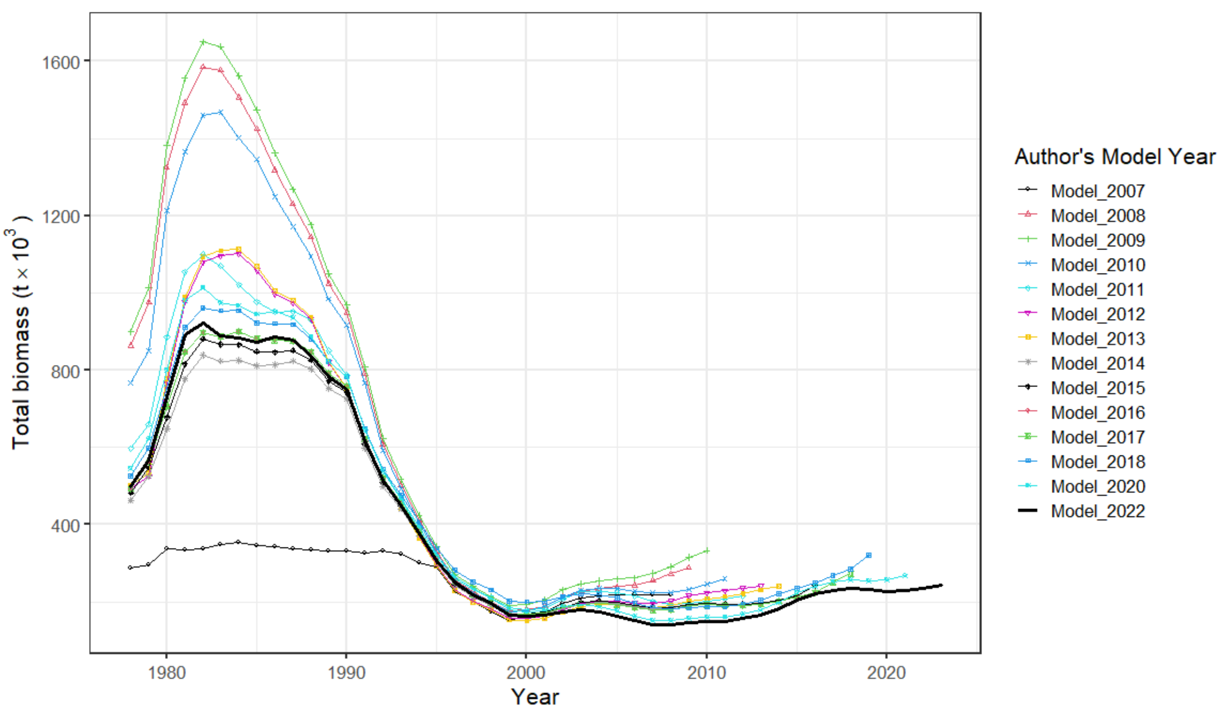


Figure 1A.15. Female spawning (top) and total (bottom) biomass trajectories for the 2022 Authors' preferred model compared with the 2007 through 2020 Authors' preferred models. Note: 2019 and 2021 were partial assessment years and therefor no models available.

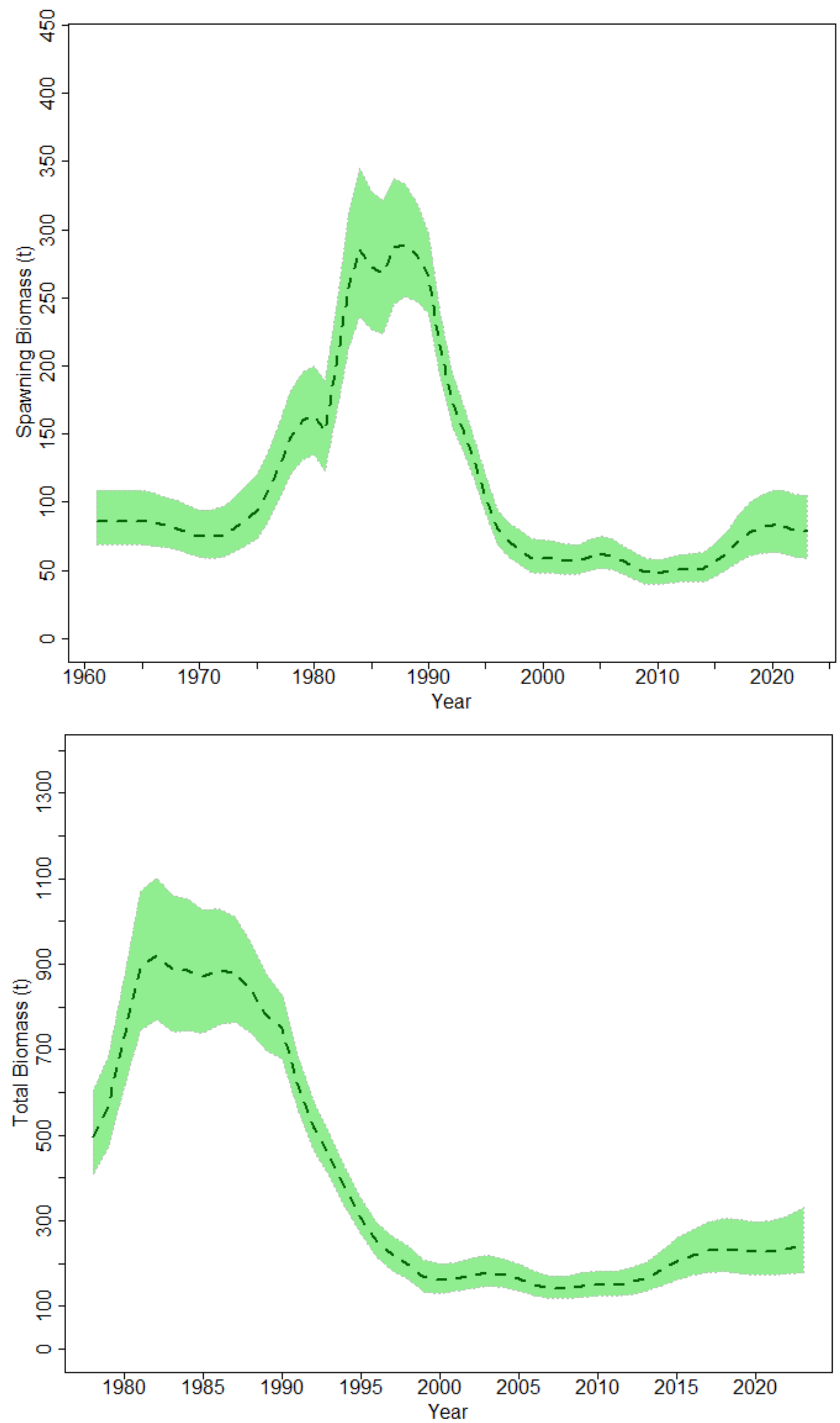


Figure 1A.16. Estimates of Aleutian Islands pollock spawning biomass (left) and age 1+ total biomass (right) in 1,000s of tons from the authors' preferred Model 15.1. Confidence intervals are two standard deviations.

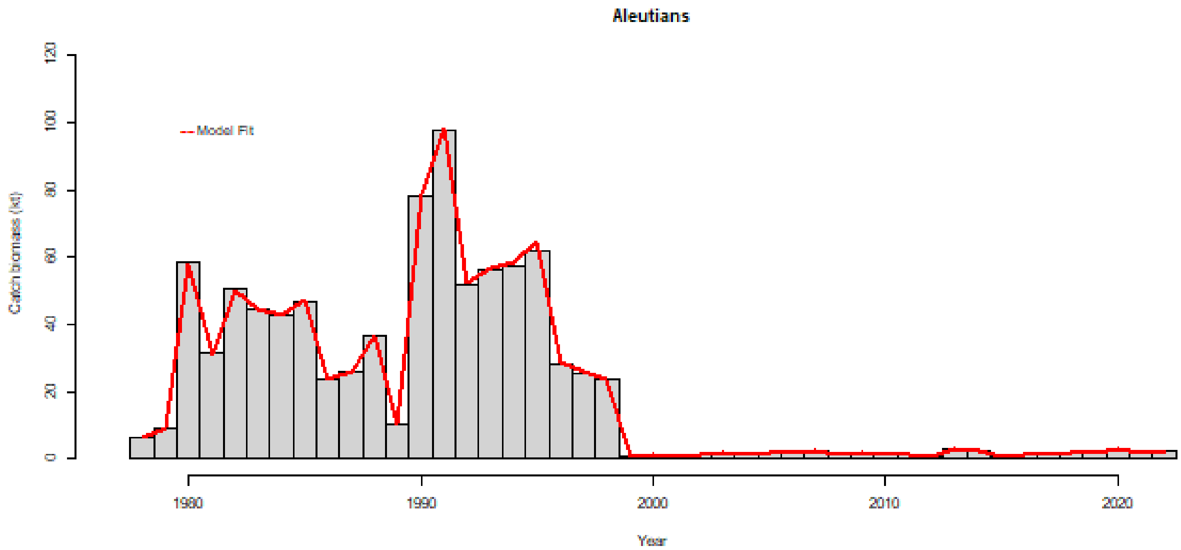


Figure 1A.17 Fits to total catch in 1,000s of tons for AI pollock over time 1978-2022.

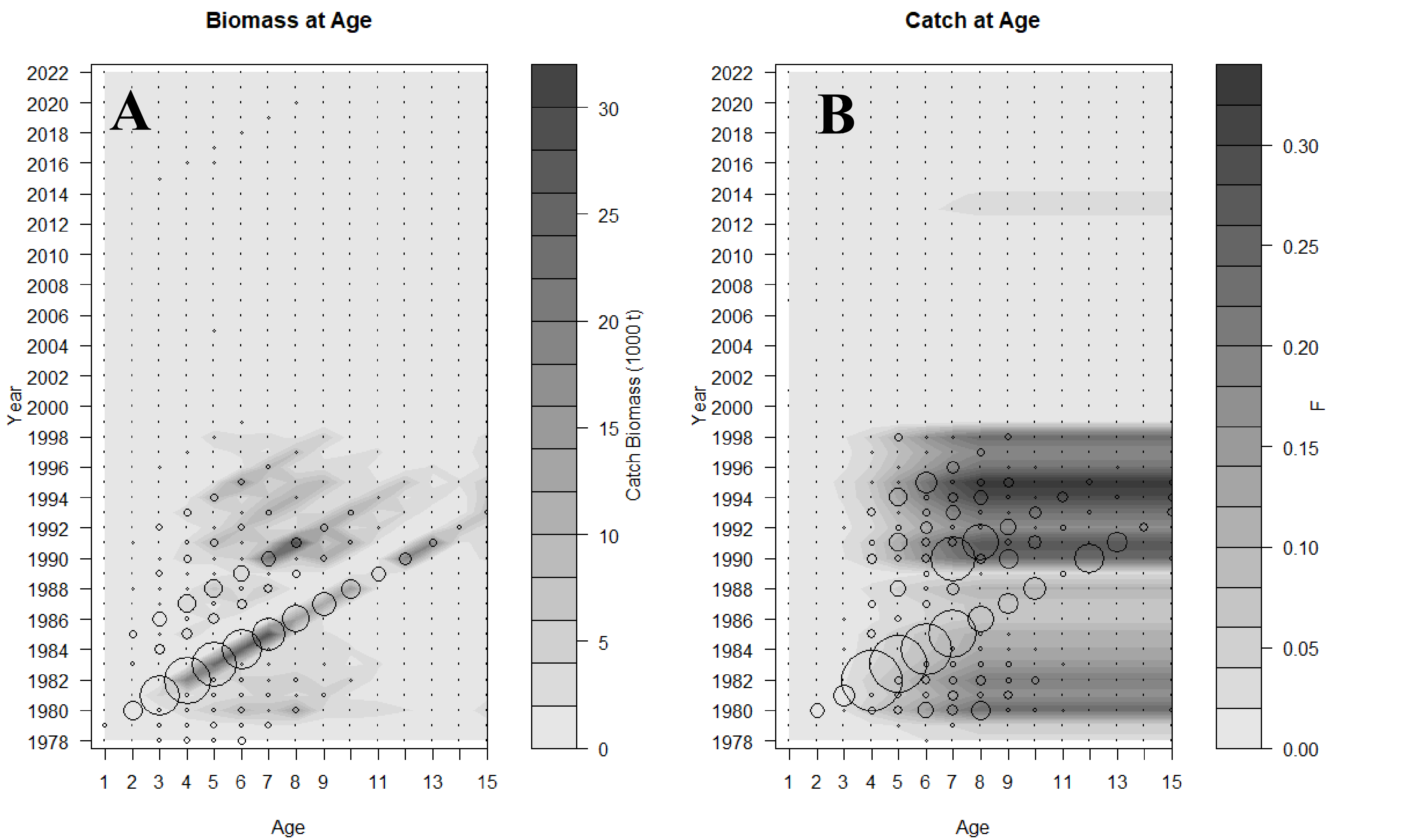


Figure 1A.18 AI pollock authors' preferred Model 15.1 (A-contour) catch biomass in 1,000s of tons and (A-bubbles) total biomass and (B-contour) fishing mortality rates and (B-bubbles) catch biomass by age. Total biomass is scaled to 1/20th of the catch biomass in the bubble plots.

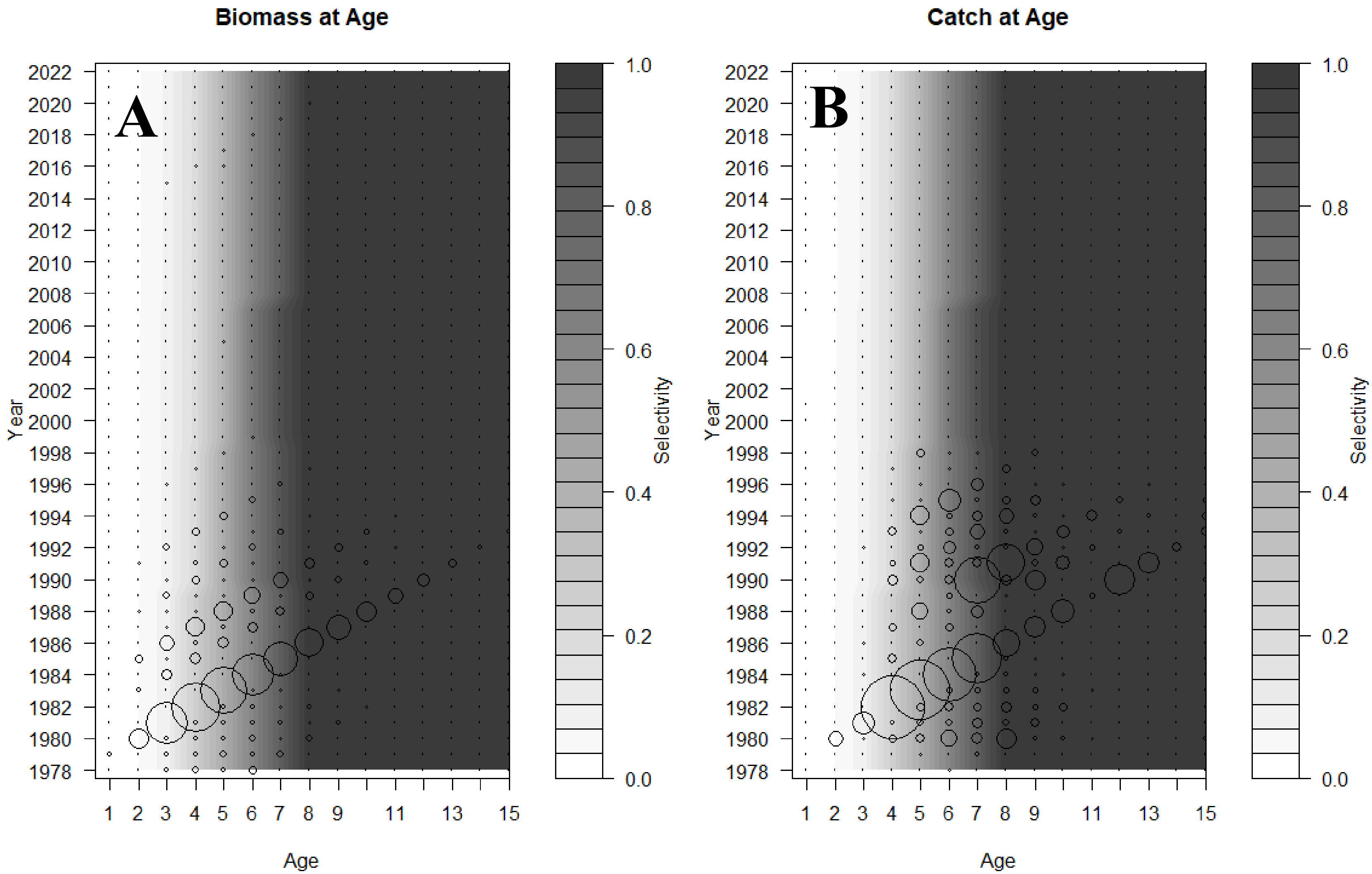


Figure 1A.19 Contour plots of fishery selectivity by age for AI pollock with bubble plots of (A) total biomass at age and (B) catch biomass at age for the Authors' preferred Model 1.0. Total biomass is scaled to 1/20 of the catch biomass bubbles.

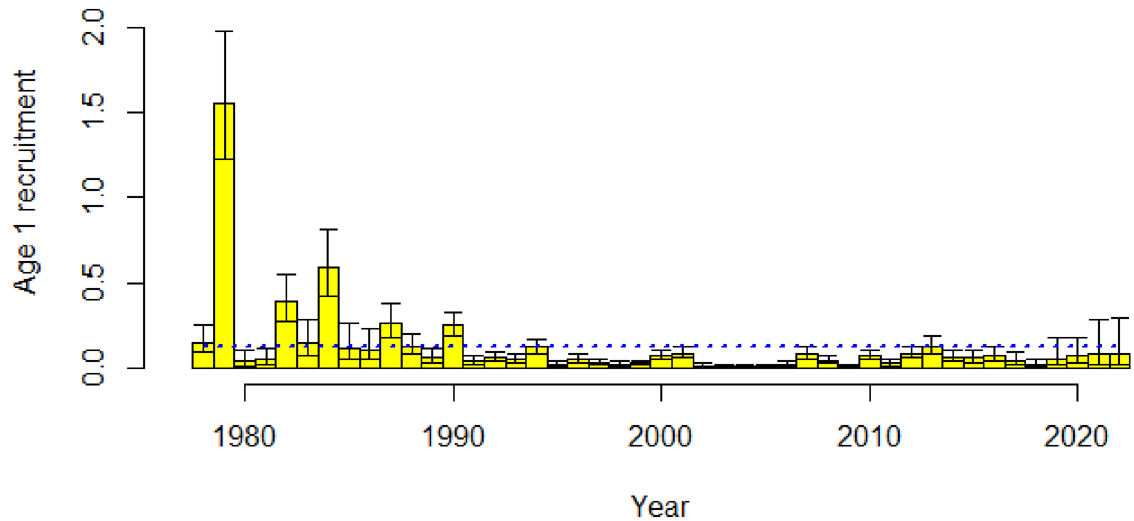


Figure 1A.20. Authors' preferred model estimates of Aleutian Islands pollock age 1 recruitment. The vertical bars represent the upper and lower 95% confidence bounds. The dotted line is the 1978-2020 mean age-1 recruitment.

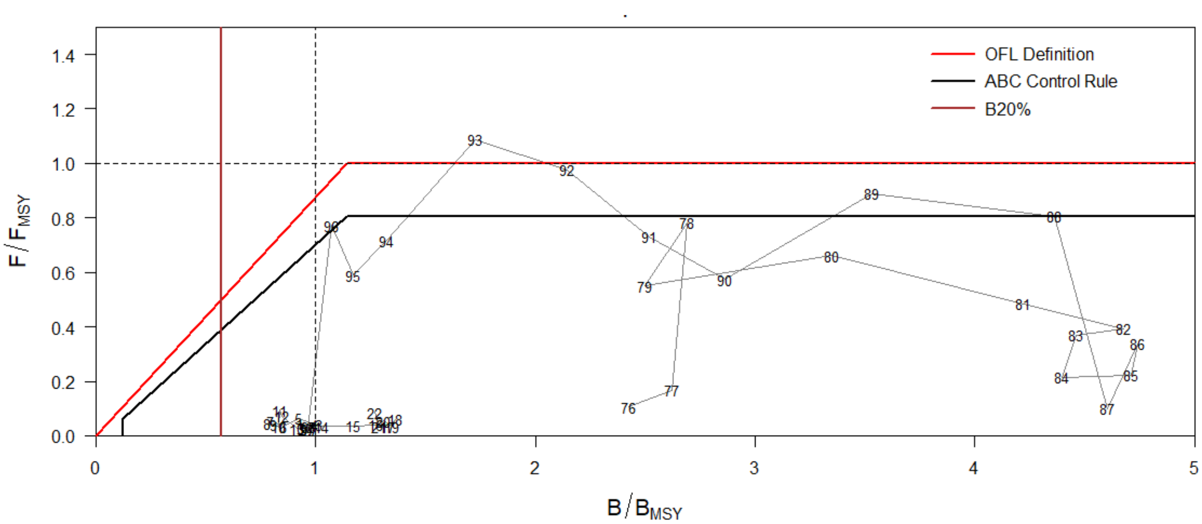


Figure 1A.21. Aleutian Islands pollock spawning biomass relative to B_{msy} and full-selection fishing mortality relative to F_{msy} (1978-2024). The ratio of fishing mortality to F_{msy} is calculated using the estimated selectivity pattern in that year. 2023 and 2024 are plotted with catch assumed to be at the 5-year average (Alternative 3).

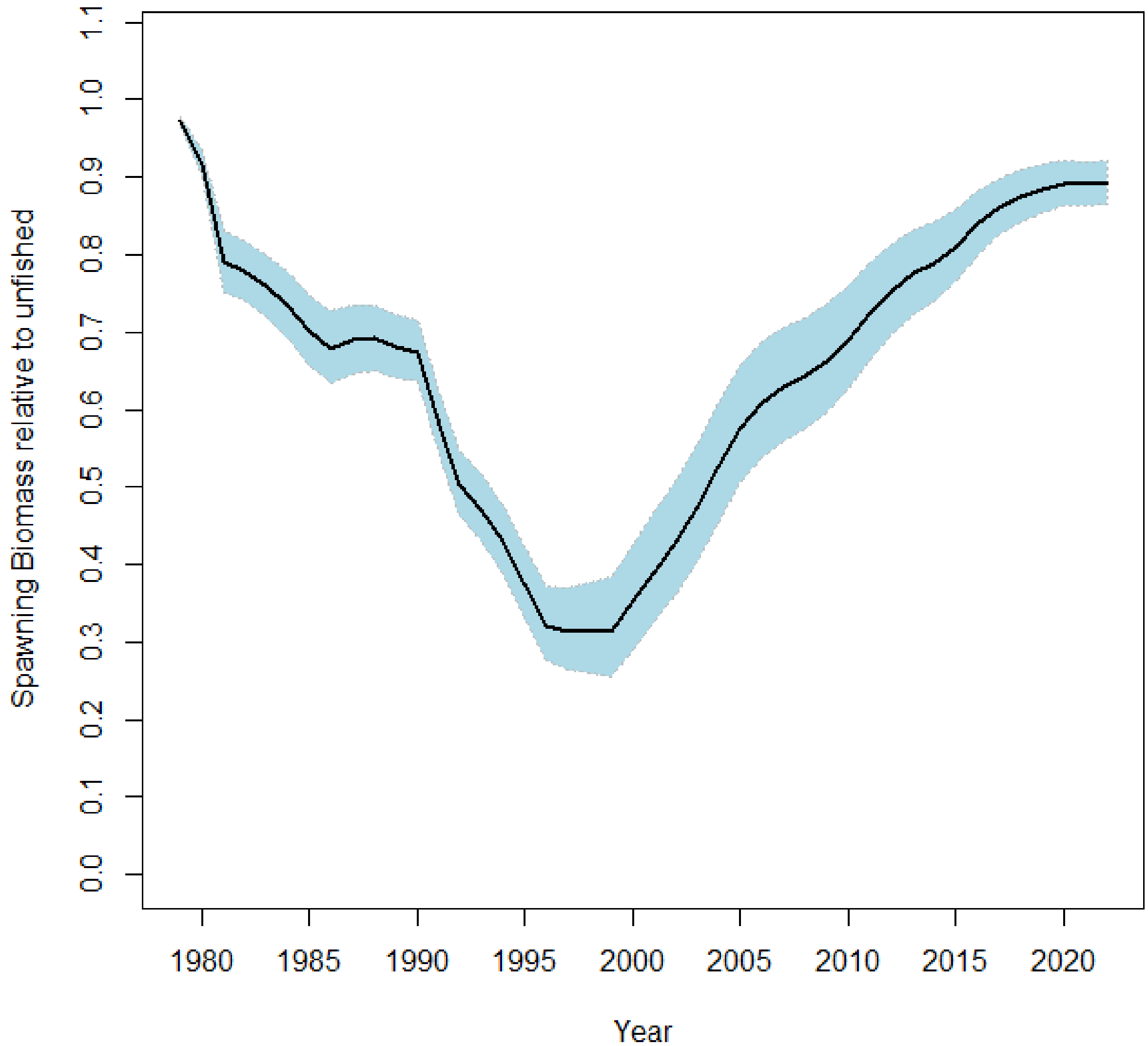


Figure 1A.22. Aleutian Islands pollock ratio of spawning biomass with fishing relative to spawning biomass without fishing for the authors' preferred model with 95% confidence interval.

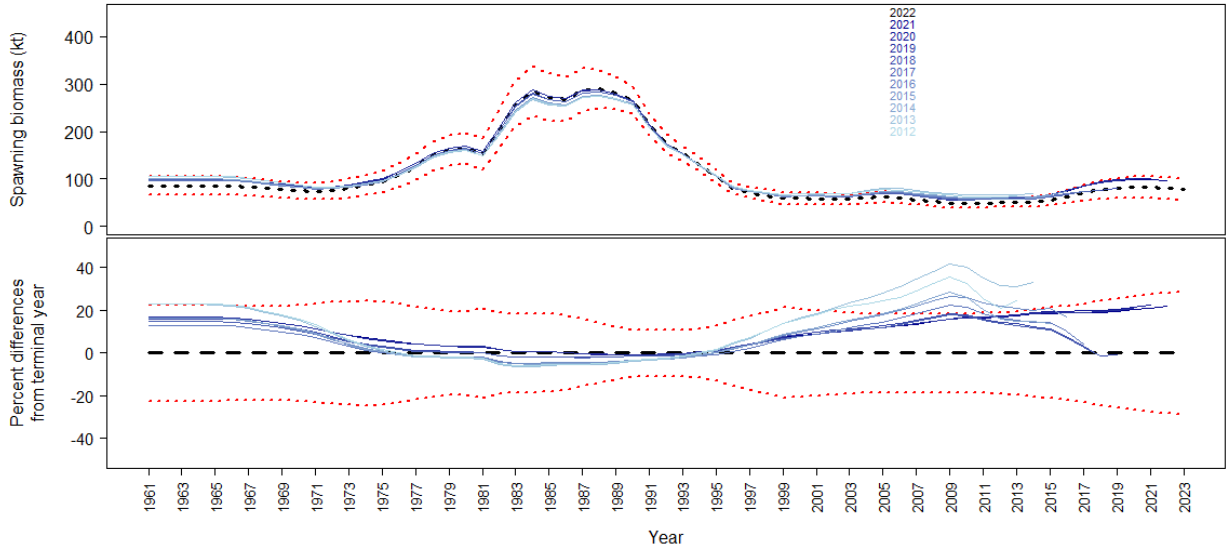


Figure 1A.23 Retrospective analysis for Authors' preferred Model 15.1 with data for the previous 10 years being systematically removed from the model. Black dashed line is the 2022 Model 15.1 estimate, the red dotted lines are the 95% confidence intervals calculated as ±1.96×standard deviation.

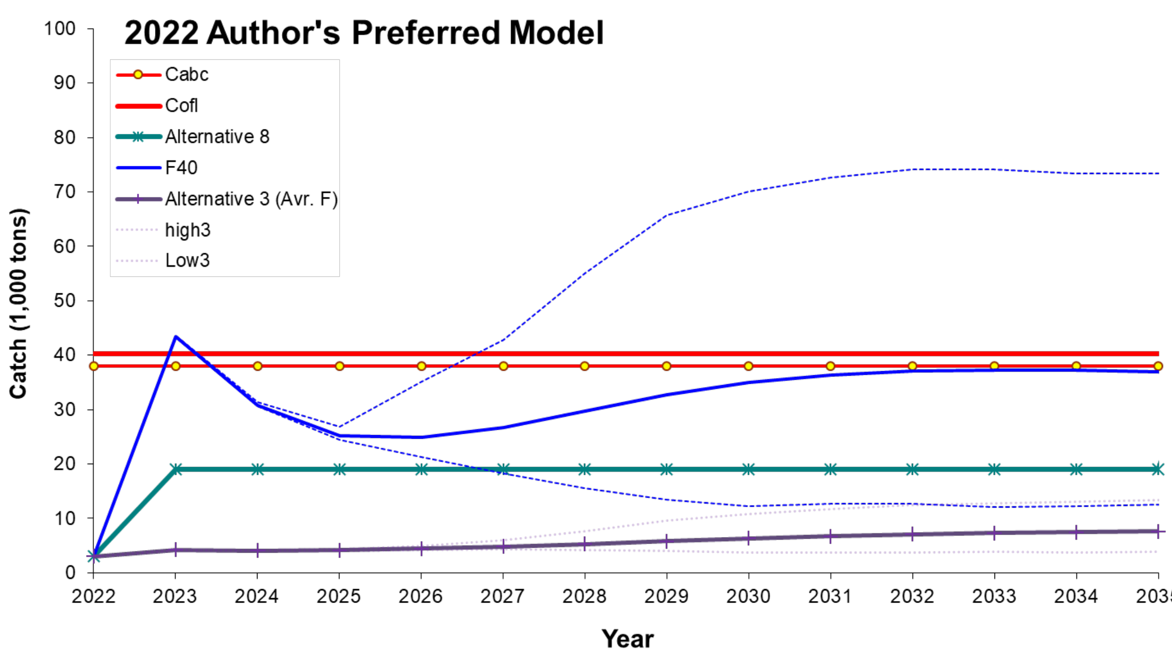


Figure 1A.24 Authors' preferred Model 15.1 projected catch for $F_{40\%}$, Alternative 3 (average F), and Alternative 8 (19,000t) ABC scenarios.

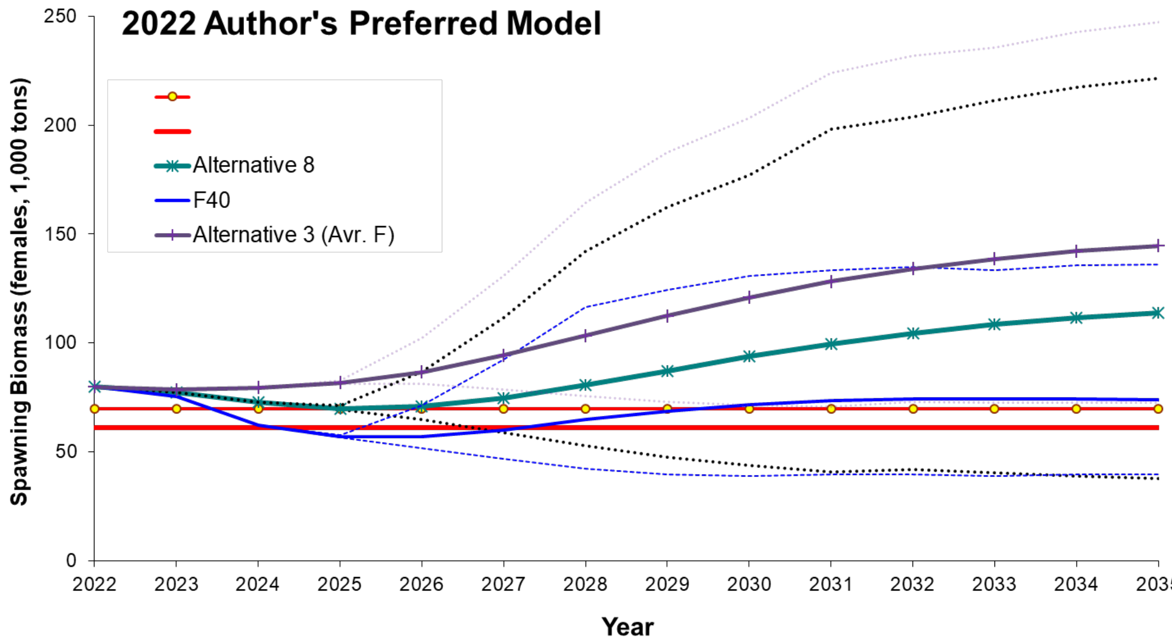


Figure 1A.25 Authors' preferred Model 15.1 projected spawning biomass for $F_{40\%}$ Alternative 3 (average F), and Alternative 8 (19,000t) ABC scenarios.

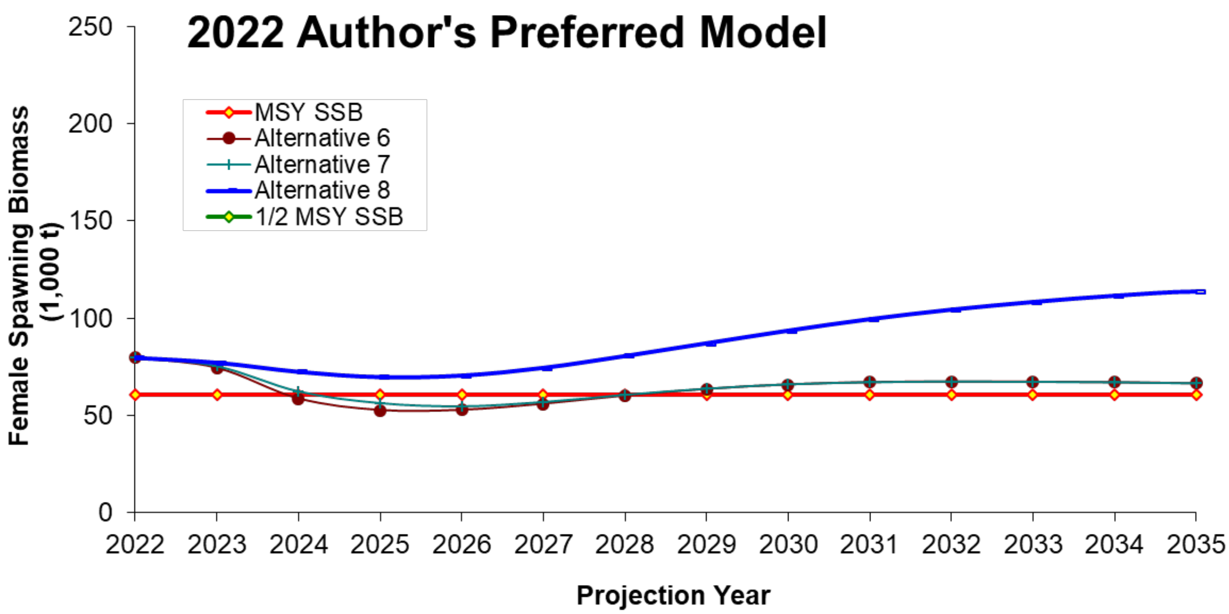


Figure 1A.26 Authors' preferred Model 15.1 projected spawning biomass for MSY, ½MSY, and Alternatives 6, 7, and 8 ABC scenarios from the authors' preferred model.

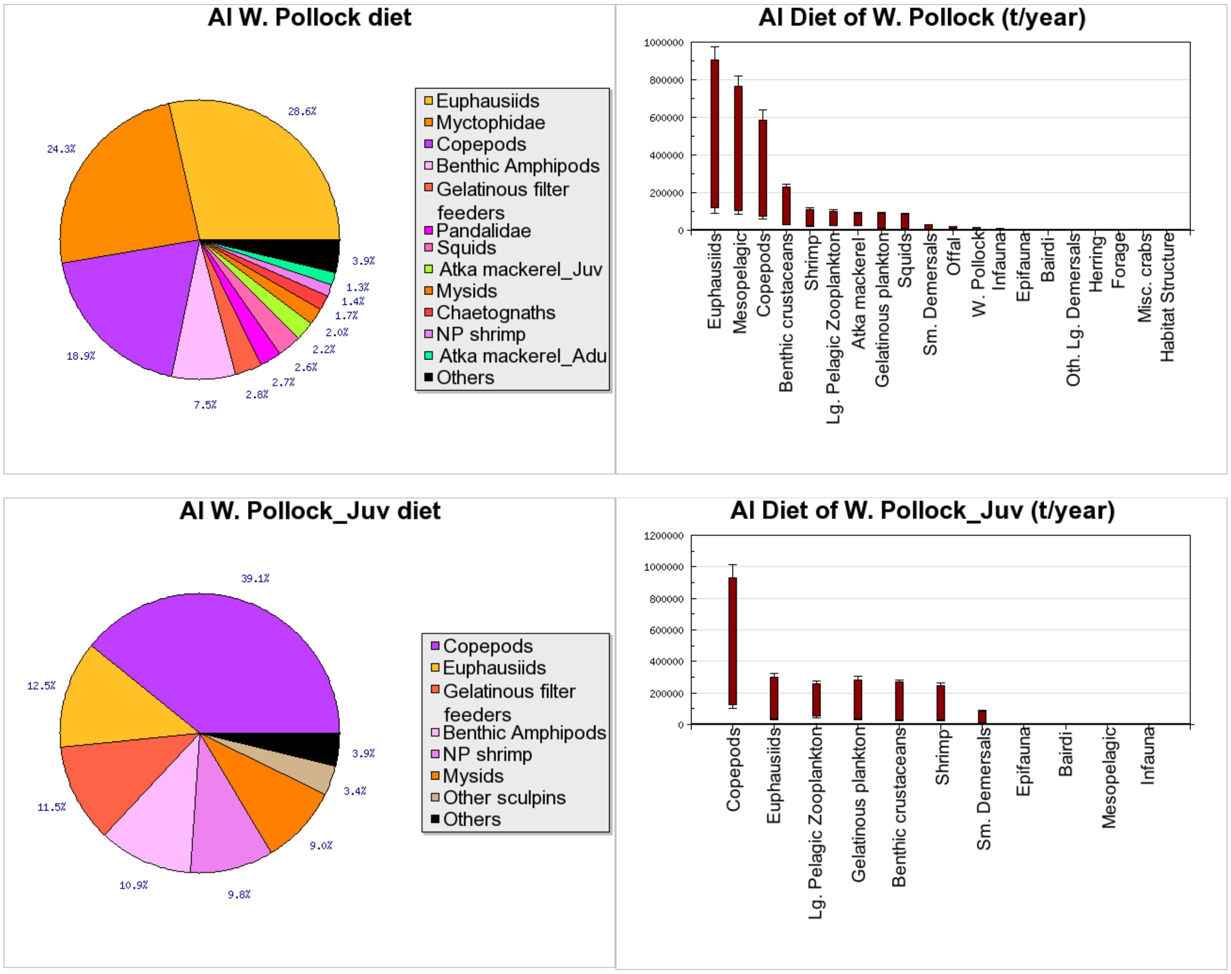


Figure 1A.27. Diet composition (left) and estimated consumption of prey (right) by AI adult (top) and juvenile (bottom) pollock. Diets are estimated from stomach collections taken aboard NMFS bottom trawl surveys in 1991-1994. See Appendix A Barbeaux *et al.* 2006 for detailed methods.

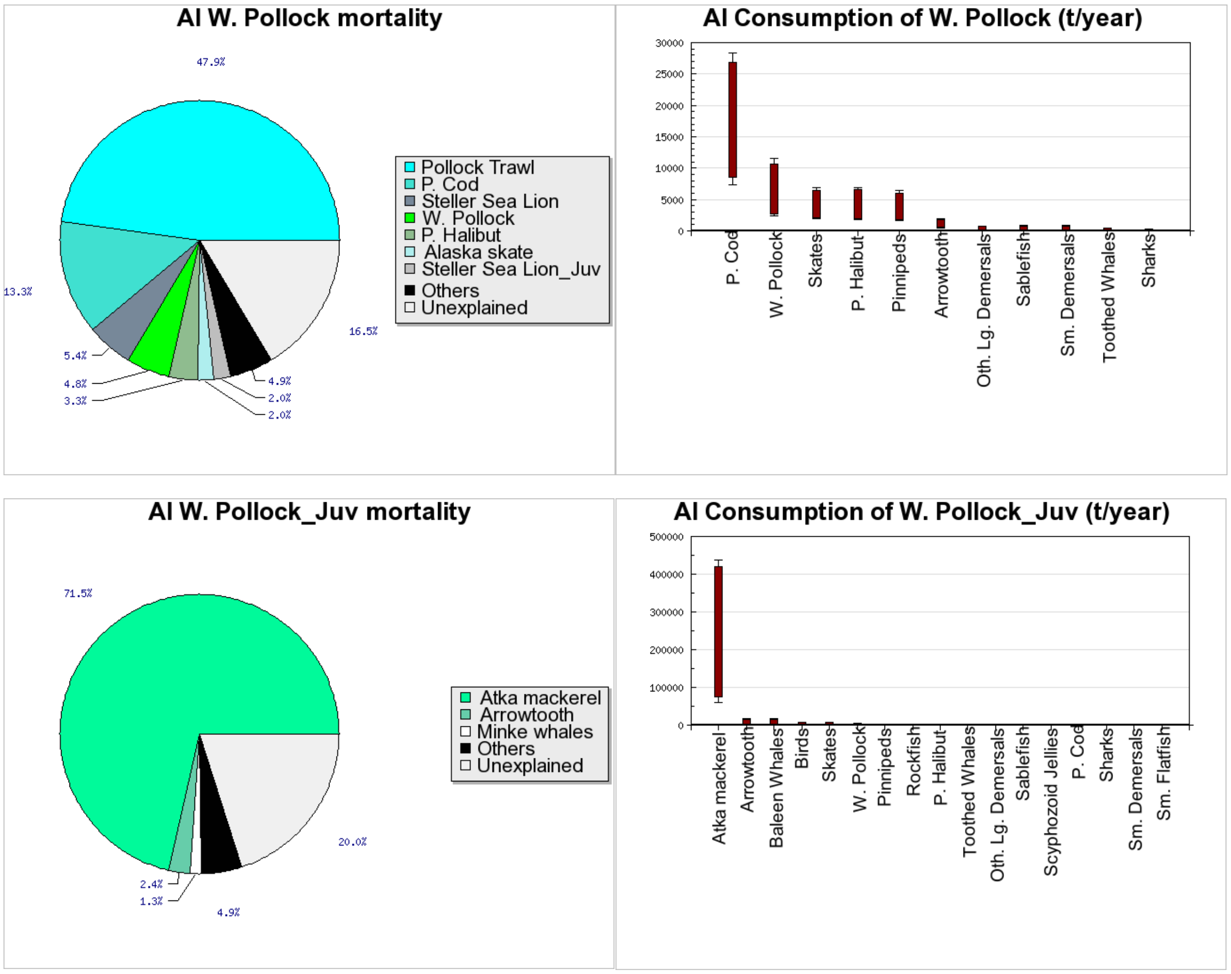


Figure 1A.28. Mortality sources (left) and estimated consumption by predators (right) of AI adult (top) and juvenile (bottom) pollock. Mortality sources reflect pollock predator diets estimated from stomach collections taken aboard NMFS bottom trawl surveys in 1991-1994, pollock predator consumption rates estimated from stock assessments and other studies, and catch of pollock by all fisheries in the same time periods. Annual consumption ranges incorporating uncertainty in food web model parameters were estimated by the Sense routines (Aydin *et al.* 2004). See Appendix A Barbeaux *et al.* 2006 for detailed methods.

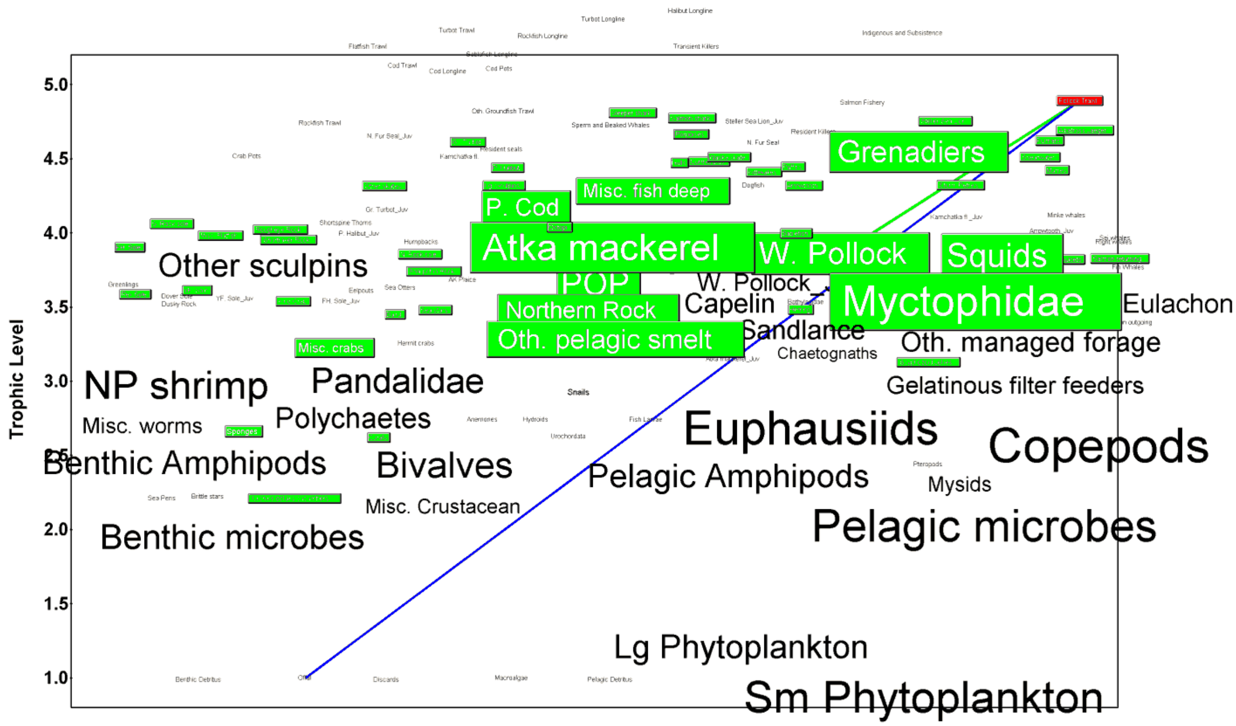


Figure 1A.29. The pollock trawl fishery in the AI food web. Species taken by the pollock fishery (in red) are highlighted in green, with the most significant flow to pollock indicated with a green line. Box size is proportional to biomass and lines between boxes represent the most significant energy flows. From Aydin *et al.* (2007).

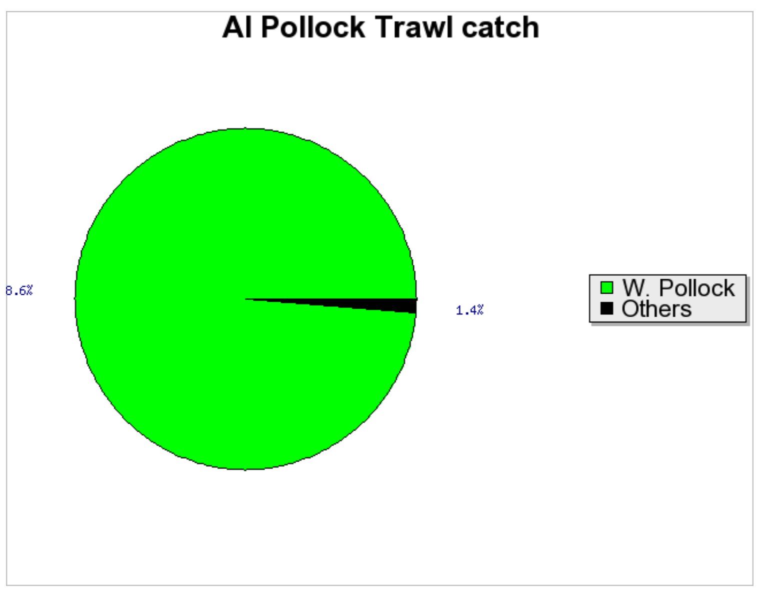


Figure 1A.30. Catch composition of the AI pollock trawl fishery during the early 1990's, as used in the food web model (Aydin *et al.* 2004).

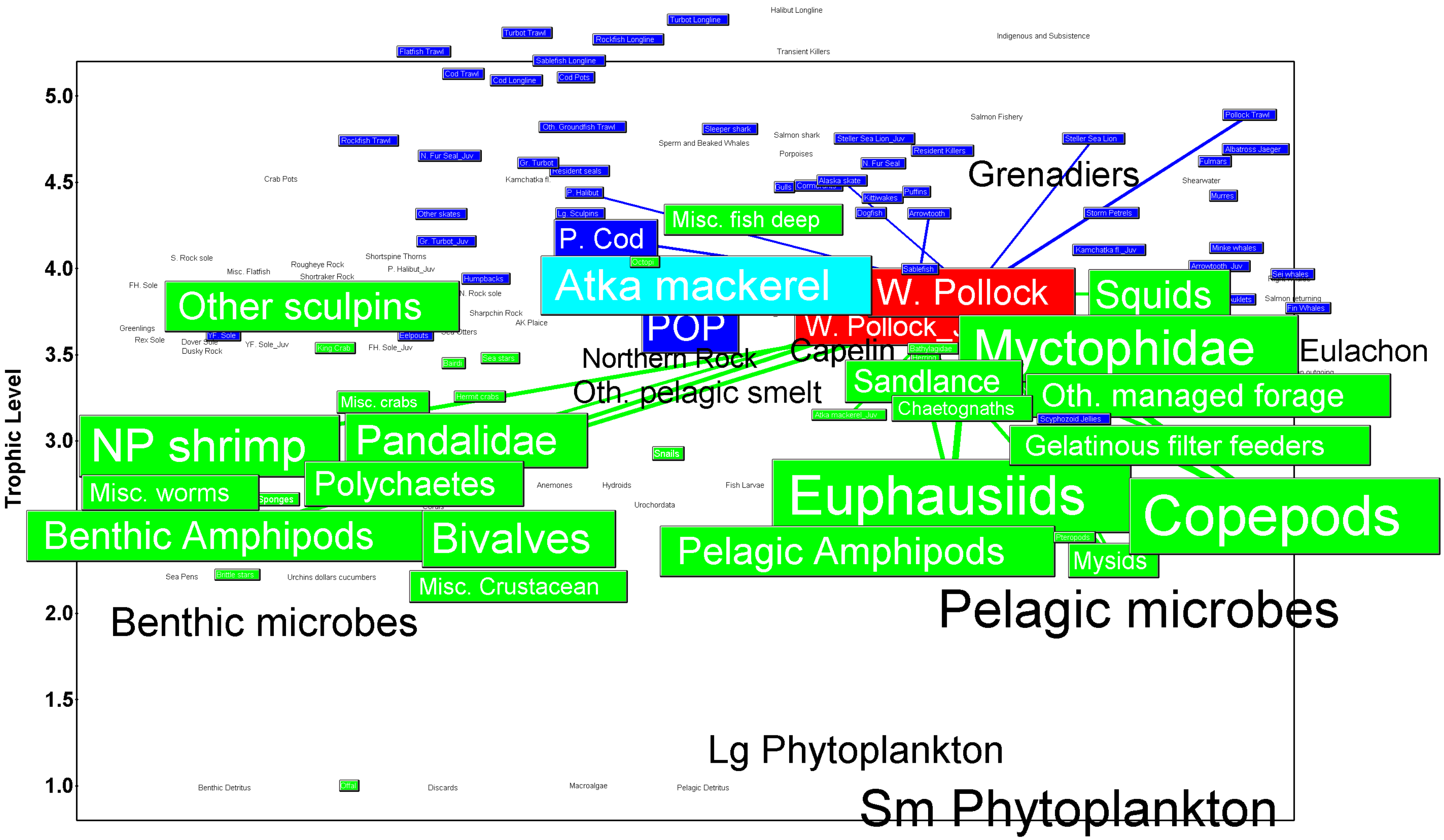
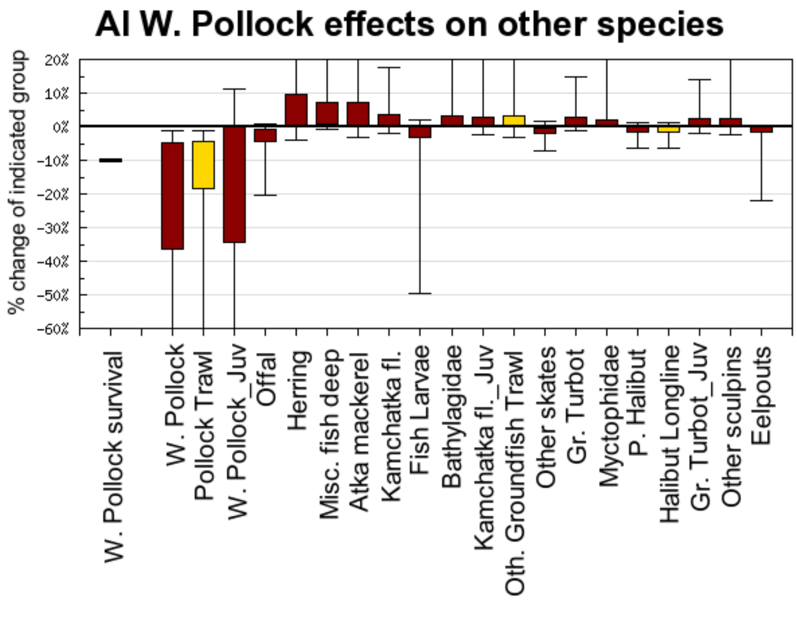


Figure 1A.31. Adult and juvenile pollock (highlighted in red) in the AI food web (Aydin et al 2004). Predators of pollock are dark blue, prey of pollock are green, and species that are both predators and prey of pollock are light blue. Box size is proportional to biomass and lines between boxes represent the most significant energy flows.



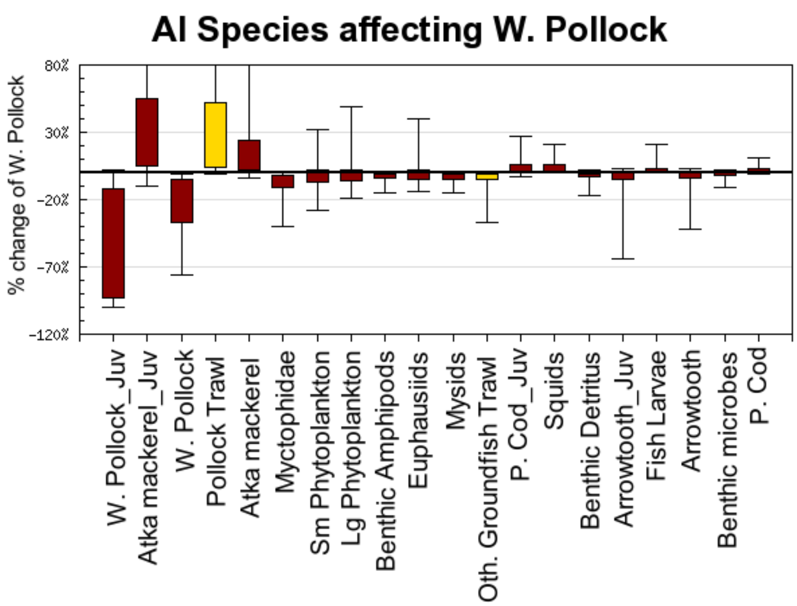


Figure 1A.32. (upper panel) Effect of changing pollock survival on fishery catch (yellow) and biomass of other species (dark red), from a simulation analysis where pollock survival was decreased by 10% and the rest of the ecosystem adjusted to this decrease for 30 years. (lower panel) Effect of reducing fisheries catch (yellow) and other species survival (dark red) on pollock biomass, from a simulation analysis where survival of each x axis species group was decreased by 10% and the rest of the ecosystem adjusted to this decrease for 30 years. In both panels, boxes show resulting percent change in the biomass of each species on the x axis after 30 years for 50% of feasible ecosystems, error bars show results for 95% of feasible ecosystems (see Aydin *et al.* 2007 for detailed Sense methods).

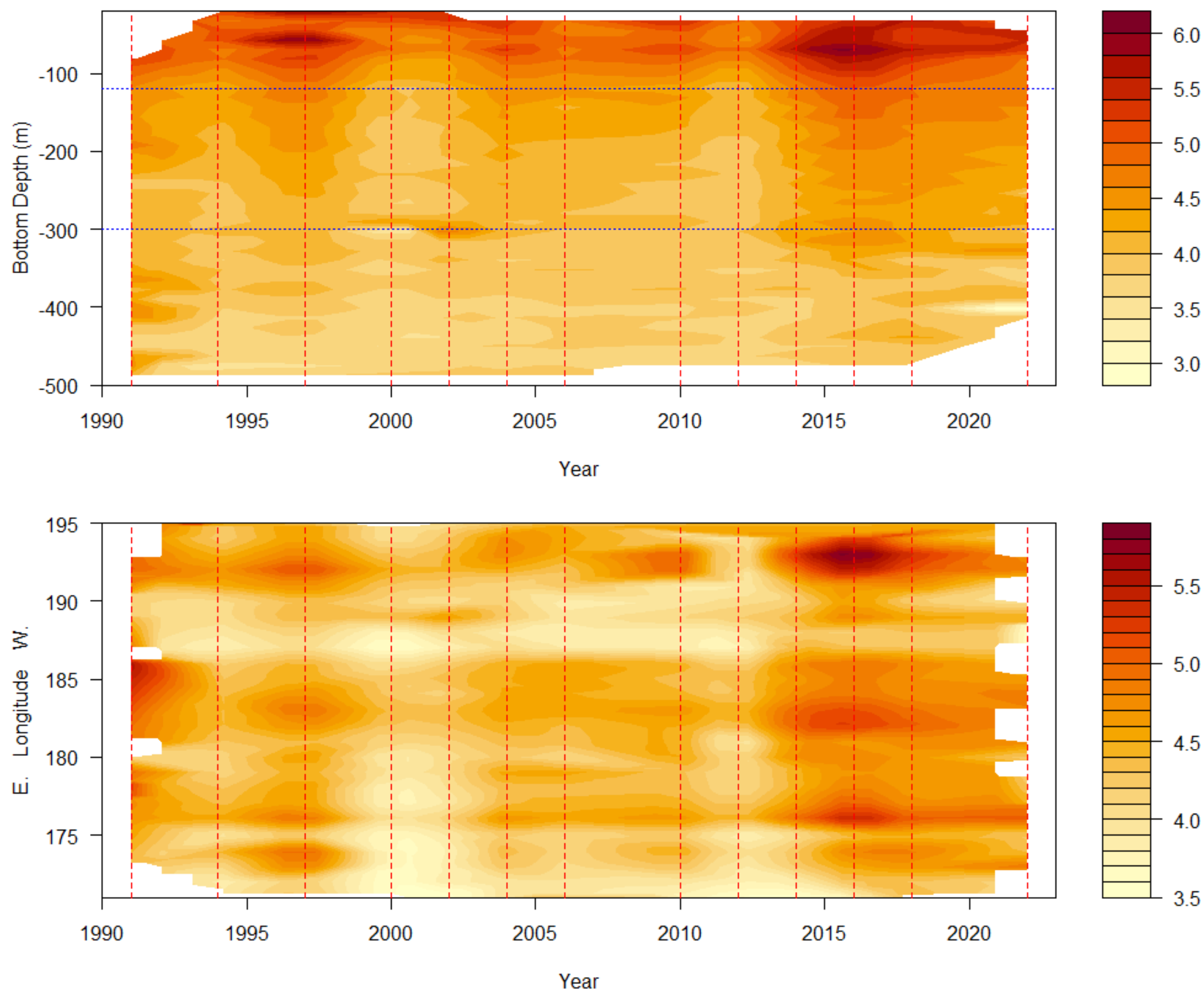


Figure 1A.33 Mean bottom temperatures by 10 m bottom depth (top) and by 1 degree longitude (bottom) by year. Red lines indicate years with survey data. Note the E longitudes (>180) are further west in the Aleutian Islands. Blue lines are at -120 and -300, the area of highest densities for pollock in the AI.

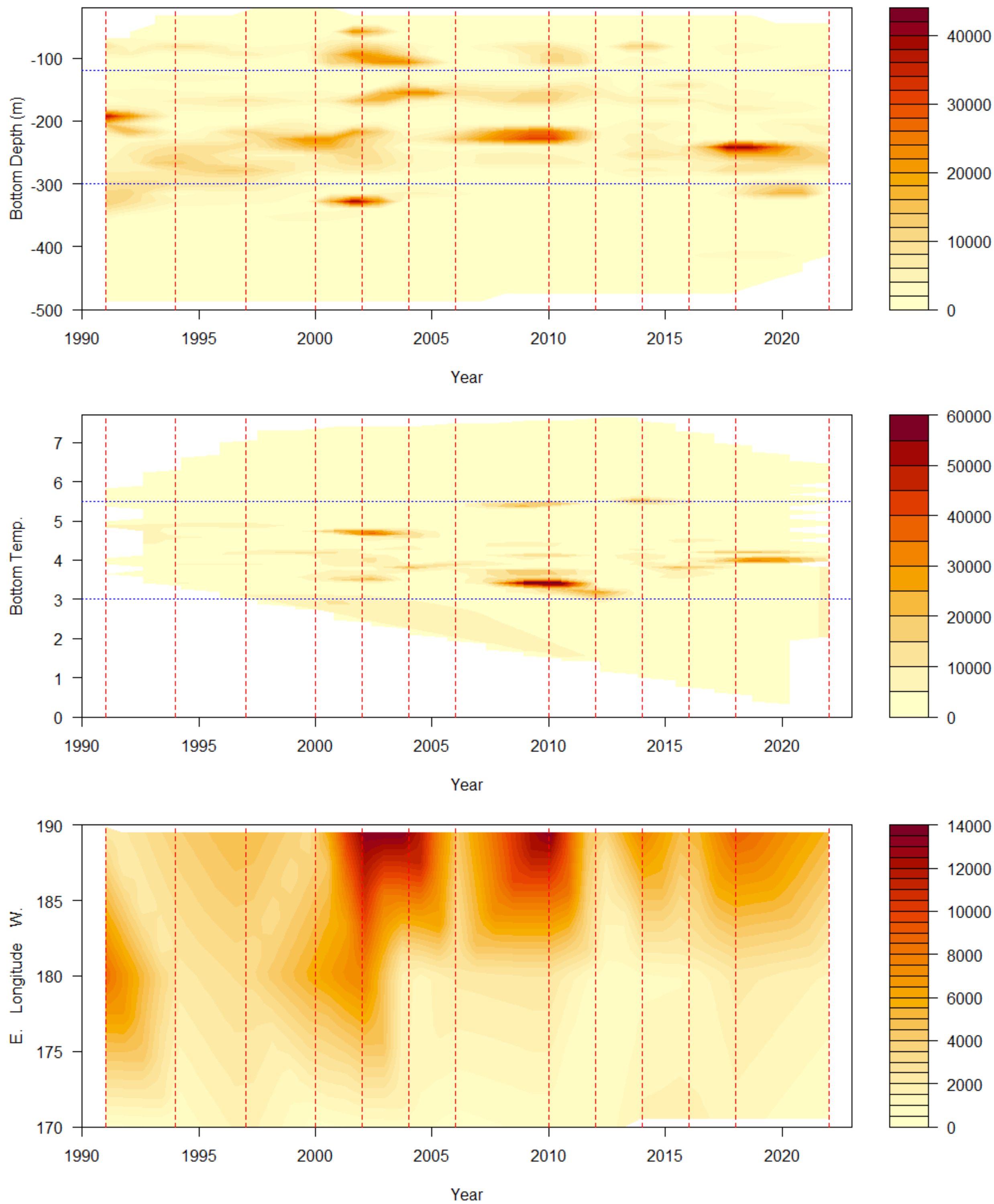


Figure 1A.34 Pollock CPUE kgha^{-1} by 10 m bottom depth (top), 0.1 °C bottom temperature (middle), and 10° longitude (bottom). Note the E longitudes (<180) are further west in the Aleutian Islands.

Appendix 1A-A

Table A-1. Variable descriptions and model specification for Authors' Preferred Model.

General Definitions	Symbol/Value	Use in Catch at Age Model
Year index: i = {1963, …., 2015}		I
Age index: j = {1, 2, 3, …, 14^+}	j	
Mean weight by age j	W_j	
Maximum age beyond which selectivity is constant	*Maxage*	Selectivity parameterization
Instantaneous Natural Mortality	M	Fit with M=0.20 and CV = 0.2, constant over all ages for Models 15.1 Model 15.2 M = vector fit as deviates from initial M.
Proportion females mature at age j	p_j	Definition of spawning biomass
Sample size for proportion at age j in year i	T_i	Scales multinomial assumption about estimates of proportion at age
Survey catchability coefficient	q^s	Prior distribution = lognormal(1.0 , σ_q^2)
Stock-recruitment parameters	R_0	Unfished equilibrium recruitment
	h	Stock-recruitment steepness
	σ_R^2	Recruitment variance
Estimated parameters		
		$\phi_i(26),\ R_0,\ h,\ \varepsilon_i(41), \sigma_R^2,\ \mu^f,\ \mu^s,\ M,\ \eta_j^s(39),\ \eta_j^f c(13),\ q^s(3)$

Note that the number of selectivity parameters estimated depends on the model configuration.

Table A-2. Variables and equations describing implementation of the Assessment Model for Alaska (AMAK).

Description	Symbol/Constraints	Key Equation(s)
Survey abundance index (s) by year	Y_i^s	$\hat{Y}_i^s = q_i^s \sum_{j=1}^{14^+} s_j^s W_{ij} e^{Z_{i,j}\frac{7}{12}} N_{ij}$
Catch biomass by year	C_i	$\hat{C}_i = \sum_j W_{ij} N_{ij} \frac{F_{ij}}{Z_{ij}} \left(1 - e^{-Z_{ij}}\right)$
Proportion at age j, in year i	$P_{ij}, \sum_{j=1}^{14} P_{ij} = 1.0$	$P_{ij} = \frac{N_{ij} s_{ij}^f}{\sum_{k=1}^{15} N_{ik} s_{ik}^f}$
Initial numbers at age	$j = 1$	$N_{1977,1} = e^{\mu_R + \varepsilon_{1977}}$
	$1 < j < 13$	$N_{1977,j} = e^{\mu_R + \varepsilon_{1978-j}} \prod_{j=1}^{j} e^{-M}$
	$j = 14^+$	$N_{1977,15} = N_{1977,14} \left(1 - e^{-M}\right)^{-1}$
Subsequent years ($i > 1963$)	$j = 1$	$N_{i,1} = e^{\mu_R + \varepsilon_i}$
	$i < j < 13$	$N_{i,j} = N_{i-1,j-1} e^{-Z_{i-1,j-1}}$
	$j = 14^+$	$N_{i,14^+} = N_{i-1,14}\, e^{-Z_{i-1,13}} + N_{i-1,15}\, e^{-Z_{i-1,14}}$
Year effect, i = 1963, …, 2015	$\varepsilon_i, \sum_{i=1963}^{2007} \varepsilon_i = 0$	$N_{i,1} = e^{\mu_R + \varepsilon_i}$
Index catchability Mean effect	μ^s, μ^f	$q_i^s = e^{\mu^s}$
Age effect	$\eta_j^s, \sum_{j=1}^{15^+} \eta_j^s = 0$	$s_j^s = e^{\eta_j^s}$ $j \le$ maxage $s_j^s = e^{\eta_{\text{maxage}}^s}$ $j >$ maxage
Instantaneous fishing mortality		$F_{ij} = e^{\mu_f + \eta_j^f + \phi_i}$
mean fishing effect	μ_f	
annual effect of fishing in year i	$\phi_i, \sum_{i=1977}^{2007} \phi_i = 0$	
age effect of fishing (regularized) In year time variation allowed	$\eta_{ij}^f, \sum_{j=1}^{15^+} \eta_{ij} = 0$	$s_{ij}^f = e^{\eta_j^f}$, $j \le$ maxage $s_{ij}^f = e^{\eta_{\text{maxage}}^f}$ $j >$ maxage
In years where selectivity is constant over time	$\eta_{i,j}^f = \eta_{i-1,j}^f$	$i \ne$ change year
Natural Mortality	M	
Total mortality		$Z_{ij} = F_{ij} + M$
Recruitment Beverton-Holt form	$\tilde{R}_i$	$\tilde{R}_i = \frac{\alpha B_i}{\beta + B_i}$, $\alpha = \frac{4hR_0}{5h-1}$ and $\beta = \frac{B_0(1-h)}{5h-1}$ where $h=0.8$ $B_0 = \tilde{R}_0 \varphi$ $\varphi = \frac{e^{-15M} W_{15} p_{15}}{1 - e^{-M}} + \sum_{j=1}^{15} e^{-M(j-1)} W_j p_j$

Table A-3. Specification of objective function that is minimized (i.e., the penalized negative of the log-likelihood).

Likelihood /penalty component		Description / notes
Abundance indices	$L_1 = \lambda_1 \sum_i \ln\left(Y_i^s \big/ \hat{Y}_i^s \right)^2 \frac{1}{2\sigma_i^2}$	Survey abundance
Prior on smoothness for selectivities	$L_2 = \sum_l \lambda_2^l \sum_{j=1}^{15^+} \left(\eta_{j+2}^l + \eta_j^l - 2\eta_{j+1}^l \right)^2$	Smoothness (second differencing), Note: *l={s,* or *f}* for survey and fishery selectivity
Prior on recruitment regularity	$L_3 = \lambda_3 \sum_{i=1963}^{2007} \varepsilon_i^2$	Influences estimates where data are lacking (e.g., if no signal of recruitment strength is available, then the recruitment estimate will converge to median value).
Catch biomass likelihood	$L_4 = \lambda_4 \sum_{i=1963}^{2007} \ln\left(C_i \big/ \hat{C}_i \right)^2$	Fit to catch biomass in each year (
Proportion at age likelihood	$L_5 = -\sum_{l,i,j} T_{ij}^l P_{ij}^l \ln\left(\hat{P}_{ij}^l \cdot P_{ij}^l \right)$	*L={s, f}* for survey and fishery age composition observations
Fishing mortality regularity	$L_6 = \lambda_6 \sum_{i=1963}^{2007} \phi_i^2$	(relaxed in final phases of estimation)
Priors	$L_7 = \left[\lambda_7 \frac{\ln\left(M \big/ \hat{M} \right)^2}{2\sigma_M^2} + \lambda_8 \frac{\ln\left(q/\hat{q} \right)^2}{2\sigma_q^2} \right]$	Prior on natural mortality, and survey catchability (reference case assumption that these are precisely known at 0.3 and 1.0, respectively).
Overall objective function to be minimized	$\dot{L} = \sum_{i=1}^{7} L_i$	

Appendix 1A-B Supplemental catch data

In order to comply with the Annual Catch Limit (ACL) requirements, we present non-commercial removals and estimates of pollock removals from the halibut fishery from the Halibut Fishery Incidental Catch Estimation (HFICE) to help estimate total catch and removals from NMFS managed stocks in Alaska.

Estimates of total removals that do not occur during directed groundfish fishing activities includes removals incurred during research, subsistence, personal use, recreational, and exempted fishing permit activities, but does not include removals taken in fisheries other than those managed under the groundfish FMP. These estimates represent additional sources of removals to the existing Catch Accounting System (CAS) estimates. Current pollock research removals are insignificant relative to the fishery catch, being smaller than the observation error assumed for the catch estimate. Total removals from activities other than directed fishery were near 29.2 tons in 2018 (Table C-1). This is 0.07% of the 2018 recommended ABC of 40,788 t. There were no data available on pollock removals due to subsistence, personal use, or recreational catch. It is assumed that pollock catches during these activities would be minimal in AI management area.

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Table C-1 Total removals of walleye pollock (t) from the NRA area from activities not related to directed fishing, since 1978.

	NMFS Acoustic	Bottom Trawl	ABL Long Line	AICASS*	IPHC	Japanese Surveys	Atka Tagging	Total
1978								
1979								
1980	2.5	37.9				97.7		138.1
1981								
1982	5.7	0.8						6.5
1983		28.1				396.7		424.8
1984								
1985								
1986		10.6				248.1		258.7
1987								
1988								
1989								
1990								
1991		30.0						30.0
1992								
1993								
1994		26.9						26.9
1995								
1996			0.09					0.1
1997		23.2						23.2
1998			0.11					0.1
1999								
2000		30.9	0.05					31.0
2001								
2002		35.5	0.10					35.6
2003								
2004		18.2	0.06					18.3
2005								
2006		17.8	0.05					17.9
2007								
2008			0.05	7.6				7.7
2009								
2010		35.3	0.26		0.02			35.6
2011					0.06		3.2	3.3
2012		13.0	0.16		0.01			13.2
2013					0.05			0.1
2014		20.7	0.23		0.10			21.0
2015					<0.01			<0.01
2016		17.8	0.08		0.02			17.9
2017	0.16							0.16
2018		29.2	0.01					29.2
2019	0.43				0.02			0.45
2020			0.08		<0.01			0.09

* Aleutian Islands Cooperative Acoustic Survey, 2008 only; 2006 and 2007 AICASS catch included in CAS