Aleutian Islands Walleye Pollock SAFE

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Executive Summary

This report details a reanalysis of historical pollock data along the Aleutian Islands region and extending into the Bogoslof region. The purpose of this study is to develop alternative approaches to assessing the pollock resources in this area that account for spatial patterns in stock distribution. Historical catch data show that pollock are found in the eastern portion of the Aleutian Islands Region and the deep basin area in the northeast portion extending west to Bowers Ridge. We identify the near shore areas of the main Aleutian chain as the Near, Rat, and Andreanof island groups (NRA). Fishery length frequency patterns from these areas support alternative data aggregation. For assessment purposes, we propose two datasets—one where the Aleutian Islands Region omits the deep-water portion of the catch in the northern area and another where this area and the area to the east of 174°W is also omitted. The catch omitted from these datasets could be pooled into the Bogoslof region for assessment purposes. Careful evaluation of these data is a necessary first step towards developing an improved stock assessment for the Aleutian Islands Region.

Analyses suggest that the NRA region west of 174°W is most consistent with the available survey data (from summer bottom trawl surveys) and fishery data. For this region, the total age 3+ biomass is estimated at about 330 thousand tons for 2004. The 2004 female spawning biomass is estimated at 160 thousand tons compared with $B_{35\%}$ estimates of 60 thousand tons. A number of alternative model configurations were evaluated, 18 of these are presented below.

The maximum permissible ABC estimate for this sub-region of the Aleutian Islands is 67,400 tons. However, noting a number of concerns regarding the preliminary nature of this assessment and the limited available data, we recommend that this be adjusted downward either by using an uncertainty adjustment (resulting in an ABC of 44,200 mt) or to the expected long-term harvest level (giving 28,600 mt). Should the North Pacific Fishery Management Council determine that the stock warrants Amendment 56 Tier 5, then this gives an ABC of 27,400 mt (for this sub-region of the Aleutian Islands).

For the area of the Aleutian Islands omitted from these calculations (i.e., east of 174°W), we recommend that this area continue to be closed to directed pollock fishing to form a contiguous protection zone with the Bogoslof area. This pollock conservation zone provides an added degree of separation between management areas and actively addresses uncertainties regarding stock structure. If this sub-area was considered for a pollock fishery, then we recommend a Tier 5 ABC level since this is conservative compared to partitioning a Tier 3 ABC level.

Introduction

Walleye pollock (*Theragra chalcogramma*) are distributed throughout the Aleutian Islands with concentrations in areas and depths dependent on season. Generally, larger pollock occur in spawning aggregations during February – April. Three stocks of pollock are identified in the U.S. portion of the Bering Sea for management purposes. These are: eastern Bering Sea which consists of pollock occurring on the eastern Bering Sea shelf from Unimak Pass to the U.S.-Russia Convention line; the Aleutian Islands Region encompassing the Aleutian Islands shelf region from 170°W to the U.S.-Russia Convention line; and the Central Bering Sea—Bogoslof Island pollock. These three management stocks probably have some degree of exchange. The Bogoslof stock is a group that forms a distinct spawning aggregation that has some connection with the deep water region of the Aleutian Basin. In the Russian EEZ, pollock are thought to form two stocks, a western Bering Sea stock centered in the Gulf of Olyutorski, and a northern stock located along the Navarin shelf from 171°E to the U.S.-

Russia Convention line. The northern stock is believed to be a mixture of eastern and western Bering Sea pollock with the former predominant. Bailey et al. (1999) present a thorough review of population structure of pollock throughout the north Pacific region. Recent genetic studies using mitochondrial DNA methods have found the largest differences to be between pollock from the eastern and western sides of the north Pacific.

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 appear to be most aptly assigned as "Basin" pollock. In this assessment, we re-organized the data along alternative boundaries that appear more consistent with survey observations and historical fishing patterns.

Fishery

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. In 1989, the domestic fleet began operating in earnest and has continued in the Aleutian Islands Region until 1999 when the North Pacific Fishery Management Council (NPFMC) recommended closing this region for directed pollock fishing due to concerns for Steller sea lion recovery.

Foreign vessels began fishing in the mid-1980s in the international zone of the Bering Sea (commonly referred to as the "Donut Hole"). The Donut Hole is entirely contained in the deep water of the Aleutian Basin and is distinct from the customary areas of pollock fisheries, namely the continental shelves and slopes. Japanese scientists began reporting the presence of large quantities of pollock in the Aleutian Basin in the mid-to-late 1970's, but large scale fisheries did not occur until the mid-1980's. In 1984, the Donut Hole catch was only 181 thousand t. The catch grew rapidly and by 1987 the high seas catch exceeded the pollock catch within the U.S. Bering Sea EEZ. The extra-EEZ catch peaked in 1989 at 1.45 million t and has declined sharply since then. A fishing moratorium was enacted in 1993 and only trace amounts of pollock have been harvested from the Aleutian Basin by resource assessment fisheries.

Data

Estimates of pollock catch in the Aleutian Islands Region are derived from a variety of data sources (Table 1A.1). During the early period, the foreign-reported database (held at AFSC) is the main source of information 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 takes into account observer data and reported catches and forms the basis of the official catch statistics until 1990. The raw observed catch shown in the fifth column provides an indication of the amount of catch observed relative to the blend data. The last two columns of this table show catch as reported in Ianelli et al. (2002) compared with the current catch estimate for the Aleutian Islands Region. Substantial discrepancies arise in 1984, 1988, 1989, and 1991. Investigating the cause for these differences revealed that improvements and revisions to the original ctch estimates had been made so that historical catch estimates changed but failed to be updated in the stock assessment document. Since 1990 estimates of pollock discard were available, and these represented a small fraction of the total catch during the years when directed fishing was allowed (Table 1A.2).

To evaluate alternative area definitions for stock assessment purposes, the spatial distribution of historical catch was examined. For the period 1977-1984, the foreign reported catch database was used to partition catches between areas while for 1985-2002, observer data were used. These proportions by the current standard Aleutian Islands Region sub-areas were then expanded to match the total catch (Table 1A.3; Fig. 1A.1).

The distribution of observed catch differed between the JV years (1977-1989) and the domestic fishery (1989-2002; Fig. 1A.2). In the early period, the JV 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 recent period (1989-1998, since the Aleutian Islands Region has been closed to directed pollock fishing since 1999) 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. Considering the spatial distribution of these fisheries, the Aleutian Islands Region was divided into areas where apparent breaks existed (Fig. 1A.3). These breaks separate the northern "basin" area from the Aleutian Islands chain and split the eastern-most portion of the Aleutian Islands Region from the Aleutian Islands. Two regional partitions were developed, one called NRA (for Near, Rat, and Andreanof Island groups) extending to 170°E, and another that excludes the eastern portion between 174°W and 170°W. The time series of catch estimates for these two groups is shown in Table 1A.4.

The number of hauls and length samples in the NRA region west of 174°W are quite small compared with the eastern and northern (basin) areas (Table 1A.5). However, the differences in the length frequencies appear to be substantial between regions (Fig. 1A.4 and Fig 1A.5). During the early period, the region west of 174°W longitude was composed of smaller fish. This region also tended to have a broader range of lengths. The Basin region was similar to the eastern most region and the Bogoslof region (during the years when a fishery was allowed there). An investigation as to whether the change for the NRA region west of 174°W could be attributed to different seasonal concentrations of fishing showed that before 1990, the fishery tended to be more concentrated later in the year (Fig. 1A.6). The occurrence of larger fish later in the time series is likely due to the fishery targeting on spawning pollock. This also seems to have affected average weight-at-age data with pollock from the early period having considerably lower mean-weights-at-age (Fig. 1A.7; Table1A. 6). Interestingly, the observed proportion of females in the catch appeared to show a decline over this period (Fig. 1A.8).

We estimate the catch-at-age composition using the methods described by Kimura (1989) and modified by Dorn (1992). Briefly, length-stratified age data are used to construct age-length keys for each stratum and sex. These keys are then applied to randomly sampled catch length frequency data. The stratum-specific age composition estimates are then weighted by the catch within each stratum to arrive at an overall age composition for each year. Data were collected through shore-side sampling and at-sea observers. The number of age samples and length samples was highly variable over this time period (Table 1A.7). For the purposes of alternative assessments (with different area-specific catch time series) observations on the age-composition of the catch was assumed to be the same. Alternatively, catch-age composition samples for the NRA region west of 174°W were limited in scope and insufficient to create separate estimates. The estimates for catch-age composition are shown in Table 1A.8.

Survey data

Bottom trawl survey effort in the Aleutian Islands region has not been as extensive as in the eastern Bering Sea. The National Marine Fisheries Service in conjunction with the Fisheries Agency of Japan completed bottom trawl surveys for 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, and 2002. Biomass estimates from the surveys conducted in the 1980s ranged between 309 and 779 thousand tons (mean 546). Biomass estimates from the five most recent RACE surveys ranged between 117 and 357 thousand tons (mean 188; Table 1A.9). The biomass estimates from the early surveys are not comparable with the biomass estimates obtained from the RACE trawl surveys because of differences in the net, 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 will result in pollock biomass estimates that are higher than those obtained using standard methods employed in the RACE surveys. Plotted on a simple catch-per-tow basis, the relative distribution of pollock appears to be highly variable between years and areas (Fig. 1A.9).

The RACE Aleutian Islands bottom trawl (AIBT) surveys indicate that most of the pollock biomass has been located in the Eastern Aleutian Islands Area (INPFC Area 541) and along the north side of Unalaska-Umnak Islands in the eastern Bering Sea region (~165°W and 170°W). The 2002 Aleutian Islands trawl survey showed that the greatest densities and estimated biomass occur in the Unalaska-Umnak area in the eastern Bering Sea

region. Within the Aleutian Islands Region (INPFC Areas 541, 542, and 543) the 2002 AIBT survey indicated the highest densities and biomass were in the Central Aleutian Islands Area (INPFC Area 542) followed by the Eastern (INPFC Area 541) and Western areas (INPFC Area 543). In earlier years (1991-2000) the highest biomass was in the Eastern Aleutian Islands area followed by the Central and Western areas. The RACE AIBT surveys revealed a decline in pollock biomass in the portion of INPFC Area 541 east of 174°W longitude from a high of 53,865 mt in 1991 to a low of 28,985 mt in the 2000 survey and then back up to 53,368 mt in the 2002 survey (Table 1A.9). The estimated biomass in the remainder of the Aleutian Islands region, west of 174°W longitude, has increased since the 1994 survey. Since the AIBT is limited to within the 500 m isobath these biomass estimates do not include mid-water pollock, nor do they include pollock located offshore from the 500m isobath. These biomass estimates therefore represent an unknown portion of the total biomass. The biomass in this area may be greater if the on-bottom/off-bottom distribution is similar to that of the eastern Bering Sea. In addition, climatic and year class variation may cause a difference in the proportion of pollock available to the bottom trawl survey.

The 2002 AIBT Survey showed an increase in pollock biomass in the Unalaska-Umnak Area from the 2000 AIBT survey of over 700 percent. Although the 2002 Echo Integration-trawl (EIT) Survey showed an increase in number of pollock in the Umnak Island aggregation from the 2001 EIT survey, the 2002 EIT survey found a slight decrease in the estimated biomass of pollock in the Bogoslof survey area (232,000 tons in 2001 to 227,000 tons in 2002). This is a further decrease from the estimated pollock biomass in the Bogoslof survey area from the 2000 EIT survey (301,000 tons). In the 2002 AIBT survey the pollock size composition for the Unalaska-Umnak area was more comparable to that found in the eastern Bering Sea than the size composition of the Eastern and Central Aleutian Islands areas (Fig. 1A.10). In the Unalaska-Umnak and the eastern Bering Sea areas the size mode was between 450 mm and 500 mm while in the Eastern and Central Aleutian Islands areas the size mode was between 570 mm and 630 mm. The pollock size composition in the Western Aleutian Islands area was bimodal with one size mode between 430 mm and 470 mm and another between 570 mm and 630 mm. These data indicate that small (450-500mm) fish from the eastern Bering Sea may move to the Unalaska–Umnak Islands. This movement would explain the apparent increase in estimated pollock biomass observed in the 2002 Aleutian Islands trawl survey. Previous AIBT surveys (2000, 1997, 1994, and 1991) showed the pollock size composition in the Unalaska-Umnak Area to be similar to that of the Aleutian Islands Region.

Unlike the 2000 and 1994 AIBT surveys there were few fish observed between the 100 and 250 mm range, indicative of 1 or 2 year old fish. The large numbers of 1 or 2 year old size pollock observed in the 1994 and 2000 surveys were assumed to have entered the fishable population in 1996 and 2002, respectively, and stabilized or increased pollock biomass in the Aleutian Islands in recent years. Differences in length distribution are apparent between areas east and west of 170°E longitude. Differences in pollock length distributions between the areas east and west of 174°E longitude in the NRA are not as apparent (Fig. 1A.11).

Analytic Approach

The 2003 Aleutian Islands walleye pollock stock assessment uses a new modeling approach implemented through the Assessment Model for Alaska (here referred to as AMAK). AMAK is a variation of the model used for the "Stock Assessment Toolbox" presented to the plan team in the 2002 Atka mackerel stock assessment, 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

The AMAK model models catch-at-age with the standard 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 15-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 (or simple mean). As in the stock synthesis model, deviations between the observations and the 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 Tables A-1 – A-3 provide a description of the variables used, and the basic equations describing the population dynamics of Aleutian Islands pollock as they relate to the available data. 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

Parameters

Parameters estimated independently

Natural Mortality

In the current assessment, a natural mortality value of 0.3 was used for Models 1, 3, and 6-9. These models assume a fixed, constant value of M based on the studies of Wespestad and Terry (1984). Wespestad and Terry (1984) provide estimates of M = 0.3 for ages 3+ (Table 1A.10). Models 2, 10, 11, and 12 allow M to be estimated assuming an informative prior for M with a mean of 0.3 and a coefficient of variation (CV) of 0.1.

Length and Weight at Age

We estimated length and weight at age separately for the survey and for the fishery. We obtained survey estimates from AIBT surveys and computed fishery estimates from observer data. For the time period between 1978 and 1990 the von Bertalanffy growth curve parameters and length weight regression parameters for length and weight at age estimates for surveys were obtained from Ronholt, et al (1994) for the 1980, 1983, and 1986 AIBT surveys (Table 1A.11). For the time period between 1990 and 2003 we calculated the average length at age by weighted averages by age and calculated the length-weight relationships using linear regression analysis. Data for these analyses were retrieved from the Resource Assessment and Conservation Engineering Division's (RACE) survey database. Length and weight at age data were available for the 1991, 1997, and 2002 AIBT surveys. For years without survey length and weight at age data we used the mean values at age for the two nearest surveys. Data east of INPFC area 542 were excluded from the data set for calculating length and weight at age for models used to explore Series A models (NRA Area west of 174°W). All survey data from INPFC areas 541, 542, and 543 were used for calculating length and weight at age for models used to explore Series B

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

models (All NRA area). For the fishery, we used year (when available) and age-specific estimates of average weights-at-age as computed from the fishery age and length sampling programs. These values are shown in Table 1A.12 and are important for converting model estimated catch-at-age (in numbers) to estimated total annual harvests (by weight). For the Series A data set, when data from east of 174°W were excluded there were not enough age data to compute accurate average weight-at-age, therefore we used all data from the NRA in the computation of average weights-at-age. Average weight-at-age estimates for the fishery do not differ between Series A and Series B data sets.

Maturity at Age

Maturity at age follows the schedule based on the studies of Wespestad and Terry (1984) (Table 1A.13).

Parameters estimated conditionally

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. The number of parameters estimated differed considerably depending on the model series.

Fishing Mortality

A number of different models were explored for the parameterization of fishing mortality. All models were parameterized with an age (selectivity) component and some were parameterized to be separable with both an age component (selectivity) and a year component. In Models 1 and 2 fishing mortality was fit to a logistic curve for all years (with data) with parameters for slope and inflection. In models 6-12 the selectivity 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; (Table A-2)). In these 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 penalty was imposed on sharp shifts in selectivity between ages using the sum of squared second differences. In addition, the age component parameters are assumed constant for the last 4 age groups (ages 12-15). Finally, depending on the model configuration, selectivity was allowed to vary over time. Two types of controls were allowed in configuring the model: selecting the year or years where the selectivity change is allowed to occur and selecting the degree to which selectivity is allowed to change. Both of these features were explored in the set of model configurations evaluated below.

Survey Catchability

For the bottom trawl survey, survey catchability-at-age follows a parameterization similar to the fishery selectivity-at-age presented above (except with no allowance for time-varying selectivity). Here we specified that the average catchability-at-age for the survey is equal to 1.00 over ages 4-12. This was done to provide a standardized view of the ages over which catchability applies. Exploration of survey catchability-at-age in a number of preliminary model runs resulted in the best fit (lowest –ln(likelihood function), with fewest parameters) being a logistic curve with a slope of 0.4 and an inflection of 11 (Fig. 1A.12). This parameterization was used for all model runs.

Recruitment

A reparameterized form of the Beverton-Holt stock recruitment relationship based on Francis (1992) was used (Table A-2). 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" of the stock-recruit relationship (h, Table A-2). 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 $h = 0.8$ implies that at 20% of the unfished spawning stock size will result in an expected value of 80% of the unfished recruitment level. The steepness parameter was set at 0.6 and sigma r

(h) was set at 0.5 for all model runs presented here. Model runs exploring assumed values of steepness, use of a prior on steepness, *h*, and the use of a prior on *h* were explored, but had little or no bearing on the stock assessment results and were not carried forward for evaluation at this time.

Model Evaluation

In order to evaluate the proposed division of the Aleutians two sets of models were explored. One set of models (Series A) used data collected in the NRA west of 174° west longitude, while the other set of models (Series B) employed all data collected in the NRA. We ran 12 model configurations for each data series. Models 3-5 were configured to assess survey catchability, but due to difficulties in assessing this parameter the results of these model configurations are not evaluated in this assessment. Survey catchability was set at q = 1.00 for all models presented in this assessment. Below we evaluate 8 model configurations for Series A and 9 for Series B in order to examine model assumptions, data sensitivities and uncertainty (Table 1A.14). Model exploration focused on the estimation of fishery selectivity-at-age, and natural mortality. A summarized list of the models follows:

Series A: NRA west of 174° west longitude

Model A1 Fishery selectivity-at-age is estimated using a logistic curve model which does not change inter-annually

Model A2 Same as model A1, but estimating *M* with an informative prior (mean of 0.3 and CV of 0.1).

Model A6 Fishery selectivity-at-age is a selectivity coefficient model with a high constraint on the selectivity-at-age curvature (CV of 0.2) with no penalty for descending. In this model selectivity-at-age remains constant inter-annually.

Model A7 Fishery selectivity-at-age is a selectivity coefficient model with a low constraint on selectivity-at-age curvature (CV of 0.7) and selectivity-at-age is allowed to change inter-annually with a low constraint (0.7).

Model A8 Fishery selectivity-at-age is a selectivity coefficient model with a medium constraint on selectivity-at-age curvature (CV of 0.4) and selectivity-at-age is allowed to change each year with a medium constraint (0.4)

Model A9 Fishery selectivity-at-age is a selectivity coefficient model with a high constraint on selectivity-at-age curvature (CV of 0.2) and selectivity-at-age is allowed to change each year with a high constraint (0.1).

Model A10 Reference Model: Fishery selectivity-at-age is a selectivity coefficient model with a high constraint on selectivity-at-age curvature (CV of 0.2) and selectivity-at-age does not change each year. *M* is estimated with an informative prior (mean of 0.3 and CV of 0.1).

Model A11 Same as Model A7, but estimating *M* with an informative prior (mean of 0.3 and CV of 0.1).

Series B: All NRA

Model B1 Fishery selectivity-at-age is estimated using a logistic curve model which does not change inter-annually

Model B2 Same as model B1, but estimating *M* with an informative prior (mean of 0.3 and CV of 0.1).

Model B6 Fishery selectivity-at-age is a selectivity coefficient model with a high constraint on the selectivity-at-age curvature (CV of 0.2) with no penalty for decrease. In this model selectivity-at-age remains constant inter-annually.

Model B7 Fishery selectivity-at-age is a selectivity coefficient model with a low constraint on selectivity-at-age curvature (CV of 0.7) and selectivity-at-age is allowed to change inter-annually with a low constraint (0.7).

Model B8 Fishery selectivity-at-age is a selectivity coefficient model with a medium constraint on selectivity-at-age curvature (CV of 0.4) and selectivity-at-age is allowed to change each year with a medium constraint (0.4)

Model B9 Fishery selectivity-at-age is a selectivity coefficient model with a high constraint on selectivity-at-age curvature (CV of 0.2) and selectivity-at-age is allowed to change each year with a high constraint (0.1).

Model B10 Fishery selectivity-at-age is a selectivity coefficient model with a high constraint on selectivity-at-age curvature (CV of 0.2) and selectivity-at-age does not change each year. *M* is estimated with an informative prior (mean of 0.3 and CV of 0.1).

Model B11 Fishery selectivity-at-age is a selectivity coefficient model with a high constraint on selectivity-at-age curvature (CV of 0.1) and selectivity-at-age changes in 1991with low constraint (0.7). *M* is estimated with an informative prior (mean of 0.3, CV of 0.1).

Model B12 Fishery selectivity-at-age is a selectivity coefficient model with a medium constraint on selectivity-at-age curvature (CV of 0.4) and selectivity-at-age changes in 1991with low constraint (0.7). *M* is estimated with an informative prior (mean of 0.3, CV of 0.1).

The models can be categorized as follows:

Model 1 Explore selectivity using a logistic curve model

Model 2 Configured as model 1 and used to explore priors on *M*.

Models 6-9 Explore different levels of constraints on the fishery selectivity-at-age curvature in conjunction with allowing selectivity-at-age to change inter-annually.

Models 10-12 Explore different levels of constraints on the fishery selectivity-at-age curvature in conjunction with the exploration of priors on *M*.

Series A Results

Key results from the Series A models are given in Table 1A.15. We explored the logistic models (Model A1 and Model A2) because they require fewer estimated parameters and we thought they could provide a biologically reasonable estimation of fishery selectivity. The difference between Models A1 and A2 is the estimation of *M* in Model A2. The logistic models favored a selectivity-at-age curve with a slope of 1 (1.02 and 0.99 for Model A1 and A2 respectively) and an intercept of 7 (7.26 and 7.11 for Model A1 and A2 respectively). Of these two models, Model A2 provided a significantly better fit (i.e. lowest –ln(likelihood function) with a minimum increase in parameters). The estimation of natural morality at 0.20 in Model A2 may indicate that *M* for the Aleutian Islands pollock stock is lower than that estimated by Wespestad and Terry (1984) and Ianelli et al (2002) for the Eastern Bering Sea (0.3).

Models A6 through A9 allow time-varying selectivity with different levels of constraint on the fishery selectivity-at-age curvature. Of these four models, Model A7, which is essentially a non-separable VPA-type model, had the lowest –ln(likelihood function), but biologically unreasonable selectivity-at-age assumptions. Model A7 assumes large shifts in selectivity between years, these shifts tended to be exacerbated by gaps in catch-at-age data (Fig.1A.13). The medium constraint on the selectivity-at-age curvature (Model A8) smoothens some of the inter-annual shifts in selectivity-at-age, but the model fit is worse with a greater number of parameters than that achieved by a high constrained (CV of 0.2), inter-annually static model (Model A6). The highly constrained selectivity-at-age (Model A9) provides biologically reasonable selectivity assumptions,

but again the inter-annually static curve (Model A6) fit the data better with far fewer parameters. A major issue with models A7-A9 in comparison to Model A6 is the high number of parameters necessary to estimate inter-annual changes in selectivity-at-age. In our opinion the high number of parameters (386) is excessive given the limited amount of data available for estimating selectivity-at-age. Of the 26 years where selectivity-at-age was estimated there are only 8 years where catch-at-age estimates are available, none of which prior to 1990.

Except for estimations of natural mortality Models A10 and A11 are the same as Models A6 and A7 respectively. In both Models A10 and A11 natural mortality is estimated using an informative prior with a mean of 0.3 and CV of 0.1. The best fit for both Model A10 and Model A11 is with *M* equal to 0.21. Like model A2 this finding supports a lower *M* for pollock in the Aleutian Islands area than that estimated by Wespestad and Terry (1984) and Ianelli et al (2002) for the Eastern Bering Sea. Like Model A7, Model A11 allows inter-annual variability in the selectivity-at-age fit and resulted in the lowest –ln(likelihood function), but at a cost of estimating 387 parameters. Model A11, like model A7, assumes large shifts in selectivity between years that are not biologically reasonable. Like selectivity-at-age in Model A6, selectivity-at-age in Model A10 is inter-annually static and is estimated over all years (with data). Model A10 requires the estimation of 87 parameters in contrast with Model A11 which requires the estimation of 387 parameters. The 300 additional parameters only decreases the –ln(likelihood function) by 7. Therefore the improvement in fit from Model A10 to Model A11 is not substantial enough to justify the estimation of an additional 300 parameters.

The major difference in fit between those models employing the logistic fishery selectivity-at-age and those employing the coefficient fishery selectivity-at-age is the fit to the fishery age composition data. The coefficient selectivity-at-age model achieved a closer fit to the fisheries age composition data than did the logistic models. The fit to the survey index, survey age composition, and catch were very similar in both model types.

Series B Results

Key results from the Series B models are given in Table 1A.16. The difference between models B1 and B2 is the estimation of *M* in Model A2. The logistic models favored a selectivity-at-age curve with a slope of 1 (0.95 and 0.98 for Model B1 and B2 respectively) and an intercept between 6 and 7 (6.59 and 6.31 for Model B1 and B2 respectively). Model B2 provided a slightly lower –ln(likelihood function), but increased the number of parameters and decreased the average effective sample size for both the survey and fishery age composition estimates. The improvement of fit from Model B1 to Model B2 is attributable to a better fitting estimation of natural mortality in Model B2 at 0.26.

Models B6 through B9 allow time-varying selectivity with different levels of constraint on the fishery selectivity-at-age curvature. Of these four models, Model B7, which is essentially a non-separable VPA-type model, had the lowest –ln(likelihood function), but, like A7, had biologically unreasonable selectivity-at-age assumptions. Model B7 results in a sudden shift in the shape of the selectivity curve in 1991 from dome shaped to a more asymptotic curve (Fig. 1A.14). This change in shape is evident in all of the models where selectivity is allowed to change inter-annually (Models B7-B9). This shift in selectivity may be due to a number of factors: 1) the shift from a joint venture fishery to a fully domestic fishery in 1990, 2) implementation of some Steller Sea lion initiatives in 1991which pushed the fishery farther offshore, 3) continued dominance of an older 1978 year class in the targeted population, and 4) potentially a change in collection of data from the foreign observer program to the domestic observer program. The medium constraint on the selectivity-at-age curvature (Model B8) smooths some of the inter-annual shifts in selectivity-at-age and provides a better fit to the data than Model B6. The higher lack-of-fit for Model B6 is due to the constant selectivity-at-age assumed during the early 1990s. The highly constrained selectivity-at-age (Model B9) provides biologically reasonable selectivity assumptions, but the constant selectivity curve (Model B6) fit the data reasonably well with far fewer parameters. Like Models A7-A9, Models B7-B9 require high numbers of parameters to estimate inter-annual changes in selectivity-at-age. Unlike the Series A models, the Series B models have much more catch-at-age data available for estimating selectivity-at-age (19 of 26 years). Model B8 fit the data the best of the Model B6-B9 series with biologically reasonable assumptions for selectivity-at-age.

Except for estimating natural mortality, Model B10 is the same as Models B6. Model B11 has a highly constrained selectivity-at-age (0.2), as in Model B7. It differs in that a single selectivity change in 1991 is specified with a low constraint (0.7). Model B12 has a medium constraint on selectivity-at-age (0.4), like model B8, but allows a single selectivity change in 1991 with a low constraint (0.7). Therefore, for in Models B11 and B12 selectivity-at-age for the 1978-1990 fishery is essentially estimated separately from the selectivity-at-age for the 1991-2003 fishery. In all three models natural mortality is estimated using an informative prior with a mean of 0.3 and CV of 0.1. The best fit for Model B10 is with *M* of 0.281. The best fit for models B11 and B12 was with an *M* of 0.256 and 0.254 respectively. These results further support a lower *M* for pollock in the Aleutian Islands area than that estimated by Wespestad and Terry (1984) and Ianelli et al. (2002) for the EBS stock. Model B10's fit to the data is significantly worse than either B11 or B12 (higher –ln(likelihood function), lower average effective sampling sizes for the fishery and the ABT surveys, and higher RMSE for the ABT survey) primarily due to its inability to fit the change in selectivity-at-age in the early 1990's. Both Model B11 and Model B12 fit the data well, with a selectivity-at-age that assumes a change in selectivity in the early 1990s, the difference between B11 and B12 is the amount of smoothing of the data between ages. Model B12 allows for sharp inclines and declines in the selectivity-at-age between ages, while Model B11 moderates these shifts. The fit for Model B12 is significantly better, due to the fishery age composition fits and the selectivity constraint penalties added to Model B11. The differences between Model B11 and B12 in predicted Fs, and long- term projected catch is minimal and the predicted mean biomass estimates are well within the error bounds for the two models.

Comparing Series A with Series B

We chose Series A data set for our reference model because it provides a more discrete analysis of the Aleutian Islands pollock stock. The Series A models are less influenced by fluctuations in the Eastern Bering Sea (EBS) pollock stock than Series B models. Series A also accentuates the biological characteristics of the Aleutian pollock stock that differ from the EBS stock. This includes a lower natural mortality and strong year classes that differ from the EBS stock (i.e. 1993 year class). The models using the Series B dataset appear to be highly influenced by the EBS 1978 year class (Fig.A1.15). In every Series B model explored the 1978 year class is the dominant characteristic of the system, even through the 1990s. In addition, from 1978 to 1995 nearly 70% of the annual catch in the NRA region was removed from the portion of the NRA east of 174° W. This we believe is due to an edge effect where fishing was targeted on the portion of the EBS and/or Bogoslof pollock stock that were found in the most eastern portion of the Aleutian Islands area. Using the Series B dataset may result in overestimates of the Aleutian Islands pollock stock productivity. Excluding NRA data east of 174° W longitude appears to provide a more consistent analysis of the Aleutian pollock stock as surveyed by NMFS summer bottom trawl gear and reduces the potential of including a portion the EBS stock. Although an influx of pollock into the Aleutians area from the Eastern Bering Sea seems to occur, the influence is appears to be far less in the NRA region west of 174°W.

Of the Series A models we chose Model A10 as our reference model based on the following features:

1) The model fit the data well (i.e., low –ln(likelihood function);
2) Relatively few estimated parameters were required compared to other Series A models;
3) A conservative fixed value of q =1.0 was assumed (though the average of the survey selectivity curve from age 6-15 was 0.46);
4) A conservative value of natural mortality (M=0.21) was estimated; and
5) There was good agreement between average effective sample size and the fixed average sample size for survey and fishery age composition data.

Model Results

The results discussed below are based on the reference model, Model A10.

Selectivity

The estimated selectivity at age schedules for the survey and fishery are shown in Figures 1A.12 and 1A.13, respectively, and given in Table 1A.17. Catch-at age data for the reference model were only available for 1990 through 1996, and 1998 fisheries. The fishery catches consist of fish 3-15+ years old. Between 1990 and 1998, fish 10+ years old made up on average 52% of the catch. The1978 year class was evident in all the fishery catch-at-age data through 1998. The 1978 year class dominated the fishery catch-at-age from 1990-1994; the 1989 year class was dominant in 1995 and 1996, and the 1993 year class was dominant in 1998. Results from AIBT surveys were inconsistent in that the 1978 year class was rarely observed . However, the 1989 year class was dominant in the 1997 survey, and the 1993 year class appeared as a mode in the 2002 survey. Since the AIBT survey age-composition data were given greater weight in Model A10 than fishery catch-at-age data, the model assumed a high selectivity for the older fish in the 1990s. The fishery selectivity-at-age assumed in Model A10 is a curve with a low slope from 0 to 9 years old, which steeply ascends after age 9, and plateaus at age 12. We assume in the reference model that fish over 12 years old differ very little in size, behavior, and location and thus should be equally susceptible to the fishery.

Abundance Trend

The estimated time series of total biomass with approximate upper and lower 95% confidence limits are shown in Figure 1A.16 and given in Table 1A.18, estimated numbers at age are provided in Table 1A.19. Prior to 1990 the reference model has only catch data to bound the biomass estimates. Reference model abundance trends in 1980s should be considered suspect given the lack of data for this time period. From 1990 to 1995 the reference model shows a steep (29%) increase in abundance. The NRA pollock fishery west of 174° W was most heavily pursued from 1995 through 1998. By 1999 the reference model estimate of total biomass decreased to 88% of its 1995 level. In 1999 the directed fishery for pollock in the Aleutian Islands Area was banned. Subsequently, the AIBT survey abundance estimates indicate a 112% increase from the 1997 survey to the 2002 survey (although the 2002 survey estimate is highly uncertain with a CV of 0.45). In contrast, the reference model total biomass estimate reflects this increase as only a 7% change, from 376,120 mt in 1999 to 403,630 mt in 2003.

Recruitment Trend

The estimated time series of age 1 recruits are shown in Figure 1A.14 and provided in Table A1.20. The fit to the Beverton-Holt stock recruitment curve is shown in Figure 1A.17. The lack of fishery catch-at-age data for the NRA west of 174° W prior to 1990, lack of survey data prior to 1991, and the selectivity-at-age assumed in the reference model for the 1980s may have caused the reference model to underestimate age-1 recruitment for the 1978 year class and therefore trends prior to 1990 should be considered highly uncertain. The strong 1989, and 1993 year classes are most notable in the reference model. The 1989 year class was also a high recruitment year class for the EBS pollock stock, but the 1993 year class appears to be unique to the NRA. The 1994-1999 year classes all appear to be near average and the 2000 year class is estimated to be below average.

One issue of interest is the correlation of above average NRA pollock recruitment for 1978, 1987, 1989, and 1993 with above average Aleutian Islands Atka mackerel recruitment in 1977, 1986, 1988, and 1992 (Fig. 1A.18; Lowe et al. 2003). The year lag between the NRA pollock recruitment and that of Atka mackerel may be an artifact of spawning season. Since Atka mackerel peak spawning is in August and pollock peak spawning is in March, recruitment success could be due to similar environmental factors. A correlation analysis of recruitment for Pollock west of 174°W and BSAI Atka mackerel 1978-2002 with pollock shifted back one year results in a correlation coefficient, r, value of 0.66 ($p < 0.001$). Further analysis should be conducted to investigate the ecological significance of this correlation.

Trend in Exploitation

The estimated time series of fishing mortalities on fully selected age groups and the catch-to-biomass (age 3+) ratios are provided in Table 1A.21 and shown in Figure 1A.19. Exploitation in the NRA west of 174° W has

been sporadic with two relatively heavy fishing periods, 1980-1984 and 1995-1998. The peak fishing year in the NRA west of 174° W was in 1995 with 58,000 mt removed (F = 0.61). Fishing was relatively low prior to 1980, again in 1985-1989, and directed fishing on pollock in the Aleutian Islands has been closed since 1999.

Model Fit

Comparing the Reference Model with the other Series A Models (excluding Model A11) shows an improved overall goodness of fit (i.e., a lower –ln(likelihood function); Table 1A.15). Although the reference model has a higher –ln(likelihood function) than Model A11, it estimates far fewer parameters than that needed in Model A11, and provides a more biologically reasonable assumption for selectivity-at-age. The coefficient of variation or *CV* (reflecting uncertainty) about the 2003 biomass estimate is 14% and the *CV* on the strength of the 1999 year class is 35% (Table 1A.15). Overall estimated recruitment variability is high (0.50 for the Reference Model). Sample size values for fishery age composition were fixed at 10 for 1990 – 1994 and 50 for 1995-1998. Sample size values for the AIBT survey age composition were fixed at 100. The reference model estimated an average fishery effective sample size (N) of 25 which is the same as the average fixed sample size. The average AIBT survey effective N was estimated to be 90, which is slightly lower than the fixed sample size of 100 used in the reference model. The overall residual mean square error (RSME) for the survey is estimated at 0.239 (Table 1A.15). The RSME is in line with estimates of sampling-error *CV*s for the survey which range from 20-45% and average 30% over the time series. The sampling-error variances should be considered as minimal estimates. Other sources of uncertainty (e.g., due to spatial variability and environmental conditions) can inflate the uncertainty associated with survey biomass estimates.

Figure 1A.20 shows a comparison between the observed and estimated survey biomass abundance values. The reference model fit most of the index estimates well, only the 1994 estimate is outside of the 95% confidence interval. The poor fit to the 1994 index estimate is primarily due to the inability of the model to fit the 43% drop from the 1991, then a 155% increase to the 2002 index estimate. Please note the low confidence in the AIBT survey estimates for NRA pollock biomass west of 174° W with a mean CV = 0.3.

The fits to the fishery and survey age compositions for Model A10 are depicted in Figures 1A.21 and 1A.22. The model fits the survey age composition data quite well and the fishery age composition data slightly less so. This reflects the fact that the sample sizes for age and length composition data are higher for the survey than the fishery. These figures also highlight the patterns in changing age compositions over time. The reference model can not fit the large 1987 year class seen in the 1991 survey, but does fit the other large year classes seen in the survey. The 15+ year class observed in the 1991-1995 fisheries was not fit well in reference model due to our cap on the selectivity-at-age which we specified in the reference model to plateau at age 12. Therefore the reference model provides a conservative (low) estimate of the 13-15+ year classes.

Projections and harvest alternatives

For projection purposes we used results from the reference model (Model A10) but with a selectivity-at-age estimate adapted from the 2003 Eastern Bering Sea (EBS) assessment (Table 1A.17). Since the Aleutian Islands directed pollock fishery has been closed since 1999, the reference model selectivity-at-age estimates may be inappropriate for a newly opened directed fishery. The selectivity-at-age estimated from the 2003 EBS pollock assessment (see relevant sections in the EBS portion of this document) may be more appropriate since the fishery would most likely be prosecuted by the same or similar vessels. Also, the selectivity-at-age assumption for the projections affects yield predictions for 2004 considerably:

Projection	With Model A10 selectivity-at-age	With adapted EBS selectivity-at-age
$F_{40\%}$ 2004 catch (mt)	121,680	67,410
$F_{35\%}$ 2004 catch (mt)	147,960	92,240

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 expected under average estimated recruitment from 1978-2003 (112.4 million age 1 recruits) 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 west of 174°W for Tier 3 of Amendment 56. For our analyses, we selected the following values from Model A10 with adapted EBS selectivity-at-age results computed based on recruitment from post-1977 spawning events:

$B_{100\%}$ = 171,600 mt female spawning biomass

$B_{40\%}$ = 68,600 mt female spawning biomass

$B_{35\%}$ = 60,000 mt female spawning biomass

Specification of OFL and Maximum Permissible ABC

For the Reference Model A10 with the adapted selectivity-at-age, the projected year 2004 female spawning biomass (SB_{04}) is estimated to be 153,600 mt under the maximum allowable ABC harvest strategy ($F_{40\%}$). The projected 2004 female spawning biomass is well above the $B_{40\%}$ value of 67,410 mt, placing NRA pollock west of 174°W in Tier 3a. The maximum permissible ABC and OFL values under Tier 3a are:

Harvest Strategy	FSPR%	Fishing Mortality Rate	2004 Projected yield (mt)
max F_{ABC}	$F40\%$	0.22	67,410
F_{OFL}	$F35\%$	0.28	92,240

ABC Considerations and Recommendation

ABC Considerations

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

1) The amount 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. Overestimation of the Aleutian Islands pollock stock productivity because of the influx of Eastern Bering Sea stock is a significant risk.

2) AIBT survey catchability was confounded with pollock mortality and limited estimation potential. We therefore employed a default value for catchability of 1.00 which provided conservative biomass estimates.

3) AIBT survey estimates of biomass are very uncertain with an average CV of 0.30. The 2002 estimate had a CV of 0.45. Since 2002 was the last AIBT survey, projections using these data have significant uncertainty.

4) The reference model only has survey and fishery age composition data available for the 1990s. Because of the selectivity-at-age assumed in this model, the 1978 year class may be underestimated (and therefore providing an added measure of conservation).

ABC Recommendation for NRA West of 174°W

The pollock biomass in the NRA west of 174°W appears to be stable to slowly increasing. The total age 3+ biomass for 2004 is expected to be 329,500 mt. The estimated female spawning biomass projected for 2004 is expected to be 153,600 mt, well above $B_{40\%}$ level of 68,600 mt, and B35% level of 60,000 mt. For the year 2004, the maximum permissible ABC alternative based on $F_{40\%}$ is 67,400 mt (F=0.22). However, we caution that this level may be high given uncertainty in the 2002 AIBT estimate and the lack of fisheries data since 1998. Also, this yield level is higher than any catches observed since 1977 from this region.

To reflect these concerns, we examined some alternative ABC values. First, we explicitly accounted for this uncertainty by using the adjustment proposed in Alternative 4.1 the draft PSEIS (NMFS 2002). In all future years, F is set equal to 0.624 of $max\ F_{ABC}$. This adjustment was based on assessment uncertainty (measurement error) from AIBT survey data and was based on the lower 90% confidence bound. The ABC recommendation under this alternative would be 44,200 mt (Fig. 1A.23 and Fig. 1A.24). The second alternative would be to set the ABC at the expected long-term equilibrium yield under $F_{40\%}$. Setting the ABC at the expected long-term equilibrium yield could be justified both for conservation purposes given the uncertainty in our stock assessment and could help prevent initial overcapitalization. The long-term average yield expected under $F_{40\%}$ harvest level is 28,600 mt. Under both the maximum ABC and under the uncertainty adjustment ABC yield decreases precipitously after the first year until the equilibrium is achieved.

Under the tier 5 assessment if we continued to employ a natural mortality of 0.3 the 2004 ABC would be 27,400 mt (121,900 mt x 0.75 x 0.30 = 27,400 mt).

ABC Recommendations for NRA East of 174°W

Setting an ABC for the NRA east of 174°W longitude poses significant difficulty given the lack of data concerns over stock structure. Should pollock fishing resume in this area Tier 5 ABC calculations can be made. These result in a maximum permissible ABC for this area of 12,000 mt based on the 2002 survey biomass estimate for this region (53,400 mt x 0.75 x 0.3 = 12,000 mt). The corresponding overfishing level (OFL) would be 16,000 mt (53,400 mt x 0.3 = 16,000 mt).

In addition, the BSAI plan team suggested providing an adjustment factor similar to that used to obtain values for the Aleutian Islands Pacific Cod population in the 2003 BSAI Pacific Cod Assessment. The ratio of the 2002 AIBT survey biomass from the NRA area east of 174°W to biomass from the NRA area west of 174°W is applied to the model output for the NRA area west of 174°W to obtain possible ABC and OFL values for the NRA east of 174°W.

Adjustment Factor:	53,368 mt / 121,915 mt = 0.438
Max ABC:	0.438 x 67,400 mt = 29,504 mt
Uncertainty Adjustment:	0.438 x 44,200 mt = 19,348 mt
$F_{40\%}$ Long-term Equilibrium:	0.438 x 28,600 mt = 12,520 mt
Overfishing (OFL):	0.438 x 92,200 mt = 40,360 mt

However, given uncertainty in the status of the pollock in the NRA area east of 174°W **it may be prudent to declare this area, along with the Bogoslof area, a protected transition zone between the Aleutian Islands, the Eastern Bering Sea, Central Bering Sea, and the Gulf of Alaska pollock stocks**. This would provide some measure of insurance over stock structure uncertainty and better justify current regional management stocks (since they will no longer be contiguous). We expect that this will also enhance the current conservation measures in place for the Bogoslof region related to the Central Bering Sea and Aleutian Basin pollock. We assume that there is some exchange of pollock between the NRA area east of 174°W, the Bogoslof area, the Central Bering Sea, the Eastern Bering Sea, and the Gulf of Alaska. However, the magnitude of exchange is uncertain. The prevalence of the 1978 year class in the fishery age composition data from the NRA area east of

174°W (Table 1A.22), the Eastern Bering Sea, and the Central Bering Sea and the absence of this year class as a major constituent of the 1991 AIBT survey age composition data suggest that pollock stocks overlap. The transition region proposed would provide a reasonable buffer between management areas. This proposed transition zone should be considered temporary until further stock structure evidence becomes available.

In terms of reduction in available pollock fishing areas, the suggested transition zone closure represents approximately 22% of the "fishable" area (Fig. 1A.25). Fishable area in the entire NRA region is defined as the surface area of the water down to 1,000 m. Since Steller sea lion critical habitat extends to 20nm around rookeries and haulouts, the fishable area *outside* of Steller sea lion critical habitat is 26% of the entire NRA fishable area. Further excluding the fishable area to the east of 174°W, leaves about 20% of the entire NRA fishable area open to fishing. The following table gives the approximate area breakdown.

	Entire NRA (170°W - 170°E)	NRA East of 174°W
Total shelf area (to 1000m depth)	82,700 km^2	22,700 km^2
Closed to 20 nm	61,300 km^2	18,000 km^2
Area outside of critical habitat	21,400 km^2	4,700 km^2
Proportion of shelf potentially open to pollock fishing	26%	21%

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 seven 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 2003 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2004 using a fixed value of natural mortality of 0.21, a fishery selectivity estimate derived from the 2003 Eastern Bering Sea pollock assessment (Table 1A.17), and the best available estimate of total (year-end) catch for 2003. 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 (March) 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 will be 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 2004, are as follow (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 of *max* F_{ABC}, where this fraction is equal to stock size uncertainty adjustment recommended in the draft PSEIS. (Rationale: This is a conservative estimate for F_{ABC} proposed as a reasonable alternative given the uncertainty in the biomass estimates).

Scenario 3: In all future years, F is set equal to 50% of max F_{ABC}. (Rationale: This scenario provides a likely lower bound on F_{ABC} that still allows future harvest rates to be adjusted downward when stocks fall below reference levels.)

Scenario 4: In all future years, F is set equal to the 1999-2003 average F. (Rationale: This is a likely scenario if the Aleutian Islands area remains closed to directed pollock fishing)

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 FOFL. (Rationale: This scenario determines whether a stock is overfished. If the stock is expected to be 1) above its MSY level in 2004 or 2) above ½ of its MSY level in 2004 and above its MSY level in 2013 under this scenario, then the stock is not overfished.)

Scenario 7: In 2004 and 2005, 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 2016 under this scenario, then the stock is not approaching an overfished condition.)

Projections and status determination

The projected age 3+ biomass at the beginning of 2004 is 329,500 mt, and the projected 2004 female spawning biomass is 153,600 mt. The projected yields, female spawning biomass, and the associated fishing mortality rates for the seven harvest strategies are shown in Table 1A.23. Under a harvest strategy of $F_{40\%}$ (Scenario 1), female spawning biomass is projected to be above $B_{40\%}$ for the 13 year projection. Female spawning biomass is projected to be above $B_{40\%}$ when fishing at F_{OFL} (Scenarios 6 & 7, Table 1A.23) until 2009 when it drops below $B_{40\%}$, but above $B_{35\%}$ for the remainder of the 13 year projection. It should be noted that in the projections, 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.

The associated long-term average female spawning biomass that would be expected under average estimated recruitment from 1978-2003 (112 million recruits) and $F = F_{35\%}$, denoted $B_{35\%}$ is estimated to be 60,000 mt. This value ($B_{35\%}$), is used in the status determination criteria. Female spawning biomass for 2004 (153,600 mt) is projected to be above $B_{35\%}$ thus, the NRA pollock stock west of 174°W is determined to be *above* its minimum stock size threshold (MSST) and is *not overfished*. Female spawning biomass for 2016 is projected to be above $B_{35\%}$ in scenario 7, thus the NRA pollock stock west of 174°W is *not* expected to fall below its MSST in two years and is *not approaching an overfished condition*.

Summary

NRA West of 174°W

Reference Model Parameters

Natural Morality:	M = 0.21	
Initial Biomass (1978):	B_0 = 370,800 mt	

2004 (Tier 3a recommended)

Maximum permissible ABC:	$F_{40\%}$ = 0.22	yield = 67,400 mt
Alternative ABCs:	*Uncertainty Adjustment*	yield = 44,200 mt
	$F_{40\%}$ *Long-term Equilibrium*	yield = 28,600 mt
	Tier 5 (M = 0.3)	yield = 27,400 mt
Overfishing (OFL):	$F_{35\%}$ = 0.28	yield = 92,200 mt

Equilibrium female spawning biomss

$B_{100\%}$	=	171,600 mt
$B_{40\%}$	=	68,600 mt
$B_{35\%}$	=	60,000 mt

Projected 2004 biomass

Age 3+ biomass	= 329,500 mt
Female spawning biomass	= 153,600 mt

NRA East of 174°W

2004 (Tier 5 recommended)

Maximum permissible ABC:	*2002 Survey Estimate x 0.75 x M*	yield = 12,000 mt
Overfishing (OFL):	*2002 Survey Estimate x M*	yield = 16,000 mt

2004 (Plan Team Adjustment Method)

Max ABC:

53,368 mt / 121,915 mt x 67,400 mt = 29,504 mt

Uncertainty Adjustment:

53,368 mt / 121,915 mt x 44,200 mt = 19,348 mt

$F_{40\%}$ Long-term Equilibrium:

53,368 mt / 121,915 mt x 28,600 mt = 12,520 mt

Overfishing (OFL):

53,368 mt / 121,915 mt x 92,200 mt = 40,360 mt

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Tables

Table 1A.1. Estimates of Aleutian Islands Region walleye pollock fisheries catch by source and compared with that presented in Ianelli et al. (2002), 1977-2002. Units are in metric tons.

Year	Official Foreign & JV Blend	Domestic Blend	Foreign Reported	NMFS Observer Data	2002 SAFE	Current Assessment
1977	7,367		7,827	5		7,367
1978	6,283		6,283	234		6,283
1979	9,446		9,505	58	9,504	9,446
1980	58,157		58,477	883	58,156	58,157
1981	55,517		57,056	2,679	55,516	55,517
1982	57,753		62,624	11,847	57,978	57,753
1983	59,021		44,544	12,429	59,026	59,021
1984	77,595		67,103	48,538	81,834	77,595
1985	58,147		48,733	43,844	58,730	58,147
1986	45,439		14,392	29,464	46,641	45,439
1987	28,471			17,944	28,720	28,471
1988	41,203			21,987	30,000	41,203
1989	10,569			5,316	15,351	10,569
1990		79,025		51,137	79,025	79,025
1991		98,604		20,493	78,649	98,604
1992		52,352		20,853	48,745	52,352
1993		57,132		22,804	57,132	57,132
1994		58,659		37,707	58,637	58,659
1995		64,925		18,023	64,429	64,925
1996		29,062		5,982	29,062	29,062
1997		25,940		5,580	25,940	25,940
1998		23,822		1,882	23,822	23,822
1999		1,010		24	965	1,010
2000		1,244		75	1,244	1,244
2001		824		88	824	824
2002		1,156		144	1,040	1,156

Table 1A.2. Estimated catch discarded and retained for the Aleutian Islands Region based on NMFS blend data, 1991-2001.

Year	Catch Retained	Discard	Total	Discard Percentage
1990	69,682	9,343	79,025	12%
1991	93,059	5,441	98,500	6%
1992	49,375	2,986	52,361	6%
1993	55,399	1,740	57,138	3%
1994	57,308	1,373	58,681	2%
1995	63,545	1,380	64,925	2%
1996	28,067	994	29,062	3%
1997	25,323	617	25,940	2%
1998	23,657	164	23,822	1%
1999	361	446	807	55%
2000	455	790	1,244	64%
2001	445	380	824	46%

Table 1A.3. Estimates of Aleutian Islands Region walleye pollock catch by the three management sub-areas. Foreign reported data were used from 1977-1984, from 1985-2002 observer data were used to partition catches among the areas. Units are in metric tons.

Year	East (541)	Central (542)	West (543)	Total
1977	3,293	1,771	2,302	7,367
1978	2,440	1,894	1,949	6,283
1979	3,190	2,716	3,540	9,446
1980	27,641	12,504	18,012	58,157
1981	30,748	10,325	14,445	55,517
1982	32,666	11,228	13,859	57,753
1983	36,129	9,470	13,422	59,021
1984	69,129	3,101	5,364	77,595
1985	19,885	38,163	100	58,147
1986	38,361	7,078	0	45,439
1987	28,086	386	0	28,471
1988	40,685	517	0	41,203
1989	10,569	0	0	10,569
1990	69,170	9,425	430	79,025
1991	98,032	561	11	98,604
1992	52,140	206	6	52,352
1993	54,512	2,536	83	57,132
1994	58,091	554	15	58,659
1995	28,109	36,714	102	64,925
1996	9,226	19,574	261	29,062
1997	8,110	16,799	1,031	25,940
1998	1,837	3,858	18,127	23,822
1999	484	420	105	1,010
2000	615	461	169	1,244
2001	332	386	105	824
2002	842	180	133	1,156

Table 1A.4. Estimates of pollock catch (metric tons) by new area definitions. "NRA" stands for Near, Rat, and Andreanof island groups, "NRA w/o E" signifies the NRA region without the area east of 174°W, "Basin" represents the northern portions of areas 541 and 542. See Fig. 1A.3 for locations on a map. (*Note: 1977-1984 area assignments are based on foreign reported data, 1985- 2002 are based on observer data).*

	NRA	NRA w/o E	Basin	Basin + E
1977	6,788	3,785	579	3,582
1978	5,989	3,846	294	2,437
1979	9,245	6,383	202	3,063
1980	55,561	31,029	2,596	27,128
1981	43,554	22,972	11,963	32,545
1982	41,384	19,993	16,369	37,760
1983	31,282	17,224	27,739	41,798
1984	31,811	6,300	45,784	71,295
1985	9,675	870	48,472	57,278
1986	17,436	704	28,003	44,735
1987	26,220	2,720	2,251	25,752
1988	36,864	574	4,339	40,628
1989	10,569	0	0	10,569
1990	79,025	10,462	0	68,563
1991	97,775	554	829	98,051
1992	20,457	8,515	31,895	43,837
1993	33,839	16,150	23,293	40,981
1994	31,769	5,969	26,890	52,690
1995	61,407	57,991	3,518	6,934
1996	28,162	23,039	900	6,023
1997	25,940	25,795	0	145
1998	23,755	23,340	66	482
1999	1,010	606	0	403
2000	1,244	908	0	336
2001	824	571	0	253
2002	1,154	318	1	837

Table 1A.5. Sampling levels in Aleutian Islands Region sub-regions based on foreign, J.V., and domestic walleye pollock observer data 1978 – 1998.

	NRA West of 174° Longitude			**NRA East of 174° Longitude**			**Aleutian Islands Area Basin**		
Year	Fish Measured	Hauls Sampled	Vessels Sampled	Fish Measured	Hauls Sampled	Vessels Sampled	Fish Measured	Hauls Sampled	Vessels Sampled
1978	1,503	64	4	4,831	135	11	0	0	0
1979	1,317	16	4	977	33	6	0	0	0
1980	2,154	53	4	4,753	119	10	0	0	0
1981	4,782	37	7	6,617	96	14	1,913	15	3
1982	7,713	102	13	29,549	331	30	11,151	84	7
1983	2,977	35	12	24,793	242	27	20,744	174	21
1984	10,844	111	22	46,037	541	49	157,388	1,223	81
1985	780	9	2	33,471	259	37	68,923	460	58
1986	0	0	0	22,939	195	18	39,875	268	48
1987	4,045	26	5	43,093	352	29	2,665	26	8
1988	378	3	2	28,423	249	24	4,528	37	14
1989	0	0	0	7,424	57	8	0	0	0
1990	12,303	131	14	55,837	587	47	55	1	1
1991	0	1	1	26,035	211	32	24,025	194	26
1992	7,405	59	15	18,771	178	50	20,769	179	27
1993	13,471	130	15	13,264	137	34	22,022	185	30
1994	5,025	47	18	29,805	305	64	5,314	56	16
1995	29,070	324	34	2,963	212	31	1,922	19	7
1996	15,307	160	35	3,462	179	41	0	0	0
1997	17,239	189	33	64	122	26	77	1	1
1998	10,439	122	15	148	107	12	0	0	0
Total	146,752	1,619	255	403,256	4,647	600	381,371	2,922	348

Table 1A.6. NRA pollock fishery average weight-at-age in kilograms.

Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1977														
1978	0.3318	0.3933	0.7603	0.6877	0.8097	0.9151	0.9065	0.9722	0.9281	1.0613	1.1674	1.1870	1.6149	1.0729
1979	0.2314	0.3476	0.5293	0.7306	0.6727	0.8250	0.9435	0.9532	1.0381	1.1638	1.0598	1.5186	1.5788	1.0206
1980	0.2392	0.5526	0.7651	0.8412	0.8629	0.9129	1.0002	1.0890	1.0628	1.0204	1.1568	1.1019	0.8521	1.5242
1981		0.4778	0.5521	0.7286	0.7637	0.7817	0.8096	0.8953	0.9021	0.8598	1.0199	1.0259	0.8929	0.9079
1982		0.4179	0.5414	0.6436	0.7838	0.8220	0.8417	0.8921	0.9842	1.0011	0.9575	0.9546	0.9058	0.9660
1983				0.7333	0.7796	0.7954	0.9264	0.9574	1.0146	0.9024			0.9740	
1984	0.4260	0.4459		0.7419	0.8099	0.8721	0.9680	0.9963	1.2704	1.6431	1.1351	1.2212		
1985	0.4675	0.5656	0.6705	0.6896	0.8028	0.8536	0.8567	1.0909	1.2330	1.5996	1.6644		1.6448	
1986		0.5114	0.6019	0.7472	0.8266	0.8698	0.9506	0.9266	1.0137	0.9428	1.0702	0.8963		
1987			0.6852	0.7562	0.8335	0.8504	0.8715	0.9809	1.0725	0.9915	1.3379	1.1546	1.0065	1.0935
1988				0.8013	0.7905	0.8208	0.9279	0.8883	0.9839	0.8933	0.7843	0.7223	0.8976	1.0621
1989														
1990		0.4778	0.5521	0.7286	0.7637	0.7817	0.8096	0.8953	0.9021	0.8598	1.0199	1.0259	0.8929	0.9079
1991			0.6668	0.6551	0.7989	0.9620	1.0755	1.1731	1.0994	1.2177	1.1573	1.0955	1.2898	1.0856
1992			0.6401	0.7418	0.7254	0.7970	0.9356	1.2457	1.0267	1.0034	1.2501	1.1451	1.0514	1.0976
1993			0.8862	0.8237	1.0335	1.0315	1.1399	1.0808	1.1638	1.1905	1.2027	1.3256	1.1373	1.1352
1994			0.6373	0.8437	0.9743	1.1361	1.1400	1.1216	1.1907	1.2437	1.2659	1.0591	1.0900	1.1517
1995		0.5512	0.8471		1.1264	1.3303	1.3972	1.3551	1.4333	1.4197	1.5010	1.4466	1.6582	1.3206
1996		0.5391	0.4753	0.9301	1.0287	1.1796	1.2751	1.3945	1.4682	1.3548	1.3777	1.3619	1.4562	1.3013
1997														
1998		0.4030	0.7631	0.7398	0.9826	1.0575	1.0850	1.2532	1.3137	1.4826	1.2785	1.3012	1.3597	1.4522

Table 1A.7. Number of aged and measured fish in the NRA pollock fishery used to estimate fishery age composition. Shaded values were not used in assessment.

	Number Aged			Number Measured		
Year	Males	Females	Total	Males	Females	Total
1978	209	322	531	1,734	4,598	6,332
1979	124	178	302	867	1,427	2,294
1980	93	167	260	2,740	4,167	6,907
1981	121	146	267	5,314	6,134	11,448
1982	473	529	1,002	17,623	19,639	37,262
1983	60	63	123	12,000	15,770	27,770
1984	84	75	159	23,605	33,276	56,881
1985	77	113	190	16,209	18,027	34,236
1986	140	147	287	10,654	12,285	22,939
1987	131	142	273	20,001	27,135	47,136
1988	34	33	67	13,439	15,362	28,801
1989	0	0	0	3,038	4,386	7,424
1990	46	49	95	35,120	34,909	70,029
1991	36	47	83	18,310	9,529	27,839
1992	110	121	231	33,594	19,090	52,684
1993	81	82	163	18,373	13,375	31,748
1994	147	141	288	24,867	14,495	39,362
1995	74	106	180	20,724	15,743	36,467
1996	95	84	179	12,336	8,792	21,128
1997	15	15	30	10,626	9,145	19,771
1998	144	170	314	6,906	5,368	12,274
1999	0	0	0	75	60	135
2000	0	1	1	70	114	184
2001	0	1	1	52	106	158
2002	0	0	0	46	61	107

Table 1A.8. Estimated NRA region pollock catch at age (millions). Highest mode for each year is shaded.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1978		0.02	0.22	0.58	0.27	1.92	0.57	0.83	0.97	0.82	0.49	0.16	0.08	0.01	0.03	6.96
1979			1.26	1.56	1.89	2.15	1.92	1.17	1.09	0.63	0.28	0.42	0.02	0.01	0.08	12.48
1980		3.49	2.32	3.59	6.66	13.48	9.97	9.70	4.38	4.29	1.25	0.45	0.09	0.34	0.06	60.05
1981			6.78	4.11	2.33	3.55	5.69	6.34	4.98	3.77	1.66	0.89	0.49	0.55		41.26
1982			0.10	56.07	7.04	1.52	2.29	3.83	3.83	2.56	1.02	0.62	0.35	0.31	0.14	79.68
1983					30.55	5.71	3.41	2.72	2.96	2.85	1.83			0.27		50.31
1984			3.98		3.06	27.17	5.66	4.16	3.41	0.53	0.07	0.05	0.65			48.85
1985		0.18	0.76	13.45	3.35	8.14	25.43	4.32	1.44	0.65	0.07	0.14		0.05		57.99
1986			2.08	0.15	3.05	0.49	2.65	9.43	3.67	1.47	2.62	0.44	0.81			26.85
1987				7.21	1.96	1.97	0.34	0.98	12.40	1.20	1.36	0.04	0.67	0.35	0.61	29.09
1988					1.67	3.65	4.52	1.82	3.92	15.09	2.52	0.63	0.91	0.50	2.09	37.30
1989																
1990			5.56	1.31	9.08	5.82	7.88	7.96	2.08	11.28	1.99	5.18	2.06	1.05	2.15	63.41
1991				1.42	1.18	8.66	2.52	3.18	9.96	1.03	2.87	8.34	21.10	5.53	20.41	86.20
1992				0.16	1.85	3.46	1.63	3.69	0.77	4.21	2.92	3.09	2.28	11.15	12.72	47.92
1993				0.64	1.60	4.06	4.88	1.94	5.26	2.90	3.06	2.92	1.40	2.58	15.73	46.96
1994				0.67	10.64	3.24	4.38	5.94	4.57	3.29	1.43	4.19	1.10	1.11	12.78	53.33
1995			0.21	0.39		11.35	1.32	5.74	5.43	1.61	2.66	2.36	4.27	0.88	9.37	45.59
1996			0.17	0.16	0.68	1.80	6.50	1.94	2.61	1.52	1.17	0.80	0.25	0.96	2.52	21.09
1997																
1998			0.04		5.71	1.70	1.10	0.97	1.74	1.24	1.04	2.46	1.33	1.20	1.52	20.12

Table 1A.9. Pollock biomass estimates from the Aleutian Islands Groundfish Survey, 1980-2002.

	Aleutian Islands Region			
	NRA West (174W-170E)	NRA East (170W-174W)	Unalaska-Umnak area (~165W-170W)	Combined
1980	243,695		56,732	300,427
1983	495,775		282,648	778,423
1986	439,461		102,379	541,840
1991	83,337	53,865	51,644	188,846
1994	47,623	29,879	39,696	117,199
1997	57,577	39,935	65,400	158,912
2000	76,613	28,985	22,462	128,060
2002	121,915	53,368	181,334	356,617

Table 1A.10. Estimated instantaneous natural mortality rates (M) by age from Wespestad and Terry (1984).

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
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	0.6

Table 1A.11. 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 (Ronholt et al 1994).

	L_{inf}	K	t_0	A	b
1980	54.01	0.374	-0.452	0.0187	2.853
1983	53.63	0.402	-0.070	0.0179	2.764
1986	53.41	0.340	-0.641	0.0134	2.845

Table 1A.12. Aleutian Islands Region pollock average weight-at-age based on observer data.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1978		0.33	0.39	0.76	0.69	0.81	0.92	0.91	0.97	0.93	1.06	1.17	1.19	1.61	1.07
1979		0.23	0.35	0.53	0.73	0.67	0.83	0.94	0.95	1.04	1.16	1.06	1.52	1.58	1.02
1980		0.24	0.55	0.77	0.84	0.86	0.91	1.00	1.09	1.06	1.02	1.16	1.10	0.85	1.52
1981			0.48	0.55	0.73	0.76	0.78	0.81	0.90	0.90	0.86	1.02	1.03	0.89	0.91
1982			0.42	0.54	0.64	0.78	0.82	0.84	0.89	0.98	1.00	0.96	0.95	0.91	0.97
1983					0.73	0.78	0.80	0.93	0.96	1.01	0.90			0.97	
1984		0.43	0.45		0.74	0.81	0.87	0.97	1.00	1.27	1.64	1.14	1.22		
1985		0.47	0.57	0.67	0.69	0.80	0.85	0.86	1.09	1.23	1.60	1.66		1.64	
1986			0.51	0.60	0.75	0.83	0.87	0.95	0.93	1.01	0.94	1.07	0.90		
1987				0.69	0.76	0.83	0.85	0.87	0.98	1.07	0.99	1.34	1.15	1.01	1.09
1988					0.80	0.79	0.82	0.93	0.89	0.98	0.89	0.78	0.72	0.90	1.06
1989															
1990			0.48	0.55	0.73	0.76	0.78	0.81	0.90	0.90	0.86	1.02	1.03	0.89	0.91
1991				0.67	0.66	0.80	0.96	1.08	1.17	1.10	1.22	1.16	1.10	1.29	1.09
1992				0.64	0.74	0.73	0.80	0.94	1.25	1.03	1.00	1.25	1.15	1.05	1.10
1993				0.89	0.82	1.03	1.03	1.14	1.08	1.16	1.19	1.20	1.33	1.14	1.14
1994				0.64	0.84	0.97	1.14	1.14	1.12	1.19	1.24	1.27	1.06	1.09	1.15
1995			0.55	0.85		1.13	1.33	1.40	1.36	1.43	1.42	1.50	1.45	1.66	1.32
1996			0.54	0.48	0.93	1.03	1.18	1.28	1.39	1.47	1.35	1.38	1.36	1.46	1.30
1997															
1998			0.40	0.76	0.74	0.98	1.06	1.09	1.25	1.31	1.48	1.28	1.30	1.36	1.45

Table 1A.13. Percentage mature females at age from Wespestad and Terry (1984).

Age	1	2	3	4	5	6	7	8	9	10	11	12	13-16
Percent	0.0	0.8	28.9	64.1	84.2	90.1	94.7	96.3	97.0	97.8	98.4	99.0	100.0

Table 1A.14. Description of models explored in Aleutian Islands assessment.

Model	**Fishery Selectivity Model**	**Age component of the selectivity constraint**	**Fishery selectivity change frequency (over time)**	**Time component fishery selectivity constraint**	**Est M?**	**M Prior**
A1, B1	Logistic	NA	None	NA	No	NA
A2, B2	Logistic	NA	None	NA	Yes	Informative
A6, B6	Coefficient	Low	None	NA	No	NA
A7, B7	Coefficient	Low	All Years	Low	No	NA
A8, B8	Coefficient	Medium	All Years	Medium	No	NA
A9, B9	Coefficient	High	All Years	High	No	NA
A10, B10	Coefficient	High	None	NA	Yes	Informative
A11	Coefficient	Low	All Years	Low	Yes	Informative
B11	Coefficient	High	Once (1991)	Low	Yes	Informative
B12	Coefficient	Medium	Once (1991)	Low	Yes	Informative

Table 1A.15. Estimates of key results for some of the Series A pollock models evaluated in this assessment. Coefficients of variation (CV) of values appearing directly above are given in parentheses. Catch projections are based on average selectivity curves.

Model	Model A1	Model A2	Model A6	Model A7	Model A8	Model A9	Model A10	Model A11
Fishing mortalities								
Max F 1978-2003	0.228	0.254	0.578	0.560	0.540	0.520	0.611	0.589
F 2003	0.001	0.001	0.002	0.001	0.002	0.002	0.001	0.001
F 2003/F40%	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002
F40%	2.75	0.97	1.66	1.63	1.56	1.26	0.66	0.70
CV	23%	32%	17%	67%	40%	23%	24%	62%
F35%	3.87	1.39	2.34	2.28	2.12	1.66	0.92	0.99
CV	32%	32%	18%	69%	42%	24%	25%	65%
Stock abundance								
Initial Biomass (1978)	638.43	362.58	631.29	620.81	620.81	629.07	370.80	367.15
CV	15%	14%	15%	15%	15%	15%	14%	14%
2003 total biomass	371.59	378.42	390.03	379.38	379.38	363.07	403.63	395.33
CV	14%	15%	14%	14%	14%	14%	14%	14%
2004 Age 3+ biomass	234.58	307.27	268.74	262.57	262.46	251.04	329.45	347.84
1999 year class (at age 1)	168.81	103.63	177.33	172.46	173.99	168.70	109.53	110.44
CV	27%	30%	31%	31%	31%	31%	35%	35%
Recruitment Variability	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Projected catch (unadjusted)								
F50% 2004 catch	100.00	67.39	104.24	103.45	101.32	88.87	78.91	79.53
CV	16%	22%	15%	26%	19%	17%	19%	33%
F40% 2004 catch	141.43	108.96	145.26	143.09	137.89	121.27	121.68	125.09
CV	15%	21%	15%	19%	17%	16%	18%	29%
F35% 2004 catch	160.61	136.33	166.65	162.06	155.89	137.86	147.96	152.03
CV	15%	20%	14%	17%	16%	15%	17%	25%
Model setup								
Survey catchability	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Natural mortality	0.30	0.20	0.30	0.30	0.30	0.30	0.21	0.21
Fishery Average Effective N	19	21	23	28	23	20	25	32
Survey Average Effective N	76	92	74	85	81	80	90	115
RMSE Survey	0.313	0.240	0.317	0.319	0.320	0.329	0.239	0.266
-log Likelihoods								
Number of Parameters	76	77	86	386	386	386	87	387
Survey index	6.64	3.16	7.93	7.65	7.78	7.75	3.82	3.83
Catch biomass	16.57	14.46	17.07	14.53	16.19	17.06	14.66	13.54
Fishery age comp	59.52	51.20	45.55	37.72	46.15	56.82	39.41	32.27
Survey age comp	32.98	35.01	33.87	32.58	32.87	32.70	35.31	33.49
Sub total	115.71	103.84	104.42	92.48	102.99	114.34	93.21	83.13
-log Penalties								
Recruitment	-21.76	-23.03	-22.28	-22.90	-22.47	-21.80	-22.85	-23.53
Selectivity constraint	0.00	0.00	4.85	11.80	11.97	19.18	4.51	9.73
Fishing mortality penalty	10.81	8.59	11.25	8.33	10.22	11.30	8.74	7.54
Prior	0.00	0.46	0.00	0.00	0.00	0.00	0.43	0.39
Total	104.78	89.90	98.25	89.71	102.72	123.04	84.08	77.29

Table 1A.16. Estimates of key results for some of the Series B pollock models evaluated in this assessment. Coefficients of variation (CV) of values appearing directly above are given in parentheses. Catch projections are based on average selectivity curves

Model	ModelB1	ModelB2	ModelB6	ModelB7	ModelB8	ModelB9	ModelB10	ModelB11	ModelB12
Fishing mortalities									
Max F 1978-2003	0.189	0.207	0.410	0.573	0.510	0.391	0.416	0.535	0.580
F 2003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
F 2003/F40%	0.001	0.001	0.001	0.0003	0.0004	0.0009	0.0013	0.0007	0.0007
F40%	1.47	0.96	1.00	3.10	2.26	1.28	0.86	1.19	1.19
CV	(10%)	(15%)	(7%)	(64%)	(38%)	(13%)	(13%)	(14%)	(15%)
F35%	1.99	1.30	1.34	4.32	3.10	1.70	1.15	1.63	1.65
CV	(10%)	(16%)	(7%)	(64%)	(39%)	(13%)	(13%)	(15%)	(15%)
Stock abundance									
Initial Biomass (1978)	1271.90	951.71	1202.60	1801.90	1721.90	1385.50	1071.00	1154.10	1128.70
CV	(8%)	(11%)	(8%)	(10%)	(10%)	(8%)	(11%)	(11%)	(12%)
2003 total biomass	440.86	455.94	469.31	652.77	617.46	498.18	475.02	637.72	663.59
CV	(12%)	(12%)	(12%)	(11%)	(11%)	(12%)	(12%)	(11%)	(11%)
2004 Age 3+ biomass	324.25	340.18	345.80	480.11	453.73	366.20	352.04	474.92	494.70
1999 year class (at age 1)	193.91	165.08	203.67	281.78	267.30	218.70	190.78	220.83	226.42
CV	(26%)	(28%)	(26%)	(26%)	(26%)	(26%)	(27%)	(27%)	(27%)
Recruitment Variability	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Projected catch (unadjusted)									
F50% 2004 catch	95.88	84.13	105.94	206.20	183.08	123.94	102.03	156.86	158.07
CV	(13%)	(14%)	(12%)	(16%)	(14%)	(13%)	(12%)	(12%)	(12%)
F40% 2004 catch	141.18	128.04	151.08	262.61	237.92	169.59	147.50	222.41	226.30
CV	(13%)	(14%)	(12%)	(14%)	(13%)	(12%)	(12%)	(11%)	(11%)
F35% 2004 catch	166.80	155.79	176.95	289.85	264.53	193.06	174.19	257.47	265.42
CV	(12%)	(5%)	(12%)	(13%)	(12%)	(12%)	(12%)	(11%)	(11%)
Model setup									
Survey catchability	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Natural mortality	0.30	0.261	0.30	0.30	0.30	0.30	0.285	0.256	0.254
Fishery Average Effective N	39	38	36	80	55	39	36	41	44
Survey Average Effective N	83	81	96	125	111	100	98	108	114
RMSE Survey	0.420	0.355	0.401	0.387	0.375	0.386	0.374	0.313	0.320
-log Likelihoods									
Number of Parameters	76	77	86	386	386	386	87	99	99
Survey index	12.93	8.45	13.53	16.04	14.95	13.44	11.40	9.66	10.03
Catch biomass	0.97	0.81	1.39	1.52	1.37	1.25	1.31	1.48	1.61
Fishery age comp	353.07	346.87	313.81	140.79	200.40	309.61	313.97	235.02	194.82
Survey age comp	103.36	114.05	93.96	78.96	81.82	89.07	97.26	97.13	97.10
Sub total	470.34	470.17	422.69	237.31	298.53	413.36	423.94	343.29	303.56
-log Penalties									
Recruitment	0.09	-5.35	0.75	-10.67	-9.29	-3.66	-1.25	-15.06	-16.52
Selectivity constraint	0.00	0.00	7.37	57.06	60.01	51.11	7.22	45.52	30.57
Fishing mortality penalty	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Prior	0.00	0.07	0.00	0.00	0.00	0.00	0.01	0.09	0.10
Total	470.57	464.98	430.93	283.83	349.38	460.93	430.03	373.91	317.77

Table 1A.17. Estimates of Aleutian Islands pollock fishery, survey and fishery selectivity-at-age used for projections from Model A10. Survey selectivity values are full selection (maximum value = 1.0) estimates.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
Fishery	0.002	0.006	0.022	0.072	0.211	0.437	0.654	0.840	1.009	1.248	1.644	2.213	2.213	2.213	2.213
Projected	0.002	0.016	0.110	0.438	0.949	1.470	1.639	1.621	1.470	1.290	1.198	1.198	1.198	1.198	1.198
Survey	0.018	0.027	0.040	0.057	0.083	0.119	0.168	0.231	0.310	0.401	0.500	0.599	0.690	0.769	0.769

Table 1A.18. Model A10 estimates of Aleutian Islands pollock biomass with approximate lower and upper 95% confidence bounds for age 1+ biomass. Also included is the age 3+ biomass.

Year	Age 1+ Biomass	Lower CI	Upper CI	Age 3+ Biomass
1978	370,800	271,528	470,072	273,130
1979	356,500	263,532	449,468	244,822
1980	343,880	254,570	433,190	275,283
1981	303,390	217,592	389,188	208,870
1982	270,470	185,864	355,076	179,839
1983	244,220	162,266	326,174	170,253
1984	229,460	148,938	309,982	169,766
1985	231,290	154,128	308,452	186,995
1986	241,850	168,064	315,636	176,668
1987	252,190	182,082	322,298	188,978
1988	268,860	199,420	338,300	184,002
1989	296,560	225,500	367,620	219,917
1990	331,780	257,468	406,092	228,506
1991	357,480	278,500	436,460	267,152
1992	388,890	308,828	468,952	307,343
1993	405,840	324,952	486,728	375,196
1994	409,220	327,538	490,902	346,839
1995	429,540	343,702	515,378	412,537
1996	395,030	305,134	484,926	365,094
1997	395,670	301,178	490,162	343,760
1998	385,310	288,164	482,456	326,666
1999	376,120	276,124	476,116	321,441
2000	388,410	286,178	490,642	329,175
2001	396,850	292,012	501,688	333,264
2002	400,460	293,656	507,264	344,196
2003	403,630	294,790	512,470	345,728
2004				329,449

Table 1A.19. Estimated Aleutian Islands pollock numbers at age in millions. 1978-2003 based on Model A10.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	% of 15+
1978	83	55	49	45	39	33	28	23	19	16	13	10	8	7	36	466	8%
1979	122	67	45	40	36	32	27	23	19	15	13	10	8	7	33	498	7%
1980	59	99	55	37	33	29	25	22	18	15	12	10	8	6	31	458	7%
1981	76	48	81	44	29	26	22	19	16	13	10	8	6	5	22	423	5%
1982	54	62	39	65	35	23	19	16	13	11	8	6	4	3	15	375	4%
1983	103	44	50	31	52	28	17	14	11	9	7	5	3	2	10	387	3%
1984	61	84	36	40	25	41	21	12	10	8	6	4	3	2	6	359	2%
1985	82	50	68	29	33	20	32	16	10	7	6	4	3	2	6	368	2%
1986	80	67	40	55	24	27	16	26	13	8	6	5	3	2	6	378	2%
1987	132	65	54	33	45	19	22	13	21	11	6	5	4	3	7	439	2%
1988	176	108	53	44	27	36	15	17	11	17	8	5	4	3	7	530	1%
1989	132	143	87	43	36	22	29	13	14	9	14	7	4	3	8	562	1%
1990	229	107	116	71	35	29	18	24	10	11	7	11	5	3	9	686	1%
1991	88	186	87	94	57	28	23	13	18	8	8	5	7	4	8	635	1%
1992	112	72	151	71	76	47	23	18	11	15	6	7	4	6	10	627	2%
1993	136	91	58	123	57	61	37	18	14	8	11	5	5	3	11	638	2%
1994	211	111	74	47	99	46	48	28	13	11	6	8	3	3	9	716	1%
1995	104	172	90	60	38	80	36	38	22	10	8	5	6	2	9	681	1%
1996	123	85	139	73	48	29	58	25	25	14	6	4	2	3	5	637	1%
1997	113	100	69	113	59	38	23	43	18	18	9	4	3	1	5	614	1%
1998	107	92	81	56	91	46	29	17	31	13	12	6	2	2	3	587	1%
1999	110	87	75	66	45	72	35	21	12	22	9	8	4	1	3	568	1%
2000	119	89	71	61	54	36	58	29	17	10	18	7	6	3	4	580	1%
2001	94	97	72	58	49	43	29	47	23	14	8	14	6	5	5	565	1%
2002	101	77	79	59	47	40	35	24	38	19	11	6	12	5	8	560	1%
2003	114	82	62	64	48	38	32	29	19	31	15	9	5	9	10	569	2%

Table 1A.20. Estimates of age-1 Aleutian Islands pollock recruitment (in millions) based on Model A10.

Year	Age 1 Recruits
1978	82.7
1979	122.3
1980	58.8
1981	75.8
1982	54.5
1983	103.0
1984	61.3
1985	82.1
1986	80.2
1987	132.3
1988	175.7
1989	131.8
1990	229.0
1991	88.3
1992	111.8
1993	136.4
1994	211.1
1995	104.1
1996	123.4
1997	113.0
1998	107.2
1999	109.5
2000	119.3
2001	94.3
2002	101.3
2003	113.5
Ave 83-03	112.4
Med 83-03	108.4

Table 1A.21. Estimates of full-selection fishing mortality and exploitation rates for pollock based on Model A10.

Year	*F*[a]	Catch/Biomass Rate[b]
1978	0.035	0.014
1979	0.061	0.026
1980	0.312	0.113
1981	0.383	0.110
1982	0.409	0.111
1983	0.414	0.101
1984	0.139	0.037
1985	0.017	0.005
1986	0.015	0.004
1987	0.052	0.014
1988	0.012	0.003
1989	0.000	0.000
1990	0.197	0.046
1991	0.009	0.002
1992	0.130	0.028
1993	0.210	0.043
1994	0.072	0.017
1995	0.611	0.141
1996	0.282	0.063
1997	0.330	0.075
1998	0.306	0.071
1999	0.007	0.002
2000	0.010	0.003
2001	0.006	0.002
2002	0.003	0.001
2003	0.003	0.001

[a] Full selection fishing mortality rates.
[b] Catch/biomass rate is the ratio of catch to beginning year age 3+ biomass.

Table 1A.22. Commercial catch from NRA area in thousands of tons with fraction of catch from the 1978 year class.

Year	Catch	1978 Year Class
1980	55.561	6%
1981	43.554	16%
1982	41.384	70%
1983	31.282	61%
1984	31.811	56%
1985	9.675	44%
1986	17.436	35%
1987	26.22	43%
1988	36.864	40%
1990	79.025	8%
1991	97.775	24%
1992	20.457	23%
1993	33.839	33%
1994	31.769	24%
1995	61.407	21%
1996	28.162	12%
1998	23.755	8%

Table 1A.23. Projections of Model A10 (with adjusted selectivity) spawning biomass (in thousands of mt), *F*, and catch (in thousands of mt) for NRA pollock west 174°W of for the 7 scenarios. The values for $B_{100\%}$, $B_{40\%}$,and $B_{35\%}$ are 171.6, 68.6, and 60.0 thousands of mt respectively. Fishing mortality rates given are based on the *average* fishing mortality over all ages.

Sp.Biomass	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
2003	160.0	160.0	160.0	160.0	160.0	160.0	152.9
2004	153.6	156.2	157.1	160.6	160.7	151.8	121.2
2005	121.5	135.0	139.8	160.8	161.3	113.0	100.3
2006	100.8	119.6	126.7	160.7	161.7	90.0	86.4
2007	88.7	109.6	118.1	161.6	162.8	77.4	75.5
2008	81.5	103.1	112.3	162.9	164.4	70.6	69.5
2009	77.1	98.7	108.3	164.1	165.8	67.1	66.6
2010	74.4	95.6	105.3	165.1	167.1	65.4	65.1
2011	72.6	93.3	103.1	165.9	168.0	64.4	64.3
2012	71.6	91.6	101.4	166.4	168.7	63.9	63.9
2013	71.0	90.5	100.2	166.9	169.4	63.7	63.7
2014	70.7	89.8	99.5	167.5	170.1	63.7	63.7
2015	70.6	89.4	98.9	168.0	170.6	63.8	63.8
2016	70.5	89.0	98.5	168.3	170.9	63.7	63.7
F	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
2003	0.001	0.001	0.001	0.001	0.001	0.001	0.218
2004	0.218	0.136	0.109	0.003	0.000	0.276	0.218
2005	0.218	0.136	0.109	0.003	0.000	0.276	0.218
2006	0.218	0.136	0.109	0.003	0.000	0.276	0.276
2007	0.218	0.136	0.109	0.003	0.000	0.276	0.276
2008	0.218	0.136	0.109	0.003	0.000	0.268	0.266
2009	0.216	0.136	0.109	0.003	0.000	0.259	0.257
2010	0.214	0.136	0.109	0.003	0.000	0.254	0.253
2011	0.212	0.136	0.109	0.003	0.000	0.252	0.251
2012	0.211	0.136	0.109	0.003	0.000	0.251	0.250
2013	0.211	0.136	0.109	0.003	0.000	0.250	0.250
2014	0.210	0.136	0.109	0.003	0.000	0.250	0.250
2015	0.210	0.136	0.109	0.003	0.000	0.250	0.250
2016	0.210	0.136	0.109	0.003	0.000	0.250	0.250
Catch	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
2003	0.3	0.3	0.3	0.3	0.3	0.3	67.1
2004	67.4	44.2	36.0	0.9	0.0	82.4	52.3
2005	52.0	37.5	31.5	0.9	0.0	59.5	42.3
2006	42.2	32.7	28.2	0.9	0.0	46.2	44.4
2007	36.6	29.7	26.1	0.9	0.0	39.0	38.2
2008	33.7	28.0	24.9	0.9	0.0	34.7	34.1
2009	31.8	26.9	24.0	0.9	0.0	32.2	31.9
2010	30.5	26.2	23.5	0.9	0.0	31.1	30.9
2011	29.7	25.6	23.1	0.9	0.0	30.5	30.4
2012	29.2	25.2	22.7	0.9	0.0	30.2	30.1
2013	28.8	24.9	22.5	0.9	0.0	30.0	30.0
2014	28.7	24.7	22.3	0.9	0.0	29.9	29.9
2015	28.6	24.6	22.2	0.9	0.0	30.0	30.0
2016	28.6	24.5	22.1	0.9	0.0	30.0	30.0

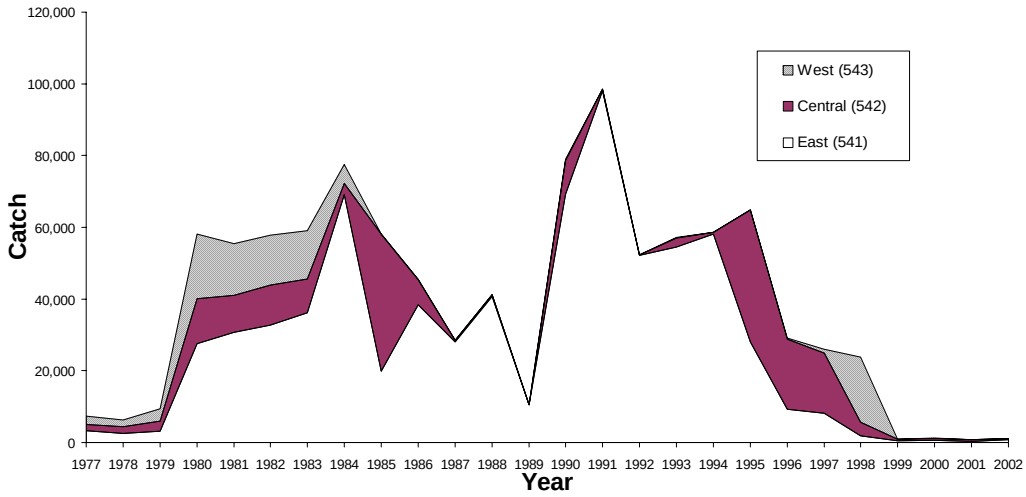


Figure 1A.1. Estimated pollock catch by sub-area of the Aleutian Islands Region, 1977-2002. Units in metric tons.

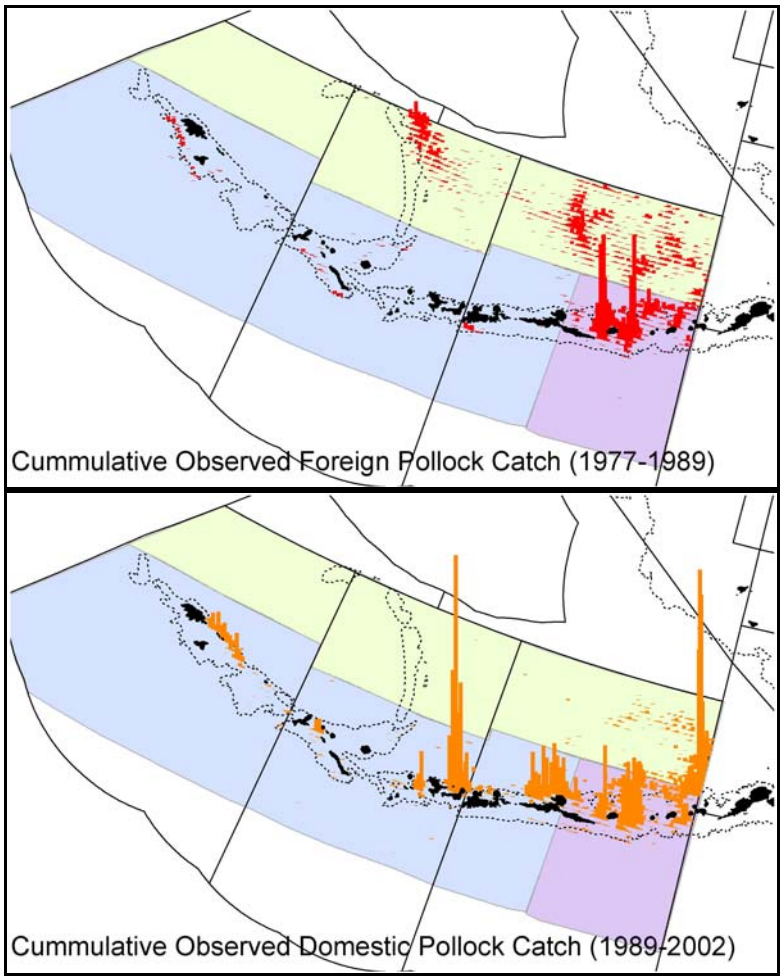


Figure 1A.2. Observed foreign and J.V. (1978-1989), and domestic (1989-2002) pollock catch in the Aleutian Islands Area summed over all years and 10 minute latitude and longitude blocks. Both maps use the same scale (maximum observed catch per 10 minute block: foreign and J.V. 8,000 t and Domestic 19,000 t). Catches of less than 1 t were excluded from cumulative totals.

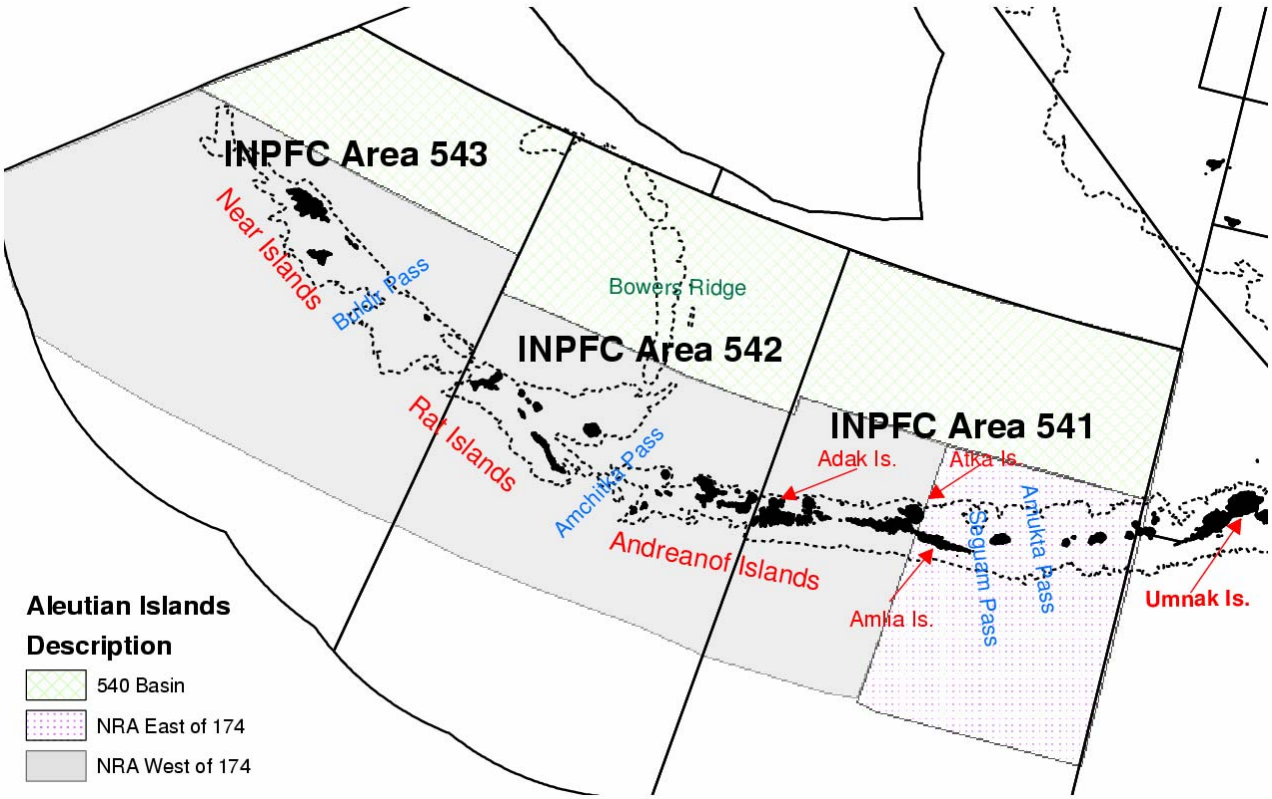


Figure 1A.3. Regions defined for consideration of alternative data partitions for Aleutian Islands Region pollock. The abbreviation "NRA" represents the Near, Rat, and Andreanof Island groups.

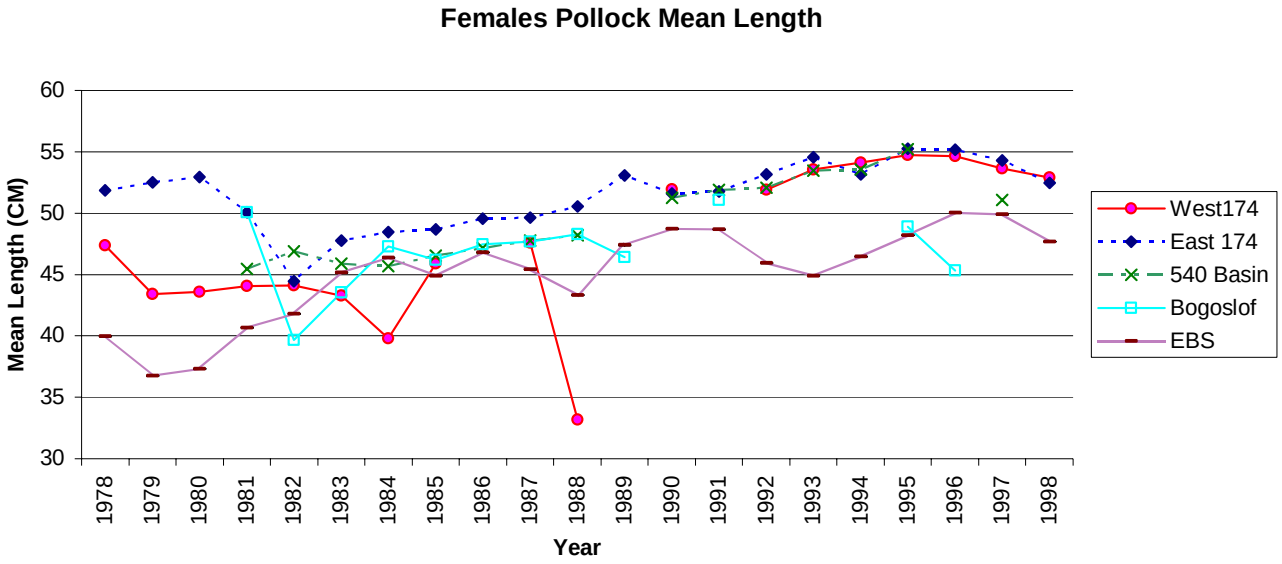


Figure 1A.4. Mean length of female pollock for various areas from observer data.

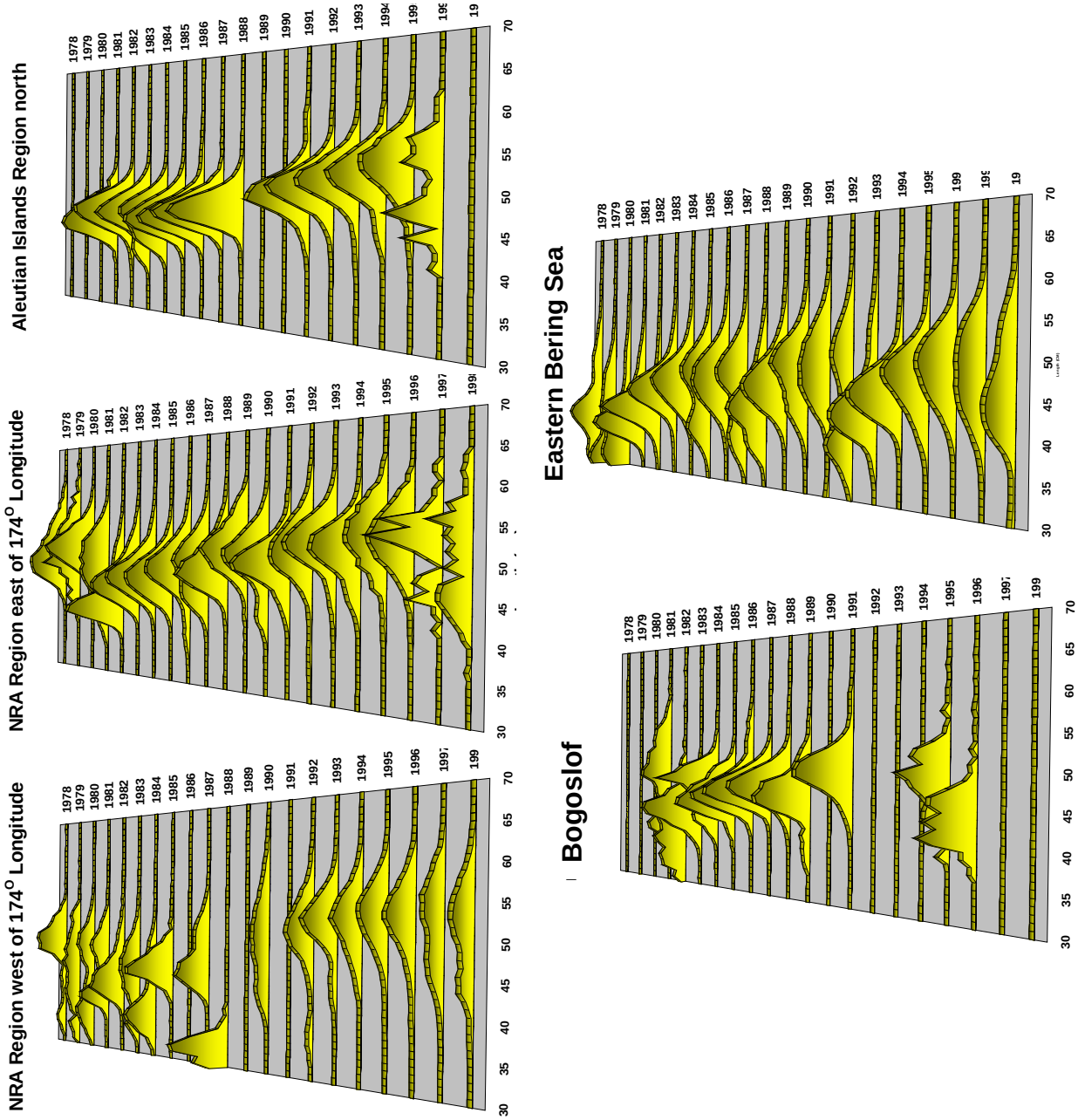


Figure 1A.5. Pollock length frequency distributions by region.

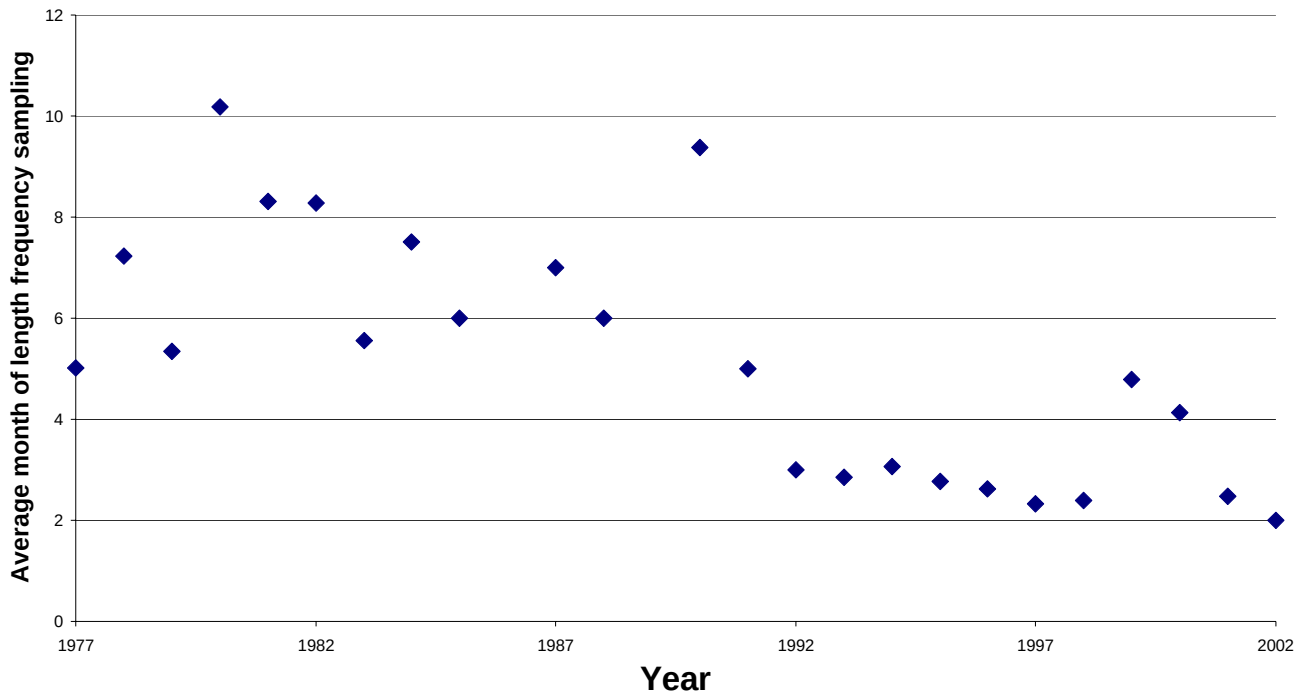


Figure 1A.6. Average month of length frequency sampling (where Jan=1, Feb=2, etc.) for pollock in the NRA region showing that sampling during the early period was from later in the year than during the more recent period.

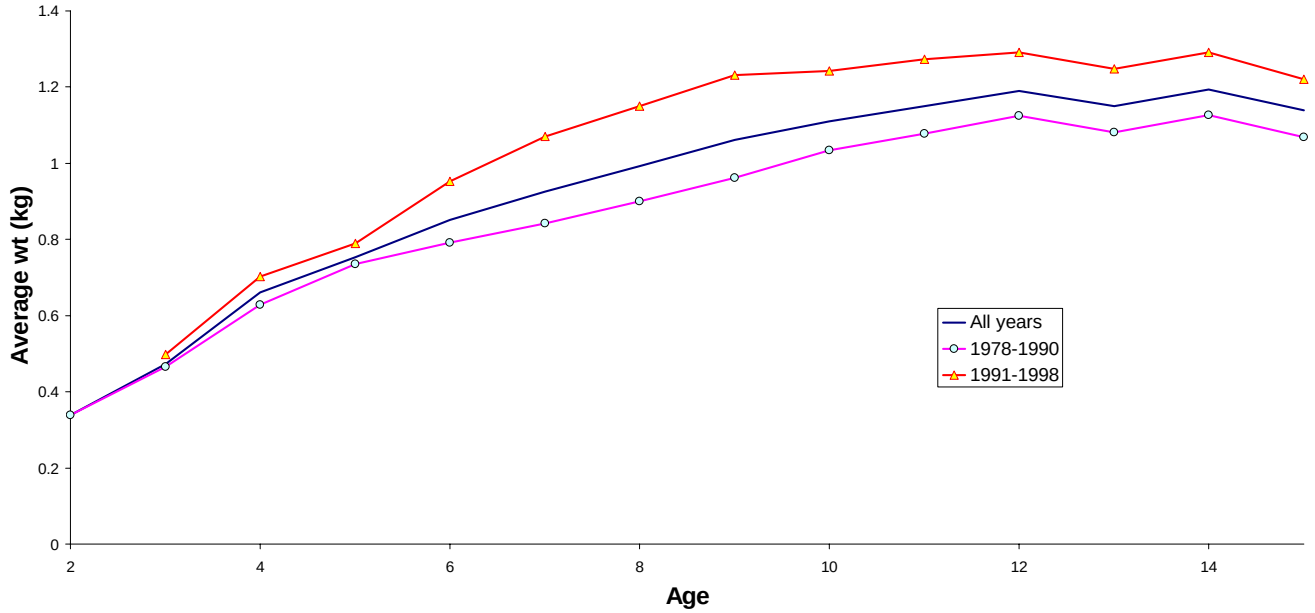


Figure 1A.7. Average weight-at-age for Aleutian Islands pollock for all years combined, 1978-1990, and 1991-1998.

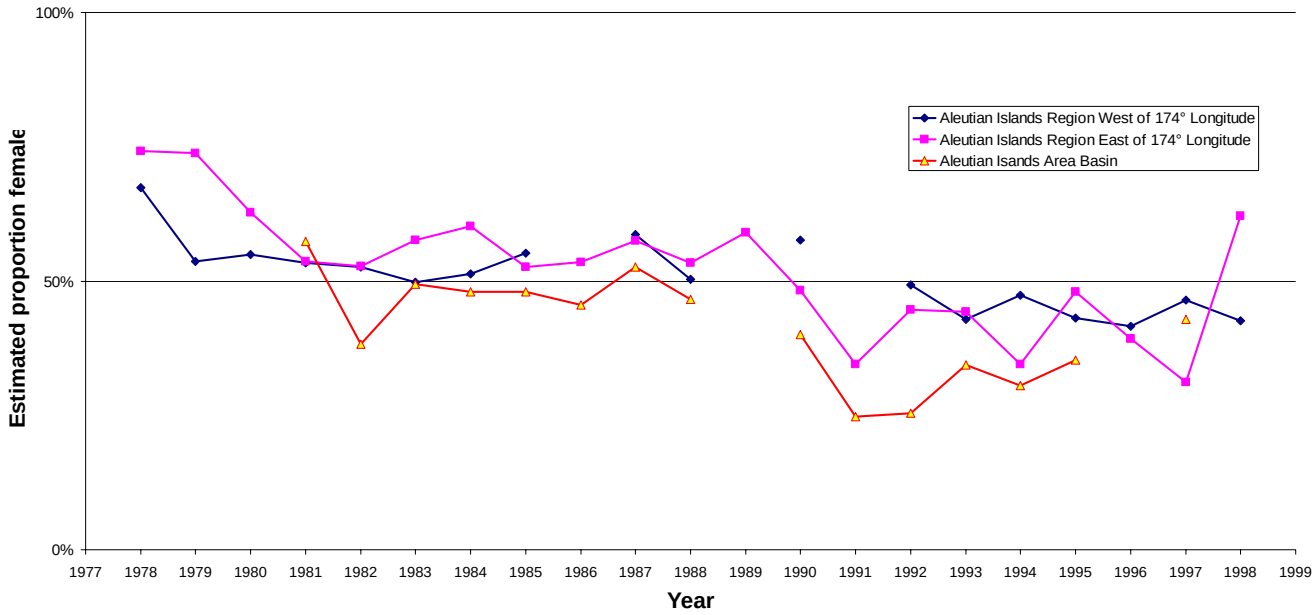


Figure 1A.8. Estimated proportion of female pollock by Aleutian Islands sub-regions, 1977 -1998 based on fishery data.

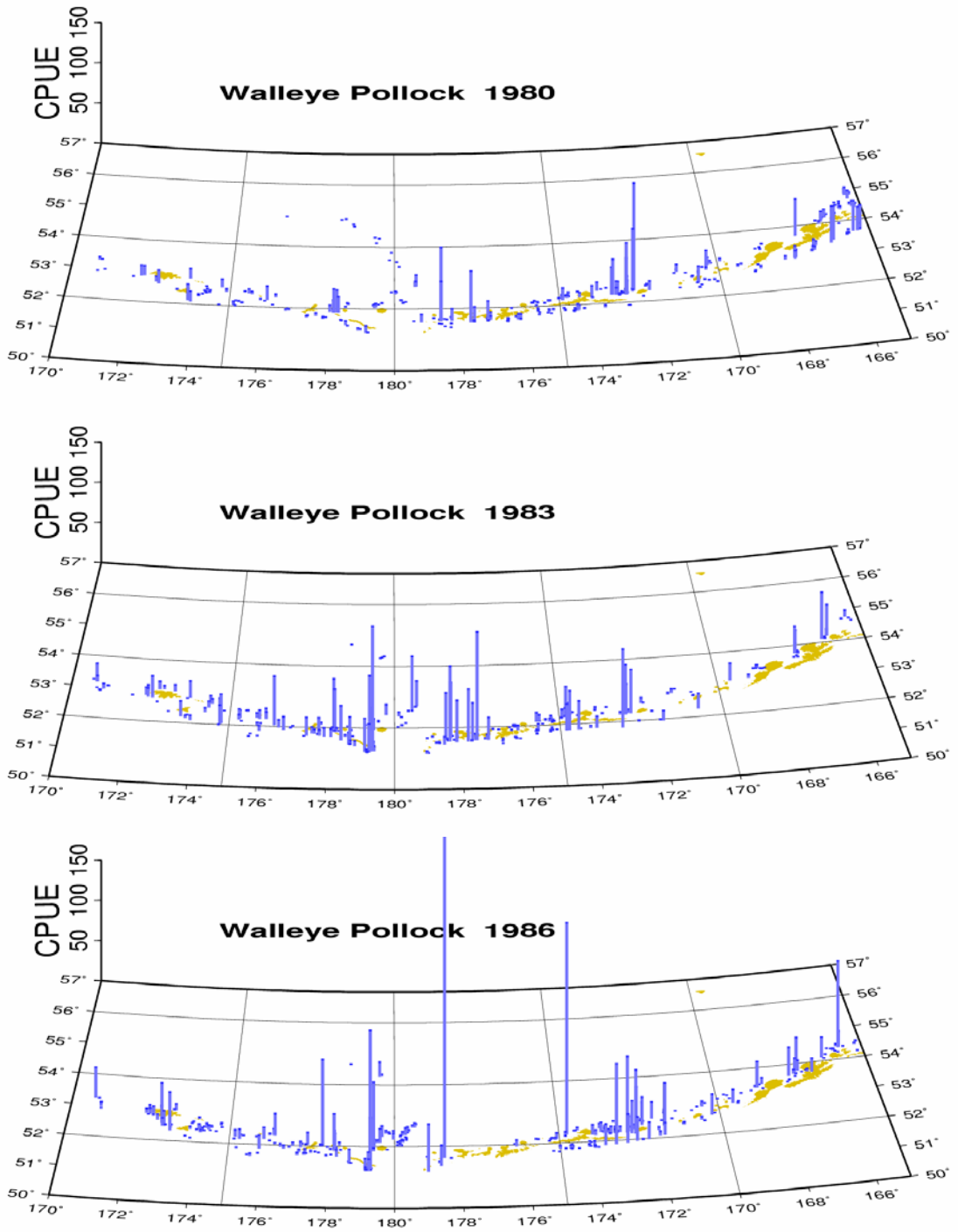


Figure 1A.9. Catch per tow (CPUE) for surveys of pollock in the Aleutian Islands Region and east of 170°W, 1980-2002.

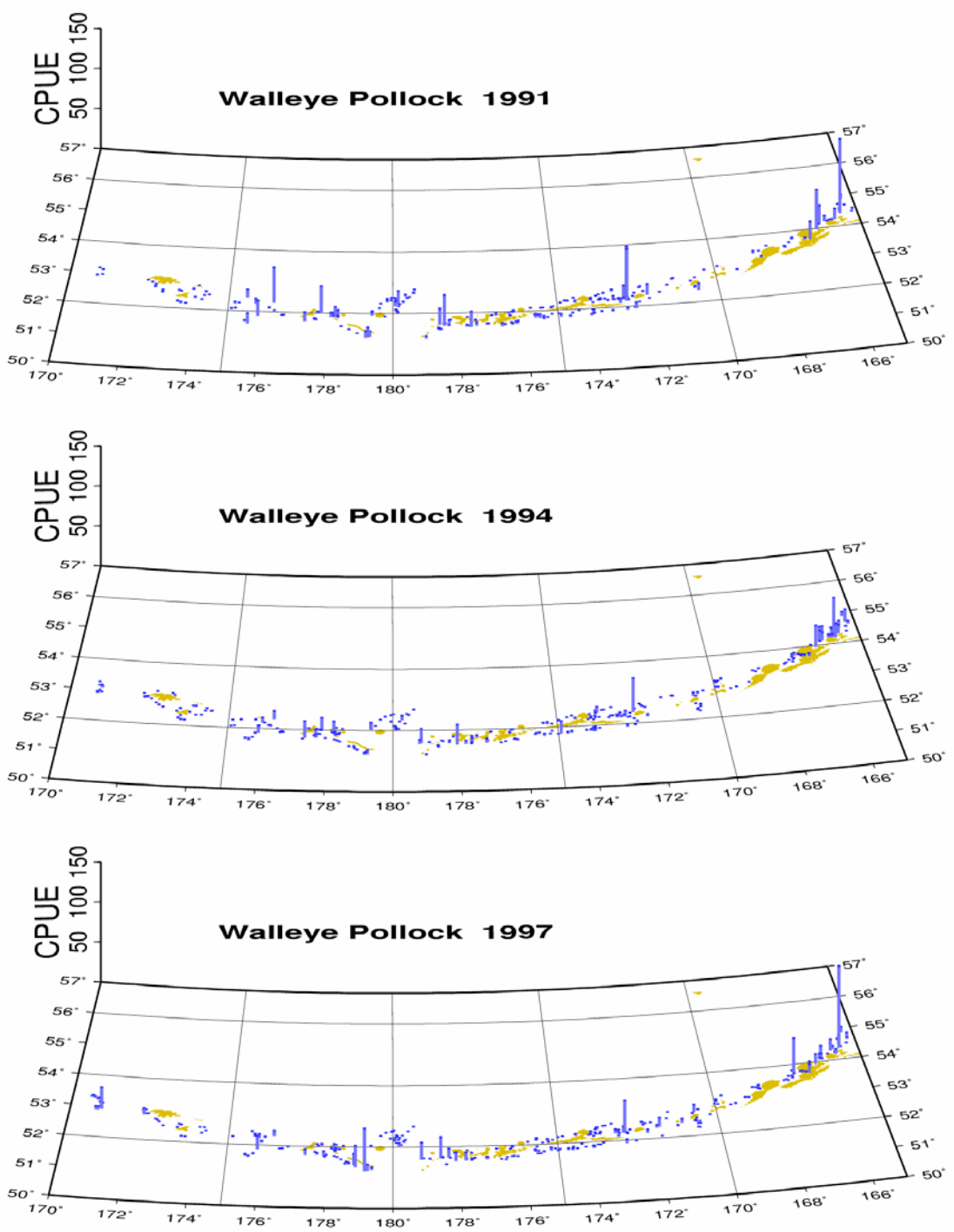
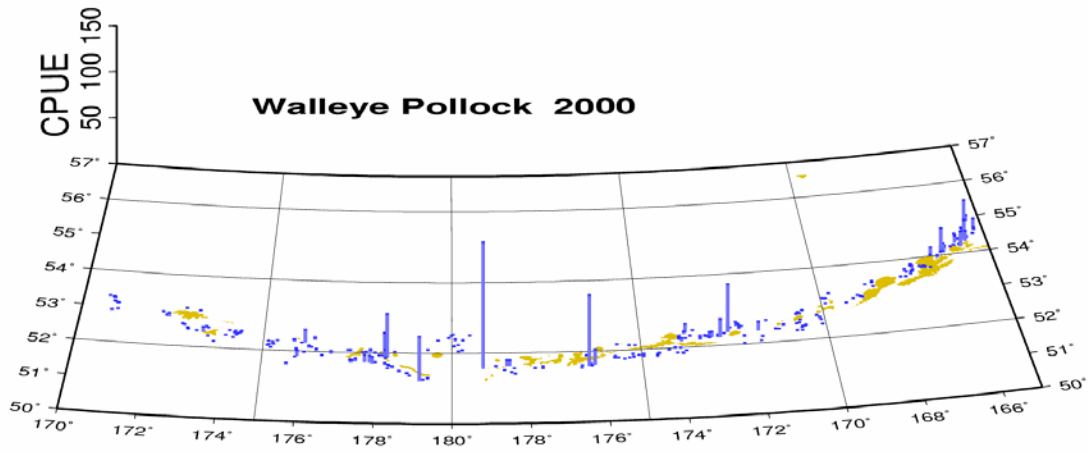


Figure 1A.9. (continued) Catch per tow (CPUE) for surveys of pollock in the Aleutian Islands Region and east of 170°W, 1980-2002.



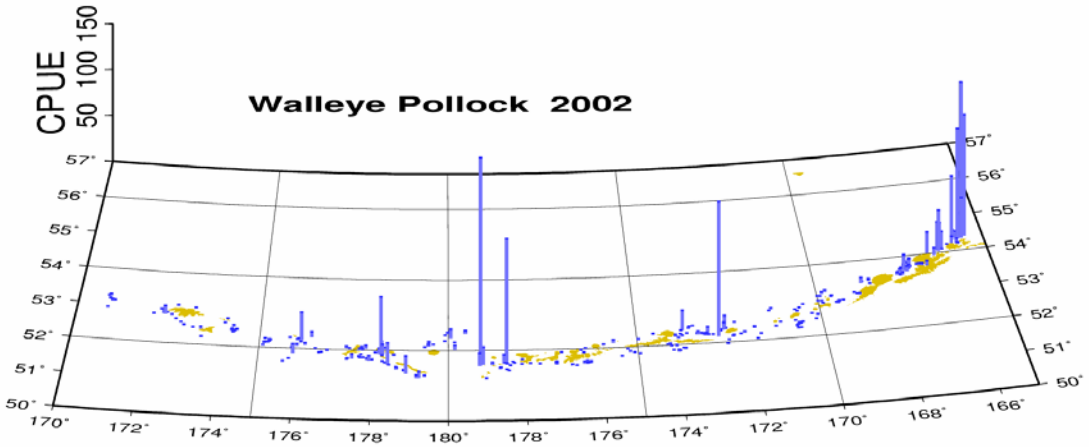


Figure 1A.9. (continued) Catch per tow (CPUE) for surveys of pollock in the Aleutian Islands Region and east of 170°W, 1980-2002.

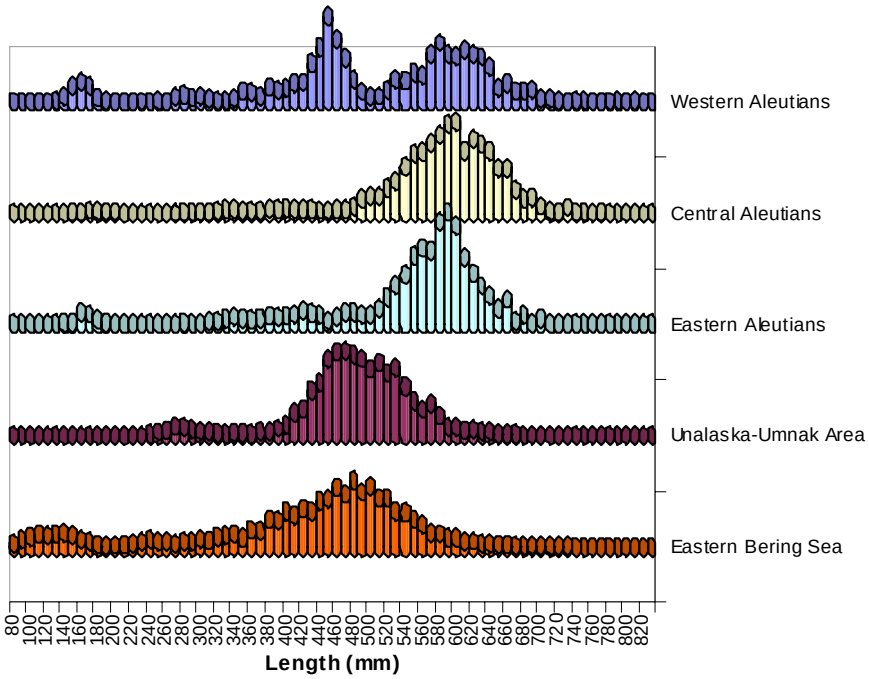


Figure 1A.10. Pollock size compositions by proportion of total at length category from the 2002 Aleutian Islands bottom trawl survey and 2002 eastern Bering Sea trawl survey.

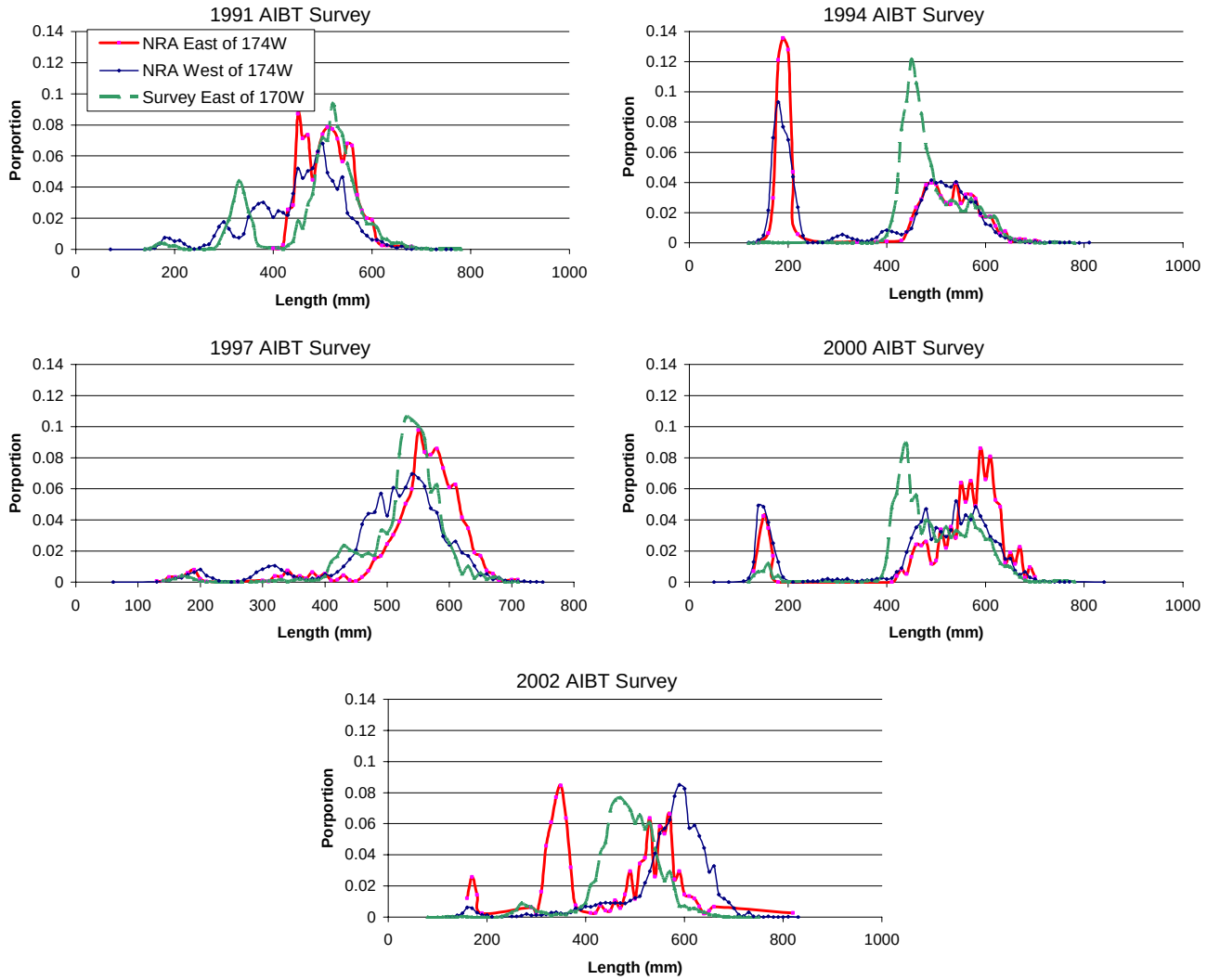


Figure 1A.11. Length-frequency from Aleutian Islands Bottom trawl surveys (AIBT) 1991-2002 showing measurements from the NRA East of 174W, NRA West of 174W, and from the AIBT surveys East of 170W.

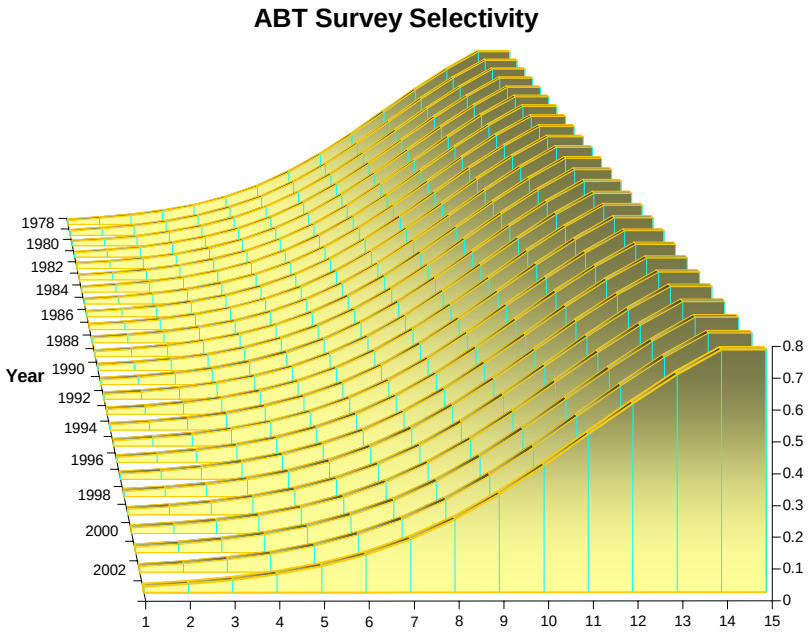


Figure 1A.12. Selectivity at age for Aleutian Islands bottom trawl surveys for all model runs.

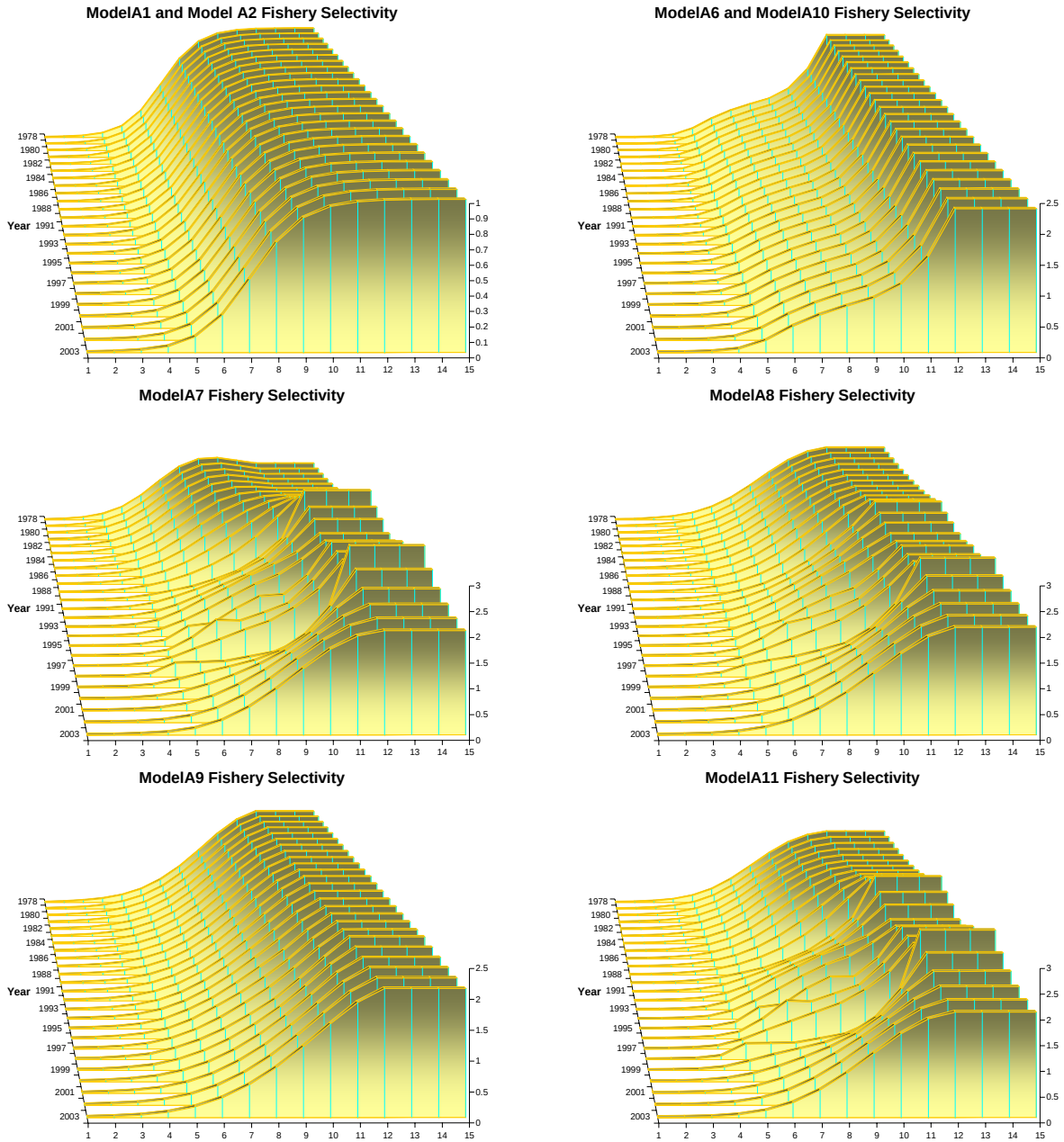


Figure 1A.13. Series A model estimates of NRA (Aleutian Islands) pollock selectivity-at-age 1978-2003.

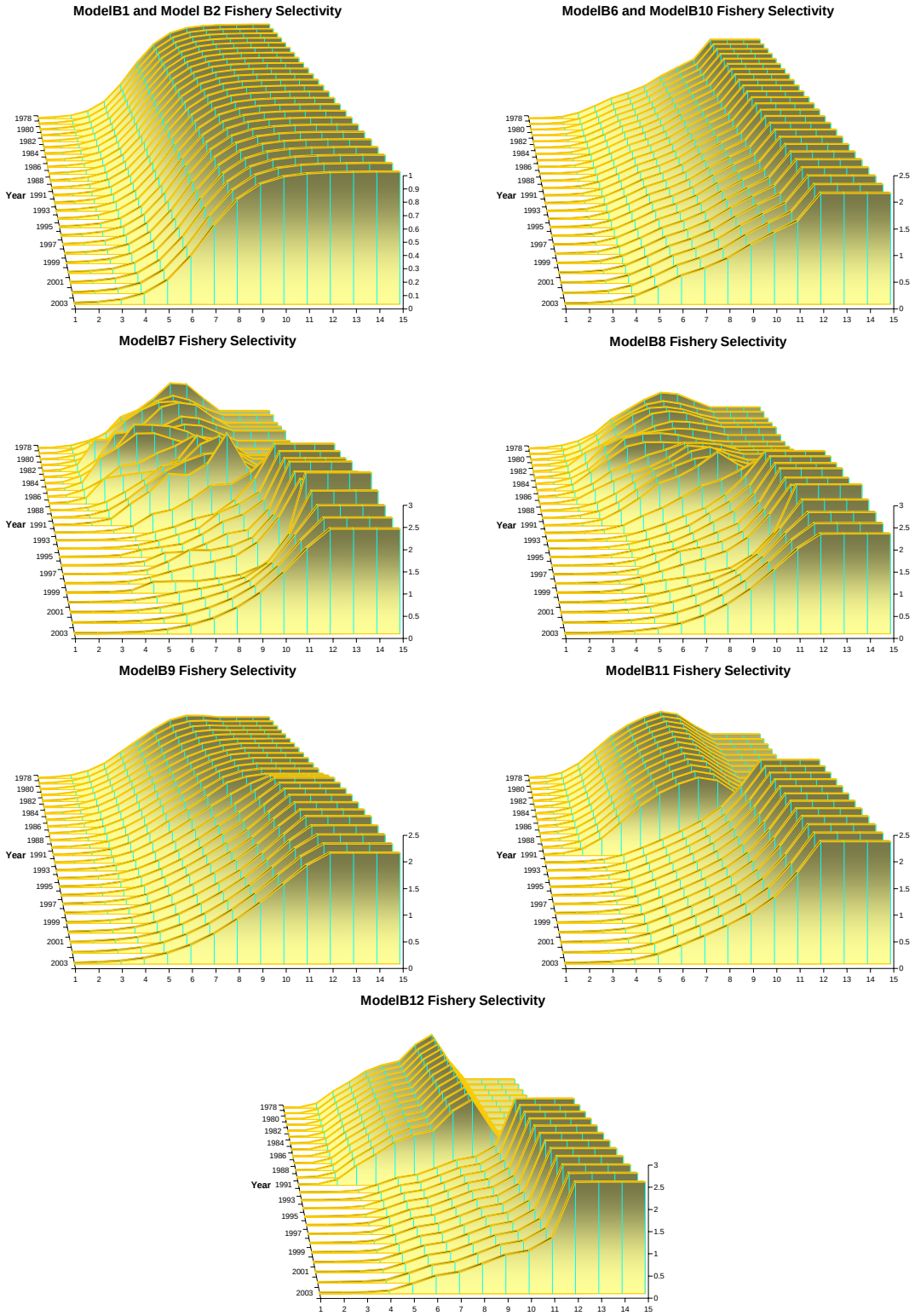


Figure 1A.14. Series B models estimates of NRA (Aleutian Islands) pollock selectivity-at-age 1978-2003.

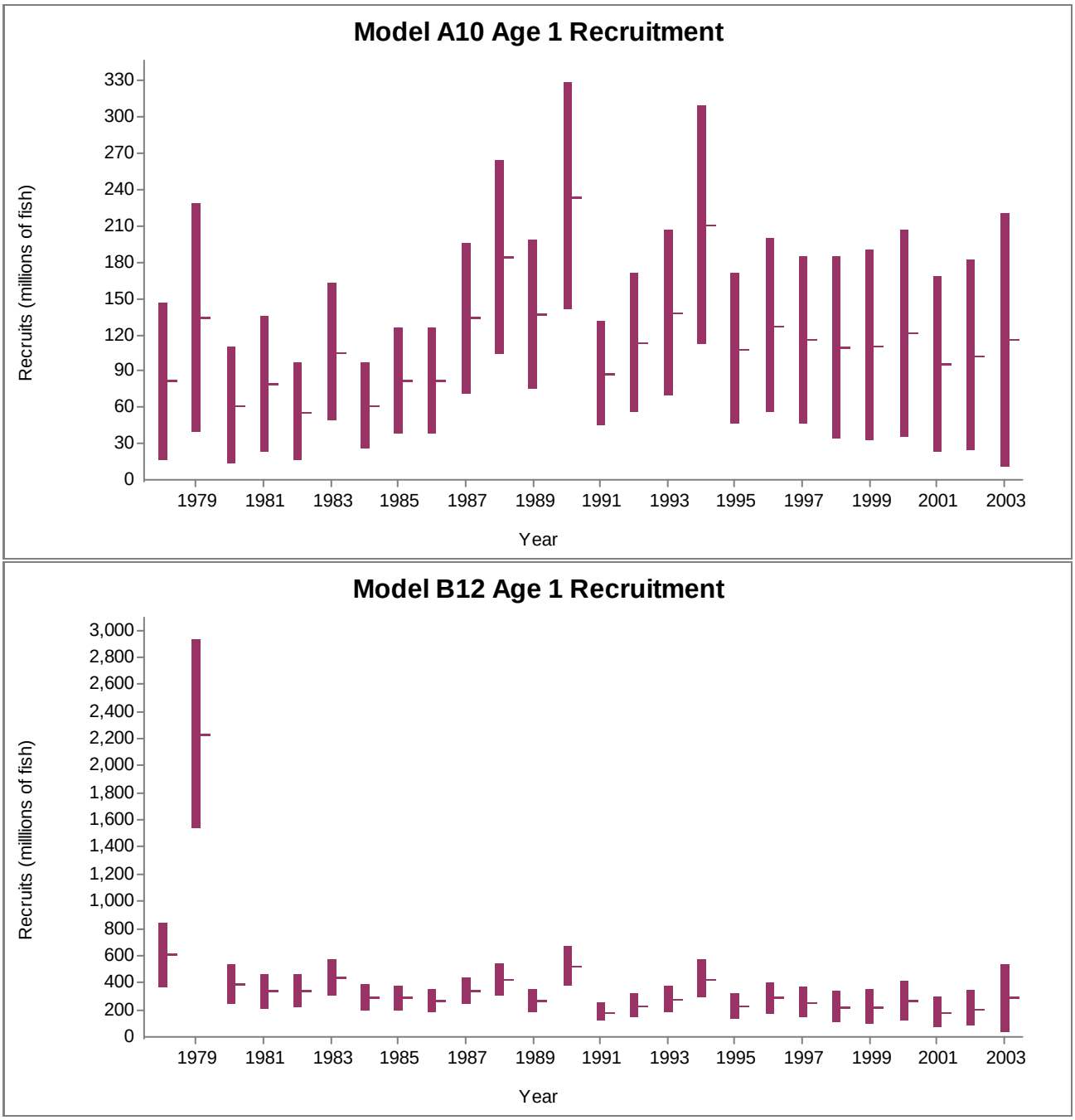


Figure 1A.15 Aleutian Islands pollock recruitment at age 1 for Model A10 and Model B12 with approximate 95% confidence intervals. Note that the Y-axis scales differ between the two models.

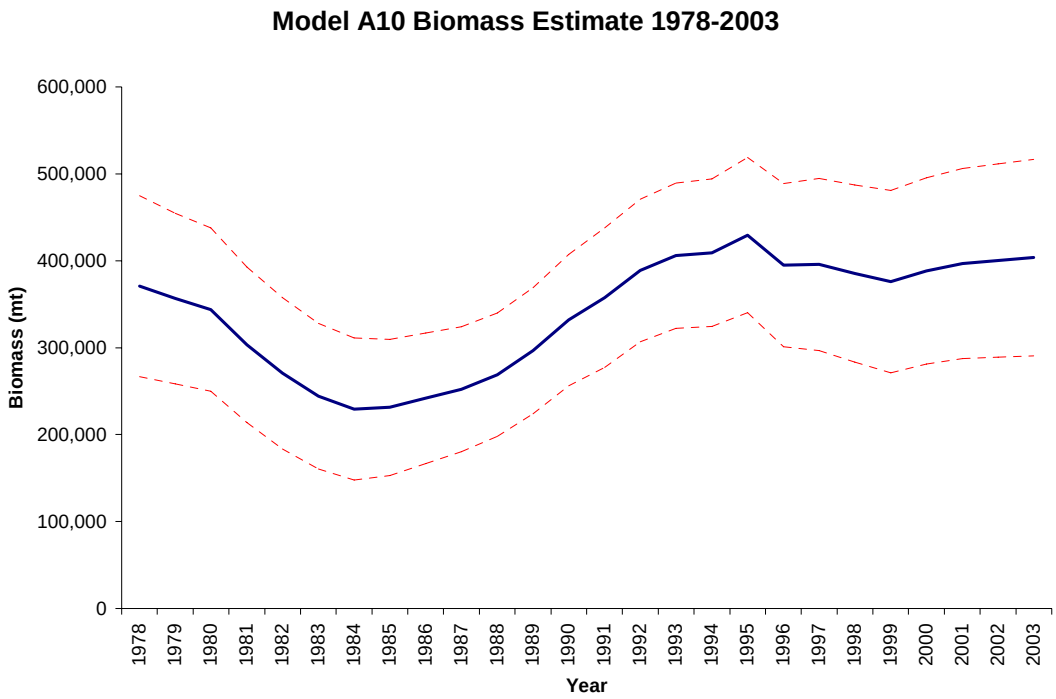


Figure 1A.16 Time series of pollock biomass in the NRA region west of 174°W from Model A10 with approximate 95% confidence intervals.

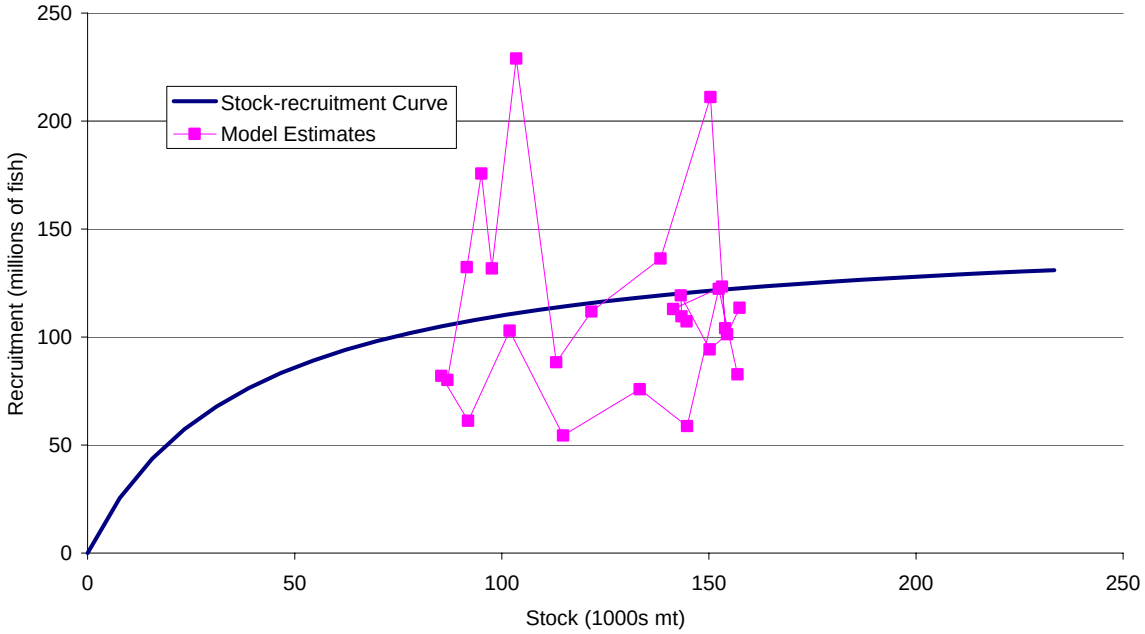


Figure 1A.17 Aleutian Islands pollock stock-recruitment curve and Age-1 recruitment of pollock in the NRA west of 174°W from Model A10 1978-2002.

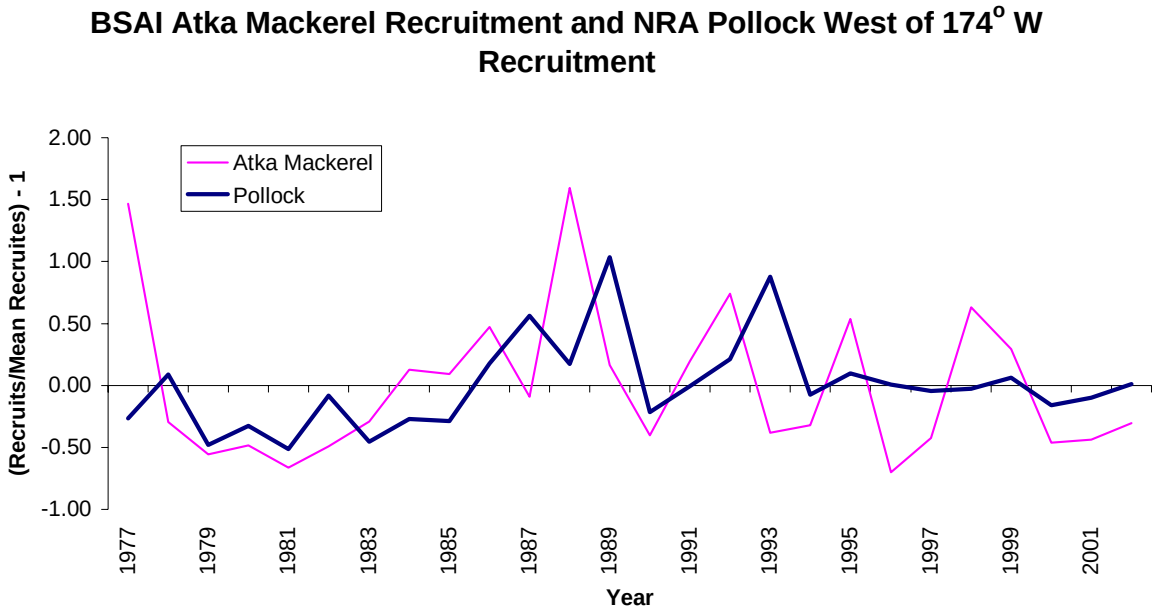


Figure 1A.18 The coincidence of recruitment of NRA pollock west of 174°W from Model A10 and Aleutian Islands Atka mackerel. Note that Atka mackerel spawn in August and pollock generally spawn in March.

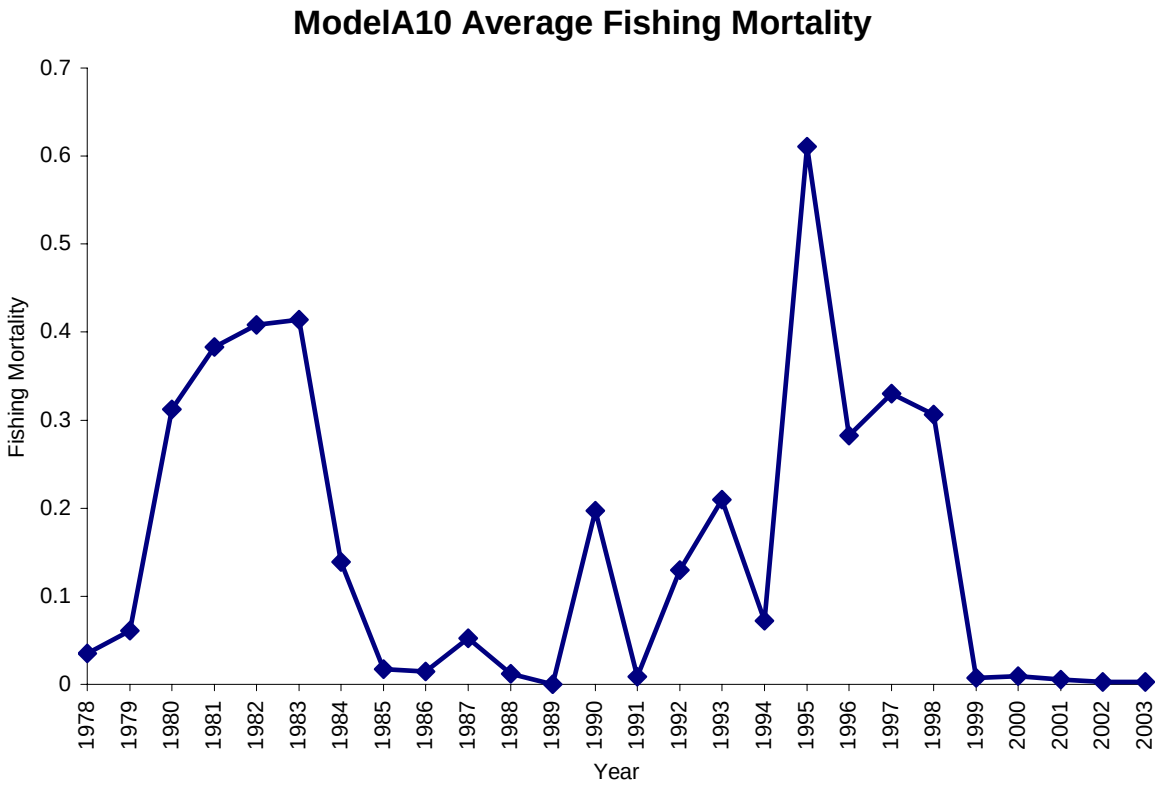


Figure 1A.19 Estimated time series of full-selection fishing mortality of pollock in the NRA west of 174°W based on Model A10.

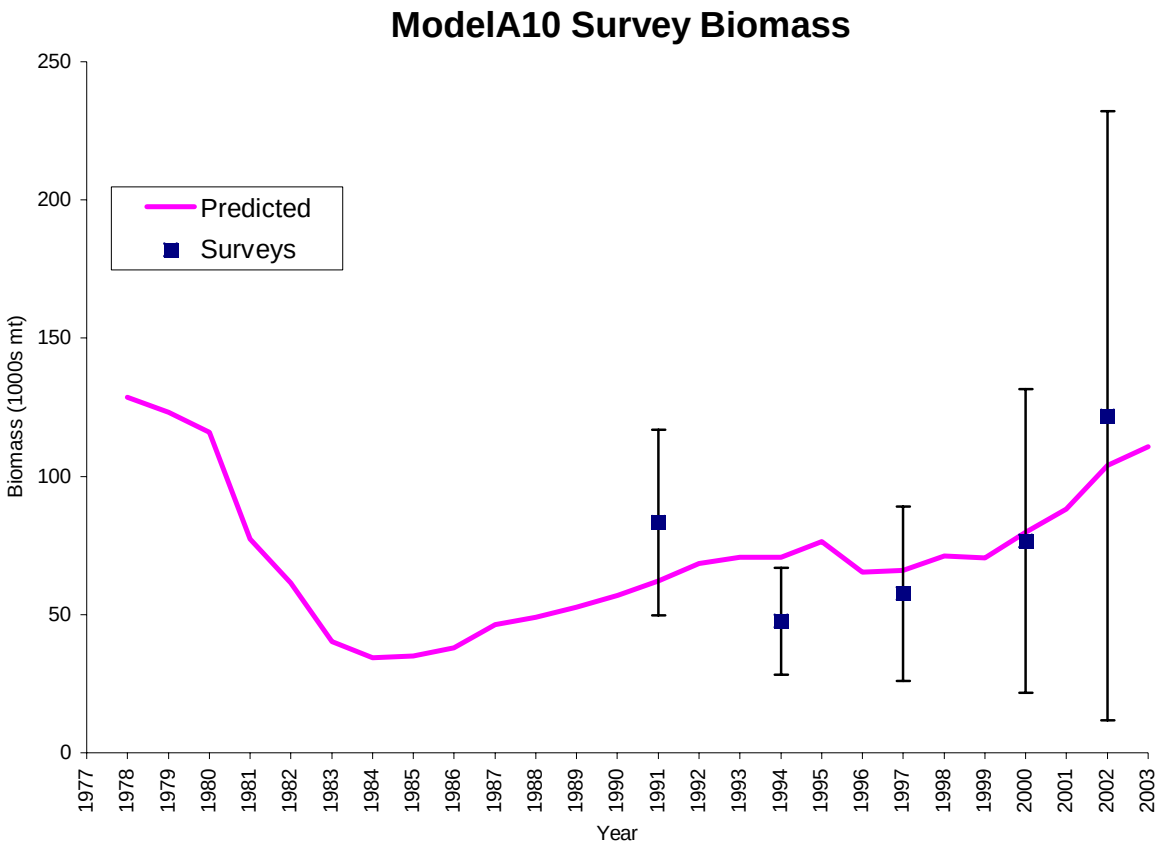


Figure 1A.20 Observed and predicted survey biomass for the NRA pollock west of 174°W based on Model A10. Error Bars approximate a 95% confidence interval.

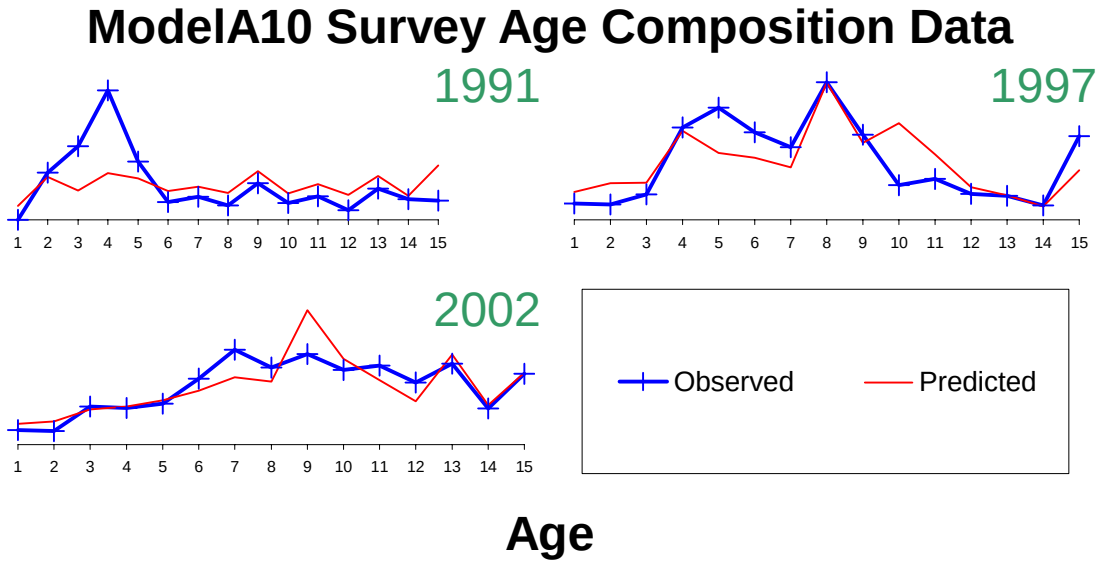


Figure 1A.21 Observed and predicted fits to the available AIBT survey age composition data for pollock in the NRA west of 174°W based on Model A10.

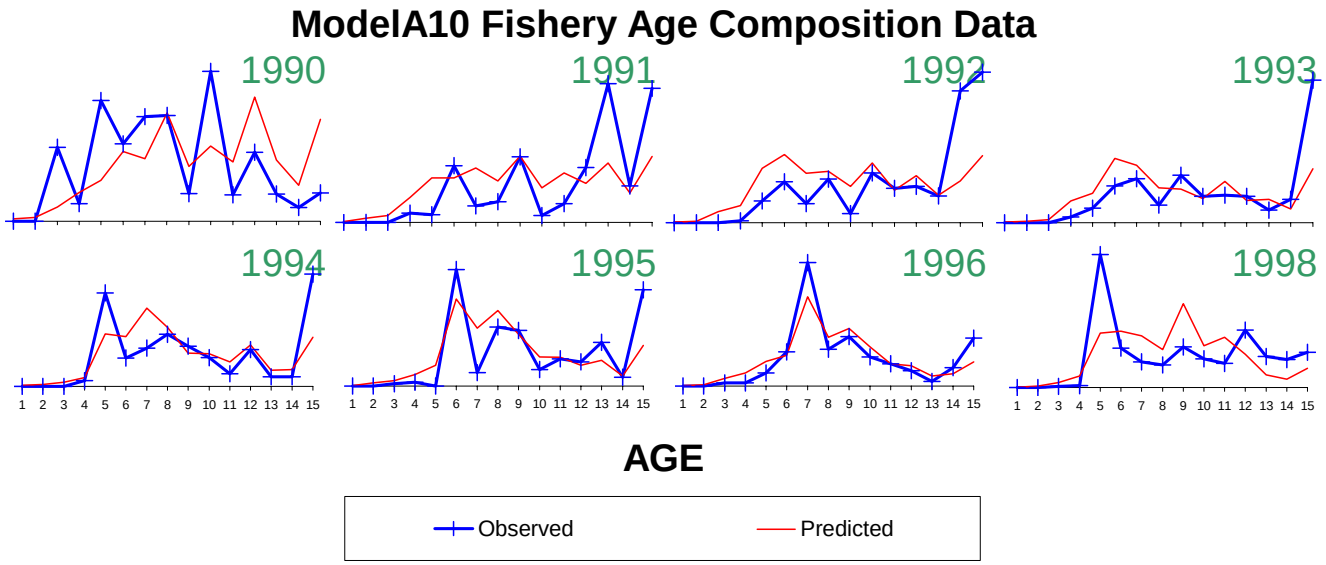


Figure 1A.22 Observed and predicted fits to the available fishery age composition data for pollock in the NRA west of 174°W based on Model A10.

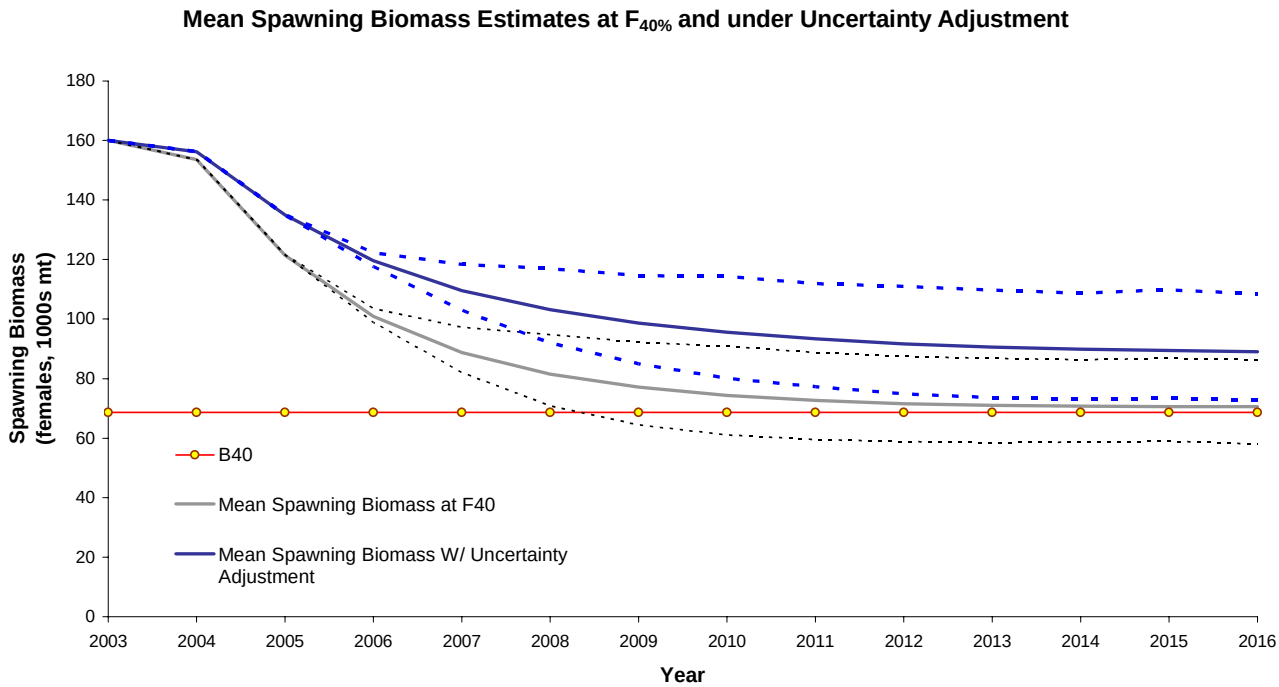


Figure 1A.23 Projected spawning biomass with harvest at $F_{40\%}$ and at $F_{40\%}$ with an uncertainty adjustment from Model A10 with adjusted selectivity-at-age.

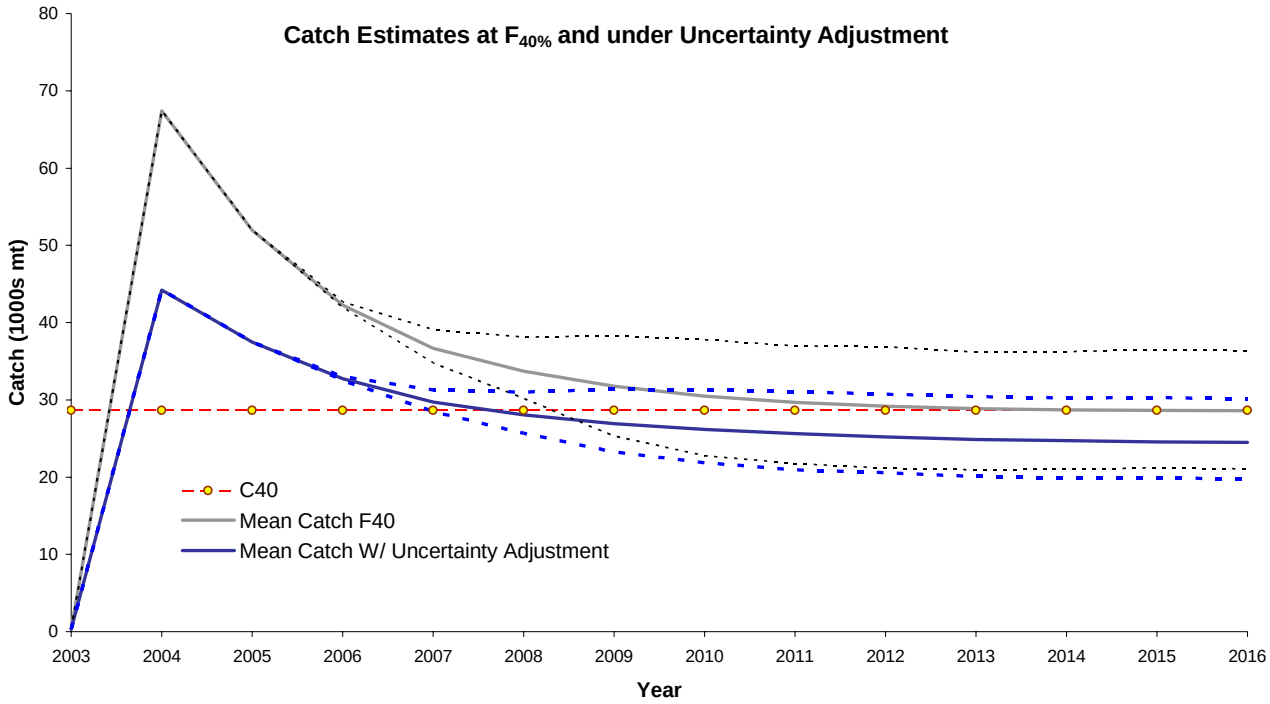


Figure 1A.24 Projected catch at $F_{40\%}$ and at $F_{40\%}$ with an uncertainty adjustment from Model A10 with adjusted selectivity-at- age.

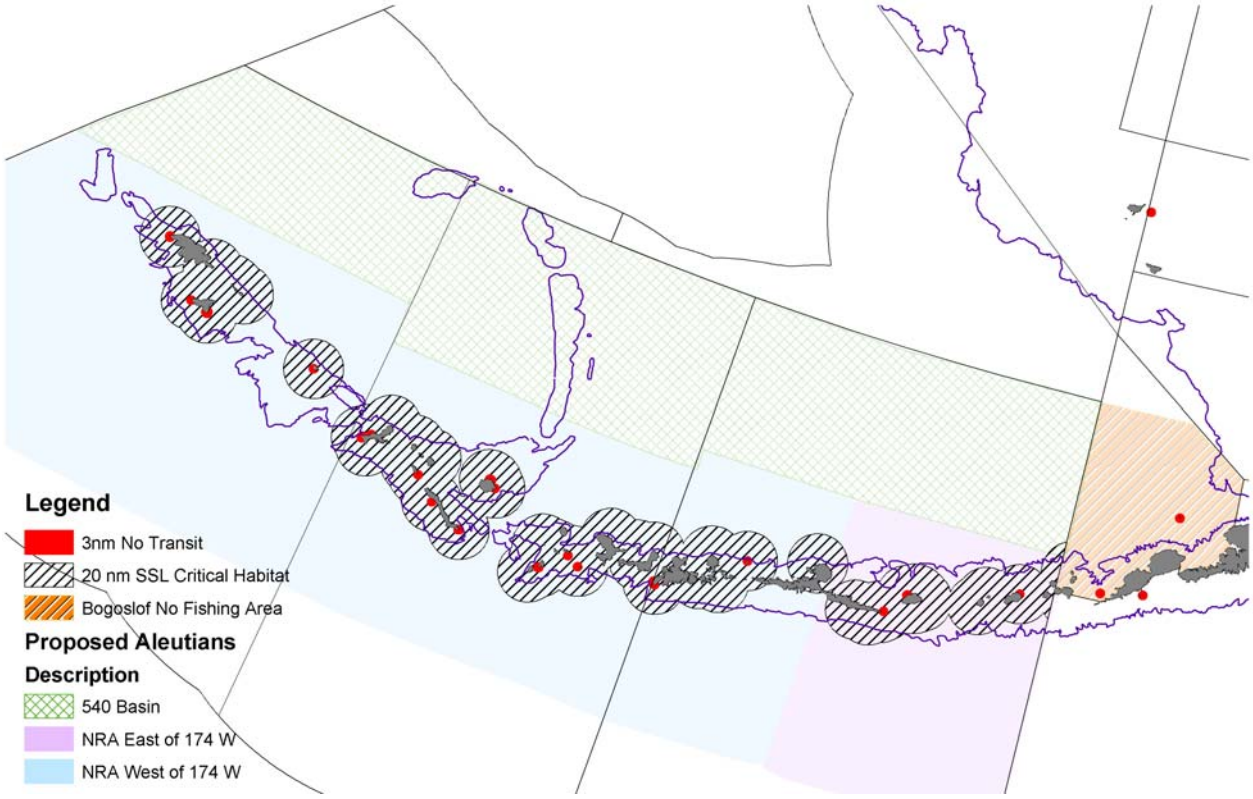


Figure 1A.25 Aleutian Islands Area with 20 nm Steller Sea Lion critical habitat and proposed pollock areas.